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Mitigation of Landfill Gas into Occupied Structures

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Mitigation of Landfill Gas into Occupied Structures

- Introduction
- Site characterization
- Type of development
- Intrusion pathways
- Goals for mitigating gas/vapor intrusion
- Regulations
- Design
- Case study summaries
- Summary







Introduction

- Redevelopment on/near landfills or other contaminated (Brownfields) sites will continue to increase with the decrease of developable land.

- Mitigation is not limited to landfills alone, other clean undisturbed sites or contaminated sites can release gaseous compounds such as methane, VOC, or Radon.

- There is a concern that the design of mitigation systems is considered simple, implying that anyone can provide adequate assessment, mitigation, and monitoring measures to protect building occupants.







Introduction – cont'd

- Observations from many landfill gas mitigation projects reveal site characterization and design shortcomings which result in personal injury, property damage, increased monitoring, increased costs, and potential for excessive subsidence and/or underground fires.

- The following discussion hopes to shed some light on the characterization, mitigation, and monitoring issues and promote fundamental concepts.



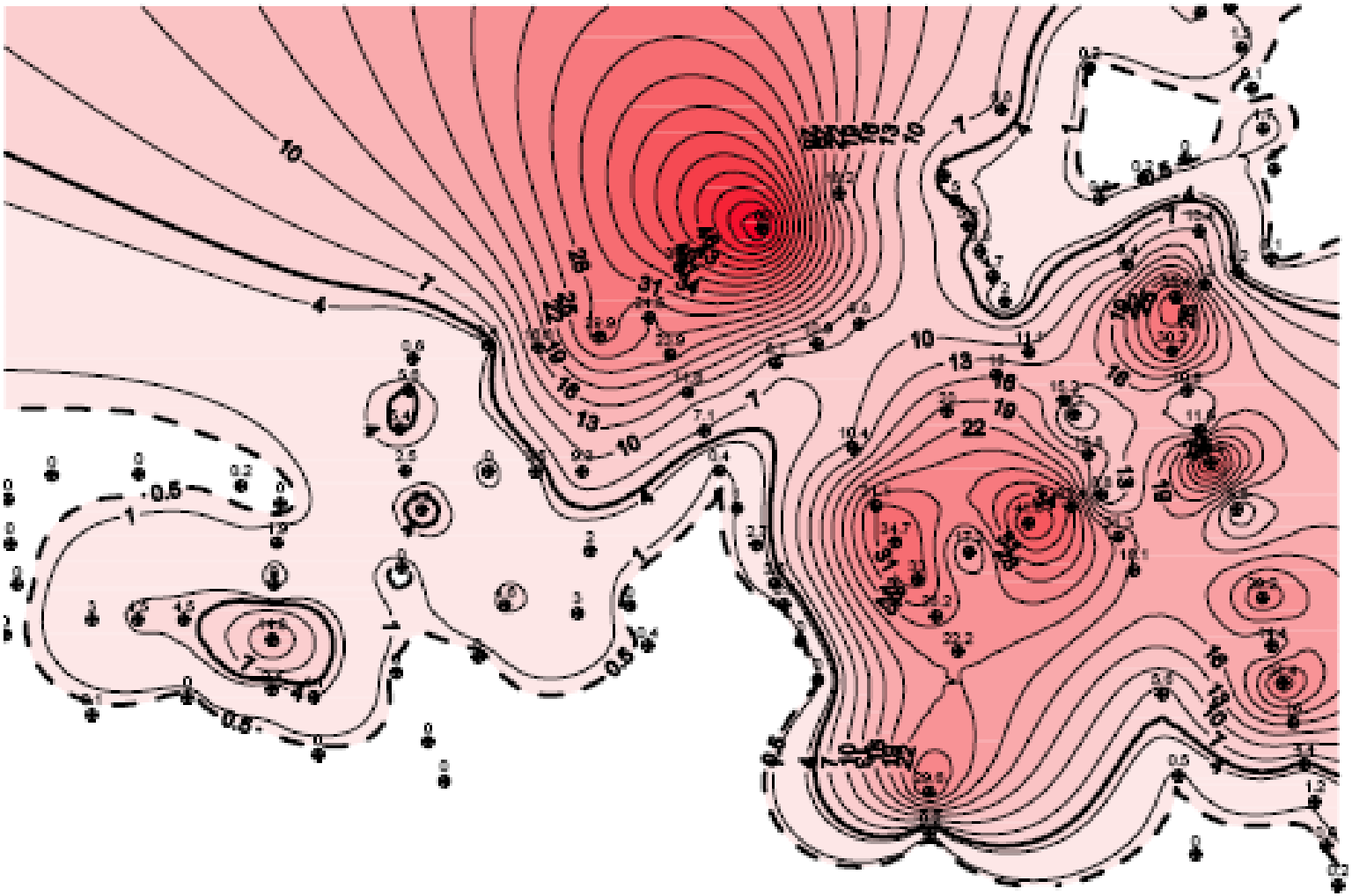




Site Characterization

- Gas and/or vapor of concern (CH_4, CO_2, VOC, Radon, other?)
- Source of gas and/or vapor (offsite, onsite, pipeline, other sources)
  - Peat, wetland deposits, hog fuel, MSW fill, CDL fill
- Extent of plume defined
- Quantity/generation defined (residual or continued production)
- Driving mechanism – convection or diffusion
- Pathways defined

Fig. 1– Map of Gas Concentrations



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Type of Development

- Open space (park, golf course, etc.)
- Pavement (parking, airport, etc.)
- Warehouse
- Office
- Residence
- Building location and construction
  - On/off waste
  - Slab on grade
  - Grade beams
  - Pilings (is subgrade expected to separate from slab?)
  - Type of Ventilation



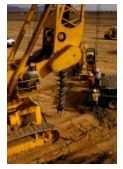




Intrusion Pathways

- Cracks in floors or walls below grade
- Utility trench pipe embedment
- Electrical power and communications conduits – pose the most risk
- Drain pipes with dry traps
- Annulus of pipe/conduit penetrations
- Geologic (porous soil, bedrock cracks or soil stratigraphy, etc.)

Fig. 2 – Bldg Plan showing Buried Utilities



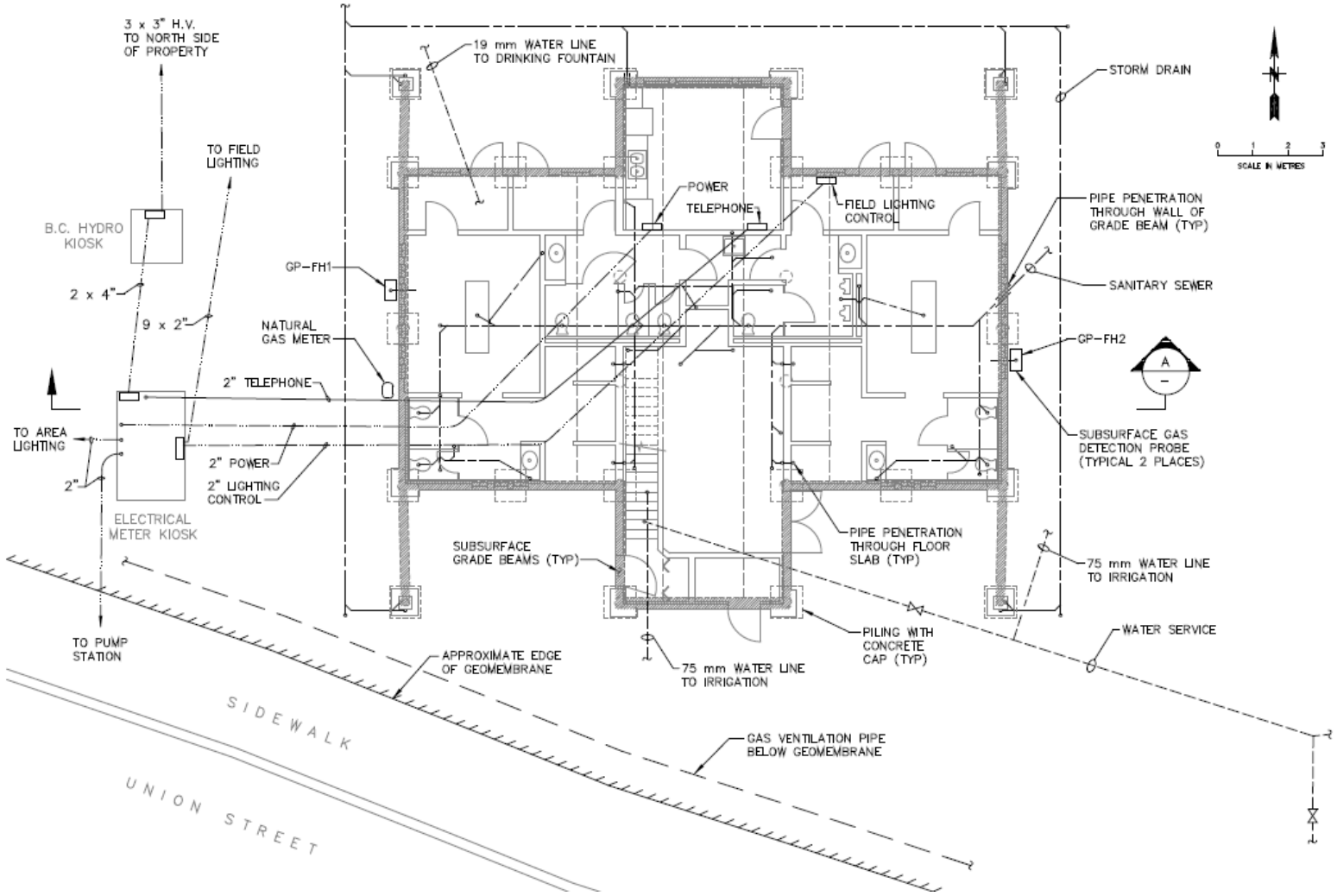



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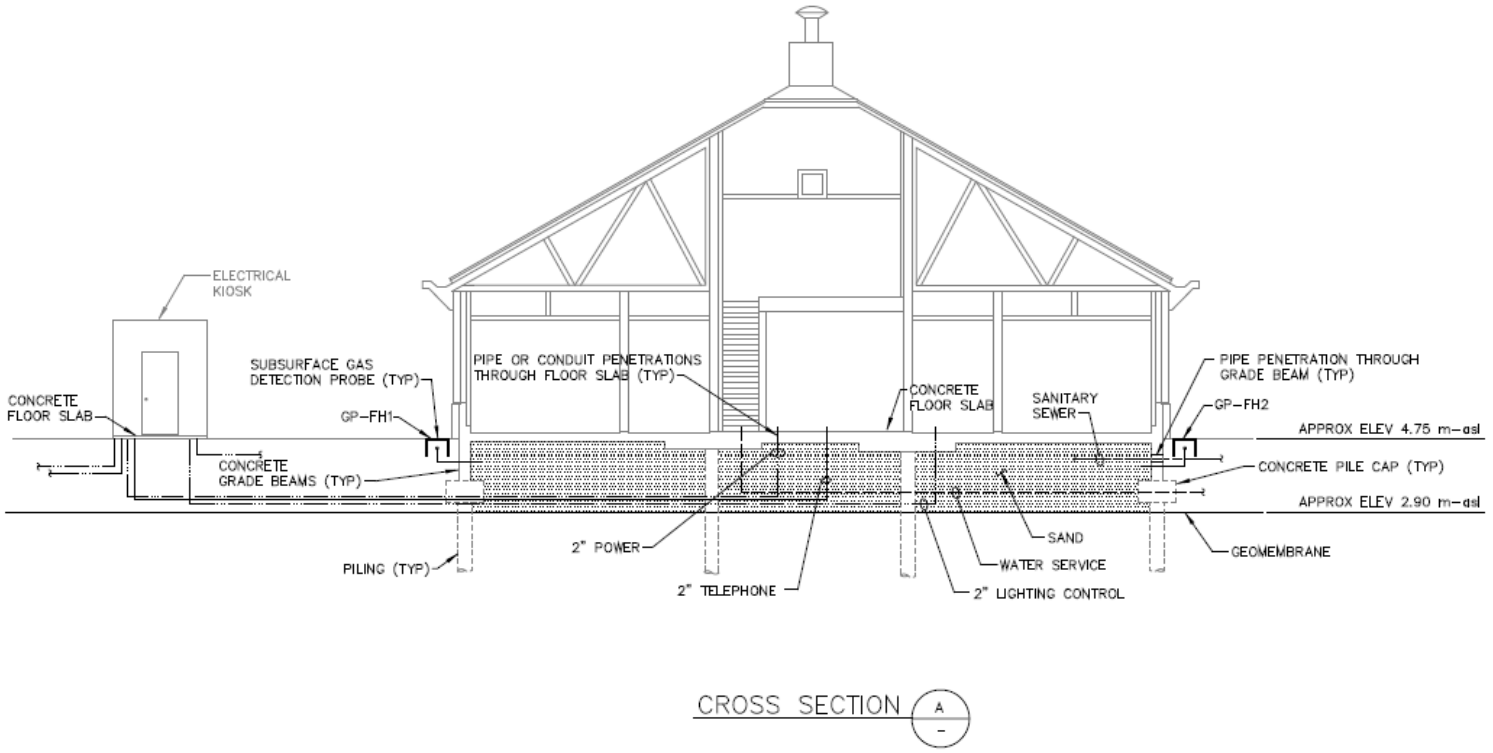
Fig. 3 – Bldg Section showing Buried Utilities



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Goals for Mitigating Gas/Vapor Intrusion

- Regulatory driven? Existing code or site specific health risk assessment-based or other.
- Threshold limit for different gases/vapors.
- Threshold limit for different locations.
  - concentration in soil/gravel layer
  - concentration in buildings
- Threshold limit for pressure in sub-slab soils.







Regulations

- Los Angeles
- OSHA
- Others

- Threshold limits concentration and pressure.
- Prescribed design standards – pipe spacing, gravel thickness/porosity, sensor spacing.
- Air change requirements.







Design

- Gas/vapor barriers
- Gas/vapor vents
- Monitoring instruments
- Monitoring locations
- Design approach/philosophy
- Design challenges







Types of Gas/Vapor Barriers

- Barrier layer (e.g., PVC, HDPE, PP, LLDPE, Liquid Boot®, others)
- Barrier trench (cutoff walls e.g., slurry wall or geomembrane curtain)
- Other barriers
  - Utility trench plugs
  - Conduit seal-offs – <u>often overlooked</u>
  - Pipe penetration seals
  - Auto trap primers

Types of Gas/Vapor Vents

- Venting layers – gravel, sand, geonet
- Venting trench
- Pipe system

Barrier layers and venting layers are typically used in combination to supplement each other. A barrier or venting layer by itself has limitation on protection.







Monitoring Locations

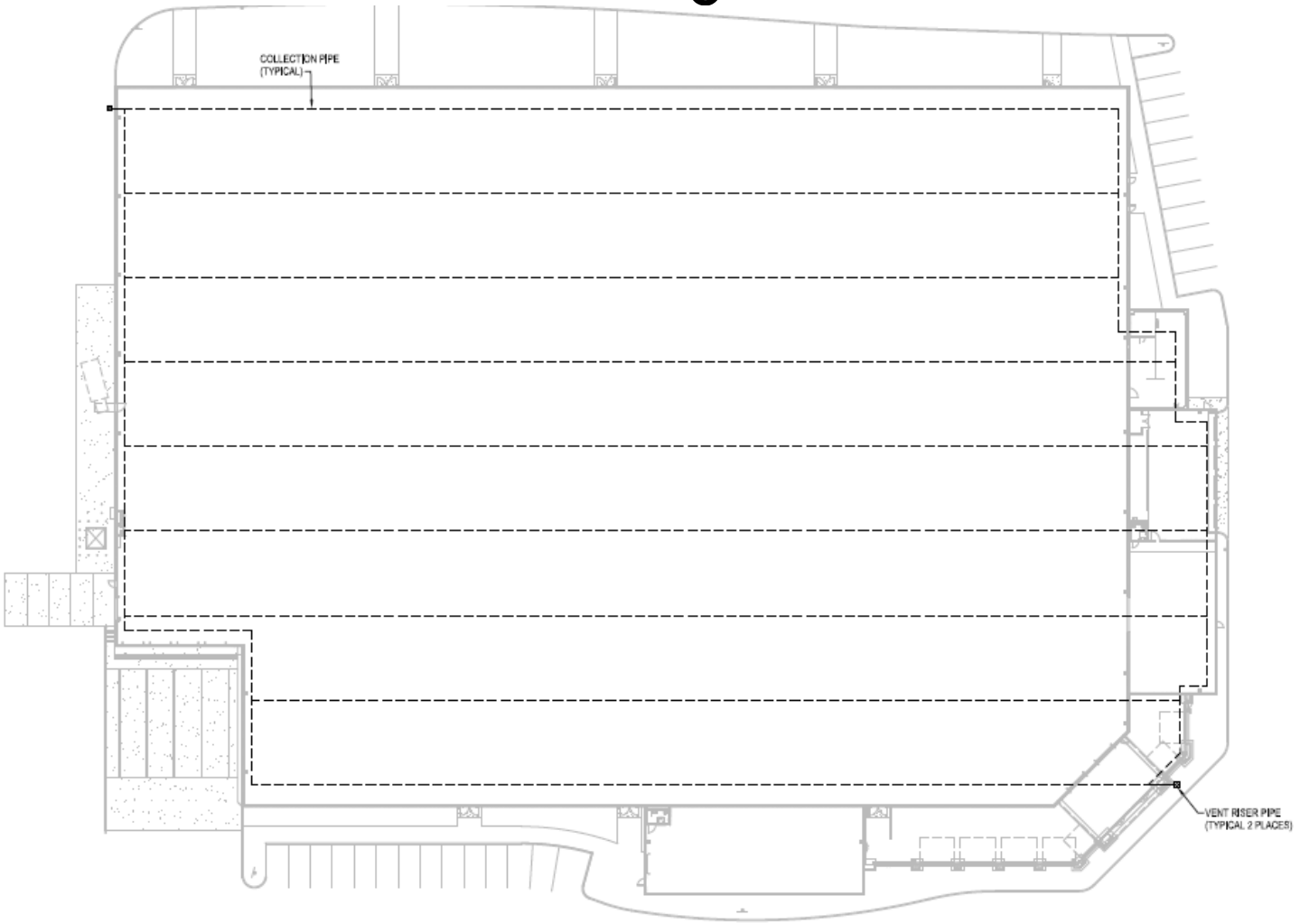
- Vent risers –
  - Note: Not good, concentrations are diluted.
- Subsurface probes in soil (conventional gas probes outside the building)
- Subsurface probes in utility trenches
- Subsurface probes in gravel vent layers
  - Note: Excessive pipe size can lead to inadequate monitoring.
  - Note: Often not enough installed.







Fig. 4 – Plan of Sub-slab Vent Pipes and Monitoring robes



FLOOR PLAN

SCALE: 1/16"=1'-0"

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Monitoring Locations – cont'd

- Building interior rooms with poor ventilation
- Rooms with floor drains
- Rooms with below ground entry of electrical power
- Rooms with below ground entry of communications
- Bottom floor rooms
- Location of stationary sensor







Types of Monitoring Instruments

- Portable instruments = Manual monitoring
- Stationary instruments = Automated/continuous monitoring
- Need to evaluate long term costs of manual (portable) and false alarms vs. Automated (stationary) monitoring







Types of Monitoring Instruments – cont'd

- Portable Instruments – infrared or thermal conductivity

  0 to 100 % vol
  - Note: Not sensitive enough for monitoring building interiors.
- Portable instruments – catalytic oxidation 0 to 5% vol (0 to 100 % LEL)
- Portable instruments - flame ionization detector (FID) – 0 to 10,000 ppm
- Stationary instruments – general purpose type
  - Note: Common false alarms, cannot calibrate, can be poisoned.
  - Stationary instruments – industrial grade type
  - Note: more expensive







Types of Monitoring Instruments – cont'd

- Portable instruments typically used with gas probes outside of buildings
- Portable instruments used for monitoring inside of buildings
- Stationary instruments used inside of buildings in lieu of portable instruments

Sub-slab Monitoring Probes

- Individual monitoring points with individual sensors.
- Less pipe, more sensors.
- Individual pipes to collect gas at discrete locations extending to a manifold for connection to a single pump and sensor.
- Single sensors, more pipe, more controls
- Preferences?







Design Approach / Philosophy

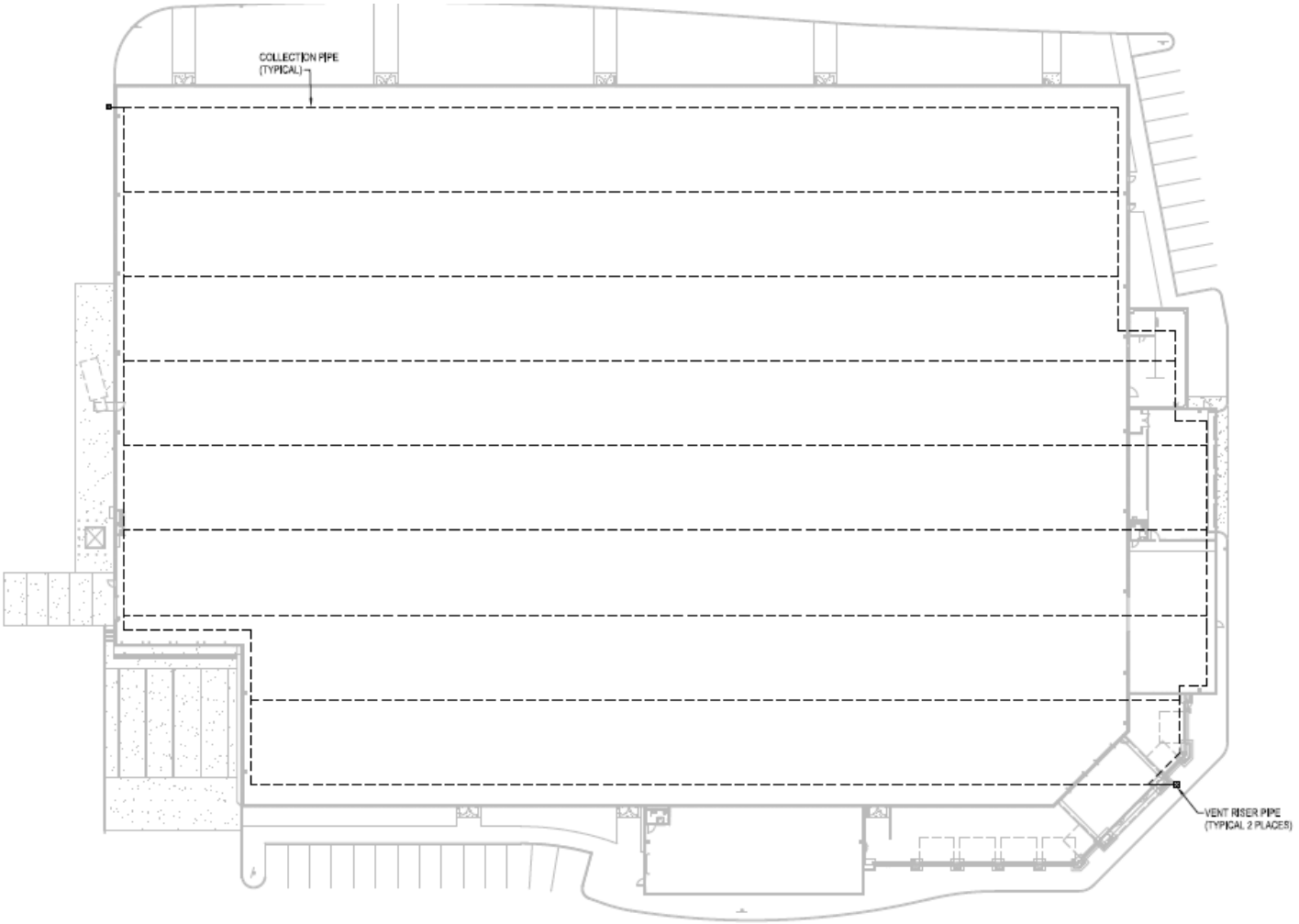
- Passive or active – design as if an active system.
- Why? Active can always be a passive system, but many passive systems make a poor active system. The cost is not significant.
  - Note: See previous plan of pipe venting system.







Fig. 4 – Plan of Typical Sub-slab Vent Pipes and Monitoring Probes



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Design Approach / Philosophy – cont'd

- Active extraction or active ventilation?
- Active extraction = Vacuum applied to every pipe which induces vacuum to gravel vent layer.
- Active ventilation = Vacuum applied to every other row of pipe, alternate rows allow fresh air in to flush or ventilate the gravel layer with ambient air.

Design Approach / Philosophy – cont'd

- Active extraction pulls all gas/vapors towards building.
- Active ventilation pulls ambient air through the gravel layer.
- Do you want to pull gas towards the building?
  - Potential to increase the gas concentration under the building & concerns if there is a power failure
  - Air intrusion into waste mass and concerns for potential accelerated settlement and/or fire
- If design costs and construction are the same, which would you prefer?

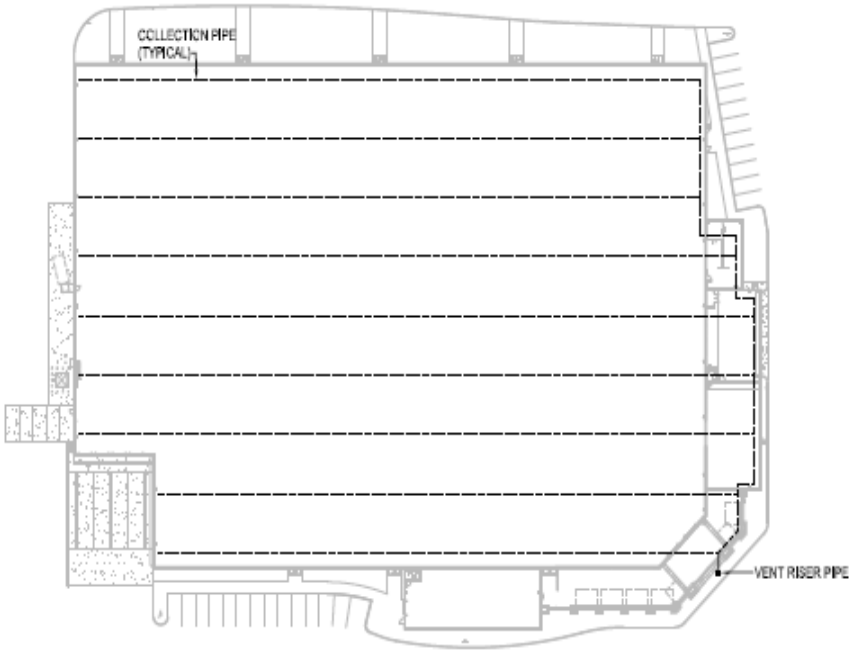




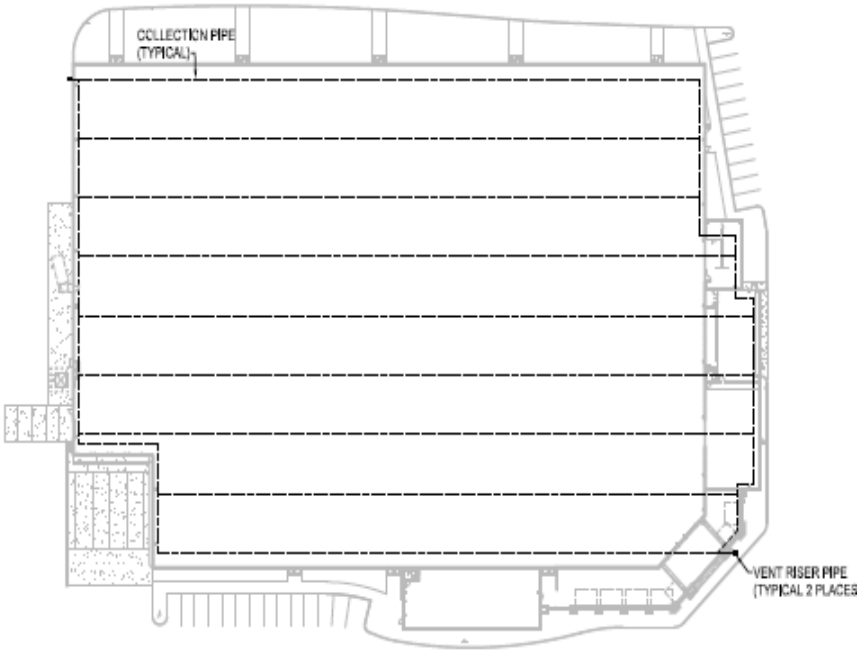


Design Approach / Philosophy – cont'd

- Active ventilation requires specific piping configuration.
- Active ventilation should require less pipe.
- Active ventilation should require less air change over.
- Active ventilation with less air change over means lower flow, smaller blowers, lower power consumption.
- Active ventilation does not pull gas towards the building and does not introduce air into the waste mass.



SCENARIO 1



SCENARIO 2

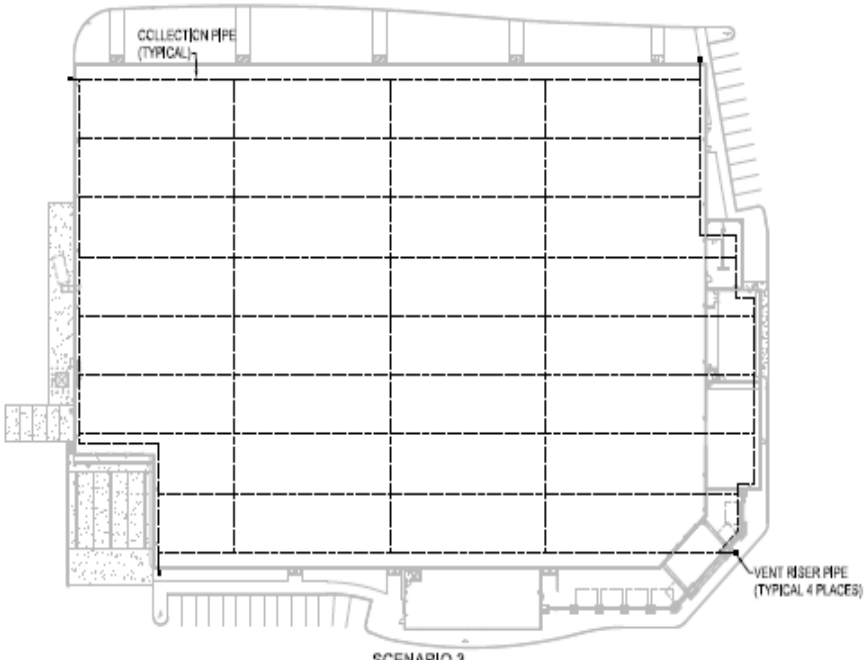


Fig. 5 – Plan view of Active Ventilation Pipe System







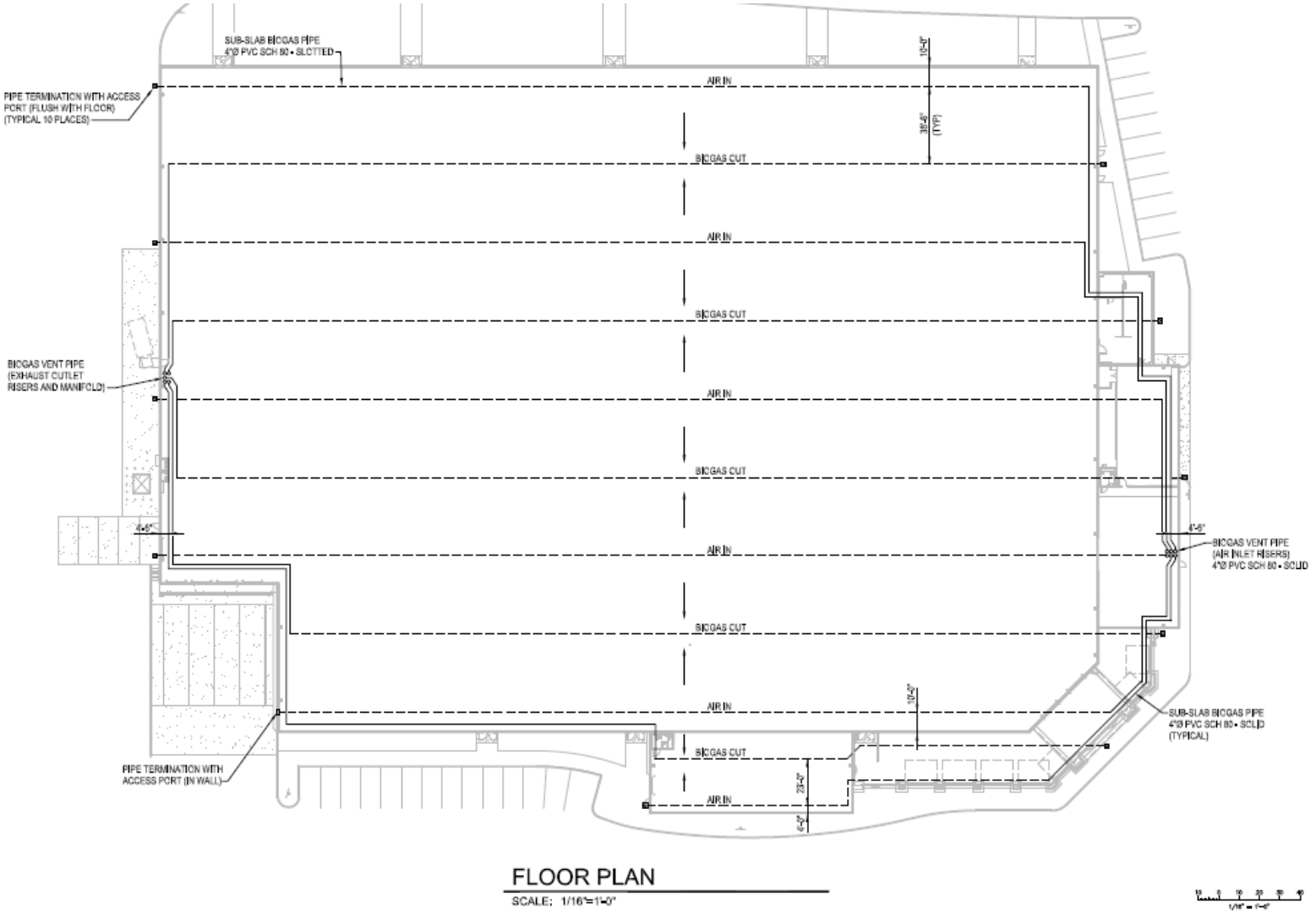


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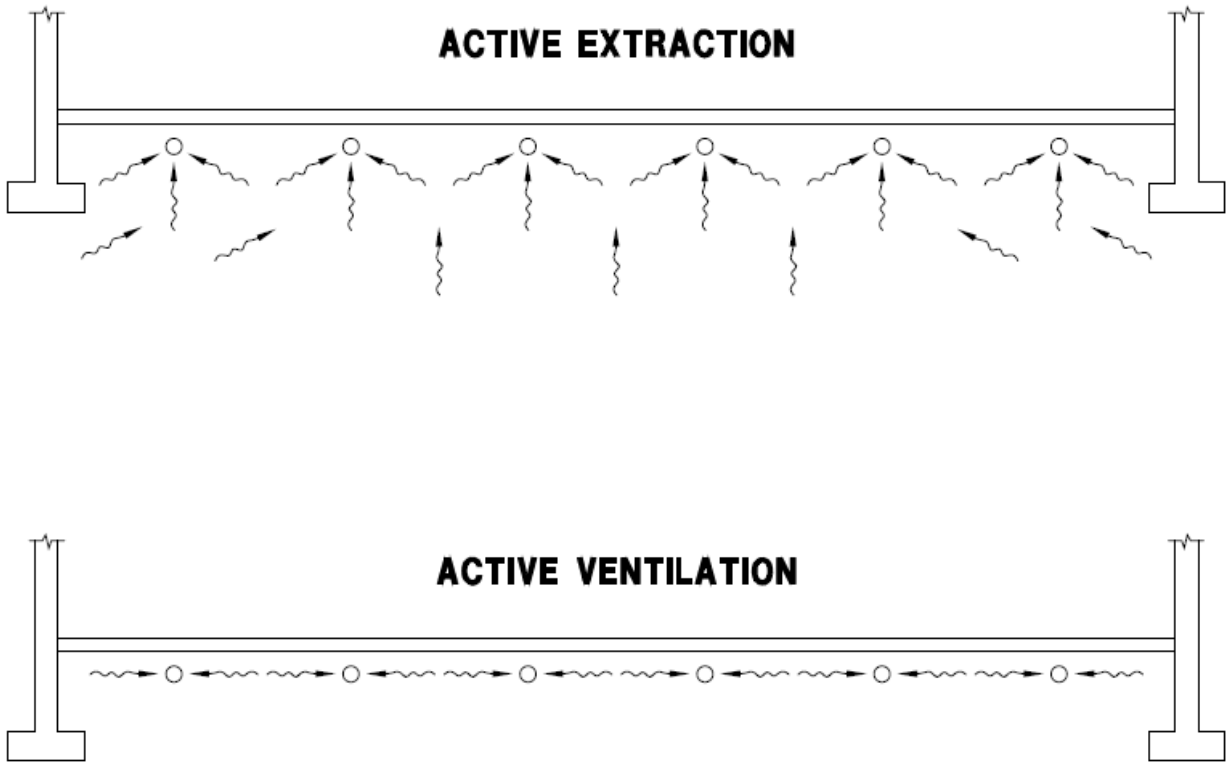
Fig. 6 – Section comparing Extraction to Ventilation Piping System









Design Challenges

- Barrier layers and venting layers for pile support buildings with anticipated subgrade separation.
- Geomembrane directly on concrete?
- Reducing venting layer thickness.
- Providing uniform pressure and flow distribution.
- Seals for building penetrations







Summary

- Lay out gravel vent layer and piping as if it would be an active system
- Design for piping for active ventilation, not extraction
- Do not use vacuum as a compliance criteria
- Design for adequate number & location of sub-slab monitoring probes.
- Consideration for stationary sensors based on overall costs vs manual monitoring & false alarms
- Design for proper placement of sensors
- Provide seals for conduits !