Background
Anaerobic Decomposition

<table>
<thead>
<tr>
<th>Aerobic</th>
<th>Anaerobic</th>
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<tbody>
<tr>
<td>Phase I</td>
<td>Phase II</td>
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<td>Phase III</td>
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<td>Phase IV</td>
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<table>
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<th>Gas component (% by volume)</th>
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<tr>
<td>100</td>
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<tr>
<td>90</td>
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<td>10</td>
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- Carbon Dioxide: 45-60%
- Methane: 40-60%
- Hydrogen: 2-5%
- Oxygen: 2-5%
- Nitrogen: 2-5%

Note: Phase duration time varies with landfill conditions
Source: EPA 1997
Anaerobic Decomposition and Temperature

Anaerobic bacteria thrive at ~98° F to 130° F
Gas Collection and Control System Operation

Over-Pulling
Air Infiltration

Under-Pulling
Gas Migration

Graphic by: U.S. Environmental Protection Agency, Landfill Methane Outreach Program, http://www.epa.gov/lmop/over-photos.htm#1
Gas Collection and Control System Operation

- Other Well Balancing Objectives:
  - Protection of Groundwater
  - Subsurface LFG Migration Control
  - Surface Emission Control
  - Odor Control
  - Beneficial Use (Energy Recovery)

- Typically, the first four objectives require more aggressive LFG collection than the fifth (Prosser, 1998).
Residual Nitrogen

Residual Nitrogen = Nitrogen (N$_2$)\% – 3.76 x Oxygen (O$_2$)\%

(Note: the ratio of N$_2$ to O$_2$ in air is approximately 3.76)
Residual Nitrogen Example

- Given the gas composition measured at a gas well: 
  CH\(_4\): 32.5\%, CO\(_2\): 28.1\%, O\(_2\): 3.7\%, Balance: 35.7\% 

- Residual nitrogen (RN\(_2\)) is calculated as follows: 
  \(N_2\) from air leakage = 3.76 x O\(_2\)\% = 13.9\% 
  \(RN_2\) = Balance - 13.9\% = 21.8\%
Residual Nitrogen as a Tool

- $RN_2 = 0$ to $12\%$: Normal operating range for interior extraction devices at most landfills.

- $RN_2 = 16$ to $20\%$: May be necessary for perimeter migration control, side slope emission control, or where other compromise is required.

- $RN_2 > 20\%$: An indication of aggressive landfill gas extraction, may lead to aerobic conditions.

{From *Landfill Gas Operation & Maintenance Manual of Practice* by SWANA, 1998}
Case Study – Residual Nitrogen Assessment at Two Landfills

**Landfill A**
- Located in the northeastern United States
- Has a comprehensive gas collection system with wells and trenches ~ 140 gas extraction devices
- The primary landfill gas control device is a flare

**Landfill B**
- Located in the northeastern United States
- Has a comprehensive gas collection system with wells and trenches ~ 100 gas extraction devices
- The primary landfill gas control device is a landfill gas to energy facility
Residual Nitrogen Comparison

Landfill A – Flare Only
Two thirds of extraction devices (in red) with >20% RN₂

Landfill B – LFGTE Facility
One extraction device (in red) >20% RN₂
Percent Methane Comparison

Landfill A – Flare Only

Half of extraction devices (in green) ≥40% methane

Landfill B – LFGTE Facility

Two thirds of extraction devices (in green) ≥40% methane
Wellhead Temperature Comparison

Landfill A – Flare Only

~20% of extraction devices (in red) with maximum wellhead temperatures >131°F

Landfill B – LFGTE Facility

No extraction devices with wellhead temperatures >131°F
Using Residual Nitrogen to Make Wellfield Adjustments
Using Residual Nitrogen to Make Wellfield Adjustments
Residual Nitrogen Summary

- Good indicator of aerobic decomposition in a landfill
- Under-utilized tool
- Important for assessing wellfield data
- Useful parameter for guiding routine wellfield adjustments
Landfill Gas System Evaluation Using Web-Based Tools
Compromised LFG Collection

Red = Low Available Vacuum
Green = High Available Vacuum
Improving LFG Collection

Red = Low Available Vacuum
Green = High Available Vacuum
TYPICAL WELLHEAD ASSEMBLY

GROUND SURFACE
6" Ø HDPE PIPE
12" INTERMEDIATE COVER

CONCENTRIC HDPE REDUCERS AS NECESSARY

6" x 6" x 6" HDPE TEE

Sweep 4" Ø HDPE condensate drain pipe to match existing slope.
Pipe to drain to primary leachate collection pipe or 20 foot 4" perforated
drain pipe, where shown.

Ballast Stone

6" Ø HDPE PIPE

8" Ø HDPE 90° ELBOW (TYP.)

PROPOSED HEADER OR LATERAL

6' MIN.

3' MIN.

3' MIN.

2' MIN.
Preferred Trap Design
Repaired LFG Collection (First Quarter)

Red = Low Available Vacuum
Green = High Available Vacuum
Sequence of LFG Collection Improvements

Red = Low Available Vacuum
Green = High Available Vacuum
Compromised LFG Collection – Multiple Surface Emissions

Red = Low Available Vacuum
Green = High Available Vacuum
Repaired LFG Collection – Limited Surface Emissions

Red = Low Available Vacuum
Green = High Available Vacuum
Contact Information

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