Distinguishing ETLFs from Fires and SSO Events

Characteristics of Elevated Temperature Situations

Bryan Staley, PhD, PE

President & CEO

EREF Environmental Research & Education Foundation

Lighting a path to sustainable waste management practices

NC STATE UNIVERSITY

UNIVERSITY of VIRGINIA

Geosyntec consultants

engineers | scientists | innovators

CUNY The City University of New York

Project Team

Morton Barlaz, Joel Ducoste, Zisu Hao
North Carolina State University

Scott Luettich, *Geosyntec Consultants*

Marco Castaldi, *City College of New York*

Craig Benson, *University of Virginia*

NC STATE UNIVERSITY

UNIVERSITY of VIRGINIA

Geosyntec consultants
engineers | scientists | innovators

CUNY The City University of New York

Introduction

- A number of landfill owners around the U.S. have reported landfills with elevated gas temperatures

- Elevated temperature landfills (ETLFs) present a number of potential problems:
  - damage to gas and leachate collection systems
  - low methane content and odorous gas
  - high leachate strength (COD upwards of 50,000 mg/L)
  - rapid settlement
  - pressure accumulation

- A lot of speculation on causation
  - Reactive wastes explain temperatures at some sites but some are largely MSW

ETLFs – The Definition is Evolving

- Municipal solid waste (MSW) landfills where gas and/or waste temperatures are **persistently well above** 55 ^{o}C (131 ^{o}F) over a **substantial area** of a cell or cells.
  - Two classes
    - landfills that are warm due to heat accumulation
    - landfills with a subsurface reaction generating heat
  - Increasing trends in:
    - wellhead temperatures
    - CO (without combustion)
    - H_2 at wellhead
  - Substantial settlement
  - Absence of oxygen

- No one item alone renders a site an ETLF.
- Not all indicators may be present.
- Definition is site specific.

Landfill Operating Temperatures

Defining Normal Operating Temperatures and Elevated Temperatures

Normal Operating Temperatures under NSPS (<131 °F or 50 °C)

- NSPS focus is to maintain methanogenesis and guard against air intrusion and subsequent temperature increases
- High Operating Variances (HOVs) to allow temperatures above 131°F are not uncommon

Distinguishing between Fire and Subsurface Reaction

Landfill Fire: surface or near-surface event in which part of the waste is burning or smoldering under aerobic conditions

- hot load, lightening, hot equipment

Subsurface Reaction (SSR): occurs relatively deep where conditions are anaerobic. SSRs appear to be chemical and may be self-perpetuating.

ETLFs – What they are NOT

- MSW landfill where oxygen is available and the landfill is exhibiting combustion (ETLF landfills **not on fire, not "smoldering"**).
- MSW landfills that have a limited number of wells with temperatures above 55 ^{o}C.
- Not all sites with elevated temperatures have problems - most do **NOT** have problems

Confounding Terminology

- **Smoldering** – occurs when oxygen is present to support limited combustion. **Inappropriate** because the absence of oxygen in ETLFs precludes combustion. Also, some ETLFs are very wet or saturated with leachate, precluding combustion.

- **Combustion** - **inappropriate** because the absence of oxygen precludes combustion. *ETLFs are not landfills with combustion.*

- **Subsurface Oxidation (SSO) – inappropriate** because **oxidation implies aerobic conditions, which are not present**.

Regulatory nomenclature may cause confusion.

Legacy terminology leads to ambiguity.

Gas Well Temperatures Above 55 °C Are Not Uncommon

Recent survey data:

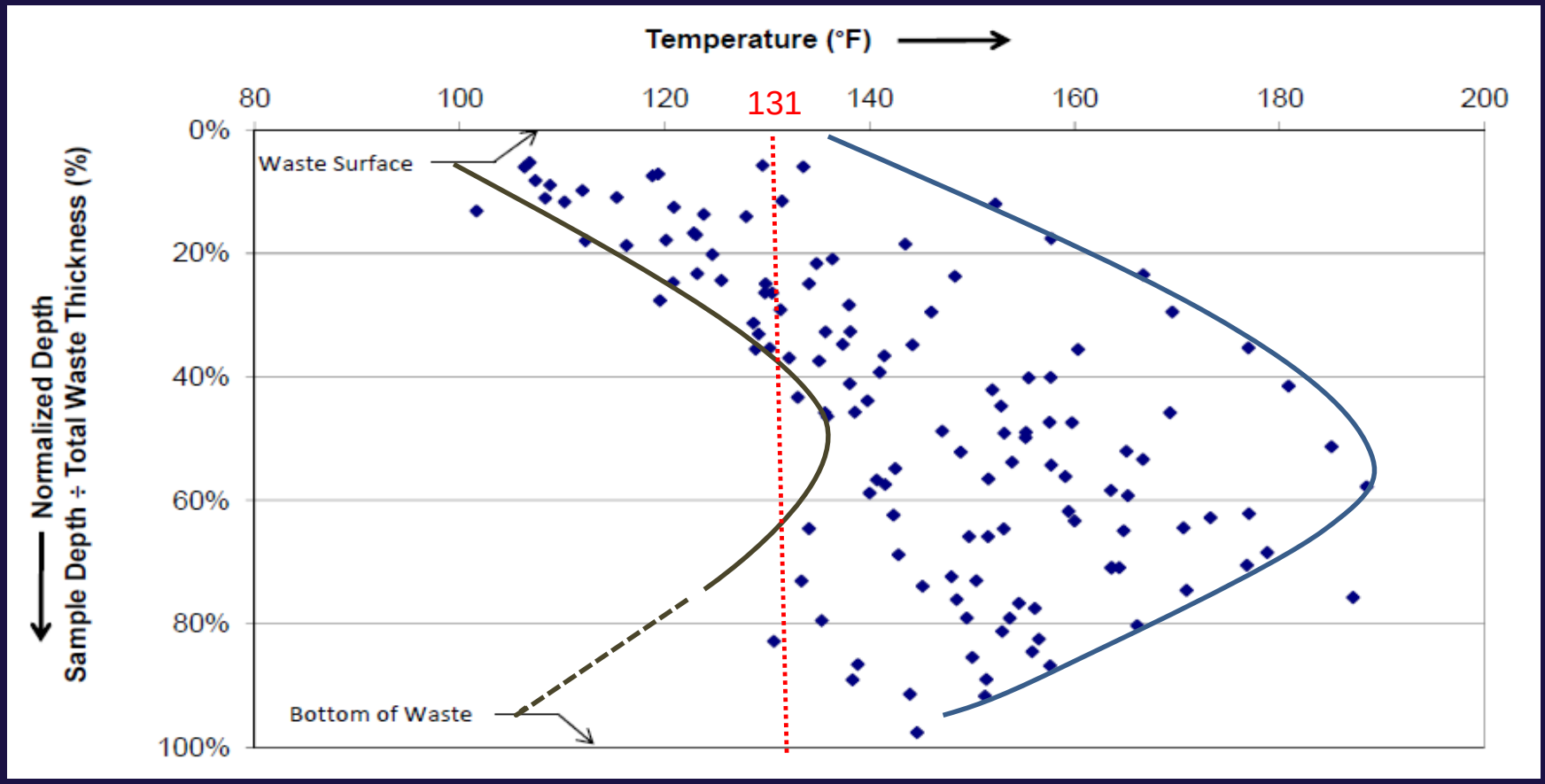
- Population of 208 landfills operated with active gas systems, 21,630 gas wells.
- 70 landfills in population (34%) issued at least one HOV.
- 2585 wells (12%) issued an HOV.
- 1652 wells (8%) have HOVs for temps above 55 °C.

- **Many landfills operate safely with wellhead temps > 55 °C. HOVs issued for these cases.**
- **Issuance of HOV for temperature ≠ ETLF.**
- **HOVs normal practice for safe & effective operation of landfills, monitoring confirms.**

7 Key Characteristics of Elevated Temperature Landfills

ETLFs – Observations/Challenges

1. Increased Temperature



ETLFs – Observations / Challenges

2. Increased Odors

- Damage to gas collection infrastructure reduces collection
- Decrease effectiveness of flare at low CH_4 content/need for supplemental fuel
- Increased gas output and gas pressures

3. Rapid and Widespread Settlement

- Municipal Solid Waste (MSW) consolidation normally produces a few feet of settlement over a few years.
- In ETLFs, settlement of several feet over periods of only a few weeks or months has been recorded.

ETLFs – Observations / Challenges

4. Low Ratio of Methane to Carbon Dioxide (CH_4:CO_2) in the Gas

Fermentation:

(Glucose)$C_6H_{12}O_6 + 2H_2O \rightarrow$

2(Acetate)$C_2H_4O_2 + 2CO_2 + 4H_2$

Methanogenesis:

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

ETLFs – Observations / Challenges

4. Low Ratio of Methane to Carbon Dioxide (CH_4:CO_2) in the Gas

Fermentation:

(Glucose)$C_6H_{12}O_6 + 2H_2O \rightarrow$

2(Acetate)$C_2H_4O_2 + 2CO_2 + 4H_2$

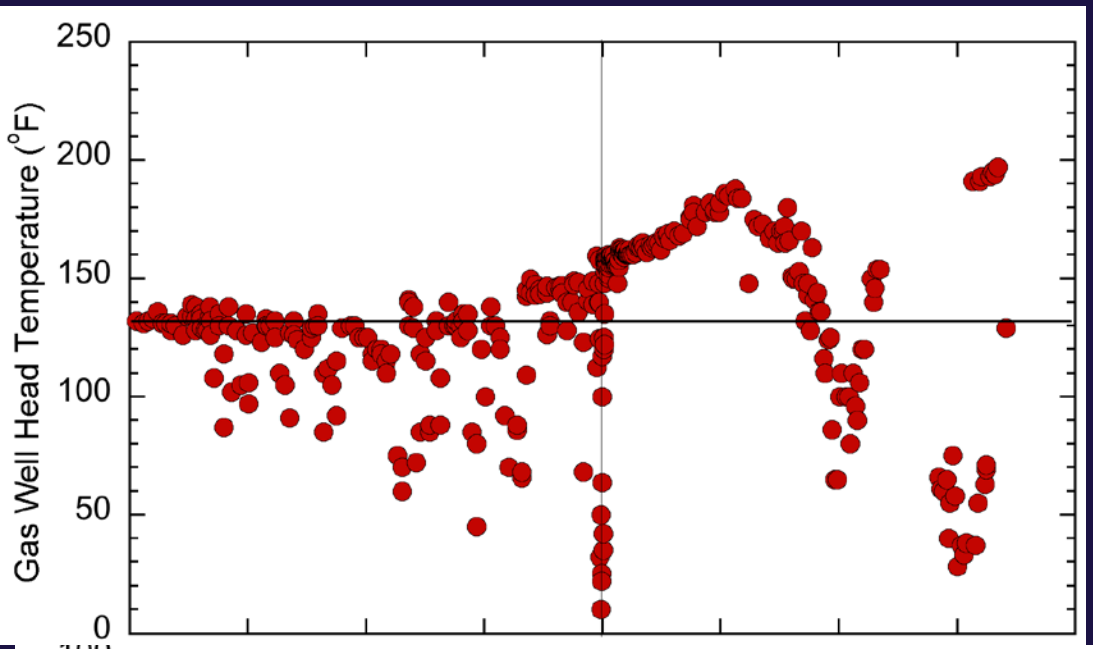
BUT IF THE ANAEROBIC STAGE IS INHIBITED

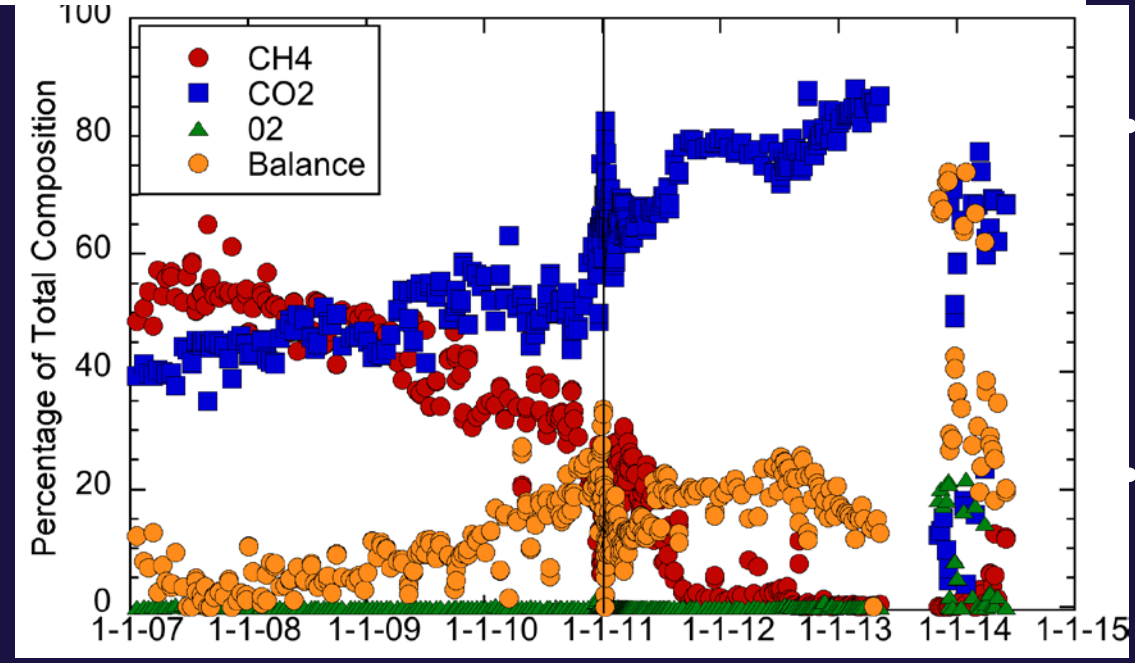
Methanogenesis:

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

In ETLFs $CH_4 : CO_2$ Ratio < 1

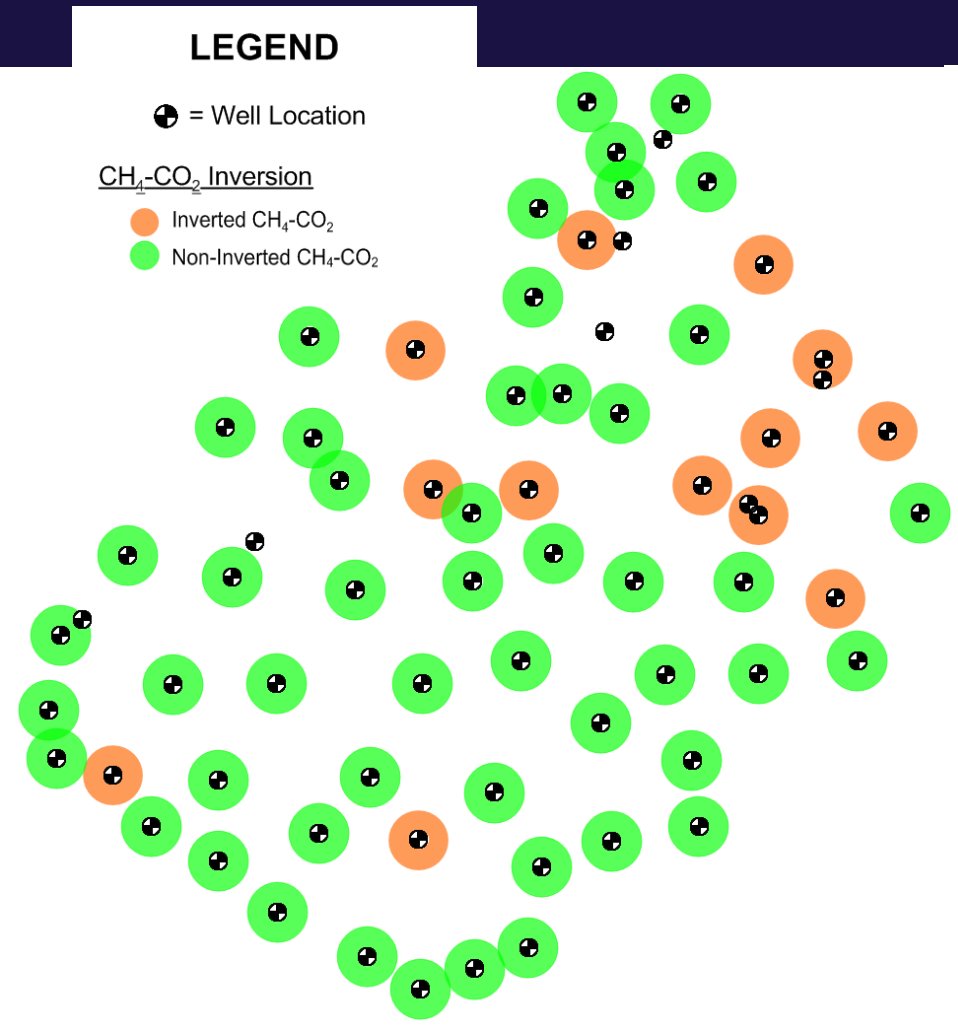
Gas Composition Change at ETLF



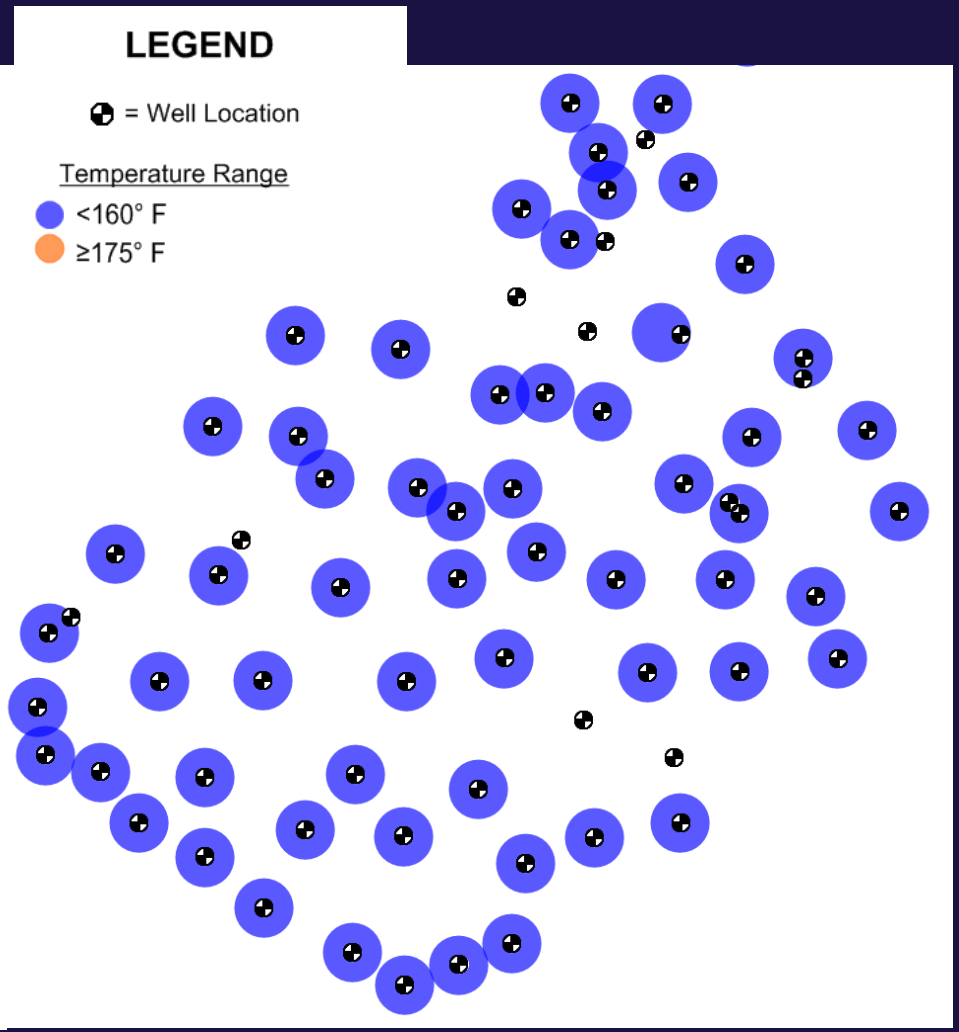


- Well running around 130 ^{o}F for several years without problems.
- Gradual change in CH_4 and CO_2.
- Temperature begins increasing in 2011 after brief shutdown. Rate of change in CH_4 and CO_2 increases too.
- Well is in very wet waste, nearly saturated. Flow is low (see next slide). Cuttings in area show dark, wet, decomposed waste.
- Note absence of oxygen – no source for combustion.

Landfill Reaction – Year 1

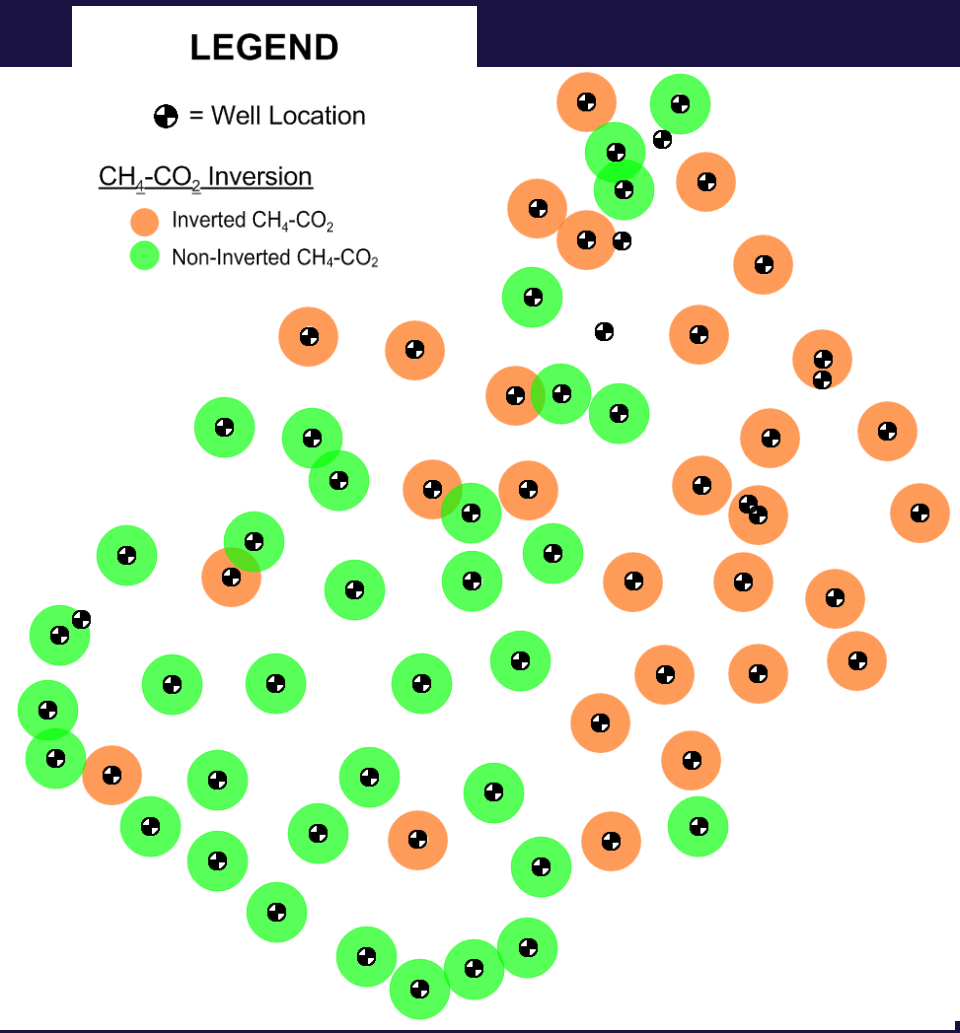


CH_4/CO_2 Ratio

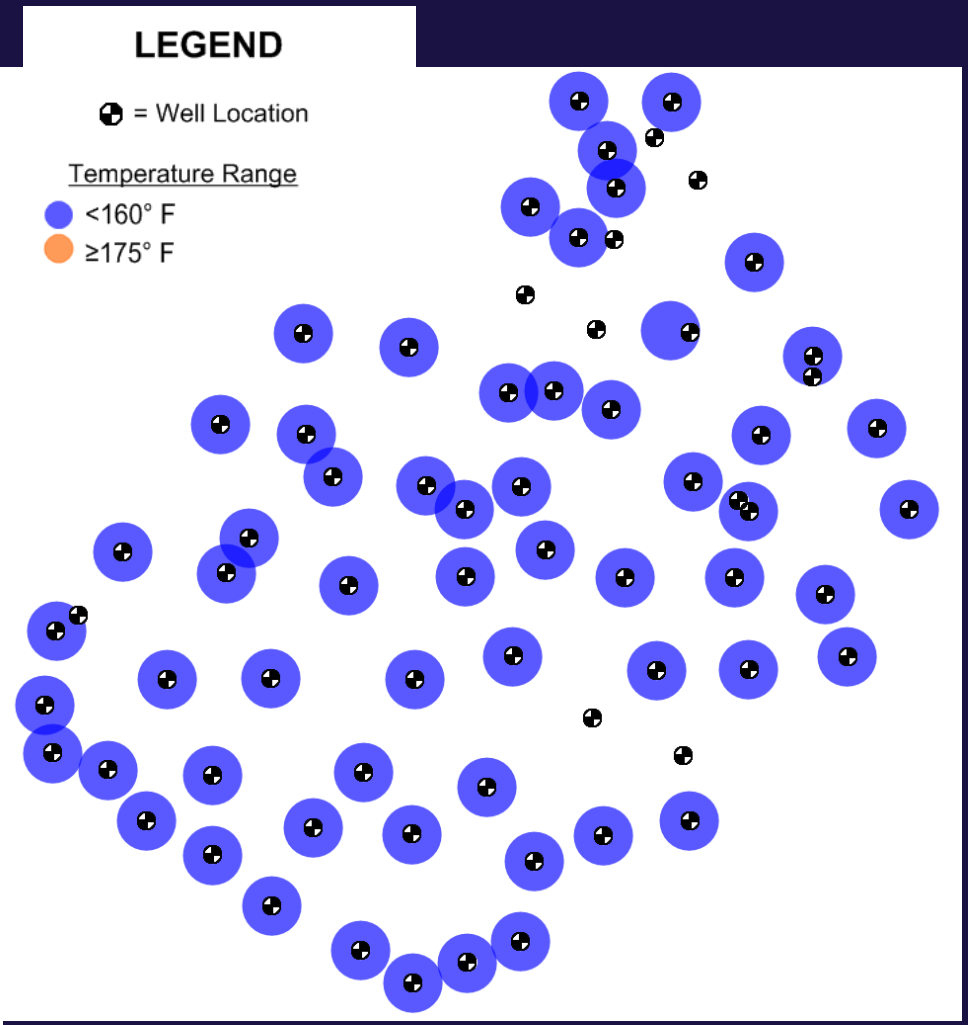


Temperature

Landfill Reaction – Year 2

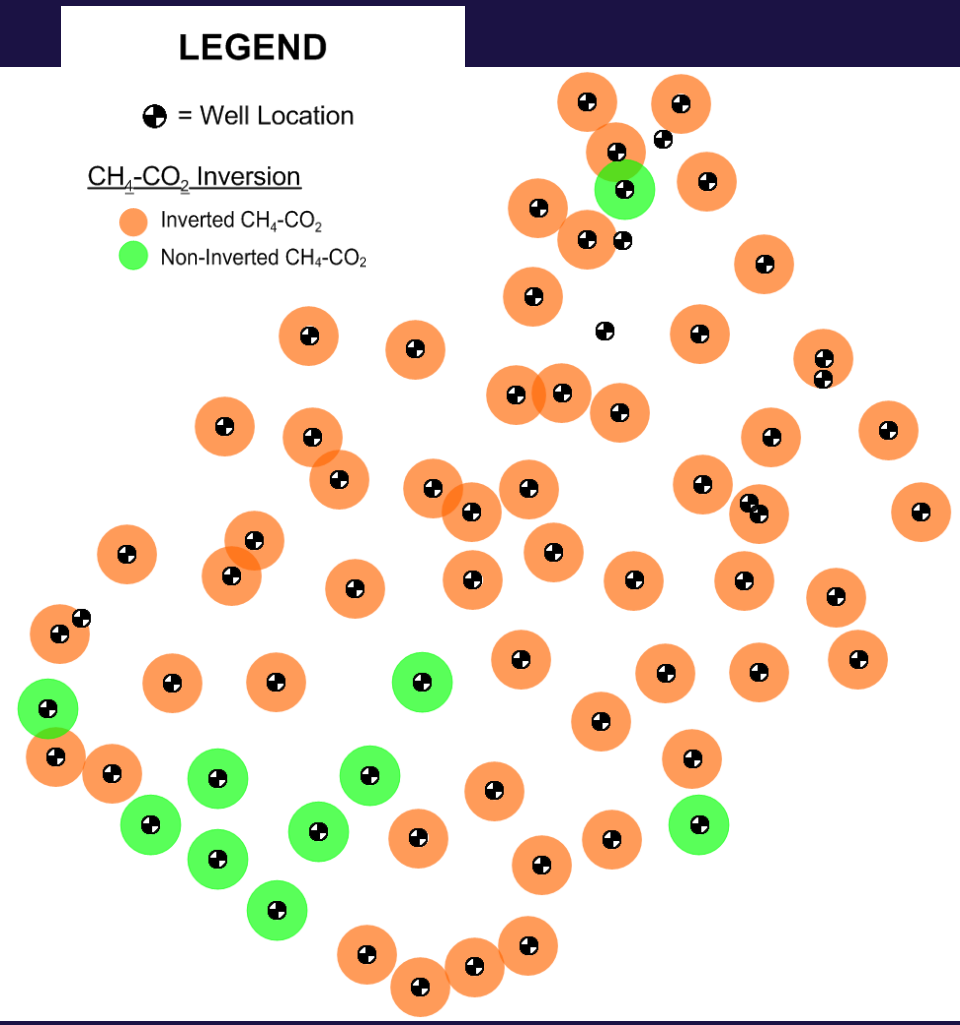


CH_4/CO_2 Ratio

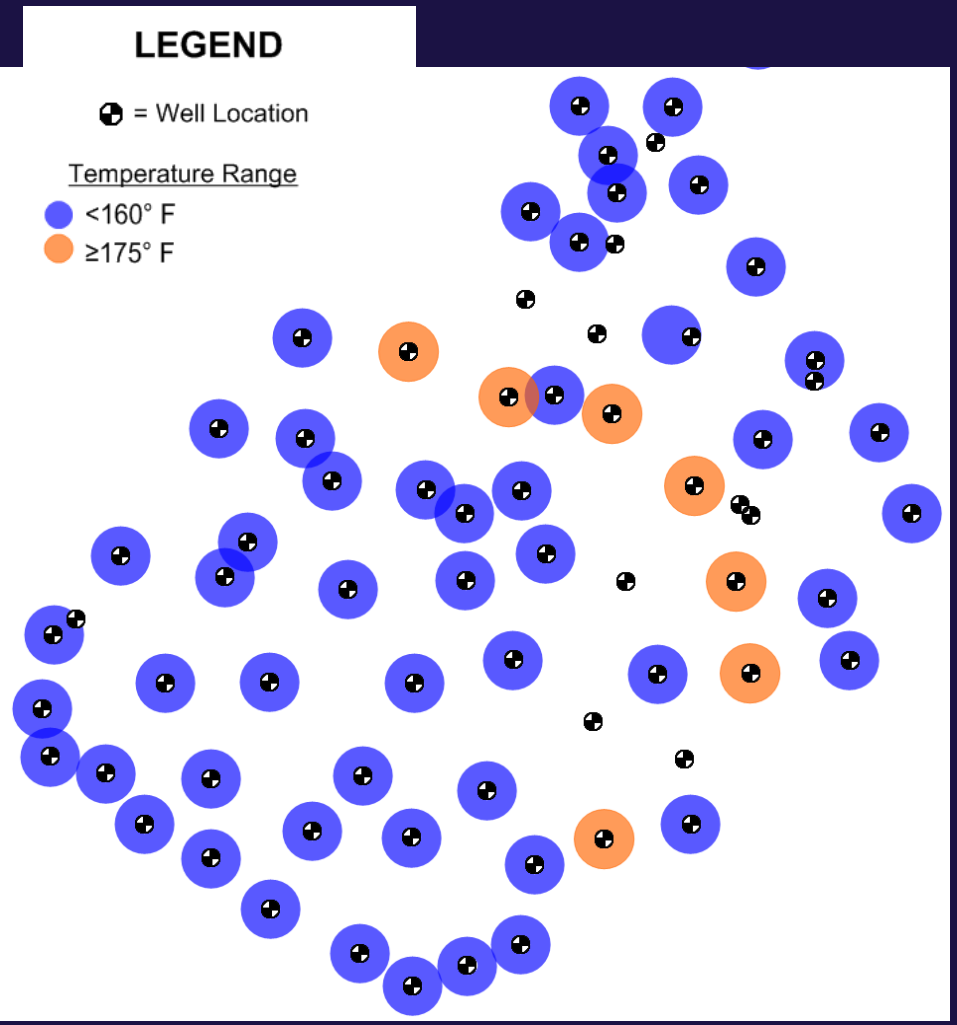


Temperature

Landfill Reaction – Year 3

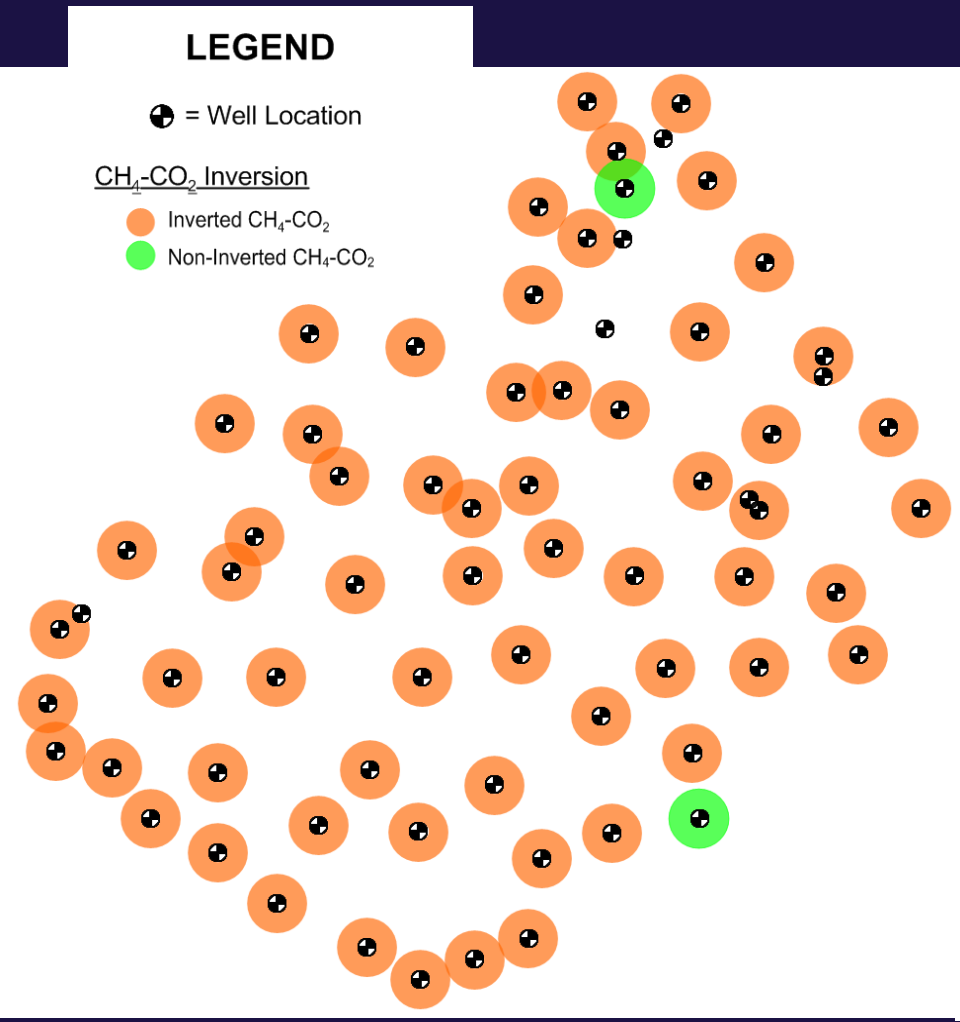


CH_4/CO_2 Ratio

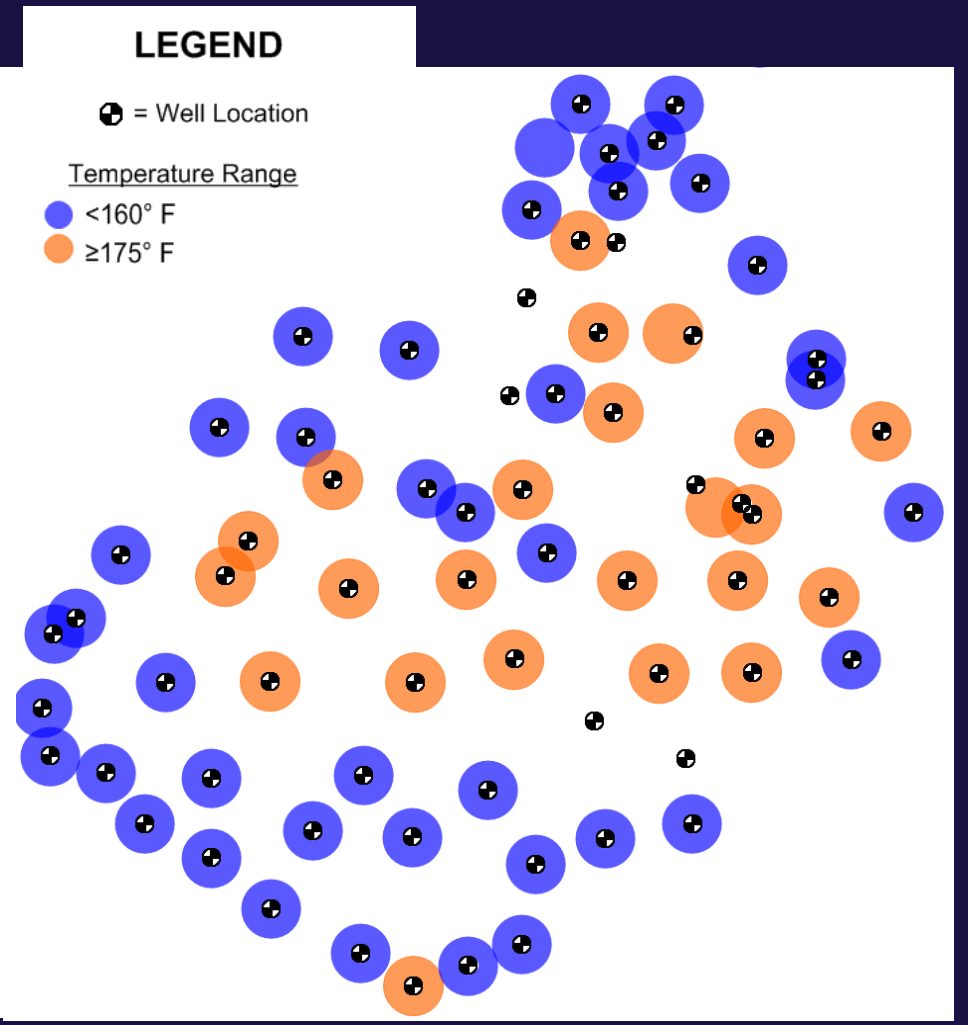


Temperature

Landfill Reaction – Year 4



CH_4/CO_2 Ratio



Temperature

ETLFs – Observations / Challenges

5. Increased Liquid in the Waste

Contributing factors vary from site to site, and may include:

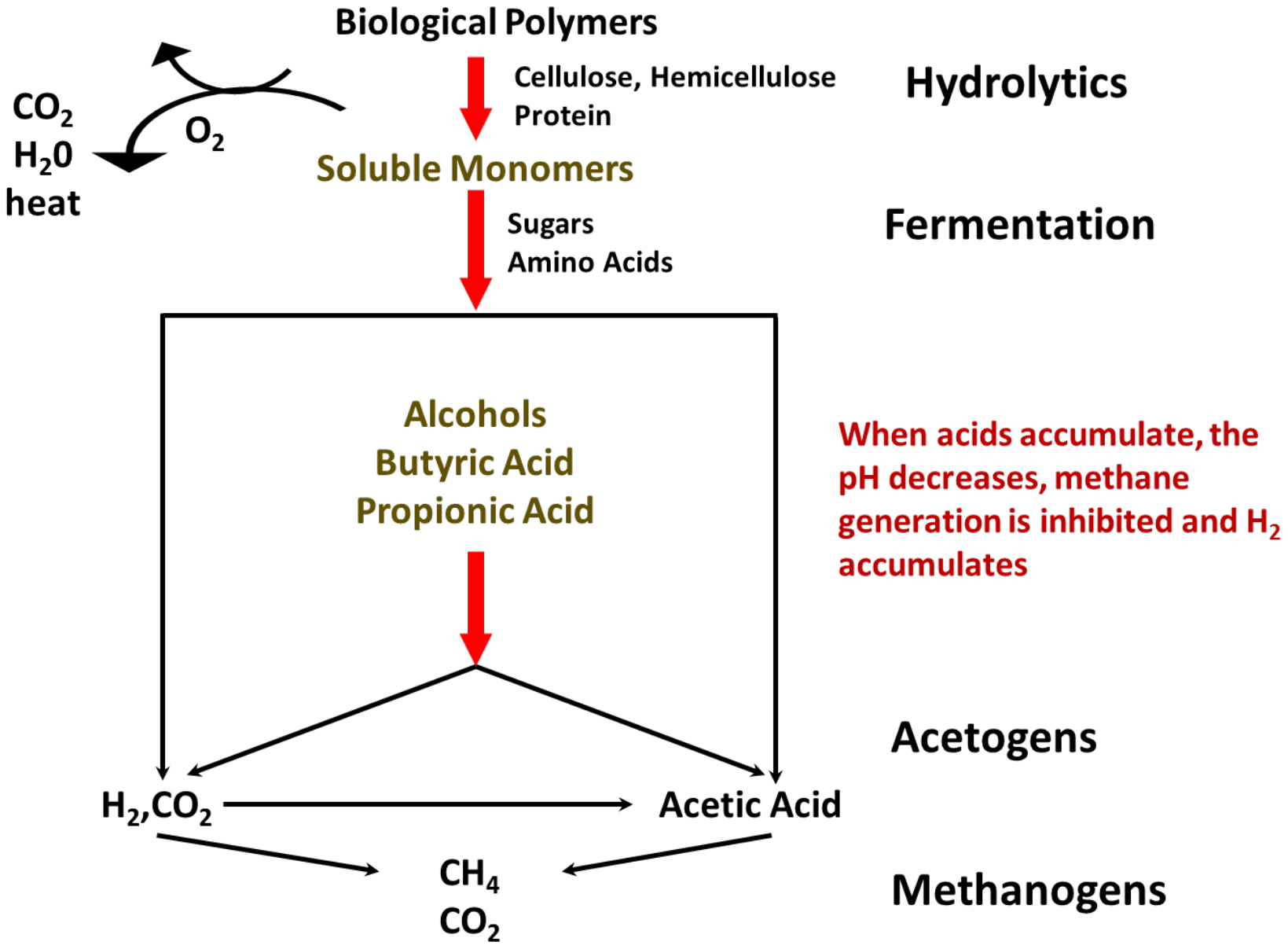
- As solids are converted to gas, the field capacity of the waste decreases (i.e., the ability of the solids to retain liquids decreases)
- Challenges with gas system may decrease removal of moisture
- Challenges with leachate collection system may reduce removal of liquid from the waste
- Increased leachate quantity and strength may require temporary liquid accumulation until suitable treatment/disposal outlets are established

ETLFs – Observations / Challenges

6. Increased Strength of Leachate

- BOD:
  - Normal leachate BOD is 1000 ~ 5000 mg/L
  - In some ETLFs, BOD >100,000 mg/L
- Increases in trace organics, carboxylic acids, salts
- Low pH

MSW Organic Degradation Processes



ETLFs – Observations / Challenges

7. Increased Hydrogen in the Gas

Fermentation:

(Glucose)$C_6H_{12}O_6 + 2H_2O \rightarrow$

2(Acetate)$C_2H_4O_2 + 2CO_2 + 4H_2$

Methanogenesis:

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

ETLFs – Observations / Challenges

7. Increased Hydrogen in the Gas

Fermentation:

(Glucose)$C_6H_{12}O_6 + 2H_2O \rightarrow$

2(Acetate)$C_2H_4O_2 + 2CO_2 + 4H_2$

BUT IF THE METHANOGENSIS STEP IS INHIBITED

Methanogenesis:

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

Common ETLF Characteristics - 1

- Gas temperatures consistently and substantially above 55 ^{o}C (131 ^{o}F) over significant area.
- Temps generally much lower than associated with combustion (250-800 ^{o}C or 500-1500 ^{o}F).
- Gas removal often challenged by wells “watered in” and have very low flow rate.
- Primary gas ratio ($CH_4 \div CO_2$) diminishing or very low.
- Can have elevated CO and H_2 in LFG.
- Frequently deep and wet (but not always).

Common ETLF Characteristics - 2

- Dark, wet, highly degraded waste common (black appearance **≠** combusted). No presence of ash color or texture.
- Leachate with high BOD, COD; elevated BOD: COD ratio, lower pH; high TSS, organics at high concentrations
- Leachate under high pressure and temperature in **some** cases.
- Large, rapid, and sometimes broad subsidence.

- Temperature profiles indicate heat internal, rather than at boundaries.

Summary

- Managing ETLFs is challenging and site-specific.
- Must differentiate between heat from fire or anaerobic subsurface reaction – they are different and require different management strategies.
  - Determine balance gas composition – N_2, H_2, CO
  - If the source of heat is an anaerobic subsurface reaction, then reducing vacuum at gas wells may not be the correct response action
- Response Action Plans must be flexible to account for unique site conditions that will likely change with time.

Thank You

Bryan Staley, PhD, PE
bstaley@erefdn.org
www.erefdn.org

EREF

Environmental Research & Education Foundation

Lighting a path to sustainable waste management practices