



NYSASWM Landfill Operator Training – Landfill Gas

Introduction

This section is intended to provide:

- Overview of the management of landfill gas (LFG)
- Review of LFG generation
- Review of design and operation of LFG collection systems
- Summary of regulatory requirements
- Overview of landfill gas use as an alternative fuel



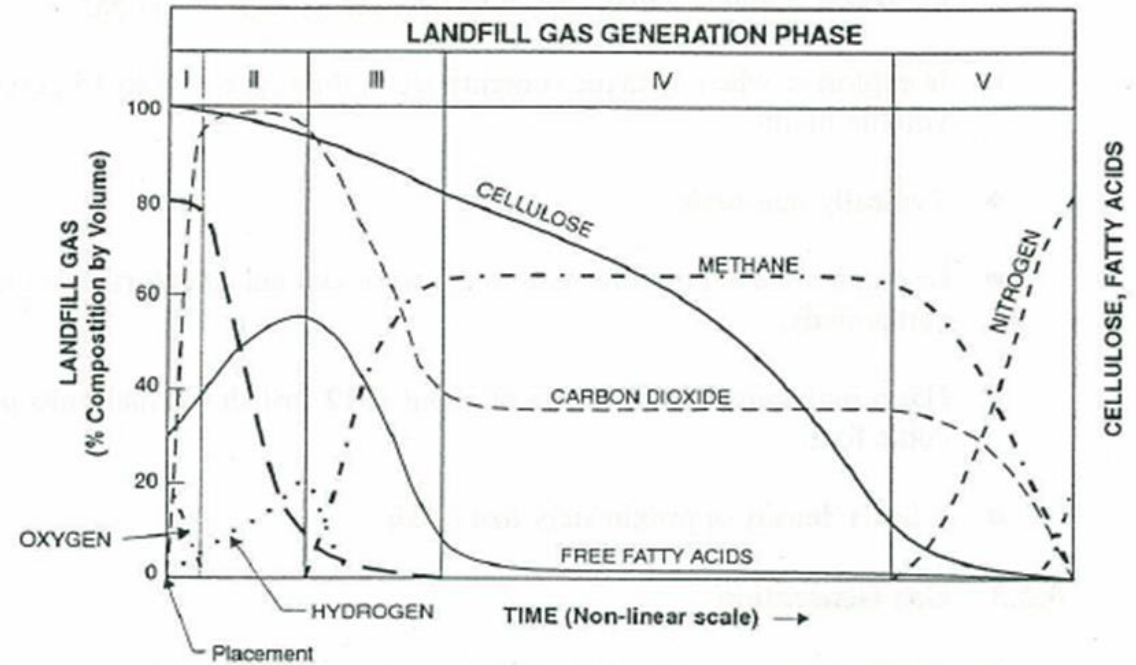


Decomposition & LFG Generation

- Organic waste material comprises about 75-80% of municipal waste deposited in US landfills (decreasing)
- Items such as food, paper, green waste, leather, textile, and some rubber products are subject to the biological decomposition that generates LFG
- Primarily an anaerobic process
- LFG production begins once waste mass conditions change from aerobic to anaerobic

LFG Generation

- Landfill gas generation is a naturally occurring process caused by the anaerobic decomposition of putrescible, or degradable materials, placed in landfills.



TIME FRAME - Typical USA

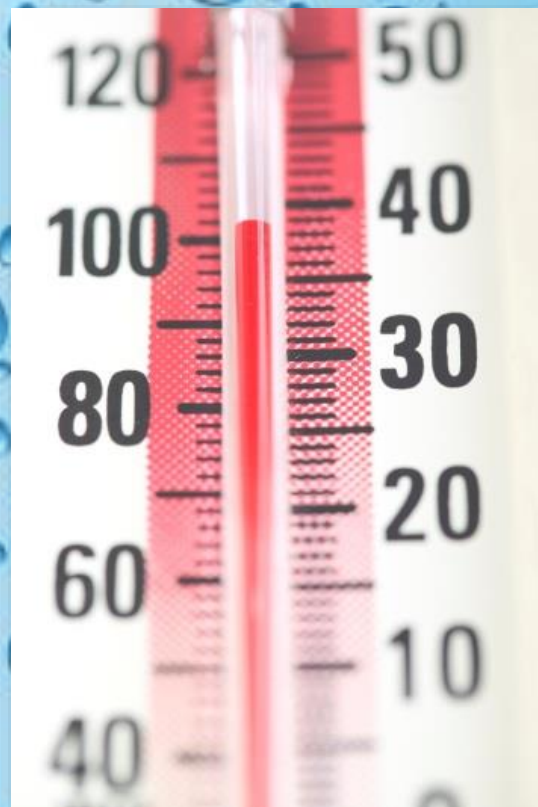
- PHASE I - hours to 1 week
- PHASE II - 1 to 6 months
- PHASE III - 3 months to 3 years
- PHASE IV - 8 to 40 years
- PHASE V - 1 to 40+ years
- TOTAL - 10 to 80+ years

SOURCE: Farquar and Rovers, 1973, as modified by Rees, 1980, and Augenstein & Pacey, 1991

Environment for Decomposition

- High moisture
- Anaerobic (lacking oxygen)
- Warm Temperature (100 to 140 degrees F)

A landfill with these conditions may produce as much as 80% more LFG in a shorter timeframe than a landfill with cooler or dryer conditions.



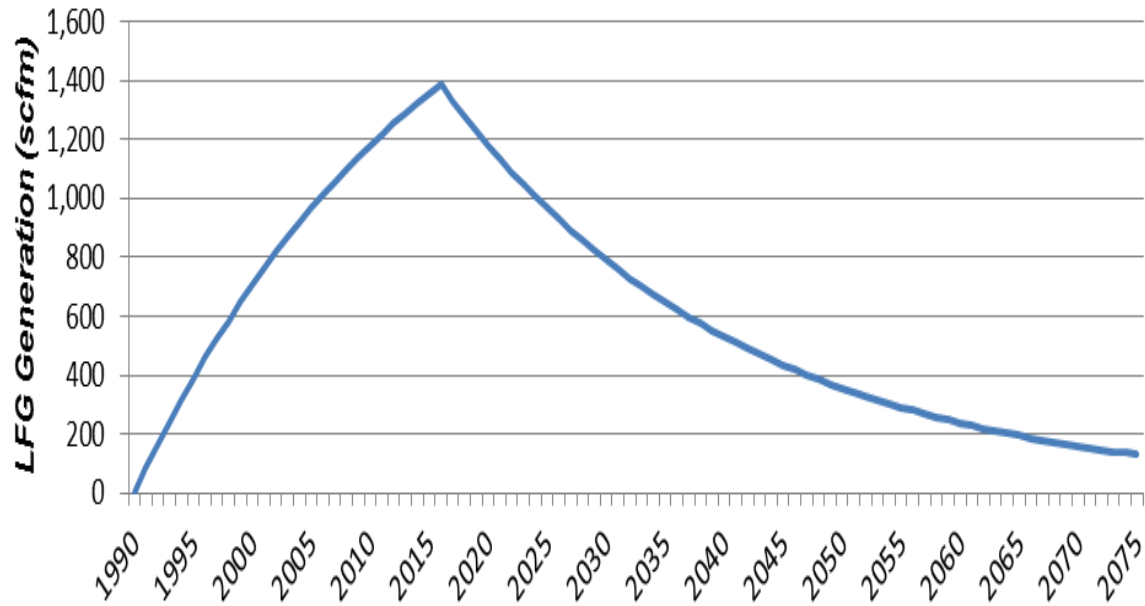
- LFG is approximately 50-55% Methane, remainder primarily Carbon Dioxide with traces of Nitrogen and Oxygen.
- Net heating value of approx. 500 Btu/cubic foot (assuming 50% methane)
- Small amount of H₂S (sulfur compounds give characteristic rotten egg odor) (typically less than 1,000 ppm or 1%)
- Trace amounts of NMOCs (typically less than 595 ppmv or 0.06% by volume).
- Trace compounds that contribute to odors. Low-level (parts per billion) concentrations can be detected by olfactory senses.

- LFG yield is approximately 3.5 to 4.3 cubic feet of methane per pound of putrescible, or degradable waste.
- Due to plastics, metals, ash, and other non-degradable materials, LFG yield is more like 2 cubic feet/pound of waste.
- The rate of LFG production is based on degradable waste placement, moisture, and time.
- Peak LFG production for a landfill facility typically occurs within the year after waste placement ceases.

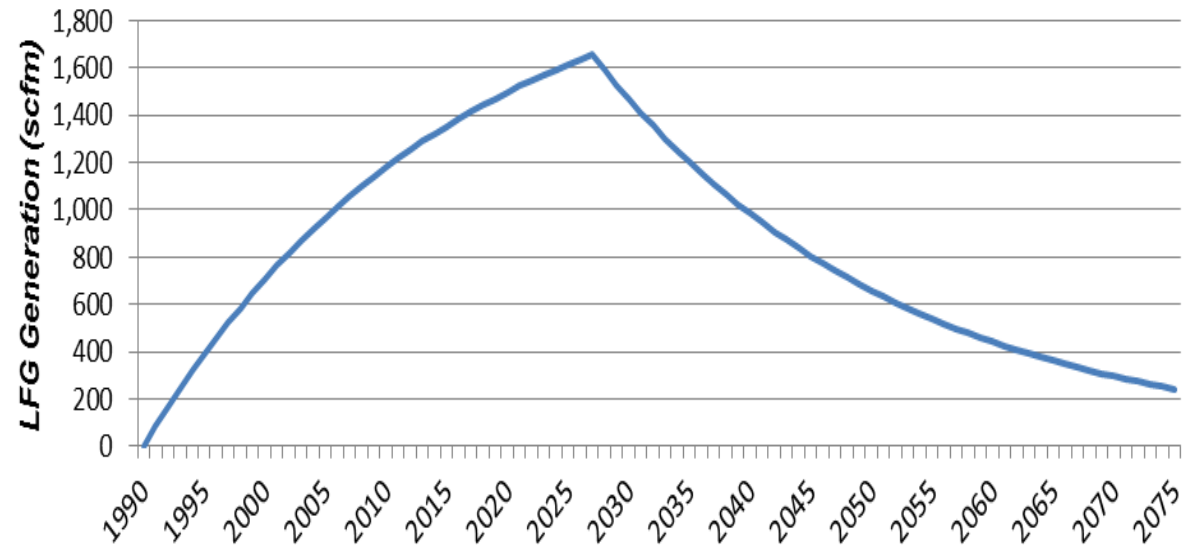
- Numerous mathematical models are available for estimation of LFG generation; however, the USEPA LandGEM model is the most widely used model for landfills in New York
- LandGEM utilizes two parameters which estimate the gas generation curve:
 - L_0 – Methane Generation Capacity of Waste
 - k – Methane Generation Rate Constant

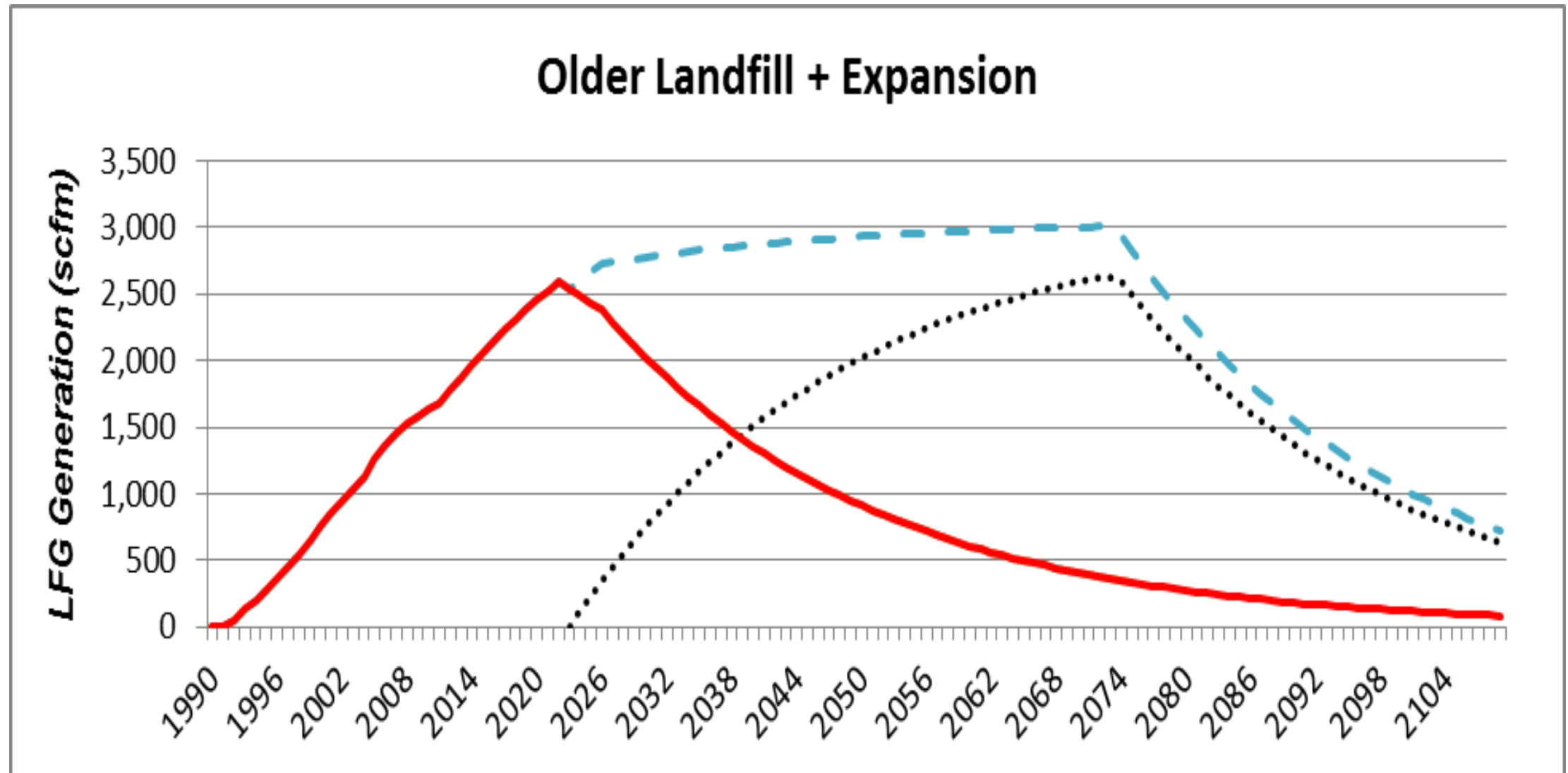
LFG Generation

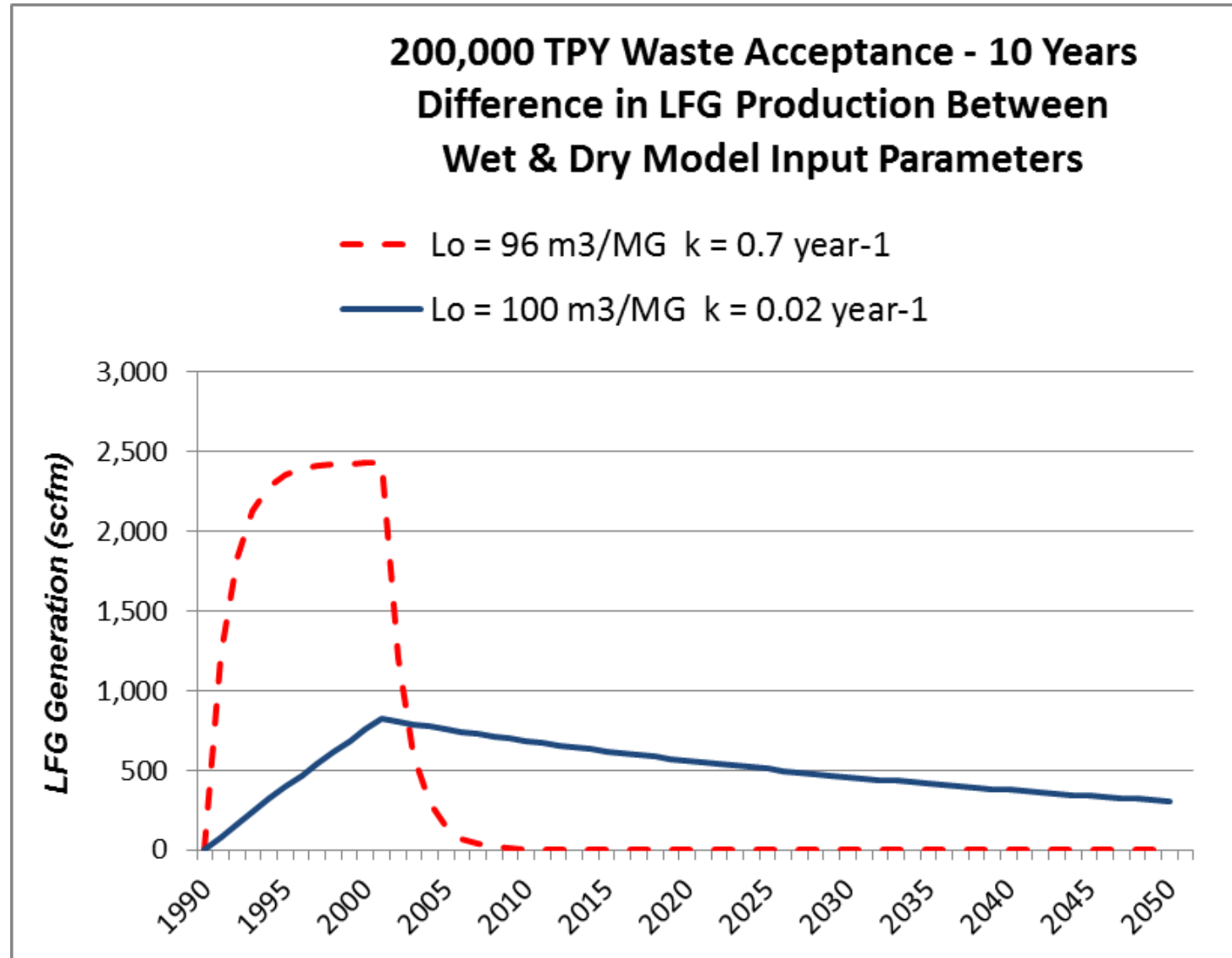
175,000 TPY Waste Placement - 25 Years



175,000 TPY Waste Placement - 50 Years







LFG Migration & Emissions

MIGRATION

- LFG Migrates Laterally and Vertically from LF
- LFG follows pathway of Least Resistance
- LFG cannot Penetrate Water

IMPACT

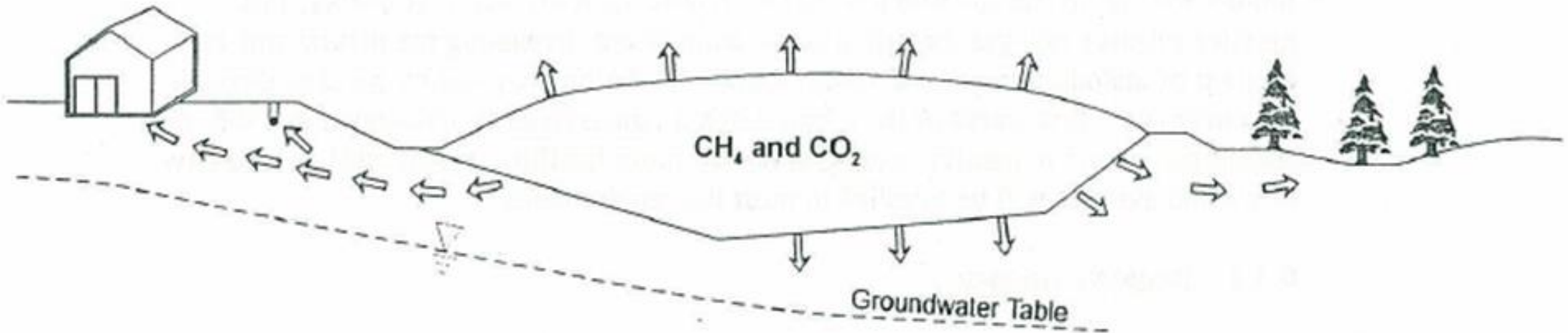
1. Groundwater Quality Impairment
2. Vegetative Stressing
3. Entry with Confined Spaces
4. Fire, Explosion, Safety

EMISSIONS

- LFG rises through over soil

IMPACT

1. Vegetation Stressing
2. Entry into Confined Space
3. Odors
4. Fire, Explosion
5. Health and Safety
6. Greenhouse Gases





- **6 NYCRR Part 363 – Landfills**
 - **363-4.6(j)** requires that the facility manual contains an odor control plan.
 - **363-4.6(k)** requires that the facility manual contains a gas monitoring and emission control plan.
 - **363-7.1(e)(1)** for landfills that received putrescible waste, horizontal gas collectors must be installed in the waste mass at a horizontal spacing of not more than 100 feet and a vertical spacing of not more than 20 feet
 - **363-7.1(e)(2)** the concentration of methane and other explosive gases must not exceed 25% of the LEL for gases at or beyond the property boundary; or within structures on-site (excluding gas recovery system components).

- Subtitle D requires that the methane concentration:
 - Not exceed 5% by volume in air (100% of the LEL) at the property boundary
 - Not exceed 1.25% (25% of the LEL) in structures or occupied spaces on site
 - Also requires that condensate from LFG collection systems can only be returned to landfills with a liner system and leachate collection system

- Federal regulation, required by the USEPA Clean Air Act, and adopted by the NYSDEC. **NSPS Subpart XXX applies to facilities modified after July 17, 2014.**
- 40 CFR 63 Subpart AAAA – Became applicable Sept. 27, 2021 (Similar to NSPS Subpart XXX Rules/Requirements)
- Provide requirements for controlling emissions of non-methane organic compounds (NMOCs)
- Facilities are subject to this rule if the landfill design capacity exceeds
 - 2.5 million metric tons (2.75 million tons), or
 - 2.5 million cubic meters (3.27 million cubic yards)

Federal NSPS – Subpart WWW / XXX
NESHAP Subpart AAAA

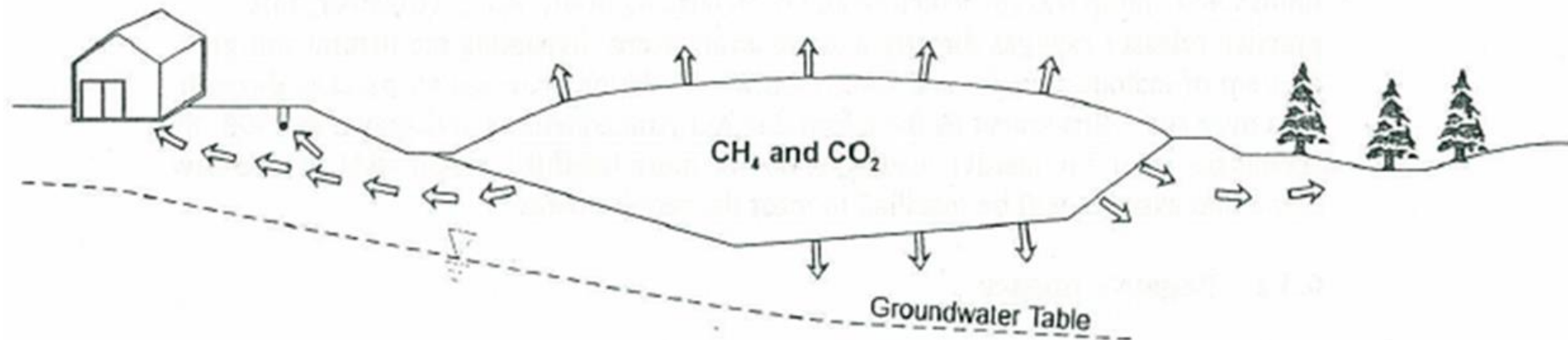
- Requires facilities to determine the site specific NMOC emission rate
- If a facility exceeds 50 Mg/YR (34 Mg/YR):
 - Subject to the full NSPS WWW (XXX) requirements
 - Required to obtain and operate under a Title V air permit
 - **Must install an active LFG collection & control system**



- If less than NSPS/NESHAP thresholds:
 - Facility may still elect to install a LFG collection system in order to prevent nuisance odors for NYSDEC Part 363 compliance.
 - Facility may still follow NSPS guidelines for LFG collection system operation and monitoring.

- “Landfill Gas Collection & Control Systems for Certain MSW Landfills”
 - Revisions Adopted September 2019
 - Incorporates by reference the federal Emission Guideline (EG) 40 CFR Subpart Cf
 - Applies to existing MSW landfills that have accepted waste **after** 11/08/1987 and began construction, reconstruction or modification **prior** to 07/17/2014.
 - Requirements similar to NSPS XXX.
 - Primary change = Lowering threshold for required gas collection and control from 50 Mg/year NMOCs to **34 Mg/year** NMOCs for active landfills

- Control and collection of LFG can be performed for several purposes
 - Control of migration and emissions of LFG
 - Reduction or elimination of odors
 - Collection for utilization



Control & Collection

Control of Odors:

- To control odors you must reduce the fugitive LFG emissions
- Goal is to collect as much gas as possible and combust to reduce the odor causing potential
- Since this is focused on “odor control” gas quality, and methane content may not matter as long as the gas can be combusted
- Improve gas collection until odors go away!
- May need increased cover soils or a temporary synthetic cover to control emissions and aid in collection & control efficiency



Control & Collection

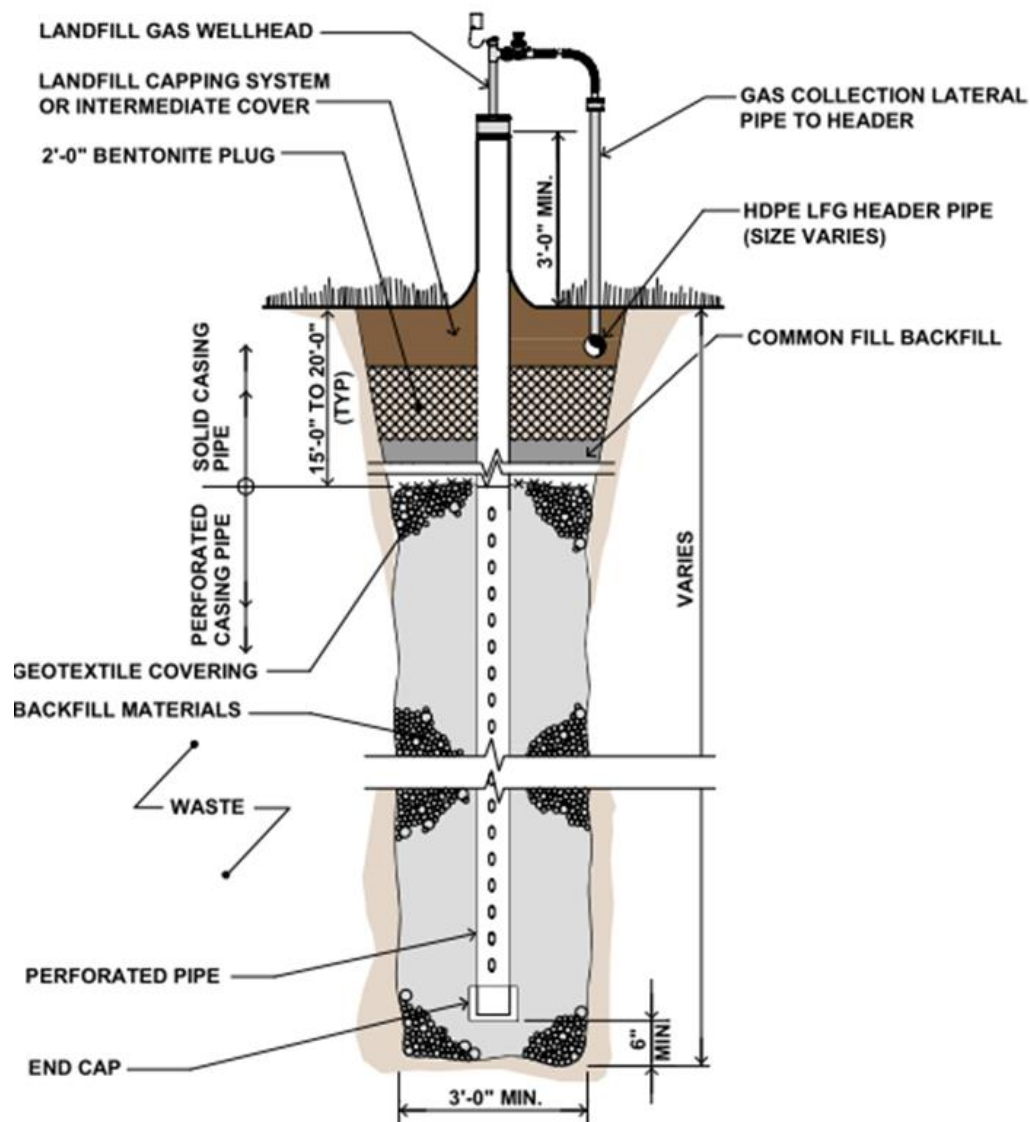
Collection for Utilization:

- Focused on monitoring LFG methane and oxygen content (50% CH₄, 0% O₂)
- Can be a conflict with migration or odor control
- Typically maintain NSPS monitoring requirements and prevent nuisance odors
- May involve installation of separate piping to different areas in order to provide variable levels of LFG collection and control

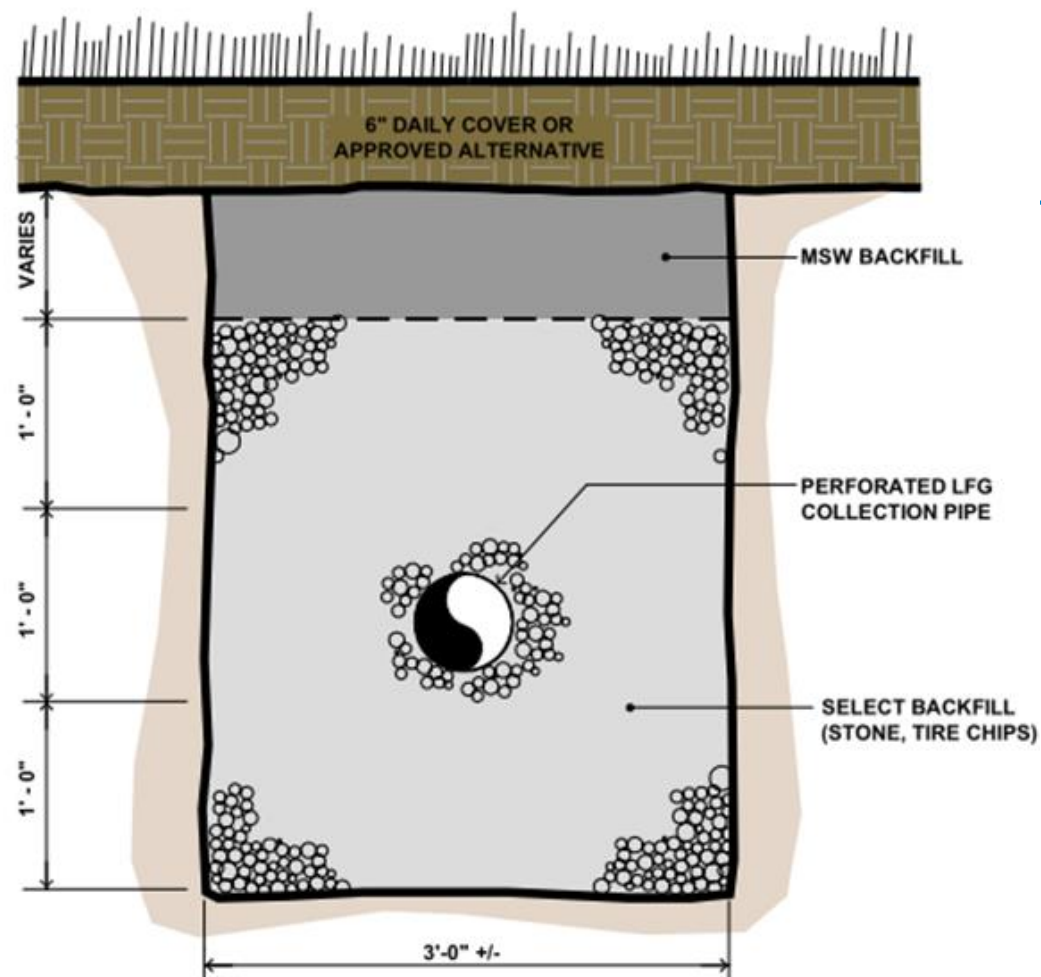


Collection Devices

- Vertical gas wells allow the collection of gas to be performed at specific locations
 - Allow the greatest flexibility controlling LFG
 - Each well has control valve and sample port



Collection Devices



- Horizontal collectors have perforated pipe laid in gravel trenches
 - Can be installed during waste placement operations
 - Can help control odors from active waste placement areas
 - Need to be hooked up and turned on to be effective

Destruction Devices

- Collected LFG cannot be directly released to the atmosphere, so it must be destroyed
- Combustion is the most cost effective and environmentally friendly way to accomplish this
- Flares are the most common combustion devices
 - Originally designed for the petroleum industry
 - Burn landfill gas in a controlled fashion



Flares





Landfill Gas Utilization

- Heating / Cooling
 - Kilns
 - Fish Farms
 - Greenhouses
- Power Generation
- Combined Heat & Power (CHP)
- Cleaned & Compressed LFG:
 - Clean LFG for Direct Pipeline Use
 - Vehicle Fueling

Monitoring

- LFG monitoring is focused on three areas:
 - Measuring LFG migration laterally or downward (subsurface gas migration)
 - Measuring LFG emissions upward from the landfill (fugitive emissions)
 - Measuring LFG in the gas extraction system (collected LFG quality)



Emissions Monitoring

- NSPS WWW and **XXX** require monitoring of the quantity of LFG combusted on-site, and periodic stack testing of combustion devices
- Both NSPS require monthly wellhead monitoring
 - Well Pressure < 0" (vacuum)
 - Temperature < 131°F
 - Oxygen < 5% or Nitrogen < 20%
 - **NSPS XXX requires monitoring, but removes the Nitrogen & Oxygen standard requiring corrective actions.**
- Both NSPS require quarterly surface scans
 - Surface Methane < 500ppm above background
 - Monitor penetrations and openings





Monitoring to Control Subsurface Fire

- Typically, subsurface fires are caused by excessive LFG extraction and/or direct pathways for air to enter the waste mass
- Cause problems to the landfill including:
 - Melted wells, headers and liner/cap
 - Abrupt Settlement
 - Inability to meet monitoring requirements



- Anaerobic decomposition produces heat by exothermic microbial reaction
 - Temperatures typically limited to 135 °F to 145 °F
- Temperatures above 145 °F are typically caused by Aerobic decomposition and/or chemical oxidation (combustion)

- A well trained LFG technician can identify the signs of subsurface fire before becoming a problem
 - Air Intrusion – Low methane and high O_2/N_2
 - O_2 Consumption – Drop in O_2 while N_2 stays high
 - In Air: 79% N_2 to 21% O_2 \Rightarrow N_2 to O_2 ratio = 3.8:1
 - In Normal LFG: 4% N_2 to 1% O_2 \Rightarrow N_2 to O_2 ratio = 3.8:1
 - O_2 Consumption: 30% N_2 to 1% O_2 \Rightarrow N_2 to O_2 ratio = 30:1
 - Rapid Increase in Well Temperature!

Troubleshooting Subsurface Fires

- Signs that a fire already exists:
 - Smoke at landfill surface or from well pipes
 - Melted LFG wells or probes
 - Combustion odor or residue in LFG collection pipes “smoke smell”
 - Rapid increase in wellhead temperature
 - LFG temperature > 170 °F
 - LFG Carbon monoxide conc. > 1,000 ppm



Troubleshooting Subsurface Fires

- How Does Air Enter the Waste & Promote Fire
 - Damaged or leaking LFG wellheads, flex tubes, or headers
 - Over pulling vacuum on LFG collection system in a landfill area may pull air through the cover
 - Landfill excavation exposing the waste while LFG collection system is operating



Steps to Control or Suppress Subsurface Fires

- Turn off all LFG collection in the area
- Eliminate the source(s) of oxygen
- Seal locations where air is entering and fill settled areas
- Soak cover soils with water for a better seal
- Cool the waste to a temperature that supports anaerobic decomposition
- Periodically open wellheads to monitor LFG quality and temperature
- After LFG temperatures decrease and combustion is suppressed, gradually re-apply vacuum to wellheads, and continue to monitor.

- Landfill gas production over time is highly dependent on waste composition and moisture content
- Landfill gas travels along the path of least resistance
- Gas migration creates risk of fire, explosion, public nuisance, and groundwater degradation
- Use of venting systems to relieve pressure within the landfill
- Use monitoring systems to verify that gas is not migrating
- Use LFG extraction systems to reduce migration or to recover gas for beneficial use

Any Questions?

THANK YOU!



ASSET
MANAGEMENT



ENVIRONMENTAL



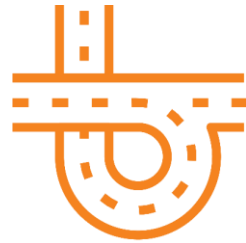
SOLID WASTE



FACILITIES



LAND SURVEYING



TRANSPORTATION



WATER RESOURCES



SUSTAINABLE PLANNING
& DESIGN