Why Manage Landfill Gas?
What is Landfill Gas?

• Gaseous by-product of decomposition of organic materials in sanitary landfills under anaerobic conditions
Conditions Required for LFG Generation

- Organic materials
- Moisture
- Nutrients
- Anaerobic conditions
- Anaerobic bacteria
Landfill Gas Composition

- Methane 35-60%
- Carbon Dioxide 30-50%
- Nitrogen 2.0-10.0%
- Oxygen 0.2-1.0%
- Ammonia 0.1-1.0%
- Sulfides 0.0-1.0%
- Hydrogen 0.0-1.0%
- Carbon Monoxide 0.0-0.2%
Factors Influencing LFG

- Refuse quantity
- Refuse composition
- Refuse compaction
- Refuse age
- Moisture content
- pH and alkalinity
- Nutrients
- Toxics
- Temperature
- Other factors
Landfill Gas Liability

- Combustion/explosion hazard
- Methane and carbon dioxide are asphyxiates
- Hydrogen sulfide is IDLH at 100 ppm (NIOSH)
- Lateral migration
- Odors
- Vegetation stress
- Ground water contamination
- Greenhouse gas/global warming
Landfill Gas Assets – Energy Recovery

- Electric generation
- Medium Btu
- Renewable Natural Gas (RNG)
- Vehicle fuel (CNG/LNG)
- Fuel cells
- Chemical feedstocks
Forces Driving LFG Management Systems

- Health, Safety and Environmental Concerns
- Regulatory Compliance
- Energy Recovery - Beneficial Use
Health Safety and Environmental Concerns

• Odor Control

• Subsurface Migration
  ▪ LEL for methane is 5% by volume - Explosive in Confined Areas

• Ground Water Impacts
  ▪ Investigations indicate that LFG can impact ground water quality
  ▪ CO2 is soluble in water and reduces ground water pH, increasing hardness and mineral content

• Surface Air Emissions
  ▪ Contributes to photochemical smog

• Vegetation Stress
  ▪ Methane and carbon dioxide can kill vegetation and create landscaping problems
Federal Regulations

- **NSPS**
  - 2-Year/5-Year Rule

- **Control of Explosive Gases**
  - Methane must not exceed 25% of LEL (1.25% by volume) in on-site structures and cannot exceed 100% of LEL (5% by volume) at property boundary. Probes must be monitored at least quarterly.

- **Clean Air Act: NSPS/EG**
  - Federal rules implemented to control air pollution from landfills
Energy Recovery

- Electric generation
- Medium Btu
- Renewable Natural Gas (RNG)
- Vehicle fuel
- Fuel cells
- Chemical feedstocks
Gas Generation Curves

- Regulatory drivers
- Gas system design
- Gas system evaluations
- Beneficial use projects
- Models have limitations
Gas Generation Curves – Gas System Design

• Used to estimate maximum LFG generated
• Used to estimate the header pipe sizing
• Used to write specification for flare system
  ▪ Blower
  ▪ Pipe size
  ▪ Valve size
  ▪ KOP size
  ▪ Stack size
Gas Generation Curves – Gas System Evaluation

• Checking the design of the flare to the landfill’s expected capacity to generate LFG
• Look at the % of the anticipated LFG that is actually being extracted
Gas Generation Curves – Beneficial Use Projects

• Evaluates the incline and decline of gas generation over the life of the project
• Helps determine the dispersion of capital investments in generation/facility equipment “phasing”
• Helps project the payback on capital investments
• Gives a physical representation of the life of the landfill
Gas Collection and Control System Components

- Condensate Management
- Wells
- Header Piping
- Control System
- Leachate Storage
- Monitoring Probes
- Leachate Collection
Gas Collection and Control System Components

• Landfill Gas Collection Points
  ▪ Vertical Wells
  ▪ Caisson Wells
  ▪ Horizontal collectors
  ▪ Leachate cleanout risers

• Landfill Gas Collection Piping
  ▪ Laterals
  ▪ Header

• Condensate Management
  ▪ Sumps
  ▪ Driplegs

• Control System - Blower/Flare Stations
Traditional Vertical LFG Extraction Well

- Drilled on existing slopes, but located based on compliance and odors
- Perforated casing allows LFG entry
- Solid pipe and bentonite used to prevent air intrusion
- Wellhead controls vacuum application and LFG flow
Traditional Vertical LFG Extraction Well

• Advantages
  ▪ Most Common
  ▪ Effective in Waste Thicknesses Greater than 40 Feet
  ▪ Less Sensitive to Vertical Waste Settlement
  ▪ Less Sensitive to Adverse Liquid Impacts
  ▪ Pumps For Liquid Removal Can Be Added Easily
Traditional Vertical LFG Extraction Well

- Disadvantages
  - Difficult to Extend and Maintain Beyond Original Installation Depth
  - May Impact Ongoing Waste Placement Activities
  - Subject To Damage By Workface Equipment
  - May Impact Closure/End-Use Activities
  - Requires Specialty Contractor/Equipment to Install
  - May Be Time Lag Between LFG Generation and Ability To Install Wells
LFG Extraction Wells With Caisson

- Drilled on existing slopes (top down)
- Installed on cell floor (bottom up)
- Perforated casing allows LFG entry
- Caisson pipe and bentonite used to prevent air intrusion
- Wellhead controls vacuum application and LFG flow
LFG Extraction Wells With Caisson

• Advantages
  ▪ Does not require re-drills
  ▪ Caisson protects well from damage
  ▪ Less Sensitive to Vertical Waste Settlement
  ▪ Pumps For Liquid Removal Can Be Added Easily
  ▪ If installed on drainage layer (bottom up), does not require pumps, air and forcemain lines
LFG Extraction Wells With Caisson

- Disadvantages
  - May Impact Ongoing Waste Placement Activities
  - May Impact Closure/End-Use Activities
  - Requires Specialty Contractor/Equipment to Install
Horizontal Collectors

- Trench excavation on existing slopes or plateaus
- Perforated casing allows LFG entry
- Soil cover, solid pipe and bentonite used to prevent air intrusion
- Wellhead controls vacuum application and LFG flow
- Low-Permeability, On-Site Soil Backfill
- Do Not Operate Without Sufficient Cover - Approximately 20 Vertical Feet
Horizontal Collectors

- Advantages
  - Minimal Impact to Ongoing Operations
  - Less Susceptible to Damage by Operations
  - Does Not Require Specialty Equipment/Contractor
  - Relatively Inexpensive to Construct
  - Allows For Earlier Implementation of LFG Control
Horizontal Collectors

- Disadvantages
  - More Sensitive to Differential Settlement
  - More Sensitive to Liquid Impacts
  - Difficult to Pump/Evacuate Liquids
  - Must Build the Collectors as You Go – Must Follow Sequencing Plan
Leachate Collection Risers

- Connections to existing LCRs – not a “new” installation, i.e. collector/riser already exists
- Generally a supplemental/interim collection point - good for odor control – good for initial waste placement
- Applicable to NSPS Monitoring Requirements unless specifically exempted
Extraction Well Spacing

• Vertical Wells
  ▪ Perimeter Wells: 100-150 feet
  ▪ Interior Wells: 200-300 feet

• Horizontal Wells
  ▪ Horizontally: 100-300 feet
  ▪ Vertically: 30-60 feet
  ▪ Keep Perforations at least 100 feet from Edge of Waste or FML

• Good Engineering and Operational Judgment
Landfill Gas Collection Piping

• Laterals
  ▪ Portion of header between well and main header
  ▪ Usually 6” – 8” HDPE

• Header
  ▪ Main portion of the collection system that conveys LFG from multiple collection points to the blower flare station
  ▪ Usually 8” to 24”
  ▪ HDPE is more flexible and easier to construct in the field
  ▪ Welds are fused not glued
Landfill Gas Collection Piping

[Diagram of Landfill Gas Collection Piping]

[Image of excavation site with construction equipment and piping]
Condensate Management

- **Sumps**
  - Designed to remove condensate from the GCCS while maintaining a seal against atmospheric conditions
  - Requires pump installation and condensate removal

- **Driplegs**
  - Designed to remove condensate from the GCCS while maintaining a seal against atmospheric conditions
  - Sideslope or Vertical
  - Gravity application – no pumps
Condensate Management - Sumps

Offset Design

Inline Design
Condensate Management - Driplegs

Sideslope Dripleg

Vertical Dripleg
Control System – Flares

• Candle Stick Flares
  ▪ Candlestick Flare is the ideal solution for simple, low cost installations where EPA’s 40 CFR, § 60.18 is the basis
  ▪ 98% destruction efficiency by rule – cannot test

• Enclosed Flares
  ▪ Efficient burner design to provide smokeless operation inside of a combustion chamber that completely conceals the flare flame.
  ▪ Can stack test for destruction efficiency – typically > 98%
Control System – Flares
Control System – Blower Skids
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