Summary of Pottstown Landfill Public Health and Environmental Protection Issues

Presentation to Pottstown Landfill Closure Committee

June 1, 2005

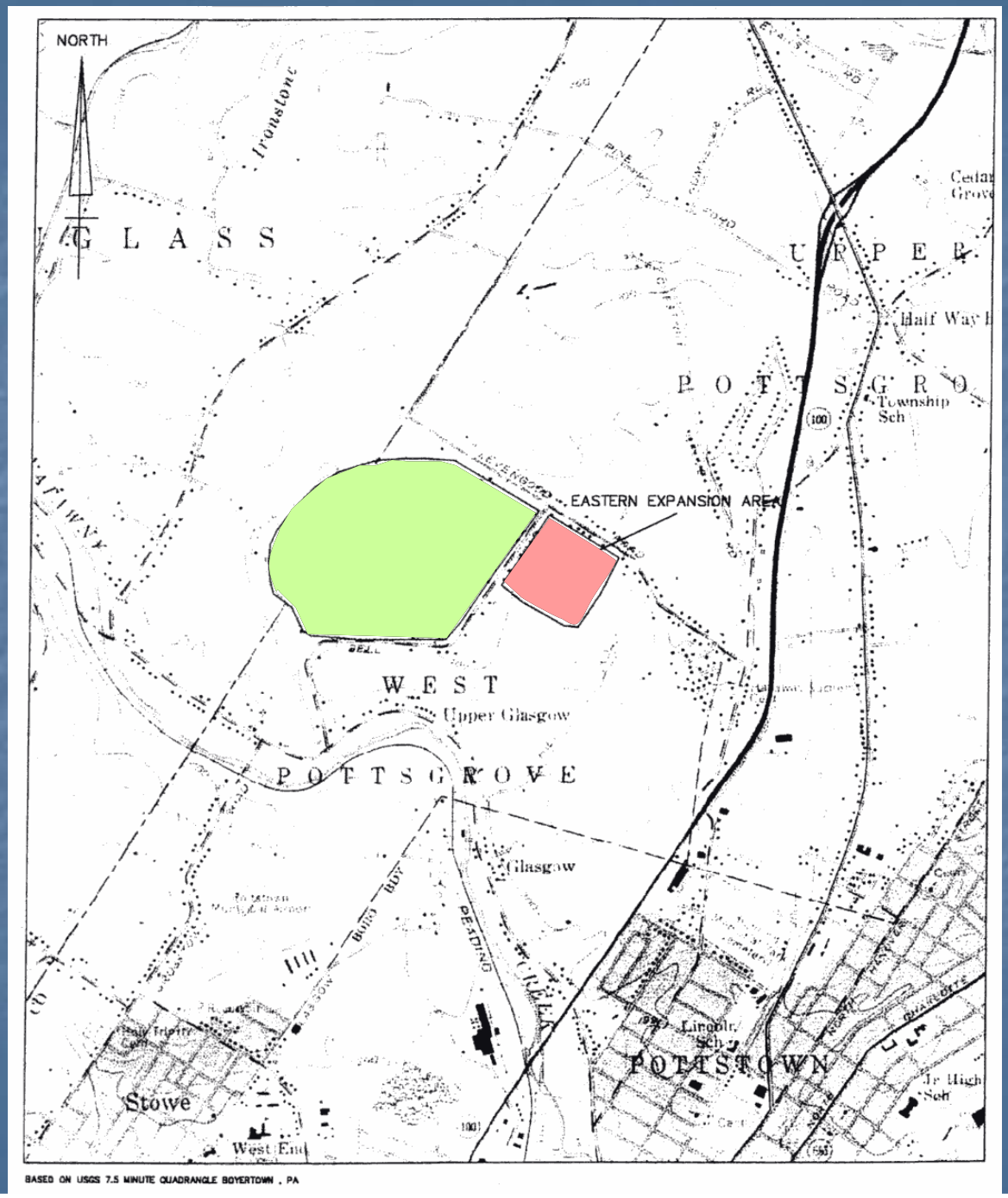
G. Fred Lee, PhD, $PE_{(TX)}$, DEE & Anne Jones-Lee, PhD
G. Fred Lee & Associates – El Macero, CA
ph: 530-753-9630 fax: 530-753-9956
gfredlee@aol.com www.gfredlee.com

Main Topic Areas

- Threat to Public Health & Environmental Quality
- Integrity of Components of Landfill Containment
- Detection of Landfill Liner Failure
- Monitoring

Issues

- Duration of Threat of Pottstown Landfilled Wastes
- Threat of Leachate & Landfill Gas to Public Health & Environment
- Landfill Processes
- Issues of Integrity of Containment Components
  - Liner - Plastic Sheeting & Compacted Clay
  - Cover
  - Detecting Liner Failure
- Landfill Groundwater Monitoring
- Landfill Gas Releases
- Pollution by Old Landfill
- Certificate of Closure
- Third-Party Independent Monitoring
- Bioreactor Operations



Pottstown Landfill Site

(from Applied Geosciences, 2001)

Duration of Threat of Pottstown Landfilled Wastes

- Dry-Tomb Landfilling Restricts Entrance of Water into Landfill That Would Lead to Waste Decomposition
  - Water Is Key to Waste Decomposition & Leaching
    - Without Water, Landfill Gas Production & Waste Leaching Stops
      - Landfill Becomes Dormant
- Dry Tomb –Type Landfills Will Be Threat to Groundwater and Air Quality Essentially Forever
- Pottstown Landfill Closure Committee Should Recognize This Situation & Prepare for It

Potential Impact of Landfill Leachate & Gas on Public Health & Environment

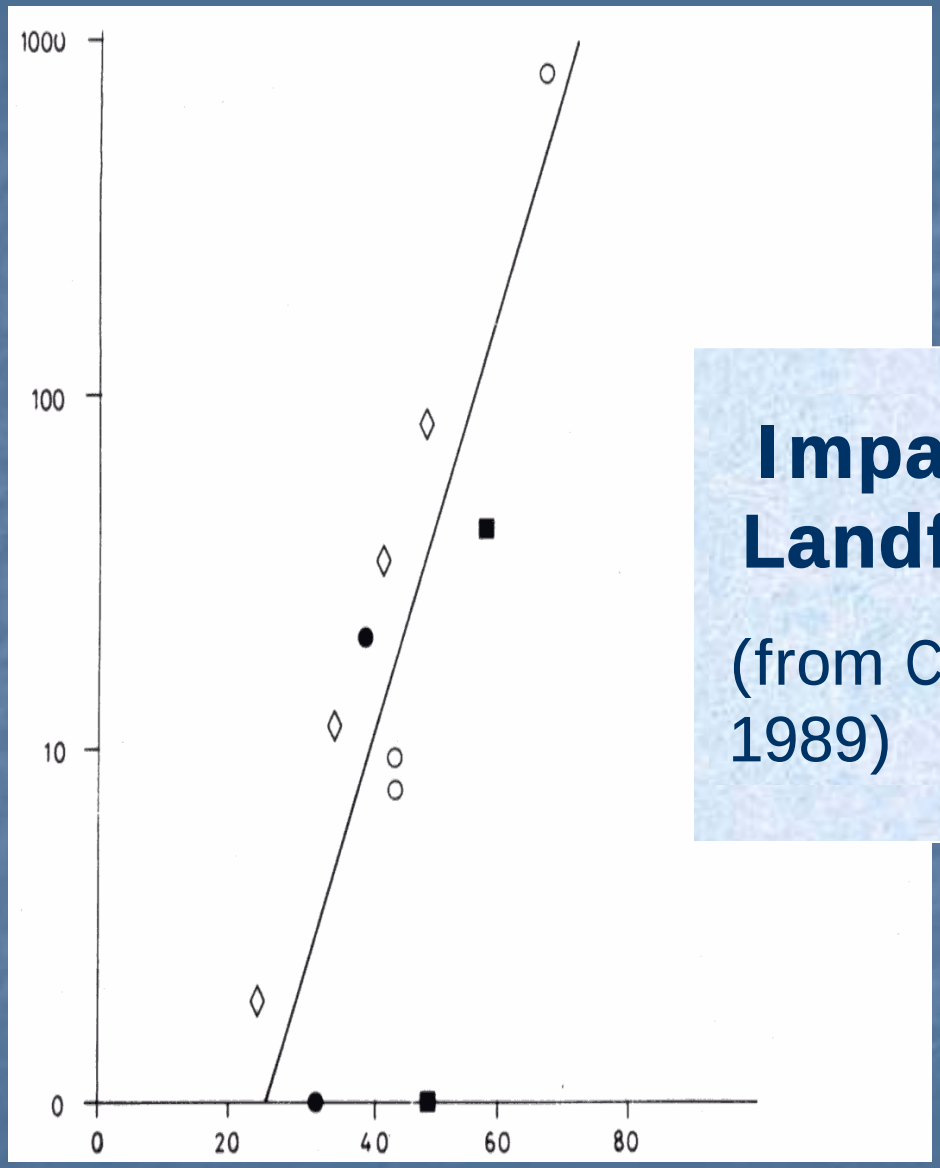
- Current MSW (Municipal Solid Waste) Not Supposed to Contain Industrial Hazardous Wastes
  - Contains Household Hazardous Wastes
  - Contains “Non-Hazardous” Wastes That Contain Chemicals Which, in Landfill Leachate & Gas, Are Hazardous to Public Health & Environment
  - Illegal Disposal of Hazardous Waste in MSW Landfills
- Pottstown Landfill Likely Received Substantial Industrial Wastes That Would Be Classified as Hazardous Wastes

Potential Impact of Landfill Leachate & Gas on Public Health & Environment

- MSW Landfill Leachate & Gas Contain Large Number of Potentially Hazardous Chemicals That Are Not Analyzed for and Are Not Regulated
  - Only Regulate Very Small Portion of Chemicals That Are in MSW Stream
- MSW Landfill Leachate Contains Variety of Chemicals That, Even Though Not Hazardous, Can Render a Groundwater Unusable for Domestic Purposes
- Landfill Gas Contains Hazardous & Otherwise Deleterious Chemicals (Odors) That Are Adverse to Public Health & Air Quality

Impact of Moisture on Landfill Gas Formation

(from Christensen & Kjeldsen, 1989)



Typical Anatomy of a Landfill

Protective Cover

1. Cover Vegetation
As portions of the landfill are completed, native grasses and shrubs are planted and the areas are maintained as open spaces. The vegetation is visually pleasing and prevents erosion of the underlying soils.

2. Top Soil
Helps to support and maintain the growth of vegetation by retaining moisture and providing nutrients.

3. Protective Cover Soil
Protects the landfill cap system and provides additional moisture retention to help support the cover vegetation.

Composite Cap System

4. Drainage Layer
A layer of sand or gravel or a thick plastic mesh called a geonet drains excess precipitation from the protective cover soil to enhance stability and help prevent infiltration of water through the landfill cap system. A geotextile fabric, similar in appearance to felt, may be located on top of the drainage layer to provide separation of solid particles from liquid. This prevents clogging of the drainage layer.

5. Geomembrane
A thick plastic layer forms a cap that prevents excess precipitation from entering the landfill and forming leachate. This layer also helps to prevent the escape of landfill gas, thereby reducing odors.

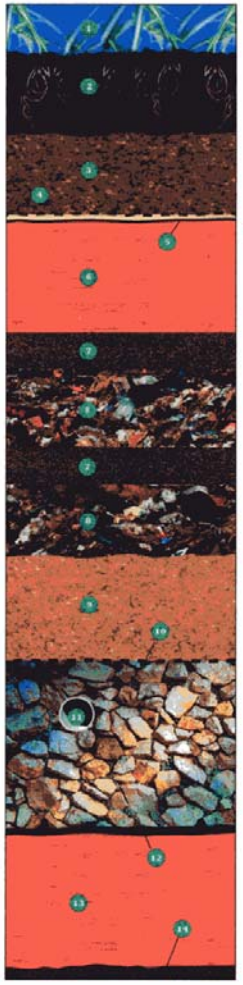
6. Compacted Soil
Is placed over the waste to form a cap when the landfill reaches the permitted height. This layer prevents excess precipitation from entering the landfill and forming leachate and helps to prevent the escape of landfill gas, thereby reducing odors.

Working Landfill

7. Daily Cover
At the end of each working period, waste is covered with six to twelve inches of soil or other approved material. Daily cover reduces odors, keeps litter from scattering and helps deter scavengers.

8. Waste
As waste arrives, it is compacted in layers within a small area to reduce the volume consumed within the landfill. This practice also helps to reduce odors, keeps litter from scattering and deters scavengers.

Please Note: This illustration depicts a cross section of the standard environmental protection technologies of modern landfills. While the technologies used in most landfills are similar, the exact sequence and type of materials may differ from site to site depending on design, location, climate and underlying geology.



Leachate Collection System

Leachate is a liquid that has filtered through the landfill. It consists primarily of precipitation with a small amount coming from the natural decomposition of the waste. The leachate collection system collects the leachate so that it can be removed from the landfill and properly treated or disposed of. The leachate collection system has the following components:

9. Leachate Collection Layer
A layer of sand or gravel or a thick plastic mesh called a geonet collects leachate and allows it to drain by gravity to the leachate collection pipe system.

10. Filter Geotextile
A geotextile fabric, similar in appearance to felt, may be located on top of the leachate collection pipe system to provide separation of solid particles from liquid. This prevents clogging of the pipe system.

11. Leachate Collection Pipe System
Perforated pipes, surrounded by a bed of gravel, transport collected leachate to specially designed low points called sumps. Pumps, located within the sumps, automatically remove the leachate from the landfill and transport it to the leachate management facilities for treatment or another proper method of disposal.

Composite Liner System

12. Geomembrane
Two thick plastic layers form a liner system that prevents leachate from leaving the landfill and entering the environment. This geomembrane is typically constructed of a special type of plastic called high-density polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by the compounds that might be in the leachate. This layer also helps to prevent the escape of landfill gas.

13. Compacted Clay
Is located directly below the geomembrane and forms an additional barrier to prevent leachate from leaving the landfill and entering the environment. This layer also helps to prevent the escape of landfill gas.

14. Prepared Subgrade
The native soils beneath the landfill are prepared as needed prior to beginning landfill construction.

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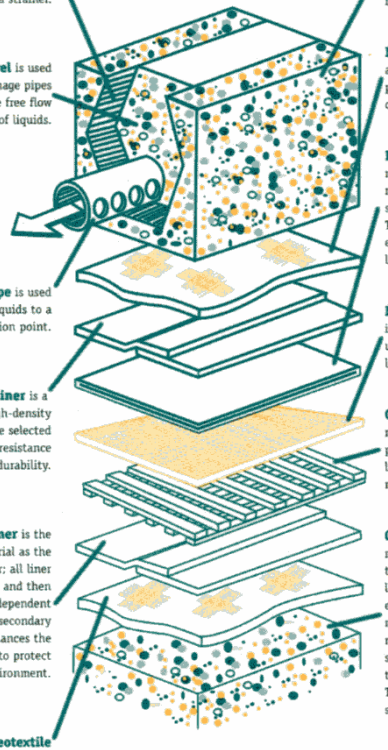
Liner System

Construction and Quality Control



Woven Geotextile is a woven fabric that allows liquid to pass through while keeping sediments out, similar to a strainer.

Coarse Gravel is used around the drainage pipes to enhance the free flow of liquids.

Collection Pipe is used to carry liquids to a central collection point.

Primary Liner is a 60 mil. high-density polyethylene selected for its chemical resistance and durability.

Secondary Liner is the same material as the primary liner; all liner seams are welded and then tested by an independent laboratory. This secondary liner further enhances the system's ability to protect the environment.

Non-Woven Geotextile acts as a cushion for the secondary liner as would carpet padding.

Fine Gravel is an 18-inch layer of natural round stone that protects the liner system and allows the free flow of liquids.

Non-Woven Geotextile acts as a cushion for the primary liner, as would carpet padding.

Bentonite Layer is a dry, man-made clay layer that responds to moisture by swelling and sealing. This material further enhances the primary liner's reliability.

Non-Woven Geotextile is a high-strength fabric used to separate the clay layer and the GEONET.

GEONET is a flow medium made of high-density polyethylene that allows liquids to flow and monitoring of the systems.

Compacted Soil is the material that makes up the foundation of the landfill. After careful site evaluation, all unsuitable materials are removed and replaced with a quality structural-grade material that is compacted in place. This minimizes potential settlement of the landfill.

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Issues of Long-Term Integrity of Landfill Liners

◄ Plastic Sheeting Liner ►

- High Density Polyethylene (HDPE) Liner – FML
  - Will Deteriorate over Time & Fail to Prevent Passage of Leachate
  - Variety of Factors Control Rate of Deterioration

    (See Lee & Jones-Lee "Flawed Technology" Review)
- How Each Factor Influences Rate of Deterioration Not Well-Defined, But No Doubt That in Time, HDPE FML Will Fail to Collect All Leachate Generated in Landfill
  - Failure Can Occur in a Few Years, Decades, or Centuries
  - Can Lead to Groundwater Pollution
- Permeation of Solvents Through HDPE
  - Organic Solvents Can Pass through Plastic Sheeting Liners within a Few Days
    - Should Require Monitoring of Solvents in Liquid Found in Leak Detection Zone

Issues of Long-Term Integrity of Landfill Liners
◄ Compacted Clay Liner ►

- Compacted Clay Liner, Including Geosynthetic Clay Liner (GCL), Has Finite Period of Time during Which It Can Delay Groundwater Pollution
  - Leachate That Penetrates HDPE Liner Will Eventually Penetrate Clay Liner
- Many Factors Influence Rate of Passage of Leachate through Clay Liner (See Lee & Jones-Lee "Flawed Technology" Review)
- Clay Liner in Pottstown Landfill of Particular Concern Due to Cation Exchange in GCL
  - Shrinkage Can Lead to Greater Rate of Penetration & Cracking Failure

Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste

G. Fred Lee, PhD, PE, DEE & Anne Jones-Lee, PhD
G. Fred Lee & Associates
27298 E. El Macero Dr. – E l Macero, CA 95618
Ph: (530)753-9630 email: gfredlee@aol.com
www.gfredlee.com
Updated, March 2005

Abstract

This report presents a review of the information available pertinent to public health and environmental quality protection issues for proposed Subtitle D landfills. Based on this review it is concluded that this type of landfill will, at most locations, cause groundwater pollution by landfill leachate and be adverse to the health, welfare and interests of nearby residents and property owners. As discussed, there is normally significant justification for those near a proposed Subtitle D landfill to oppose the development of the landfill.

Causes of Liner Failure

Plastic Sheeting FMLs	Soil/Clay Liners
Holes at Time of Liner Construction	Desiccation Cracks
Holes Developed in Waste Placement	Differential Settling Cracks
Stress-Cracks	Cation-Exchange Shrinkage (for Expandable-Layer Clays)
Free-Radical Degradation	Inherent Permeability
Permeable to Low-Molecular-Weight Solvents – Permeation	Interactions between Leachate and Clays
Inherent Diffusion-Based Permeability	
Finite Effective Lifetime – *Will Deteriorate & Ultimately Become Non-Functional in Collecting Leachate and as a Barrier to Prevent Groundwater Pollution*	*Highly Permeable –* *Allow Large Amount of Leakage under Design Conditions and Subject to Cracking & Other Failure Mechanisms*

(From Lee and Jones-Lee (2005) “Flawed Technology” Review)

Eventual Failure of Landfill Liner Systems

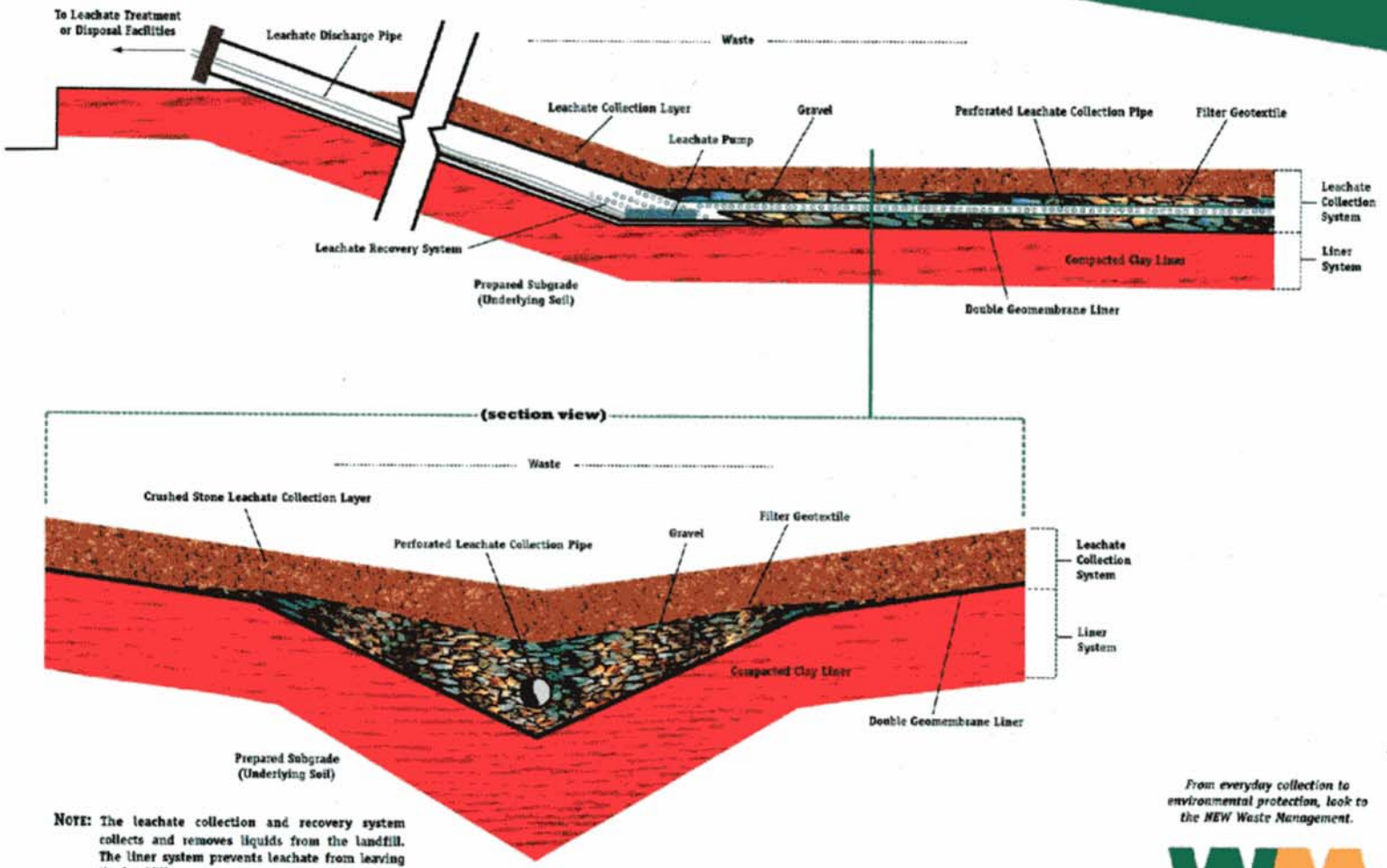
- US EPA Stated, as Part of Developing Subtitle D Regulations (Federal Register, August 1988)

  "First, even the best liner and leachate collection system will ultimately fail due to natural deterioration, and recent improvements in MSWLF (municipal solid waste landfill) containment technologies suggest that releases may be delayed by many decades at some landfills."

- US EPA Criteria for Municipal Solid Waste Landfills (US EPA, 1988) Stated:

  "Once the unit is closed, the bottom layer of the landfill will deteriorate over time and, consequently, will not prevent leachate transport out of the unit."

Typical Leachate Collection and Recovery System



NOTE: The leachate collection and recovery system collects and removes liquids from the landfill. The liner system prevents leachate from leaving the landfill.

(Not to scale)

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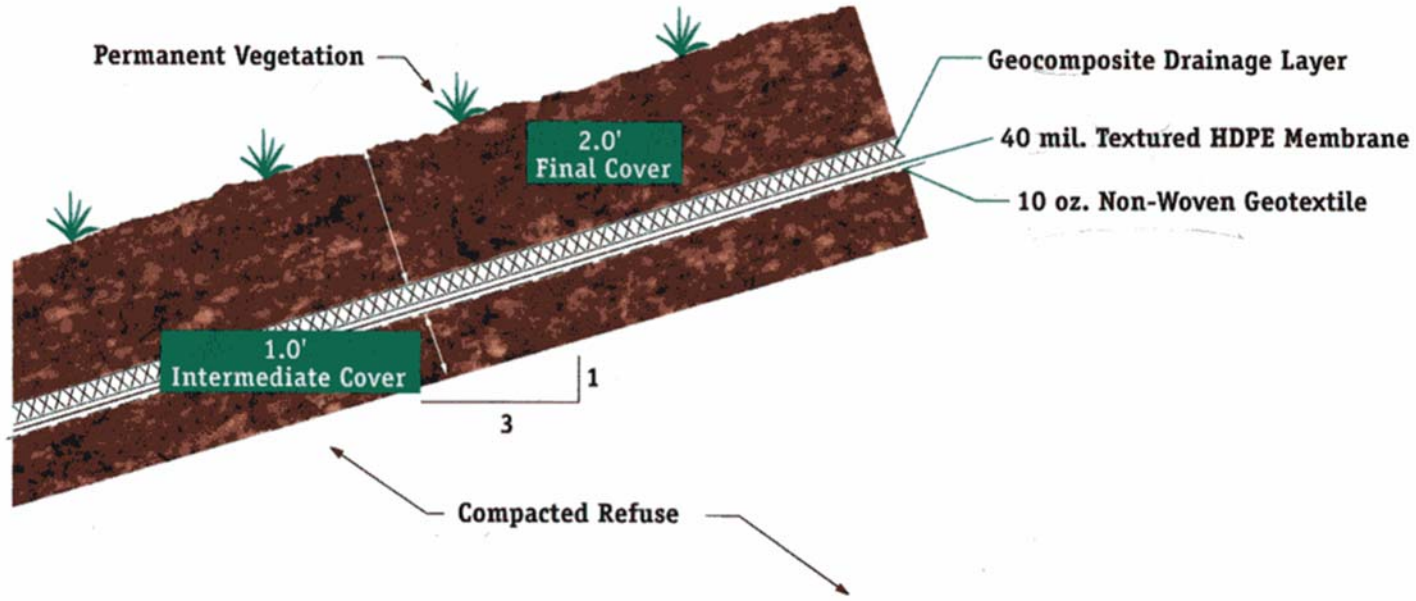
Final Cap System



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(Not to scale)

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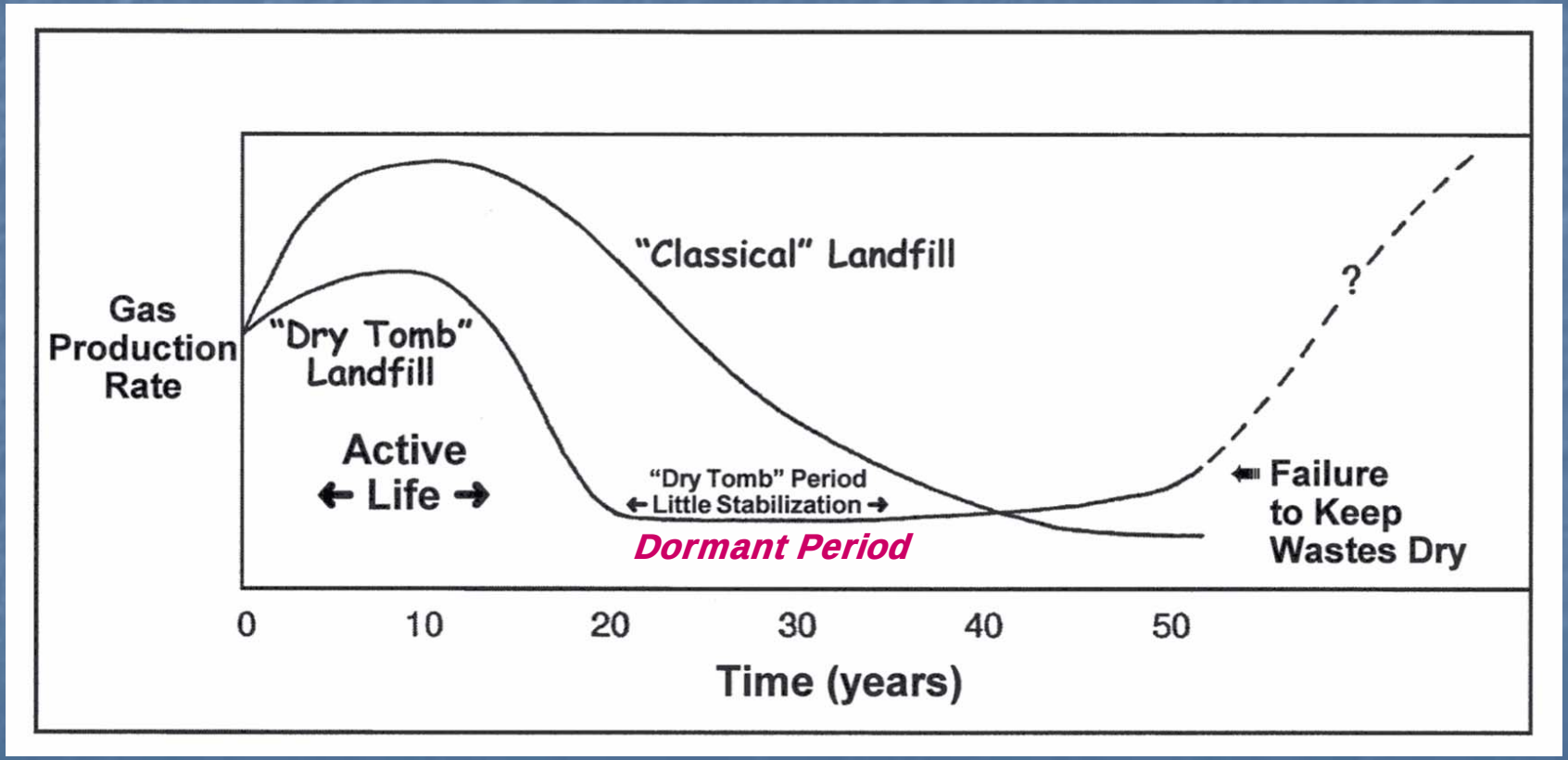
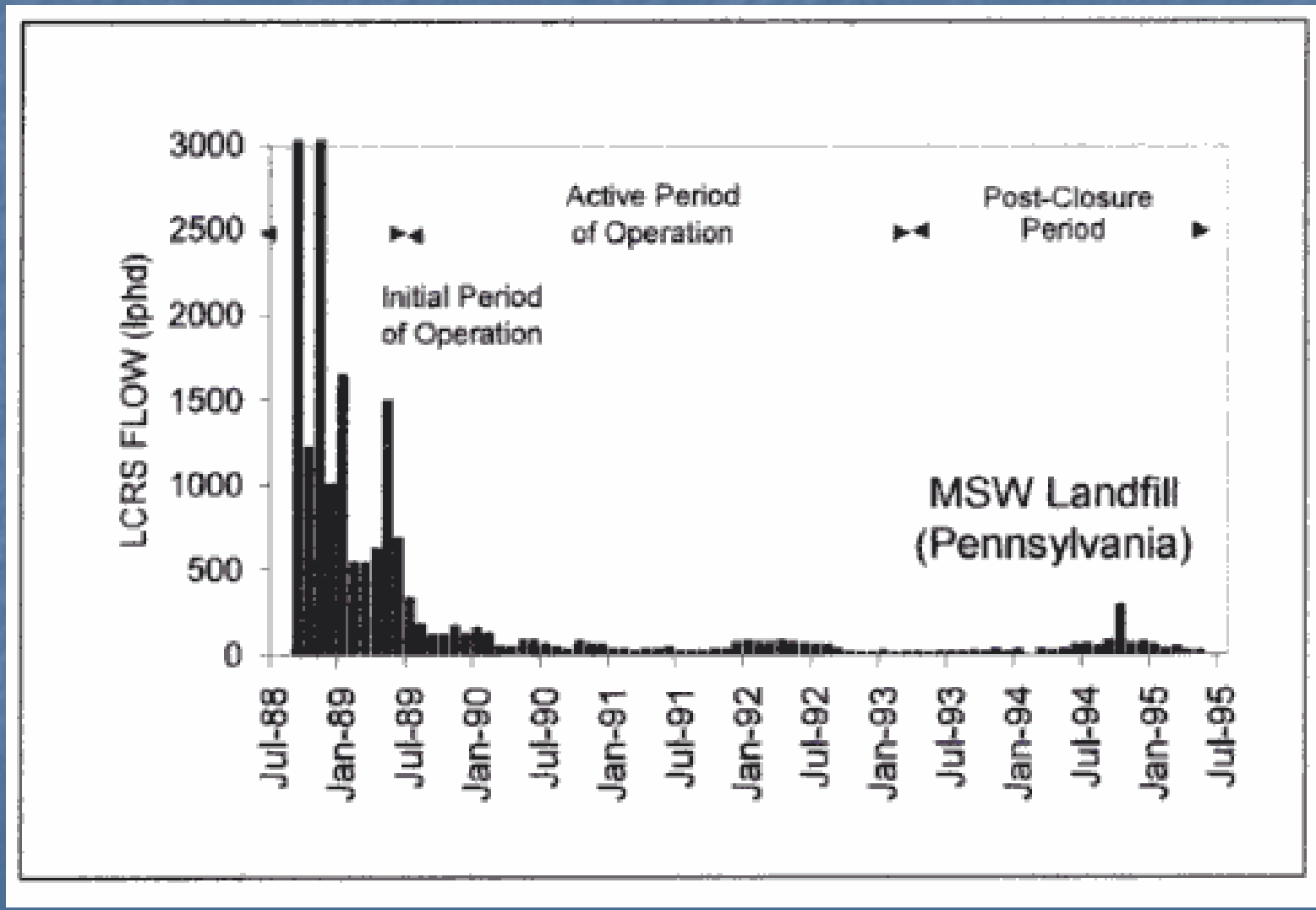
Comparison of Pattern of Landfill Gas Generation over Time at Classical Sanitary Landfill & "Dry Tomb" Landfill

(from Lee and Jones, 1991)



Leachate Generation Pattern

(Bonaparte et al., 2002)

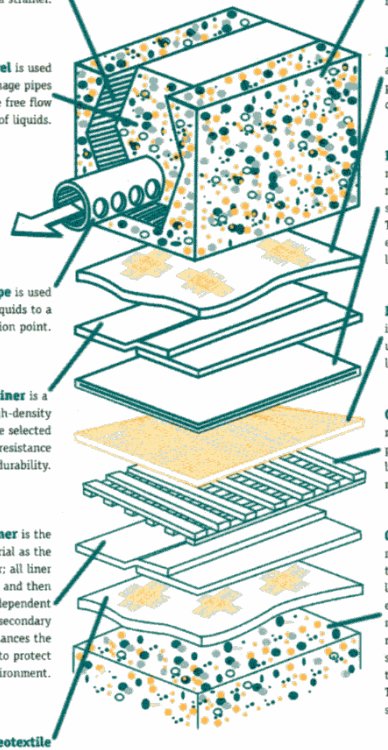


Landfill Cover Integrity Issues

- Integrity of Plastic Sheeting Layer in Landfill Cover Key to Keeping Wastes Dry
  - Plastic Sheeting Layer in Cover Can Be Constructed to Severely Limit Entrance of Water into Landfill
    - Put Landfill into Dormant State
- Over Time, Plastic Sheeting Layer in Cover Will Deteriorate, Reducing Its Ability to Limit Entrance of Water into Landfill
- Difficult to Determine Condition of Plastic Sheeting Layer in Cover during Dormant Period
  - Plastic Sheeting Layer in Cover Buried below Top Soil & Drainage Layer
  - Can Deteriorate Sufficiently to Allow Entrance of Moisture Without Being Detected by Visual Inspection of Landfill Surface
- Concern That Waste Management Has Not Constructed/Maintained Low-Permeability Covers That Are Effective in Preventing Entrance of Water into Wastes to Generate Leachate & Landfill Gas

Liner System

Construction and Quality Control



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Reliability of Detecting Failure of Landfill Liner

- Key to Preventing Off-Site Pollution of Groundwater by Leachate Is Early Detection of Liner Failure
- Pottstown Landfill Has Leak Detection Zone for Detecting Liner Failure
  - May Detect Liner Failure Early in Post-Closure Period
  - Expected to Deteriorate over Time and Fail to Indicate Insipient Liner Failure
  - Must Be Monitored throughout Post-Closure Period
    - Monitor for Chemicals Including Solvents in Leachate
      - Solvents in Leachate Should Be Added to Current Monitoring of Leak Detection Zone

Reliability of Groundwater Monitoring

In accordance with 1991 US EPA Subtitle D Municipal Solid Waste regulations the eventual landfill liner failure should be detected by the groundwater monitoring program that is required by regulations.

These regulations require detection of leachate-polluted groundwater when it first reaches the Point of Compliance for Groundwater Monitoring.

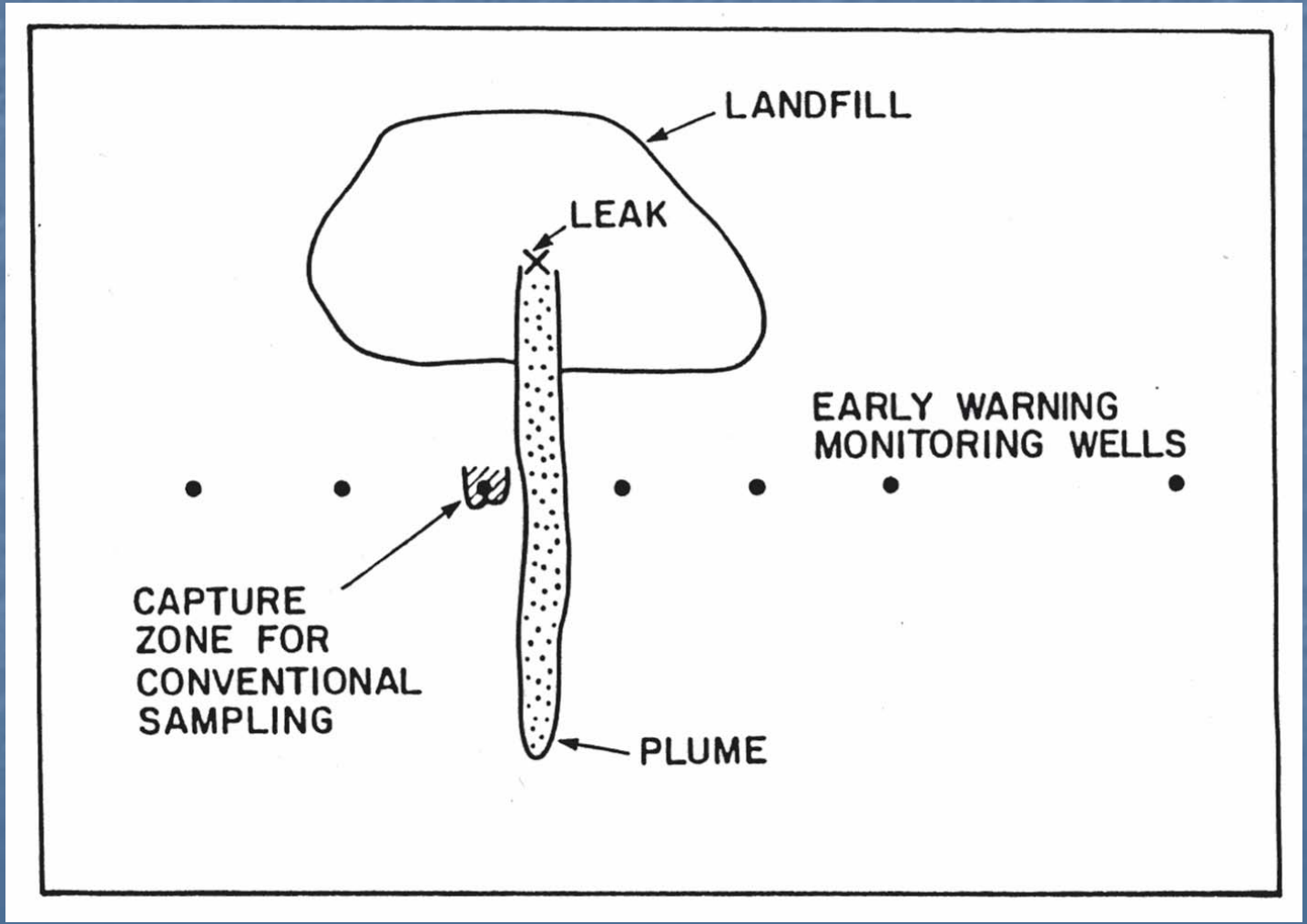
However, the approach used to develop groundwater monitoring at Subtitle D landfills has a poor reliability of detecting leachate-polluted groundwater when it first reaches the Point of Compliance for Groundwater Monitoring.

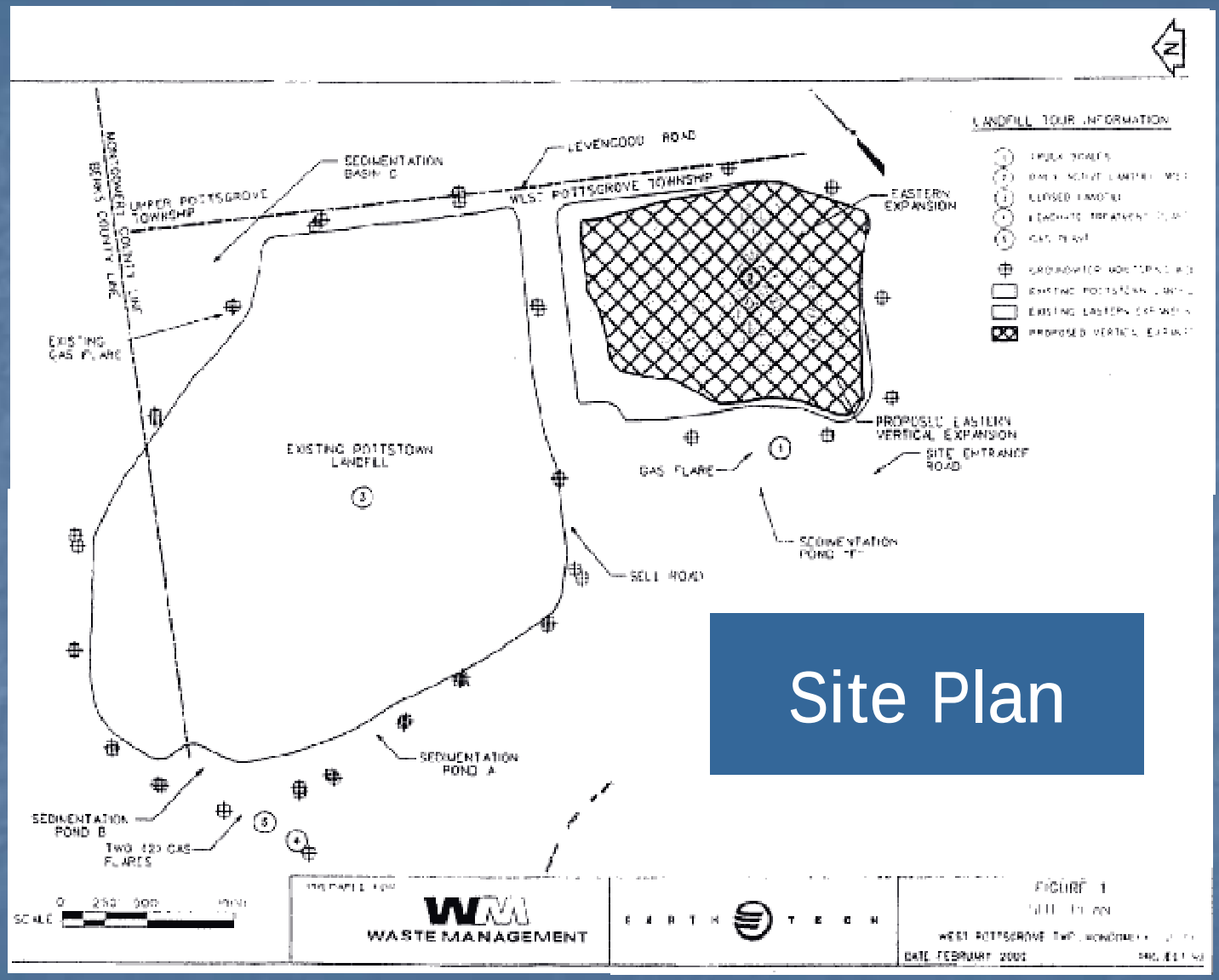
Reliability of Groundwater Monitoring

- Problems
  - Groundwater Monitoring Well Array Ignores Manner in Which Plastic Sheeting-Lined Landfills Will Initially Leak through Limited Area of Plastic Sheeting Liner
  - Finger-Like Plumes That Can Be a Few Feet Wide at Point of Compliance
  - Groundwater Monitoring Wells Allowed to Be Spaced Hundreds of Feet Apart at Point of Compliance
  - Each Monitoring Well Only Samples about 1 ft about Each Well
  - Monitoring Well Arrays Are Allowed Without Evaluation of Potential Reliability of Monitoring Program
- Groundwater Monitoring Well Array Should Be Required to Have Ability to Reliably Detect Incipient Groundwater Pollution at Point of Compliance with 95% Reliability

Leachate Leakage from Lined Landfill

(from Cherry 1990)




LANDFILL TOUR INFORMATION
LEVENGOOD ROAD
SEDIMENTATION BASIN C
UPPER POTTSGROVE TOWNSHIP
WEST POTTSGROVE TOWNSHIP
EASTERN EXPANSION
EXISTING GAS FLARE
EXISTING POTTSTOWN LANDFILL
PROPOSED EASTERN VERTICAL EXPANSION
SITE ENTRANCE ROAD
GAS FLARE
SEDIMENTATION POND "F"
SELL ROAD
SEDIMENTATION POND A
SEDIMENTATION POND B
TWO (2) GAS FLARES
SCALE
WASTE MANAGEMENT
EARTH TECH
FIGURE 1
DATE FEBRUARY 2002

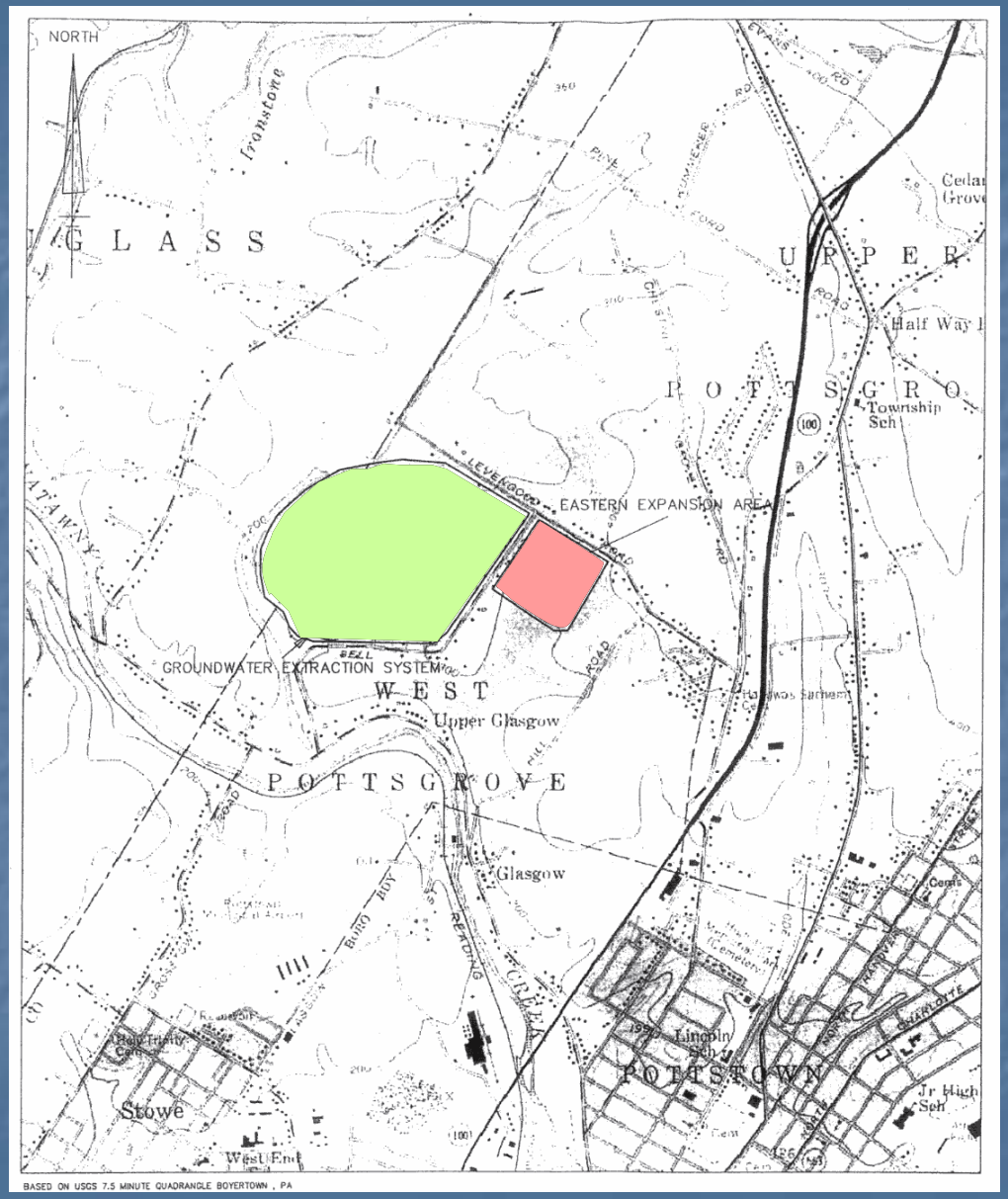
Site Plan

Groundwater Monitoring at Pottstown Landfill

- Monitoring Well Array Inadequate to Reliably Detect Groundwater Pollution before Off-Site Pollution of Groundwater – Even If Hydrogeology of Area under Landfill Were Simple
- Hydrogeology under Pottstown Landfill Complex Fractured Rock System
  - Essentially Impossible to Reliably Detect Groundwater Pollution before Off-Site Pollution Occurs Using Groundwater Monitoring Wells
- Landfill Liner Failure Should Be Able to Be Detected as Long as Leak Detection Zone
  - Is Monitored AND
  - Functions as Intended

Landfill Gas Releases

- Some of Waste Components in Pottstown Landfill Can Be Converted to Landfill Gas (Methane & Carbon Dioxide)
  - Explosive Hazard in Structures in Which Landfill Gas Accumulates
- Landfill Gas Contains Variety of Known, and Many Unknown or Unrecognized Volatile Chemicals That Can Be Hazardous to Public Health
- Migration of Landfill Gas at Pottstown Landfill Difficult to Reliably Monitor to Prevent Off-Site Migration



Pottstown Landfill Site

(from Applied Geosciences, 2004)

Pollution by "Old" Pottstown Landfill

- Original Pottstown Landfill Unlined; As Expected, Polluted Groundwater Under & Downgradient from Landfill
  - Discovered in Late 1980s
  - Led to Pre-Superfund Site Investigation
    - Not Listed as NPL Superfund Site (Many Factors Influence Listing)
  - Groundwater Polluted by Hazardous Chemicals That Are Threat to Human Health
    - Requires Groundwater Cleanup by Extraction (Pumping) of Groundwater
  - Landfill Gas Migration from Old Landfill Caused Groundwater Pollution by Hazardous Chemicals – Vinyl Chloride
- Old Landfill Still Polluting Groundwater
  - Water Enters Old Landfill through Cover & Generates Leachate
    - Need Low-Permeability Cover for Old Landfill to Retard Leachate Generation

Landfill Post-Closure Care Funding Issues

- Funds Will Be Needed Forever at Pottstown Landfill to
  - Maintain Landfill Containment and Collection Systems
  - Monitor Groundwater
  - Potentially Clean up Polluted Groundwater
- Funding Only Available for Some of the Issues That Will Need Attention
  - No Funding Assured for
    - Replacement of Landfill Cover
    - Remediation of Polluted Groundwater

Landfill Post-Closure Care Funding Issues (cont)

- Waste Management Obligated to Pay for Monitoring, Maintenance & Remediation for as Long as the Wastes in Landfill Are a Threat
  - Will Waste Management Be Available to Fund the Post-Closure Care?
    - Massive Liabilities Are Developing Due to Landfills That Will Ultimately Pollute Groundwater, Creating a “Superfund”-Like Cleanup
  - How Will the Post-Closure Care Be Funded If Waste Management Is No Longer Available?
- State of PA May Not Have Funding to Pay for the Post-Closure Care If Waste Management No Longer Able

Certificate of Closure Issues

- DEP Can Issue a Certificate of Closure That Would Relieve Waste Management of Further Responsibility for Monitoring and Maintenance of the Landfill
- If Certificate Issued While Wastes in Landfill Still a Threat, i.e., While Landfill Is in Dormant Period, Could Lead to
  - Failure to Detect Pollution of Groundwater by Landfill Leachate
  - Failure to Detect Migration of Landfill Gas to Off-Site Areas
  - Pollution of Off-Site Production Wells
  - Impacts on Benthic Organism Assemblages in Goose Run Where Groundwater Surfaces
- Landfill Closure Committee Should Continue to Be Active in Review of DEP Consideration of Issuance of Certificate of Closure

Third-Party Independent Monitoring

- Landfill Closure Committee May Want to Work with DEP to Establish Funding for Independent, Third-Party Monitoring of the Landfill
  - Improve Likelihood of Adequate & Reliable Monitoring & Maintenance during Post-Closure Period
  - Address Complacency during Dormant Period
    - Landfill Could Be Dormant for Decades before Beginning to Exhibit Signs of Landfill Gas & Leachate Generation
- Cost of Independent Monitoring Should Be Borne by Waste Management
- Independent Monitor Should Report Directly to Landfill Closure Committee & DEP

Flawed Technology of Dry Tomb Landfilling

- Subtitle D Dry Tomb Landfilling Is Flawed Technology
  - Significant Error by US Congress; Congress Misled by "Environmentalists"; Did Not Understand Landfill Processes
  - Wastes in Dry Tomb Landfill a Threat Forever
  - Liners Will Fail While Wastes Are Still a Threat
  - Unreliable Groundwater Monitoring Approach
  - Post-Closure Period Funding Not Assured
- Likely Lead to Subtitle D Landfills' Becoming Future "Superfund"-Like Sites
- Alternative to Dry Tomb Landfilling Is Bioreactor Approach

Bioreactor Landfill Operation

- Concept: Add Moisture (Leachate & Water) to Landfilled Waste to Accelerate Waste Fermentation
  - Produce Landfill Gas
  - Leach (Remove) Leachable Components of the Waste
  - If Conducted Properly, Can Develop Landfill That Would Not Be Long-Term Threat to Generate Leachate & Landfill Gas
- Could Reduce Magnitude of Many Long-Term Problems of Pottstown Landfill
  - Crushed Plastic Garbage Bags Hide Wastes from Moisture; Delay Waste Stabilization until Plastic Decomposes; Prolong Waste Stabilization Period
  - See Lee & Jones-Lee Papers on Considerations for Proper Fermentation/Leaching of Wastes
- Will DEP Regulations Allow Addition of Leachate/Water to Pottstown Landfill?
- Old Landfill Should Not be Operated as a Bioreactor
  - Increased Pollution

How Should Pottstown Landfill Closure Committee Proceed?

- Recognize That Pottstown Landfill Is & Will Continue to Be, Threat to Area Public Health and Environment, Forever
- Develop an Approach That Anticipates Inevitable Failure of Containment and Monitoring Systems
  - Establish Procedures That Have High Probability of Detecting Failure Before Off-Site Pollution Occurs
    - Define Most Likely Pathways for Releases of Chemicals
  - Establish Post-Closure Funding Mechanisms to Carry Out Additional Monitoring Needed to Improve Detection of Releases from Landfill