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Landfill Redevelopment Can Be Smart Growth

Mike McLaughlin

2011 Ohio Brownfields Conference

January 20, 2011

Landfill Redevelopment Can Be Smart Growth

- Good surface transportation access
- Existing infrastructure
- Urban and suburban corridors have extended to once-isolated landfill sites

Landfill Redevelopment Can Be Smart Growth

- Historical approach: Can’t put buildings on a landfill
- Modern thinking: Intense land uses are possible, and lead to more active management of environmental controls
- Regulations and guidance are lagging practical experience

Challenges to Redevelopment of Closed Landfills

- Legal Issues
  - Strict liability concerns under Federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, or Superfund)
  - Similar concerns under state laws (e.g. state Superfund laws, spill acts, open dump laws, Ohio Rule 13, etc.)
- Technical Issues
  - Gas mitigation
  - Foundation settlement

What Matters for Redeveloping a Land Fill Site

- For *a few* sites, potential for groundwater contamination, or buried hazardous wastes, is significant. GW is normally not the major environmental problem.
- For most of these sites, critical issues are mitigation of decomposition gas containing methane, and foundation support or settlement issues.

Landfills as Brownfields: Market Drivers

- Real Estate: Location, Location, Location
  - Landfills often located near major highways
  - Once rural, some landfills are surrounded by development
- Not really landfill regulations
  - Exceptions: Texas (Subchapter T) and Ohio (Rule 13)
  - Unless the landfill holds a permit (increasingly the case)
- Real estate developers are key
  - Liability for developing such sites?
  - Voluntary remediation programs and recent changes to Superfund reduce liability concerns

Definition of a Brownfield Site

"Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."

Section 211 (a), Small Business Liability Relief and Brownfields Revitalization Act of 2002

"A closed landfill."

Mike McLaughlin, Ohio Brownfields Conference, 2011

Bona Fide Prospective Purchaser

- All disposal of hazardous substances at the facility occurred before the person acquired the facility.
- All appropriate inquiries into the previous ownership and uses of the facility
- All legally required notices with respect to the discovery or release
- Full cooperation, assistance, and access

BFPP, Continued

- Institutional Controls
  - Complies with any land use restrictions established or relied on in connection with the response action
  - Does not impede the effectiveness or integrity of any institutional control
- BFPP not otherwise responsible party, and not affiliated (familial or corporate) with responsible party

BFPP, Continued

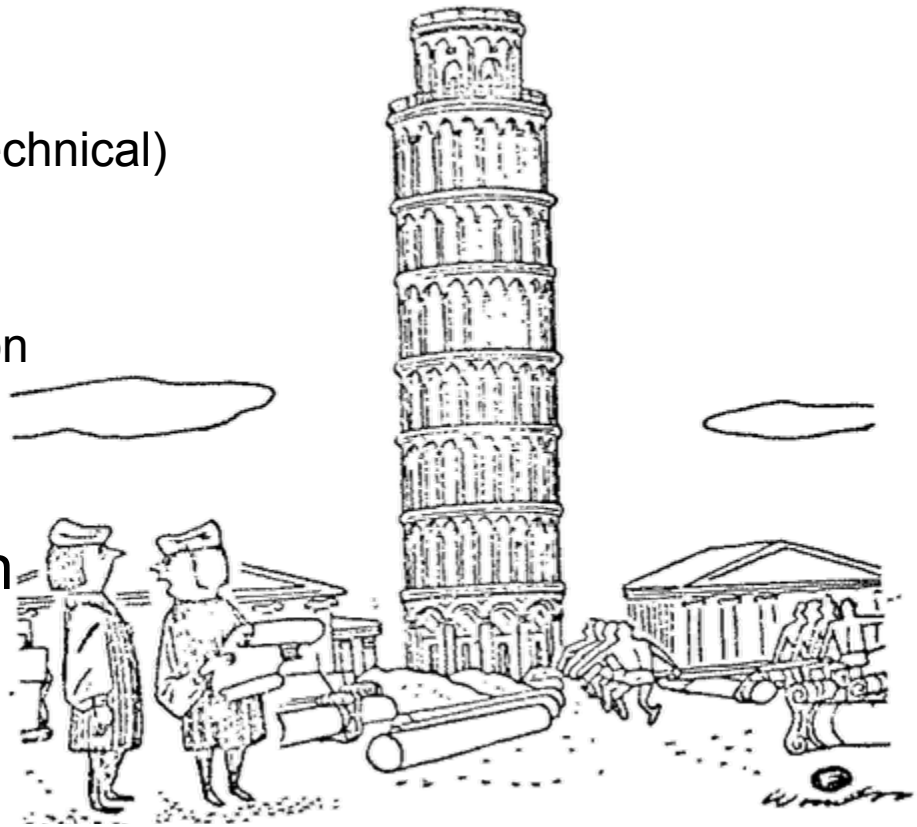
- The person exercises appropriate care with respect to hazardous substances found at the facility by taking reasonable steps to—
  - stop any continuing release
  - prevent any threatened future release
  - prevent or limit human, environmental, or natural resource exposure to any previously released hazardous substance.

Technical Concerns

- At a closed landfill site, “appropriate care” probably includes protecting against decomposition gas and maintaining integrity of cap
- Foundation and settlement issues
- Construction worker health and safety issues

Foundation and Settlement Issues

- Nature of the waste
  - Type, age, physical (geotechnical) properties
  - Depth and lateral limits
  - Daily cover and compaction
  - Liquid levels
  - Settlement history
- Subsurface information
  - Borings & test pits
  - Geophysics
  - Field load tests
  - Topographic maps



"I skimped a little on the foundation, but no one will ever know it!"

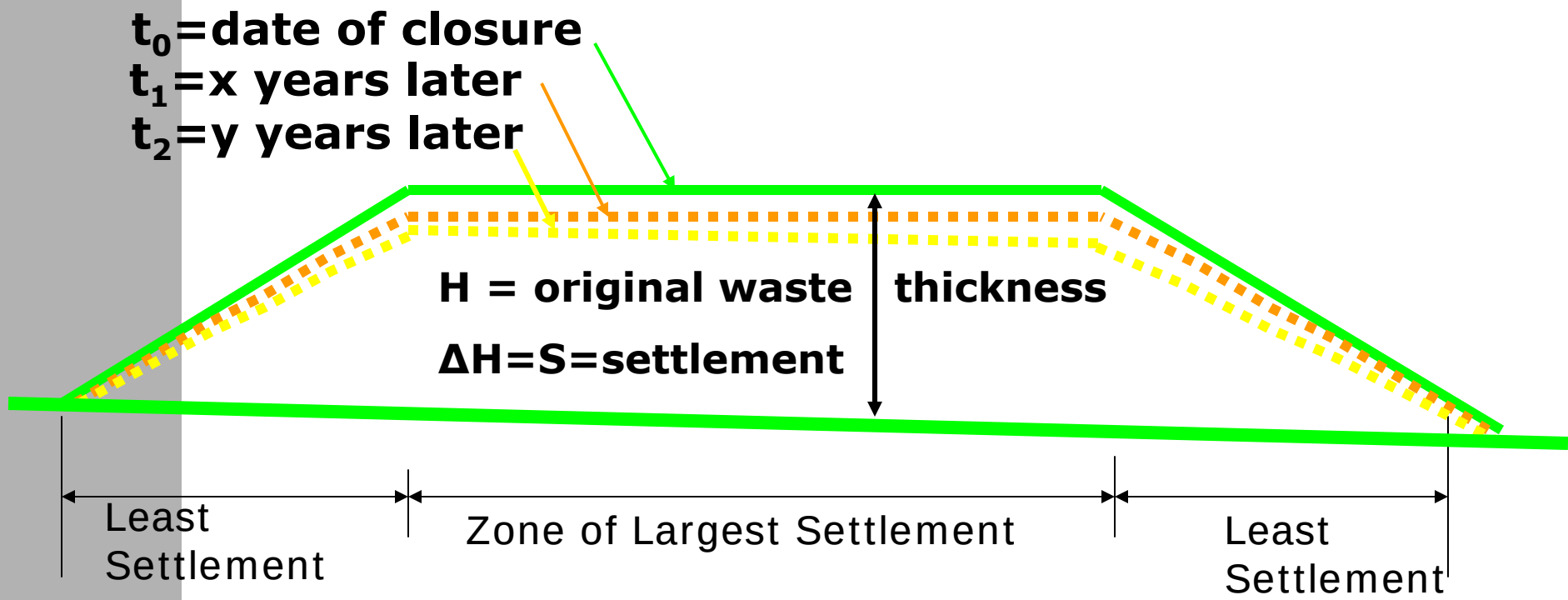
Foundation and Settlement Issues

- Landfills settle differentially—depends on
  - Depth of fill, nature of waste
  - Trench versus area fill, compaction
  - Age of waste
- Hard to predict settlement. Empirical approach (settlement plates and surcharge) often better than guessing/modeling
- Structures on deep foundations (hard edges) may separate from surrounding land surface (soft edges)
  - Shear utility connections
  - “Watch your step!”

Settlement

- Waste is not weak, but it is compressible
  - MSW reacts like a soft clay or peat
  - CDD, rubble & inert waste is more “soil-like”
- MSW settlement is **Time and Load** dependent
  - Biological decomposition of organics
  - Chemical reactions
  - Measured in years to decades
  - New loads from fill, foundations, roads, etc.

Time Dependent
No Additional Loadings ($\Delta P=0$)

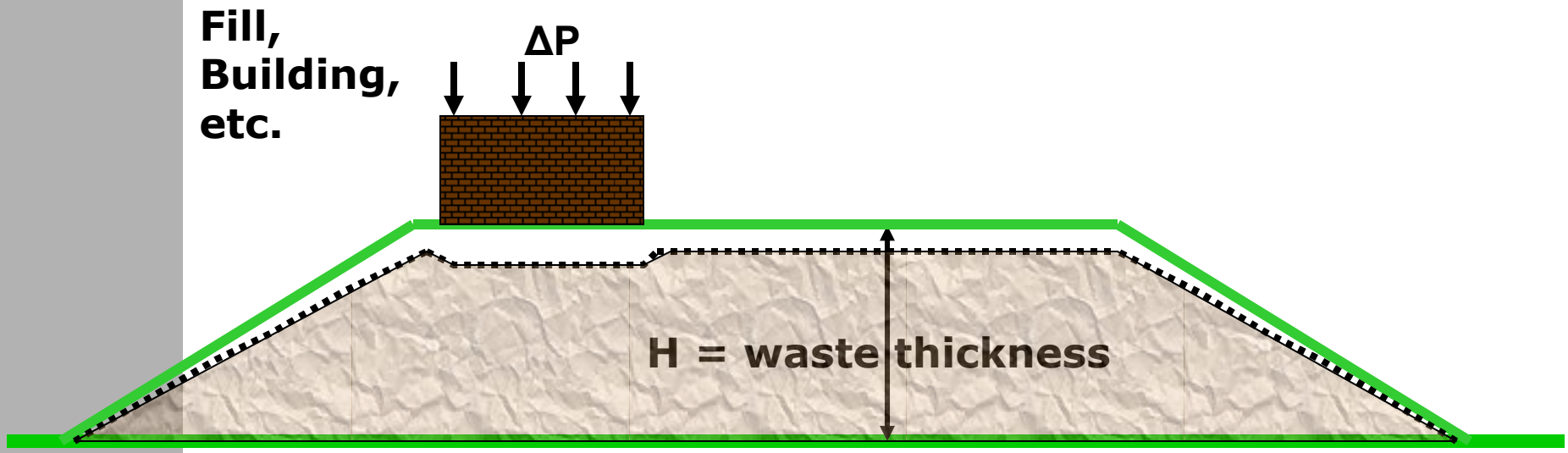


Total Settlement over time, $\Delta H^* \sim (10\% \text{ to } 30\%)*H$

H=100 feet of waste→10 to 30 feet over time….

Total ΔH over several years to decades….at decreasing rates

Load Dependent (ΔP=new building)



S = settlement from loading

Cc = compression coefficient

e = waste void ratio

H = waste thickness**

ΔP = new loading

Pi = original load

S=(Cc/1+e)*H*log((1+ΔP)/Pi)

****S is directly proportional to waste thickness**

Building Foundation and Utility Support Design

- Shallow footings and slabs
- Deep foundations (driven piles, drilled piers, grade beams, structural slabs)
- Reinforcement (geogrids, etc.)
- Ground improvement (surcharge, deep dynamic compaction)
- Waste removal and replacement with structural fill (partial or complete)

“Soft” Edge Settlement

- Waste compression varies
  - Depth, type, compaction….
  - Loading
- Drainage patterns change
  - Excessive grades
  - Undulations
  - Ponding and reverse flow directions
- Utility line grades change
  - Which way will sewage flow?
- Paving cracks develop
- Angular distortion for lighting, fencing, etc.

“Hard” Edge Settlement

Ground Improvement

- Excavate waste and replace with structural fill ($$$)
- Reinforcement
  - Geogrids, other mechanical devices
  - Reduces abrupt differential settlement
  - Does not reduce total settlement

- Pre-loading (surcharging)
  - Old reliable method
  - Requires time and source of cheap fill
  - Allows settlement measurement & prediction

“Deep Dynamic Compaction”

- Brute force approach
- Areas should be level
- Depth of improvement ~25 to 30 feet in MSW
- Good for near surface stabilization
- Difficult on slopes

$d_{max} = n \times (W \times h)^{0.5}$

****for soils, <u>less for waste</u>**

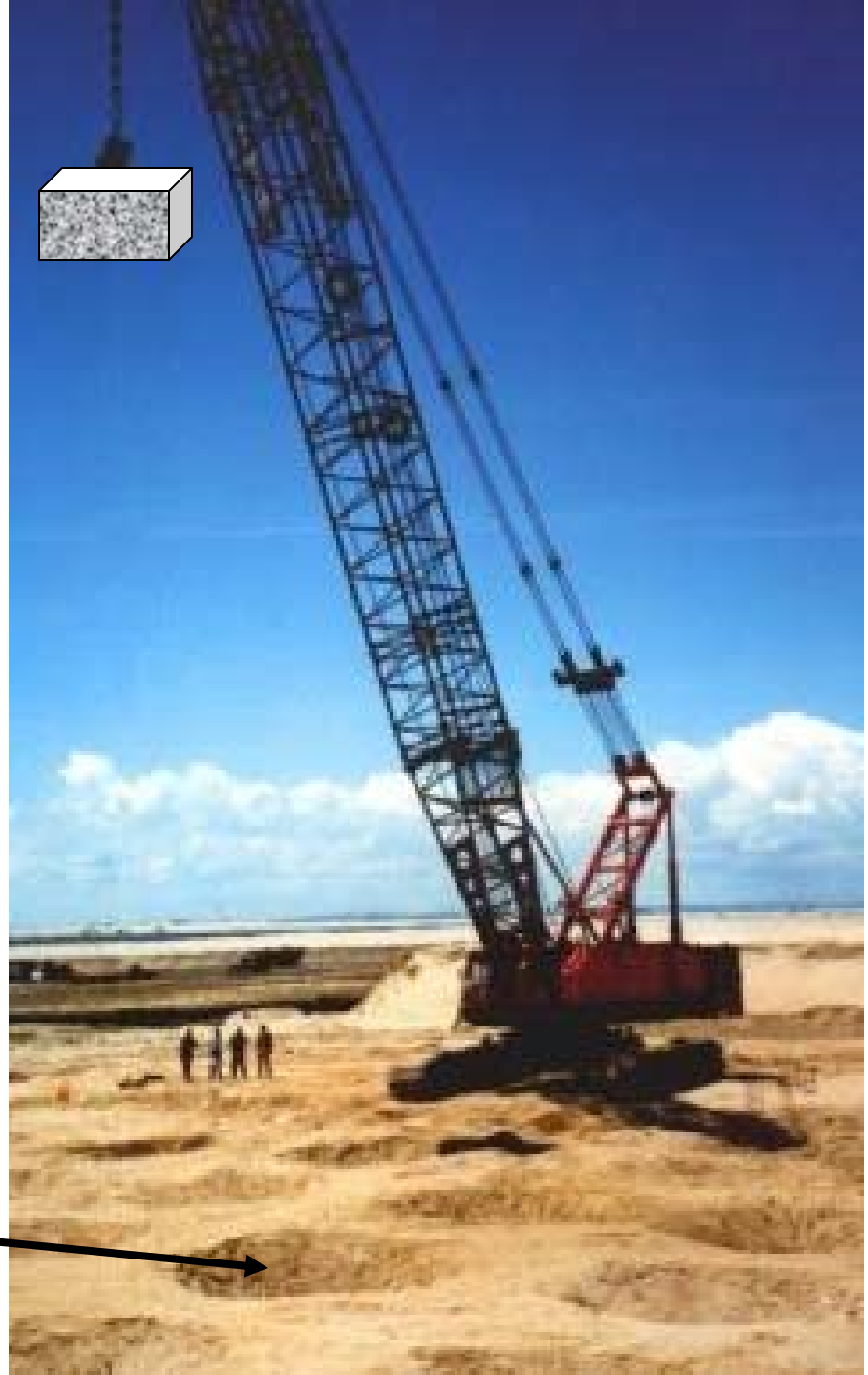
n = 0.3 – 0.5

W=weight (tons)

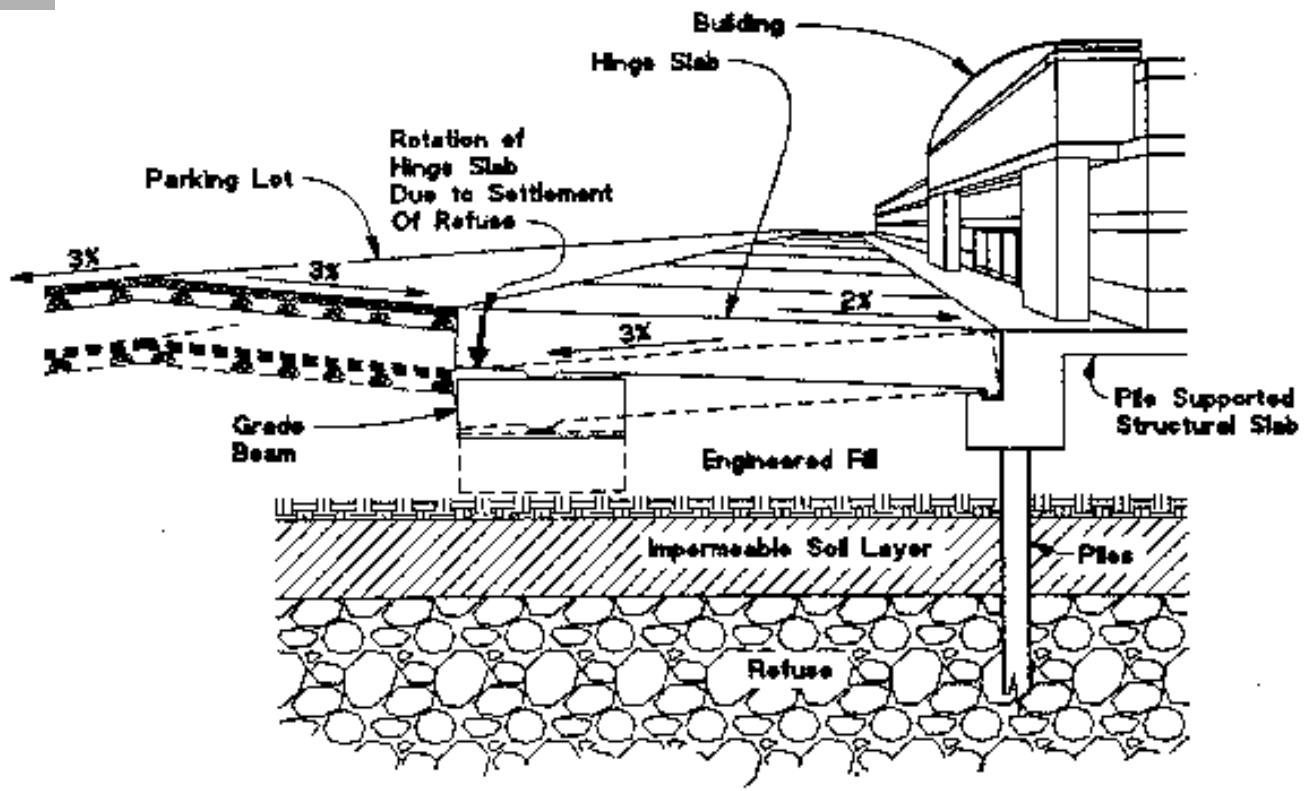
h=drop ht. (meters)

d_{max}= 7 to 8 meters for 15 ton wt, dropped 15 meters

Craters to be filled

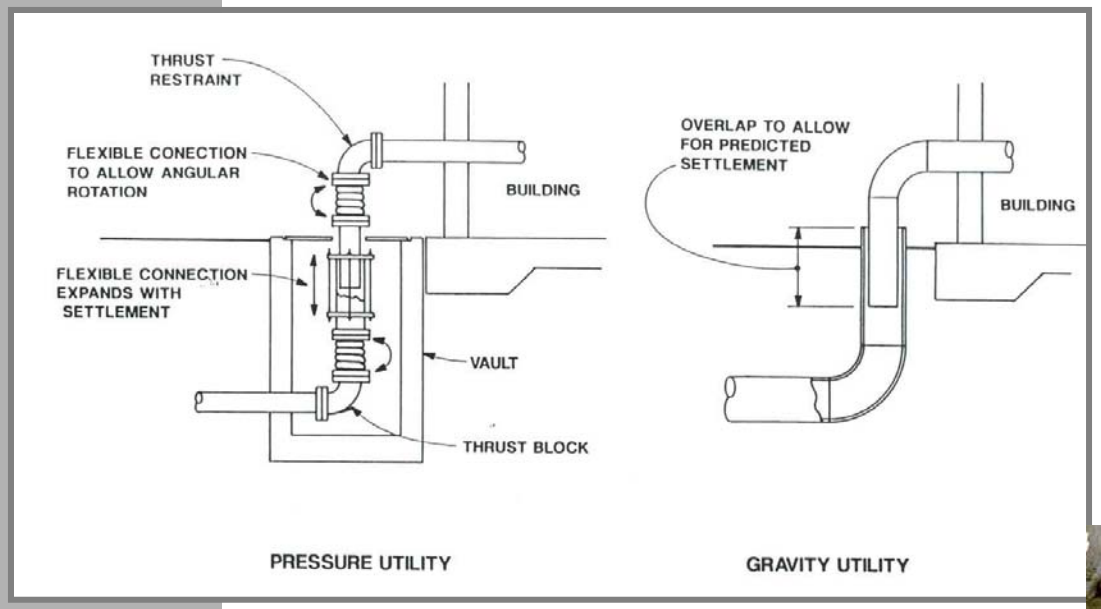


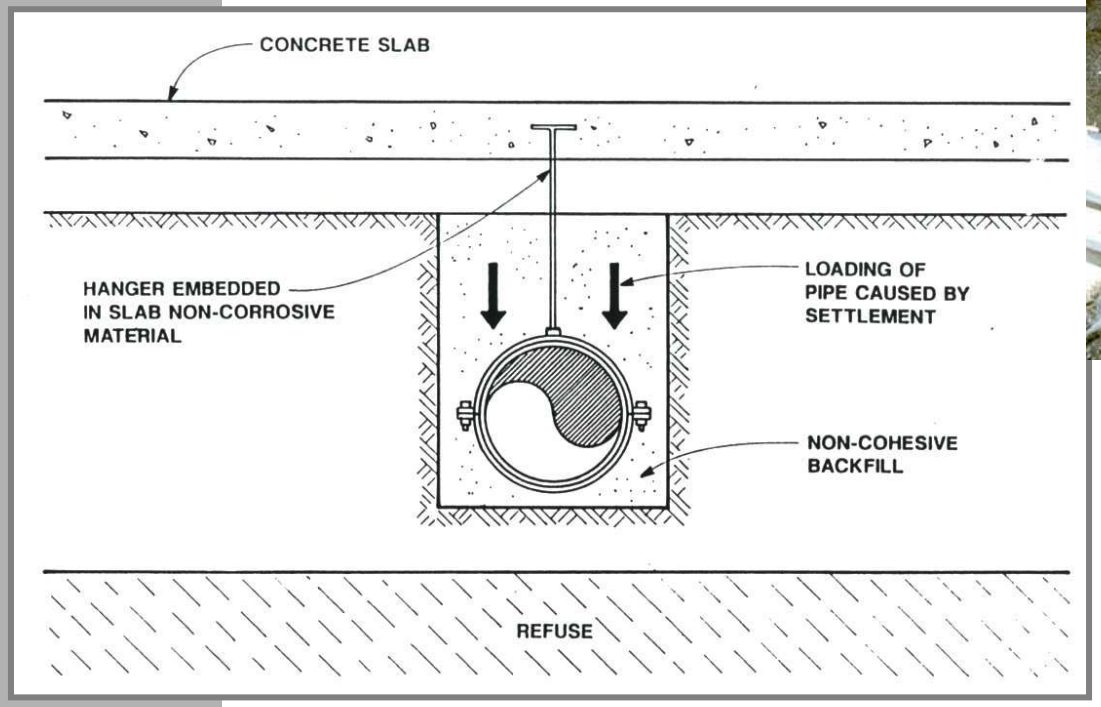
THE HOME DEPOT



HINGE SLAB FROM CONSTRUCTION TO ONE HALF DESIGN SETTLEMENT (2'±)

Utility Support & Sealing Systems





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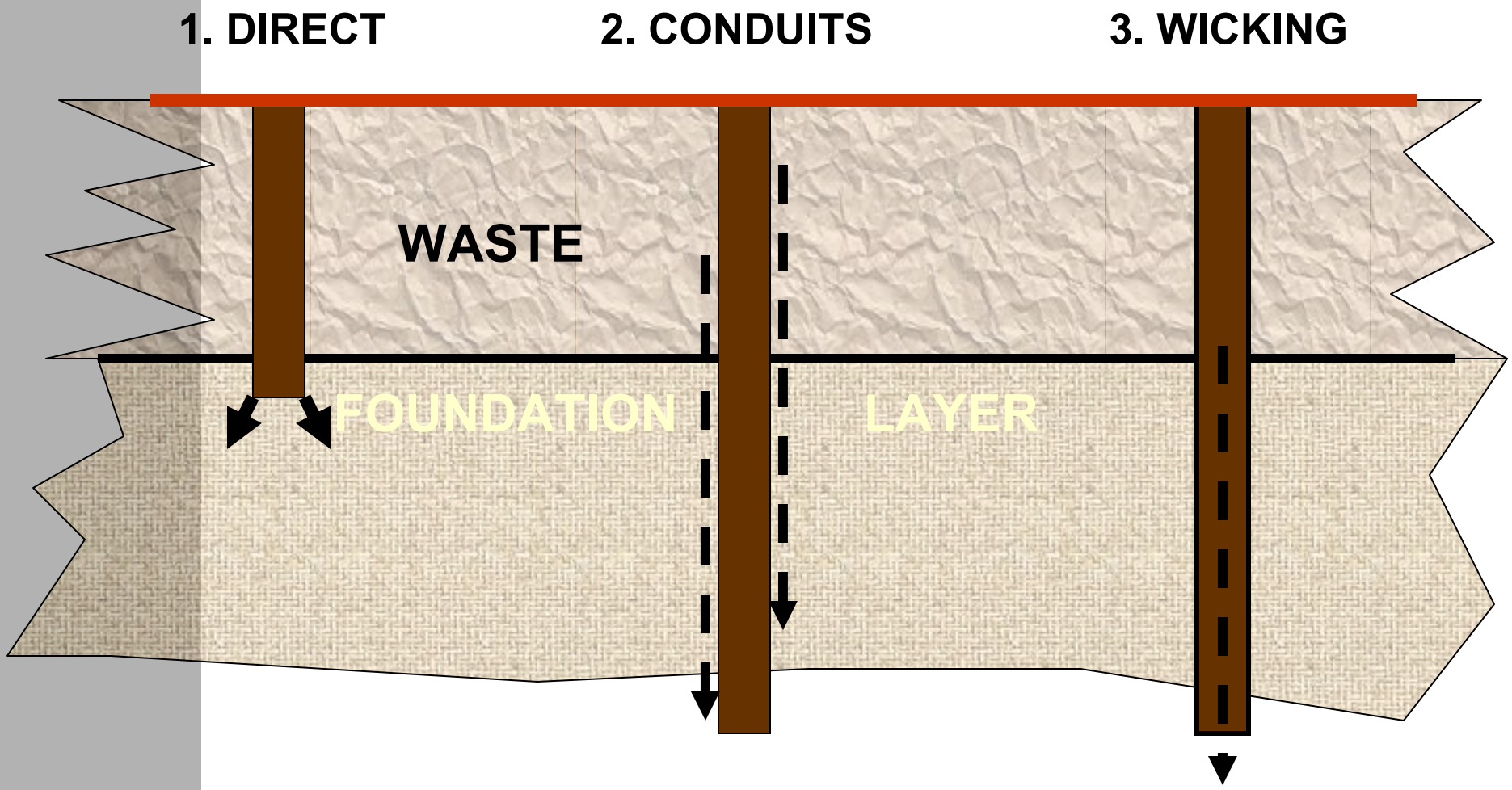
Are Piles Potential Migration Pathways?



Very low

Unlikely

Timber piles only

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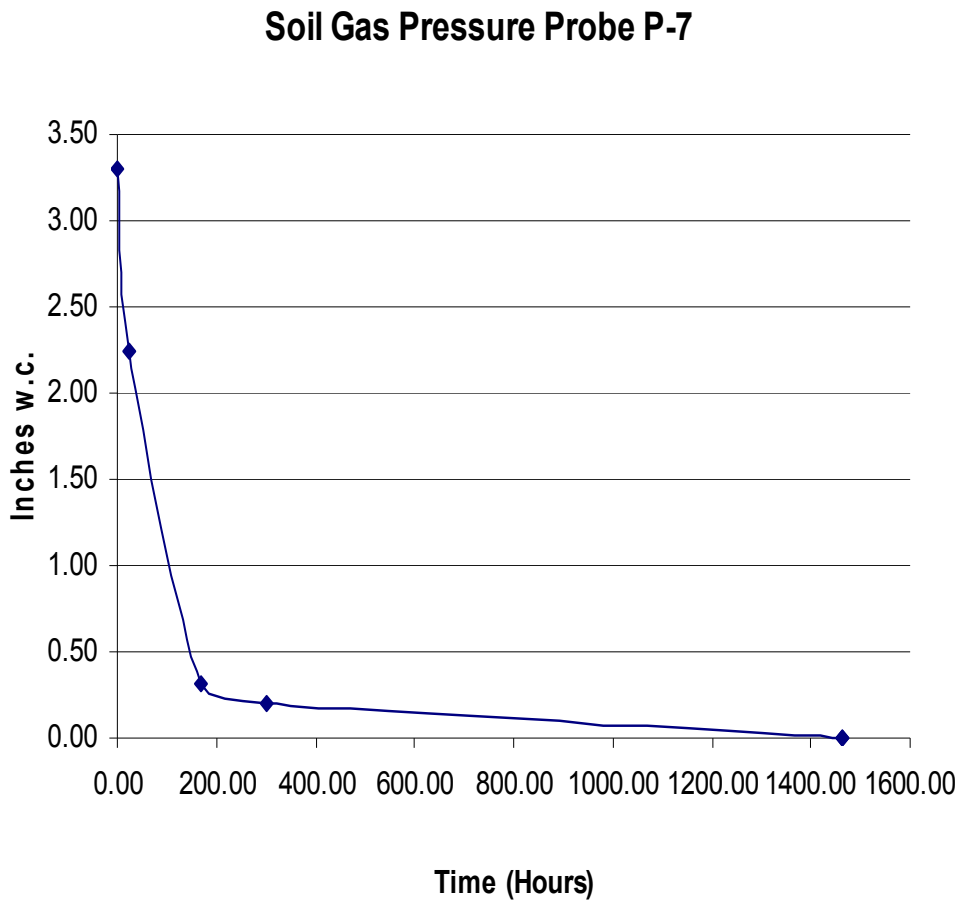
Landfill Gas Mitigation

- Nature of fill is important
  - Large quantity of relatively recent fill high in organics under anaerobic conditions may require elaborate gas mitigation
  - Small quantity of older fill low in organics can still produce gas, but probably in small volumes
- Nature of development also is important
  - Any occupied structure must be protected
  - Commercial development may be more suited to active controls (maintenance infrastructure)
  - Residential development can be challenging

Landfill Gas Mitigation

- Sustained gas pressures (e.g., over 0.5” w.c. for several weeks) indicate more gas production than no gas pressures
  - Geology matters. What really creates pressure (in addition to rotting trash) are confining layers of relatively lower permeability soils.
  - Meteorology matters. In the presence of a confining layer, barometric pressure can induce significant soil gas pressure. One web site for data: http://www.wunderground.com
  - Beware the pressure pocket.
- Gas quality (percent methane) also important

Landfill Gas Mitigation



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Landfill Gas Mitigation

- My LFG colleagues scoff at data with >~55% methane: "must be an instrument problem" (e.g., interfering compound or inexperienced operator)
- Particularly for slow-moving decomposition gas (e.g., swamp gas), characteristics can be altered by water—CO_2 is much (75X) more soluble than methane.
- Altered decomposition gas can exceed 90% methane
- Instrument problems still exist
  - Interfering compounds (simple hydrocarbons)
  - Data clipping by GEM (where CH_4 plus CO_2 add to 1.0)

Landfill Gas Mitigation

- Regulations and Guidance
  - Landfill regulations require factor of safety of four—methane must be less than 25 percent of the Lower Explosive Limit (LEL) in buildings
  - Wisconsin suggests no more than 25 percent of the LEL in soil gas (impractical)
  - Texas is only state with prescriptive statewide regulations (Subchapter T)
  - Ohio statewide regulations are subjective (Rule 13)
  - Local building officials handle through specific ordinances (Los Angeles, Alexandria) or fire marshal review—higher factors of safety (e.g., 10 or 20) are typical

PASSIVE EXAMPLES

9 25 '97

Construction Worker Health and Safety Issues

- Older landfills may contain industrial & hazardous wastes
  - Sludges, dusts, residues
  - Drums of liquids or semi-liquids
- Federal and State regulations, industry guidance (e.g., SWANA Safety Guidelines) and prudence require caution
  - Written health & safety plans
  - Air monitoring
  - Contingency plans
  - Notification may be required (e.g., asbestos NESHAP)

Construction over Landfills Can Cost More

- Structural slabs and deep pile foundations for typical retail or office park development can add $12 to $25 per square foot of building or more
- Deep dynamic compaction for parking areas can add $1 per square foot of treated area or more
- Passive gas protection system can add $2.50 to $6.00 per square foot of building footprint or more
- Maintenance cost for parking areas, etc. is higher

Project Examples

- Produce Market Facility, Philadelphia, PA
- Scannell Properties Belvoir Commerce Park and FedEx Ground, Newington, VA
- Lakeside MarketPlace, Acworth, GA
- Lake Archway Subdivision, Virginia Beach, VA
- Bayshore Technology Park, Redwood City, CA
- Tides at Seaboard Point, North Wildwood, NJ
- And about 150 others

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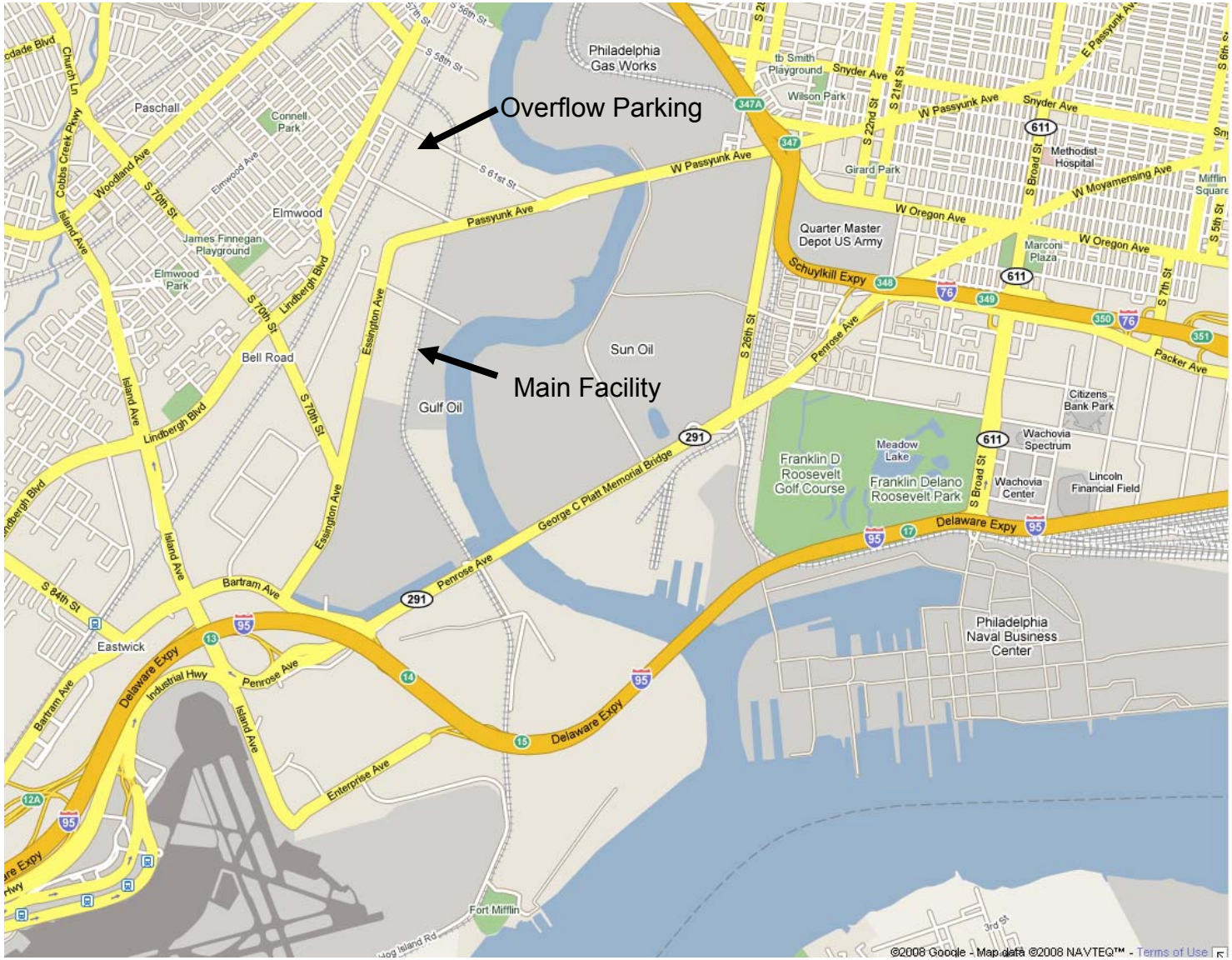
Case Study: Produce Market Philadelphia, Pennsylvania

O'Neill Properties Group for

Philadelphia Regional Port Authority



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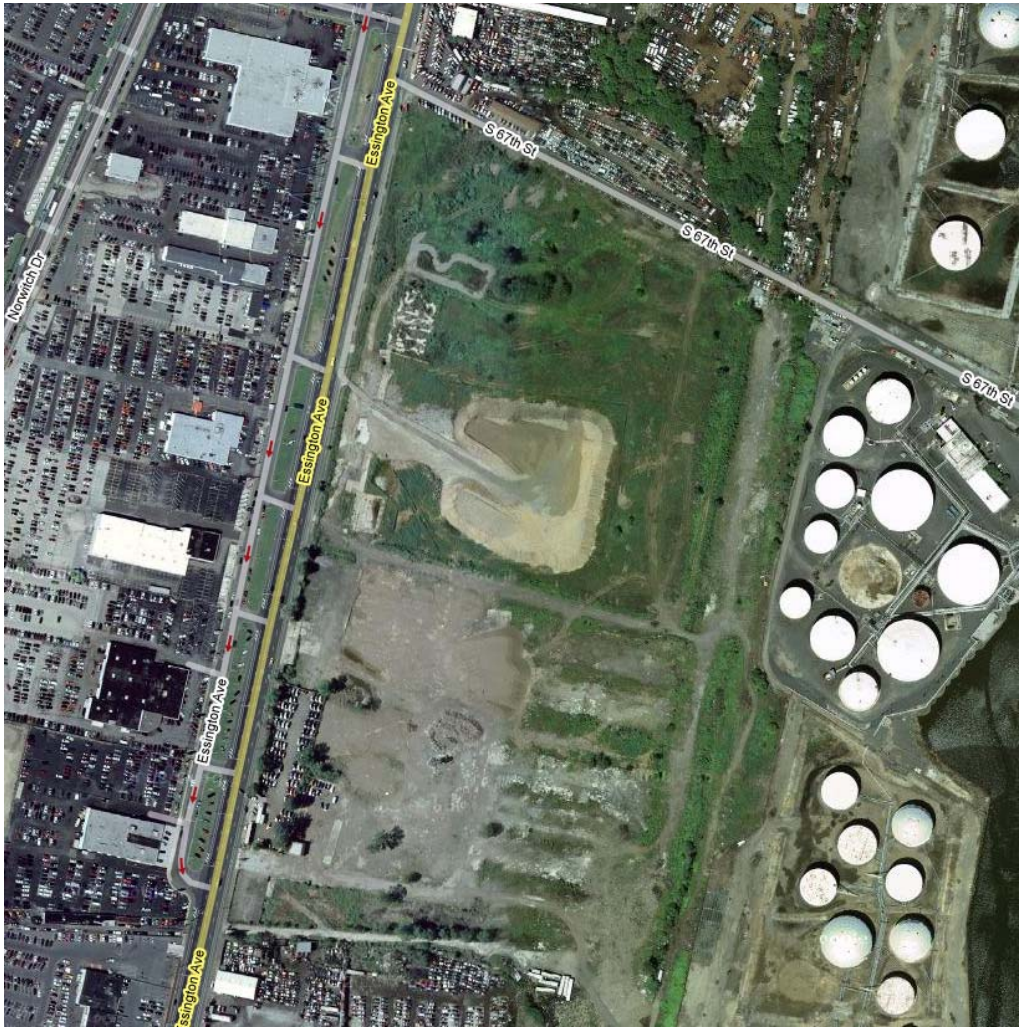


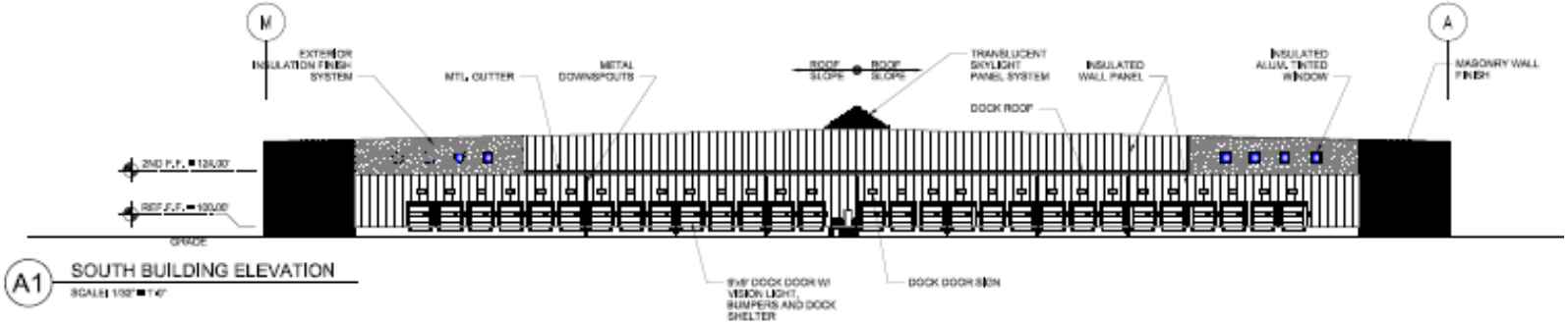
Main Facility (6700 Essington Avenue)

Produce Market Site

- About 50 acres, half of which is former landfill area (~15 to ~25 feet deep)
- Pennsylvania Act 2 Land Recycling Program
- Methane found at 40 to 60 percent, mostly at ambient pressures (one probe at 0.2 inches w.c.)
- Previous consultant recommended active gas extraction system with eight extraction wells, and reported pump test with 60 percent methane and 29 cfm from single well

Proposed Development

- Main site: 550,000 sf produce market facility, with truck loading docks on all sides
- Overflow Parking: asphalt parking lot with small gatehouse to control access
- Developed by O'Neill Properties Group for Philadelphia Regional Port Authority and Regional Produce Cooperative



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Groundbreaking September 2008

Join us as we announce the new
Philadelphia Regional Produce Market!

Date: Thursday, September 4th
Time: 12:00 p.m. (Noon)
Place: 6700 Essington Avenue

From a Brownfield, a Produce Market

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“Topping Off” October 2009

O’Neill Properties Group

invites you to celebrate a construction milestone at the

“ Topping Off Party”

of the brand new

Philadelphia Regional
Produce Market

A state-of the-art, 667,000 square foot facility
that will provide fresh produce to the entire region
and thousands of jobs to the area

Lunch & Refreshments
Live Entertainment

Wednesday, October 14, 2009
12:00 noon to 2:00 pm

Site Of The Philadelphia Regional Produce Market
6750 Essington Avenue • Philadelphia, PA

Please reply on or before
October 7th, 2009

RSVP To Nina Norakus
610.992.5886 or NNorakus@OneillProperties.com

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Methane Mitigation Measures Proposed by SCS

- Main Facility
  - Gravel vent layer
  - Liquid Boot membrane (60 mil, field fabricated)
    - CETCO (owner of Liquid Boot) suggested factory-fabricated membrane instead
    - Cost savings not as large given number of penetrations
  - Rooftop blower to actively ventilate sub-slab vent layer
  - Six methane monitors (electrical closets and maintenance room), and eight sub-slab monitoring probes
  - No gas extraction or flare (assuming MSW, SCS model estimated only 80 cfm over 25-acre site)

Other Interesting Facts

- Main building was to be supported by timber piles
  - Alternate foundation technology, which employs Controlled Modulus Columns (CMC) a new process that injects grout into the soils on 6 or 9 foot centers.
  - We're talking 10,000 columns here!
  - There is a 3 foot layer of engineered fill over the columns and then a slab on grade with exterior foundation walls.
- Construction schedule was almost two years

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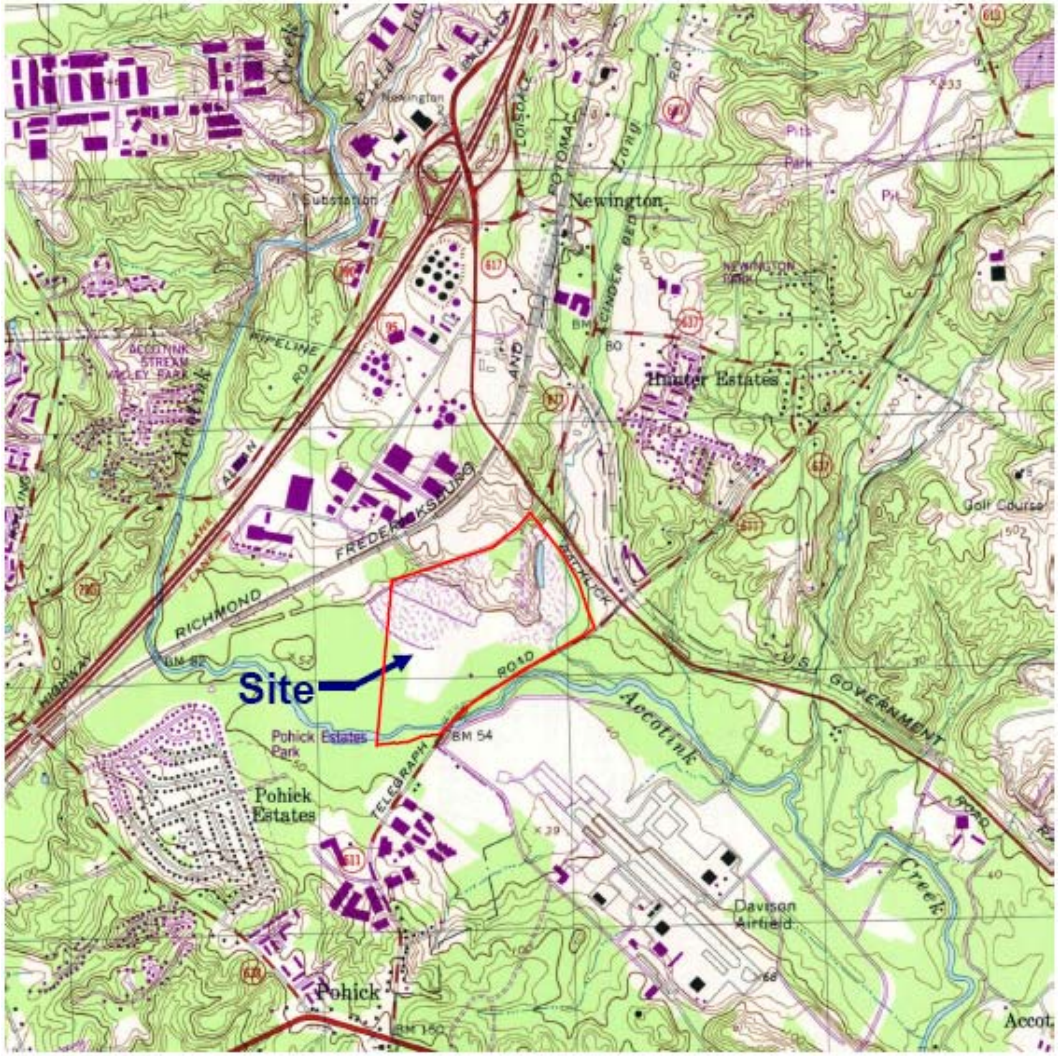
Belvoir Commerce Park

(Former BFI Telegraph Road Landfill)
Newington, VA

Client: Scannell Properties

Site Background

- Site is former BFI C&D landfill (also received some paper waste) between 1977 and 1984
- Entire parcel is 134 acres (mostly floodplain), with landfill covering about 60 acres in two mounds (“east” and “west”)
- Washington Gas transmission line right of way between waste mounds
- Waste is 35 to 50’ deep, covered with 3’ to 6’+ soil cap



0 2000 4000

Scale in Feet

Former Telegraph Road Landfill
Lorton, Virginia

Source: Fort Belvior, VA USGS 7.5-minutes Topographic Map, 1965, photrevised 1983

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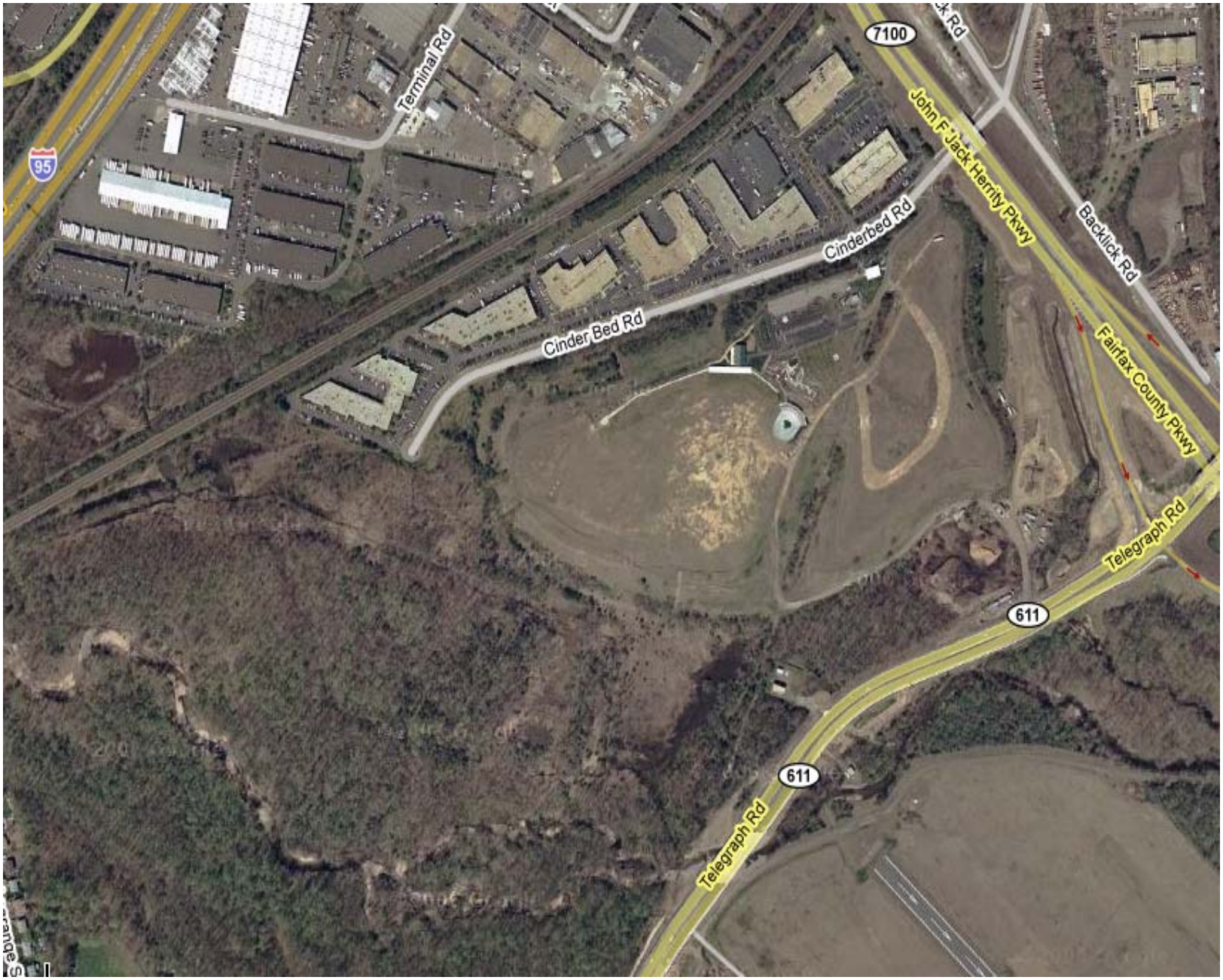

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Site Background

- Active SWF permit for gas extraction and flare system (operated 16 hours per week before decommissioning)
- Leachate drains are connected to public sewer
- Site is beyond 20-year moratorium imposed by Fairfax County ordinance for redevelopment of closed landfills
- Site was developed as sports park about 12 years ago (now defunct)
- West mound lies in approach path to Davison Army Airfield (Ft. Belvoir)

Former Telegraph Road Landfill

- BRAC is bringing some 20,000 new jobs to Ft. Belvoir, and need for office space is acute
- Good transportation, with Fairfax County Parkway and Telegraph Road adjoining
- Proposed FedEx Ground facility on east mound, with about 200,000 sf office on west
- West mound lies in approach path to Davison Army Airfield (Ft. Belvoir)

Highlights

- Entered into Virginia Voluntary Remediation Program (VRP)
  - Required appeal to Director of DEQ (due to active SWF permit)
  - Also obtained BFPP Brownfields letter
- Site characterization included groundwater, surface water, sediment, soil vapor, gas, and waste sampling and analysis
- Risk assessment found major risk to be control of methane migration into structures
- Methane mitigation to include redundant passive membrane and active sub-slab ventilation

Highlights

- Gas migration control following closure of active gas extraction and flare system, as needed, will be combination of passive vents and utility trench dams
- Buildings on pile foundations
- Remediation Waste Management Unit (RWMU) designation for portion of the site obtained from VDEQ
  - Allows re-placement of excavated waste in a RWMU area onsite
  - Requires periodic sampling to confirm wastes are not hazardous
  - If 6,000 CY of wastes disposed in RWMU instead of offsite, greenhouse gas emissions reduced by 12 tons.

Former Active LFG Extraction System

Remediation Waste Management Unit

Eastern Mound for FedEx Ground

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Eastern Mound for FedEx Ground

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Eastern Mound for FedEx Ground

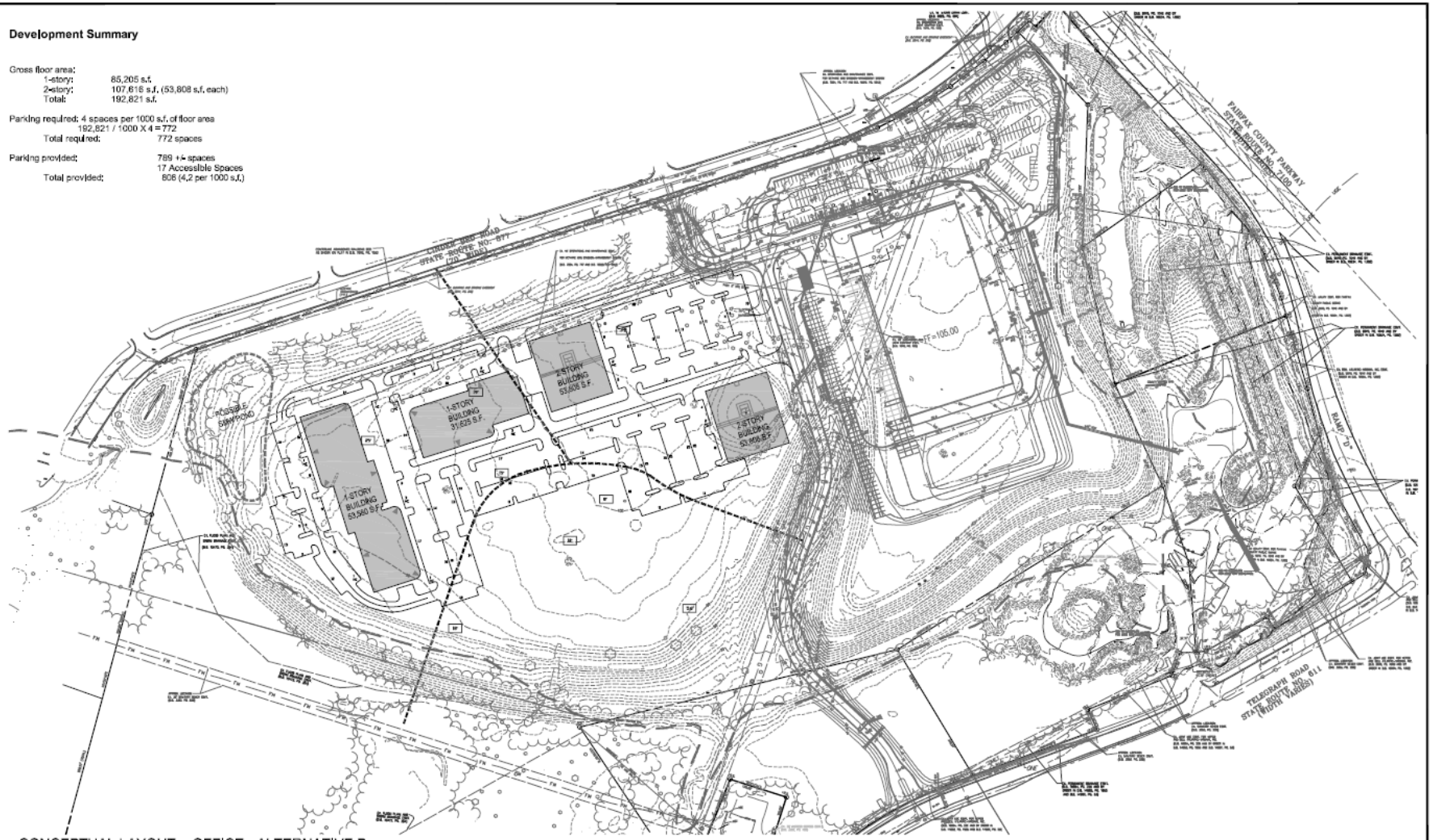
Development Summary

Gross floor area:

1-story:	85,205 s.f.
2-story:	107,616 s.f. (53,808 s.f. each)
Total:	192,821 s.f.

Parking required: 4 spaces per 1000 s.f. of floor area
192,821 / 1000 X 4 = 772
Total required: 772 spaces

Parking provided: 789 +/- spaces
17 Accessible Spaces
Total provided: 806 (4.2 per 1000 s.f.)



CONCEPTUAL LAYOUT - OFFICE - ALTERNATIVE B

urban

ROBINSON PROPERTY

Fairfax County, Virginia

0 50' 100' 200' 400'

Scale: 1"=100'

April 29, 2008

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Future Work

- Repairs to leachate discharge line—solar pump?
- Enhancements to passive vents for LFG—solar fans?
- VRP Certificates (Eastern Mound “soon”)
- Western Mound development to include another RWMU (in part to accommodate underground stormwater retention tank)

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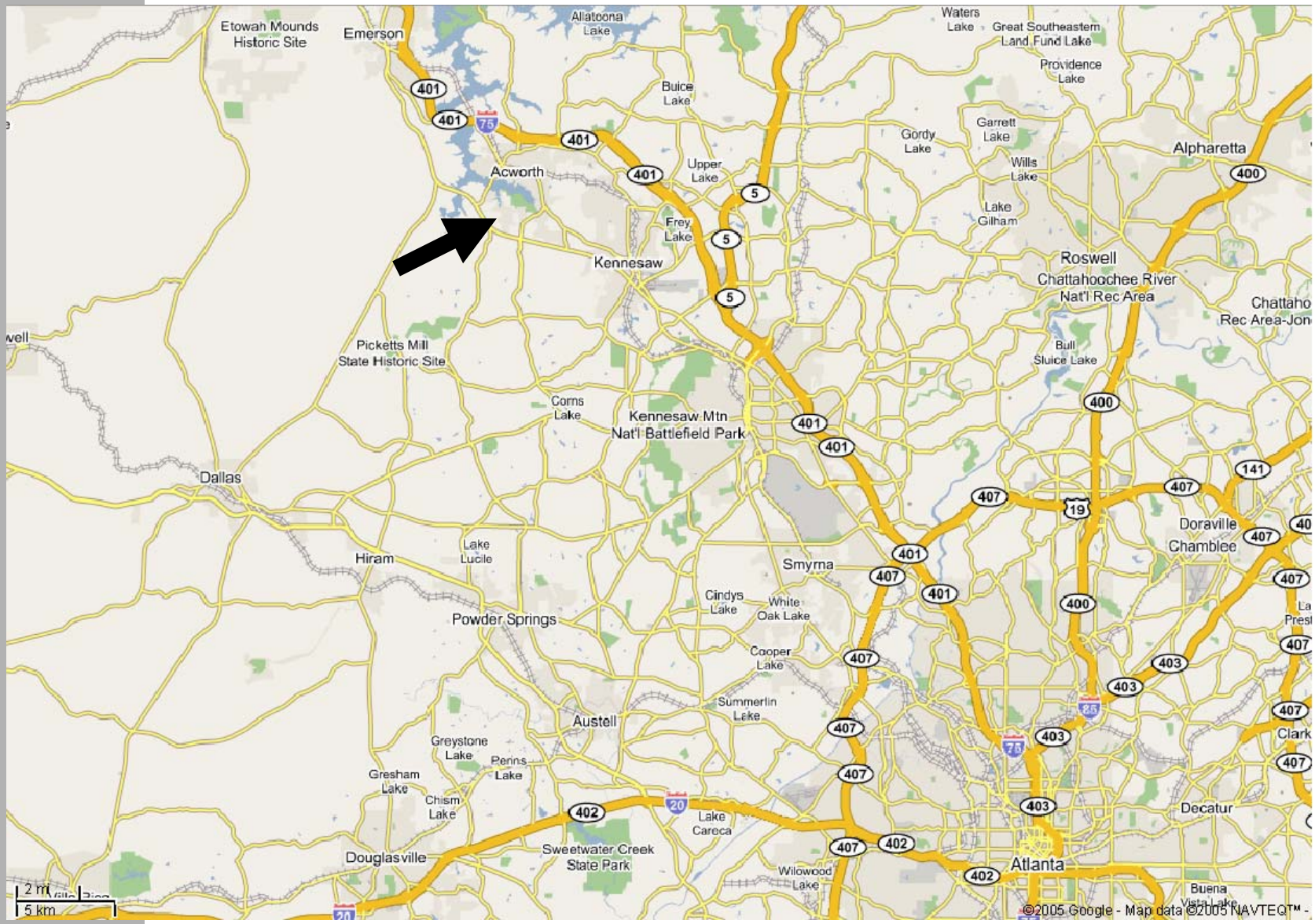
Case Study: Lakeside MarketPlace, Acworth, Georgia

Lakeside MarketPlace

- Located on Cobb Parkway (Highway 41) in fast-growing Acworth, GA
  - 36-acre “inert” waste landfill up to 60 feet deep
  - Significant amounts of vegetative wastes (allowed in inert landfills in Georgia)
  - Subsurface methane up to 60 percent; gas pressures up to 0.5” w.c.
  - Portions of site subsurface smoldering



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Lakeside MarketPlace

- Site had been used as flea market
- Neighbors include Kohl's Department Store to east, Home Depot to south
- Site to be redeveloped for "big-box" retail, with SuperTarget, Circuit City, Ross, Books-a-million, Petco, and others

Lakeside MarketPlace

- Stores over deepest fill to be supported on piles; dynamic compaction and aggregate piers used on other portions of the site
- Subsurface combustion addressed by sealing sideslopes and injecting CO_2
- Falling temperature and carbon monoxide, and increasing methane, show combustion controlled

Lakeside MarketPlace

- Buildings protected with passive methane mitigation system (vent layer plus Liquid Boot spray-applied membrane)
- System beneath SuperTarget converted to active ventilation, as methane increased following control of combustion

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CAUTION

STINGER

Famous Footwear

Lakeside MarketPlace Conclusions

- Lakeside MarketPlace is well served by existing infrastructure (e.g., interstate highway, water, sewer)
- First stores opened in February 2006
- Target held Annual Meeting of Shareholders in May 2006
- Entire shopping center opened in July 2006

Lakeside MarketPlace Conclusions

- Alternative landfill closure (construction of shopping center) approved by Georgia EPD
- Innovative Tax Allocation District bond financed $6 million remediation
- Lakeside MarketPlace provides convenient shopping for thousands of nearby residents of Acworth and the surrounding community

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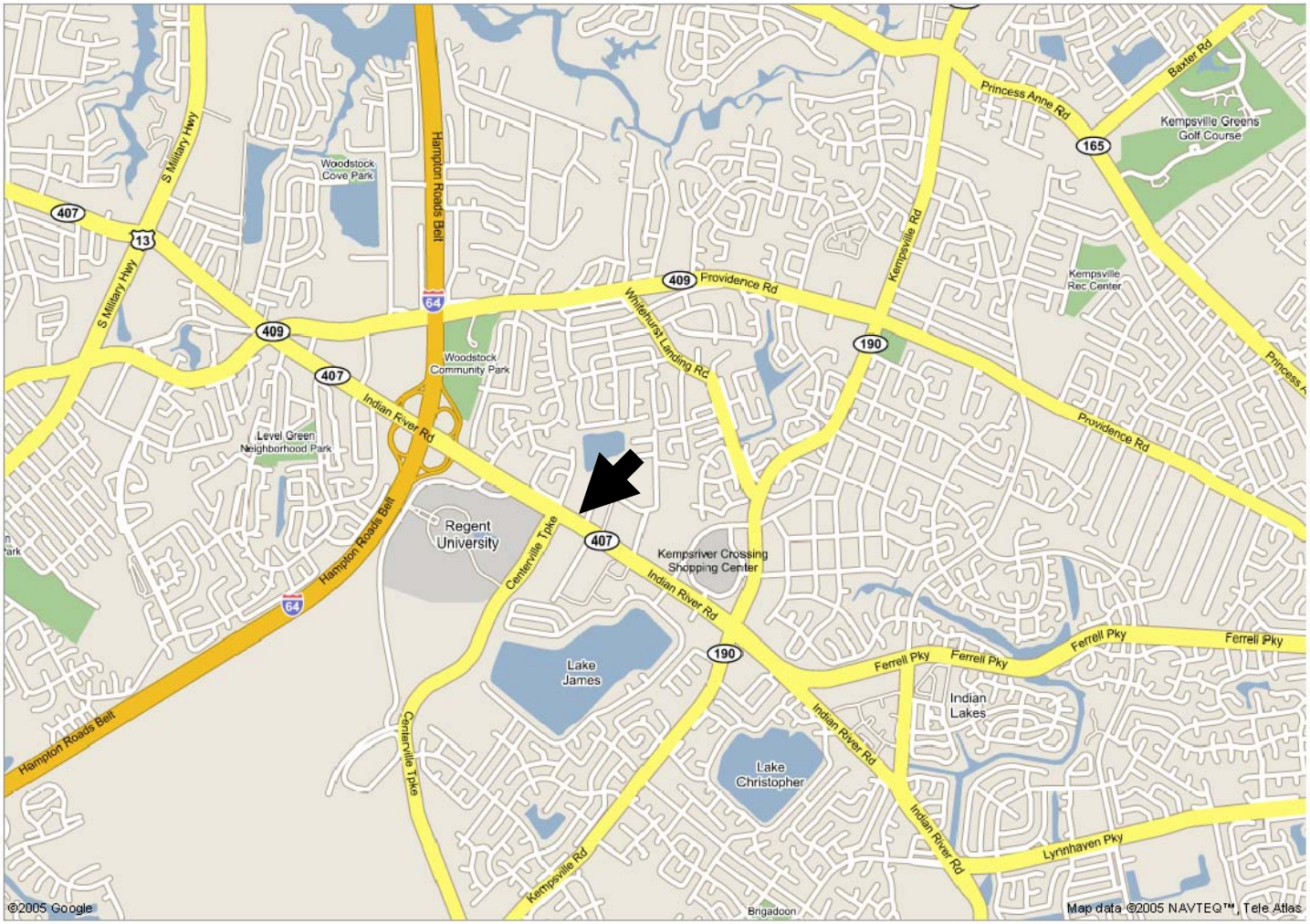
Case Study:
Lake Archway
Virginia Beach, Virginia

Lake Archway Subdivision

- Located off Indian River Road, near Regent University
- Site includes 16.9 acres, almost all of which served as a borrow pit during construction of nearby Interstate 64
  - 13.6 acres backfilled (up to about 20’) with clean fill (<1 percent organics), mostly roadbed undercut materials
  - 3.3 acres remain as pond: Lake Archway



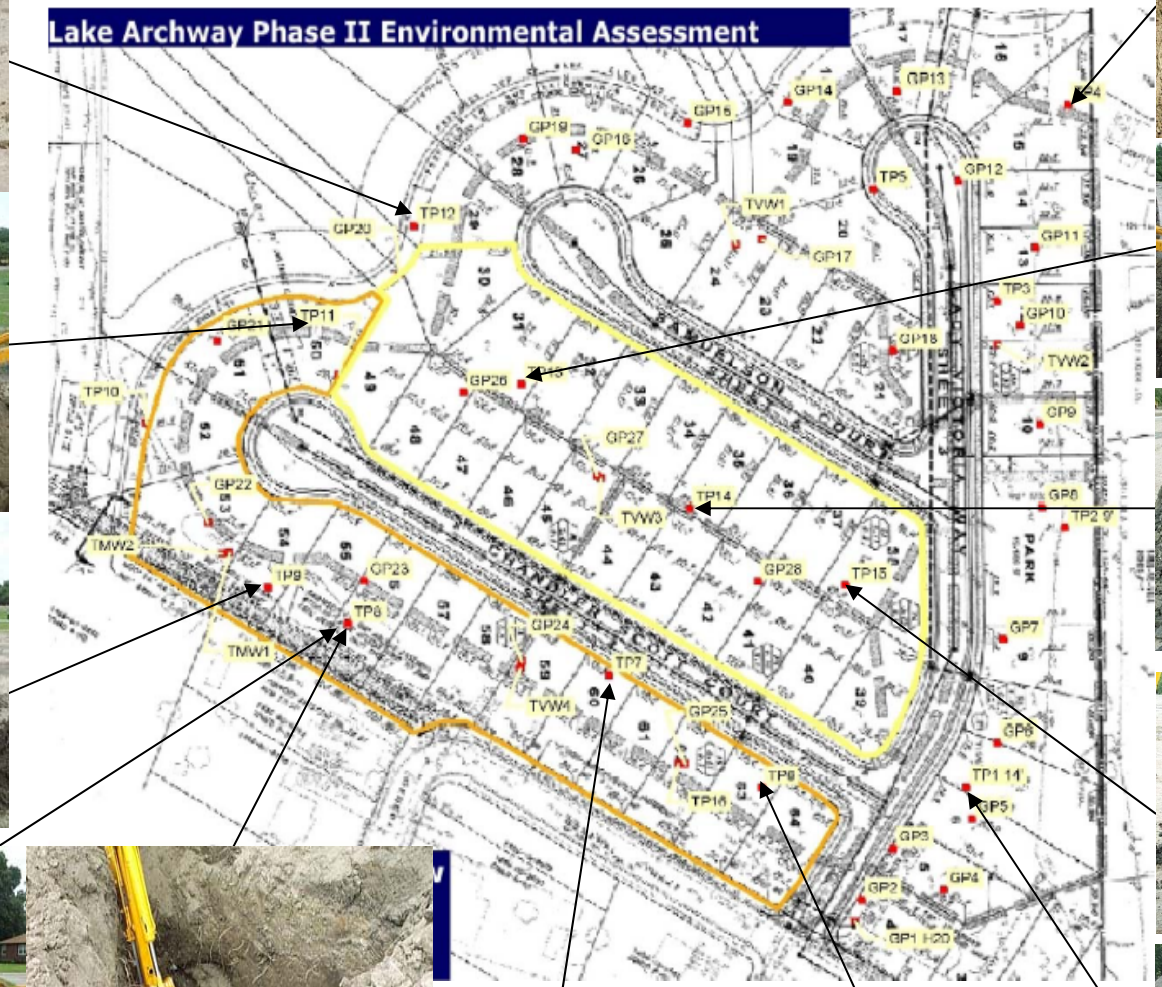
Virginia Beach, VA

Virginia Beach, VA

Lake Archway Site History

- Backfill was placed under a “Land Fill” permit issued in 1991 by City of Virginia Beach
  - Acceptable fill material was to include dirt, sand, concrete, brick, cinderblock, and asphalt, all subject to approval
- Numerous complaints by neighbors regarding improper “dumping”
- Inspections by City generally found the complaints unwarranted
- Test pits and borings confirmed nature of fill

Lake Archway Phase II Environmental Assessment



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Lake Archway Site History

- Preliminary subdivision plan was approved for 67 single family lots
- Site infrastructure (utilities, roads) was installed by 2002.
- City received reports that elevated methane concentrations (over 80% methane by volume) had been found at the site, and on that basis refused to approve final subdivision plan (halting development)

Lake Archway Site History

- City hired experts (Malcolm Pirnie) and developer hired experts (SCS Engineers), and ultimately the experts agreed
  - To conduct a site investigation gathering more definitive gas pressure and gas quality data
  - To design unique redundant passive methane mitigation systems (two vent layers, two membranes)
- Construction completed (2007-10)

LAKE ARCHWAY

Virginia Beach, Virginia

Venting layer beneath membrane

Membrane to protect structures

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LAKE ARCHWAY

Virginia Beach, Virginia

SCS ENGINEERS

LAKE ARCHWAY

Virginia Beach, Virginia

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Lake Archway Conclusions

- Methane problem at Lake Archway was a surprise, leading to City regarding the site more like a landfill than a Land Fill. Avoid surprises.
- Reasonable minds can disagree. They also can agree. Let the technical experts have a chance to work things out.
- Lake Archway Subdivision will provide 67 families with a nice, safe place to live in one of America's nicest cities.

Summary

- Scores of landfills in North America have been developed for a wide range of land uses, from recreation to retail and even residential
- Technical challenges of settlement and foundation design, gas control, and construction worker safety have proven solutions, but are site-specific
- Closed landfills often well-served by existing services (utilities, transportation)—developing these sites can be Smart Growth