



*Idaho National Engineering and Environmental Laboratory*

# ***Landfill Gas Interactions with ET Covers***

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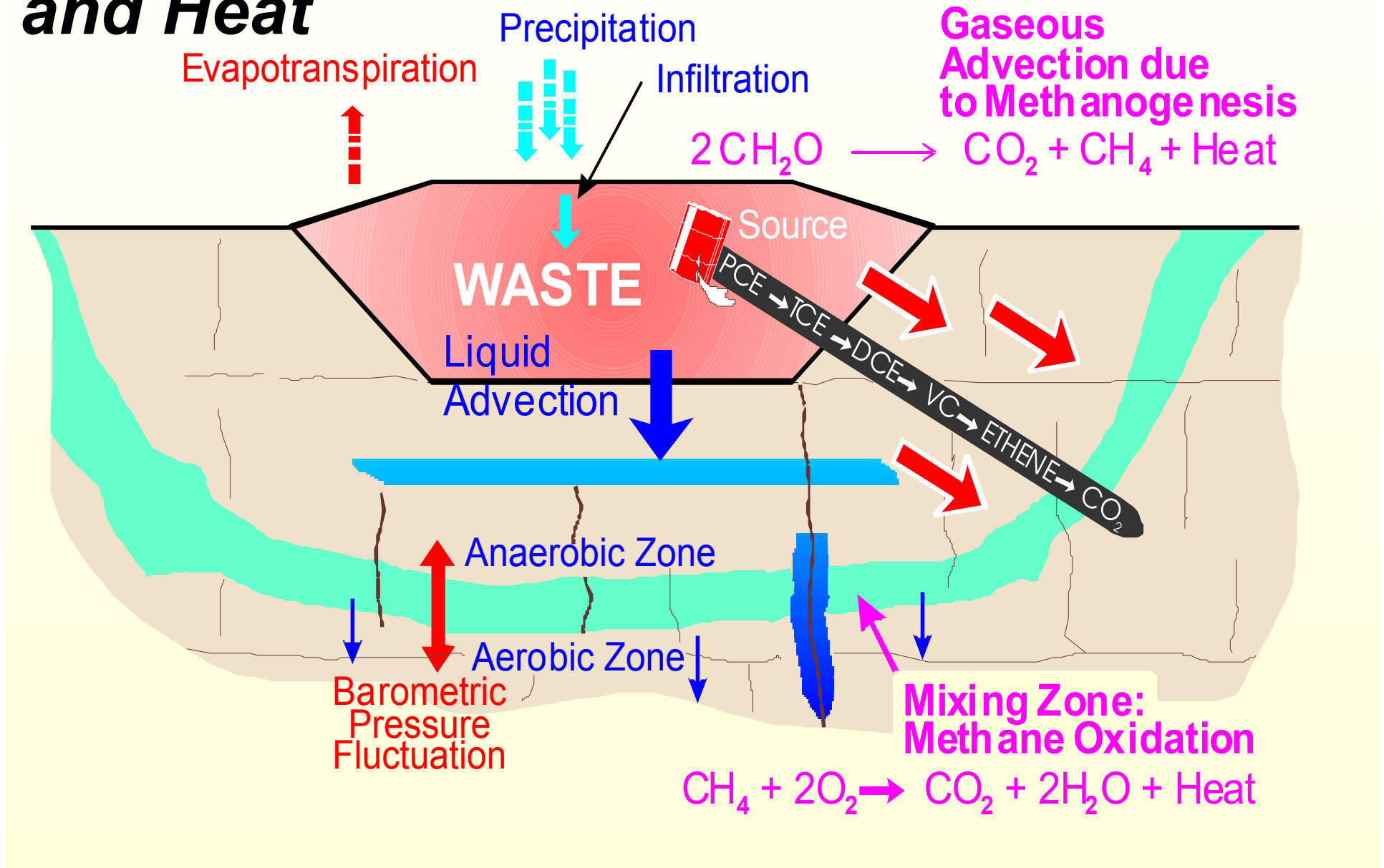
***Mark Ankeny, Ph.D.***

*March 10, 2004*

# ***Outline***

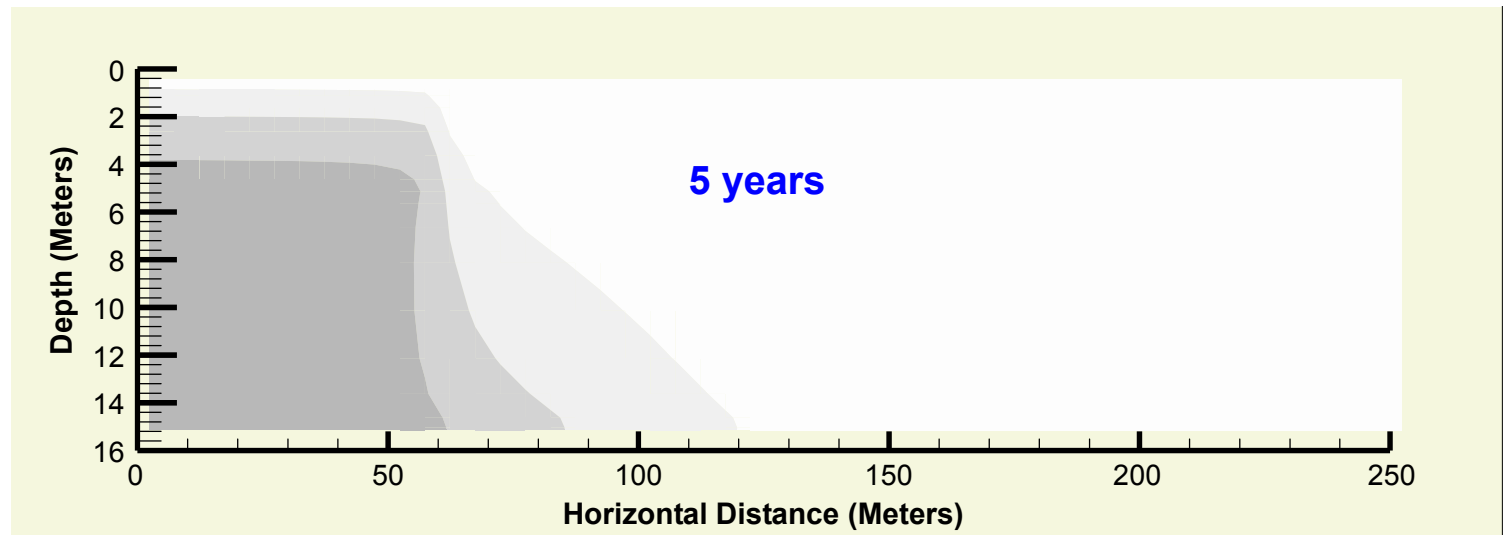
- *Landfill gas effects on plants*
- *Barometric pressure effects on landfill covers*
- *Methane oxidation effects on cover system:*
- *Soil gas/soil physics dynamics in a Texas landfill cover*
- *NM, CO landfill gas/vegetation data & modeling*

# Landfills Generate a lot of Water, Gases and Heat

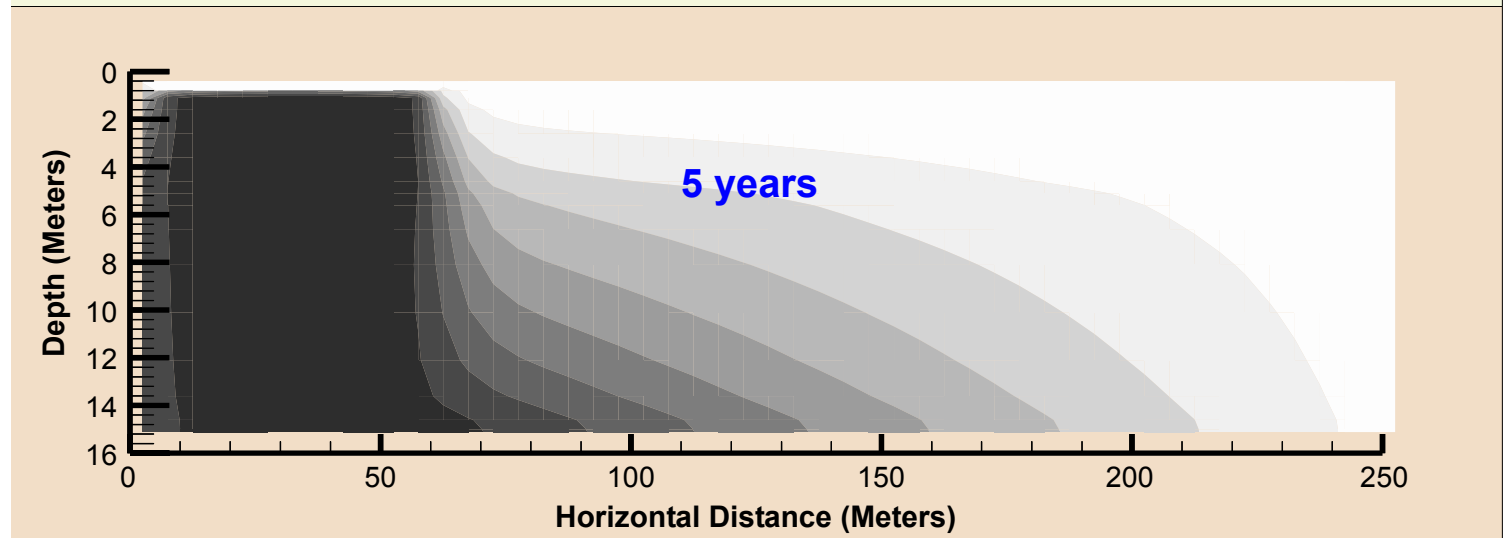


# Landfill Cover Gas Movement: Up and Down

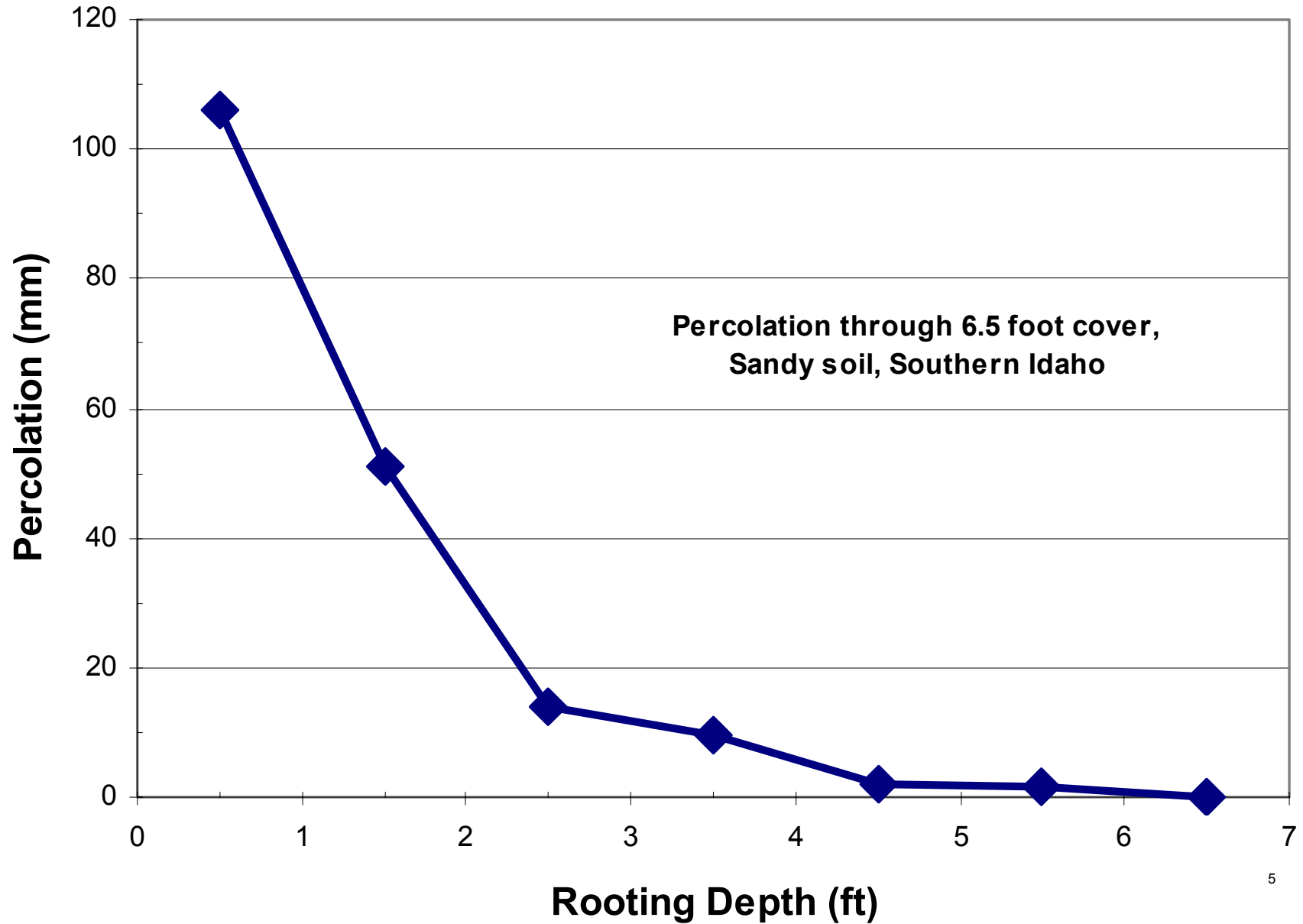
**High K  
Cover**



**Low K  
Cover**



# *The Problem: Percolation as a Function of Rooting Depth*



# ***Native Site: Gramma Grass, TX***



# ***Native Site: Dry to 8 feet +***



# ***Native Soil Profile***





# ***Engineered Cover: ~ 95% Proctor***



***Engineered Cover . No roots  
below two feet. Anaerobic***



# ***Soil Cover: ~90% Proctor***



***Soil Cover. ~90% Proctor. Aerobic. 'Dry'.***



# Methane Generation and Oxidation

$$0.4 \text{ Mg/ m}^3 * \frac{170 \text{ m}^3 \text{ methane}}{1 \text{ Mg waste}} * 8\text{m} = 544 \text{ m}^3 \text{ methane/ m}^2 \text{ of landfill surface}$$

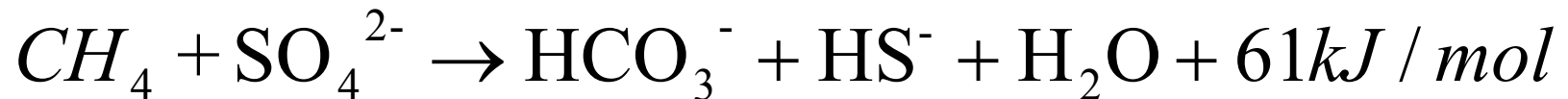
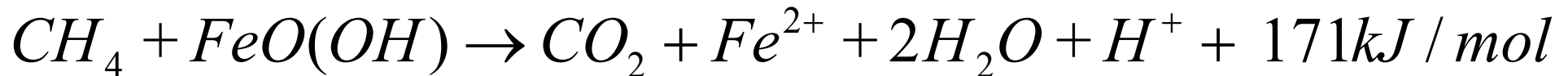
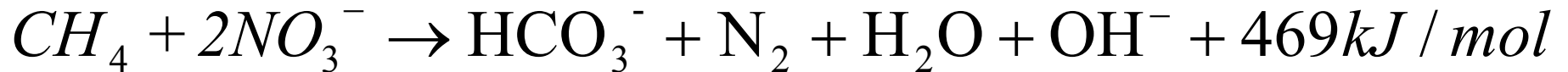
An equal volume of CO<sub>2</sub> also will be generated

$$544 \text{ m}^3 \text{ CH}_4 * \frac{1 \text{ mol}}{0.0224 \text{ m}^3 / \text{mol}} * 1 \text{ m}^2 * \frac{36 \text{ g H}_2\text{O}}{1 \text{ mol CH}_4} * \frac{1 \text{ kg}}{1000 \text{ g}} * \frac{0.001 \text{ m}^3}{1 \text{ kg}} = \frac{0.874 \text{ m}^3 \text{ water}}{1 \text{ m}^2 \text{ landfill surface}}$$

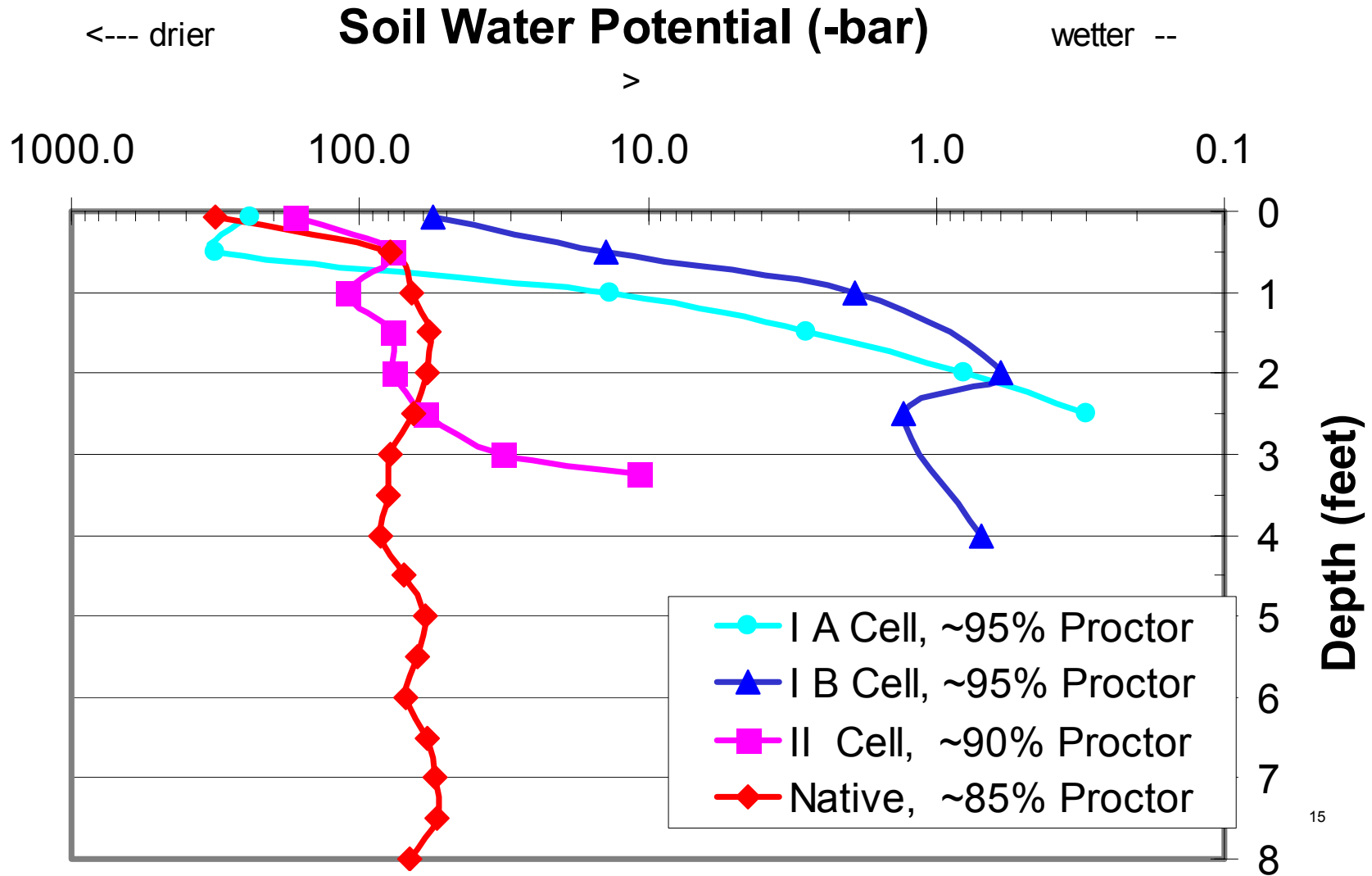
**88 cm of new water in the profile**

And loss of water holding capacity

## ***Methane Oxidation Can Create Water, Contaminants and Heat***



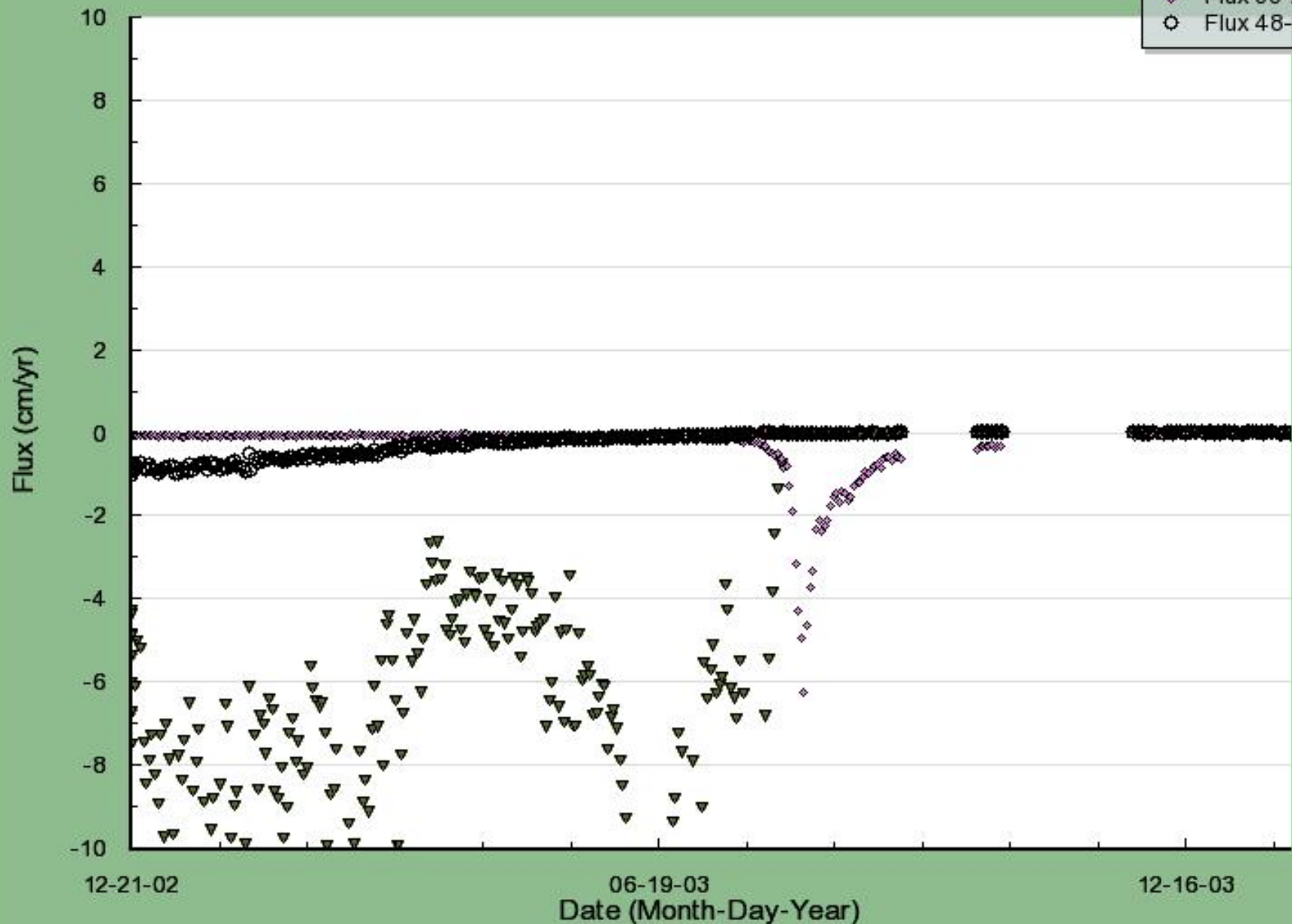
# More Compaction, Less Oxygen, Increased Percolation: TX



# TEXAS LANDFILL SENSOR DATA

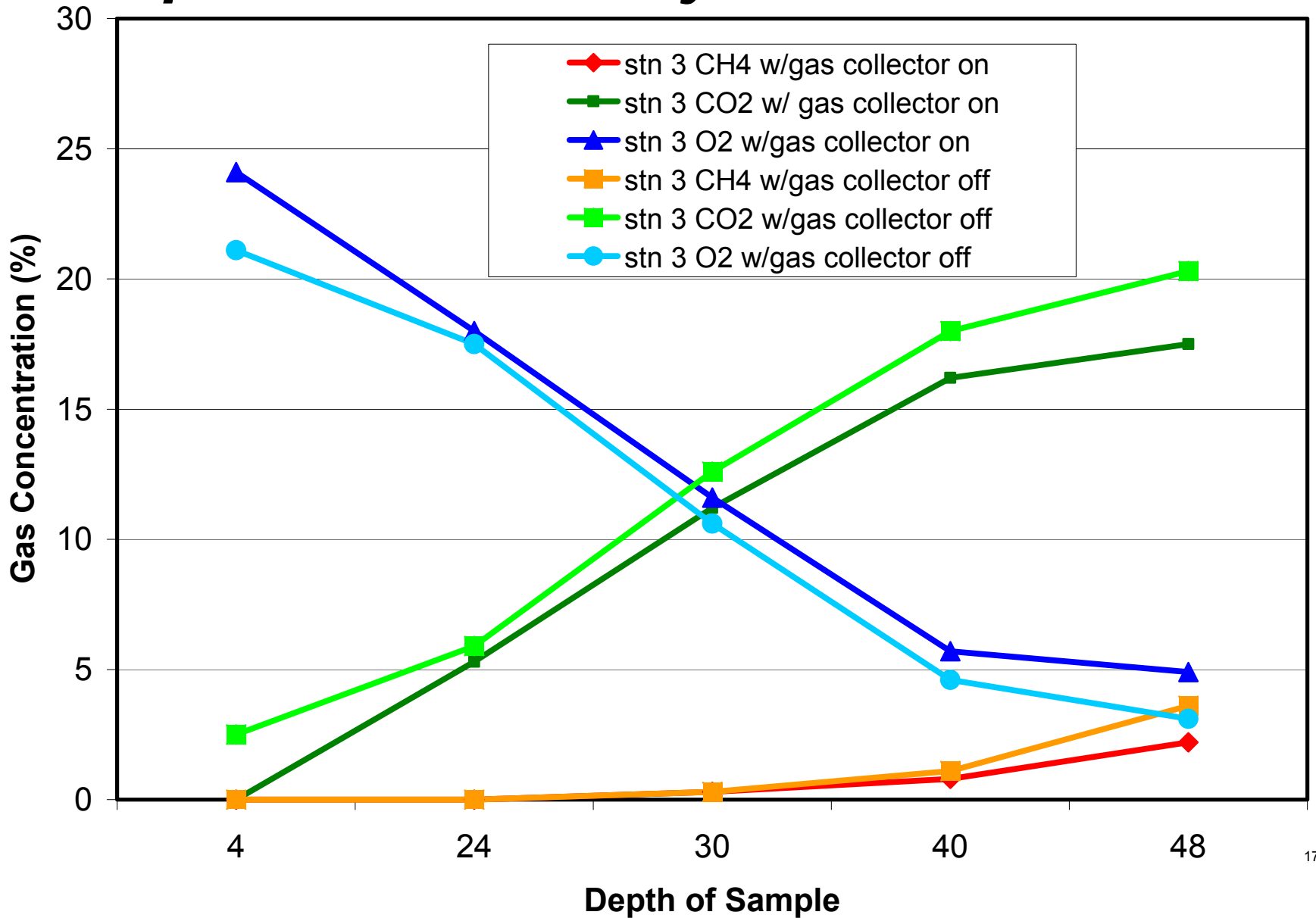
DEC 21 2002 - JAN 21 2004

- ▲ Flux 12-8 inches
- ▼ Flux 24-12 inches
- ◇ Flux 30-24 inches
- Flux 48-30 inches

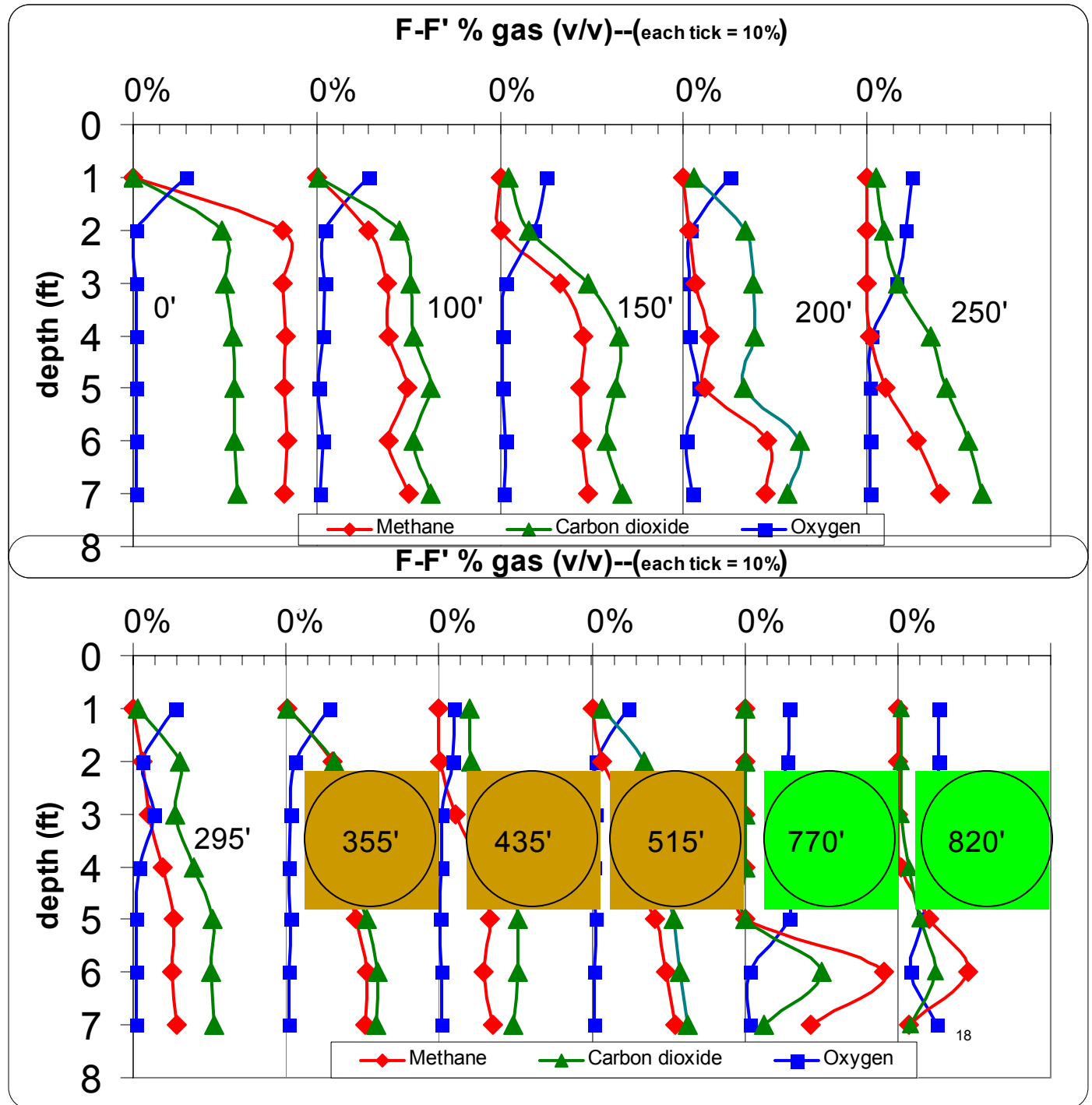




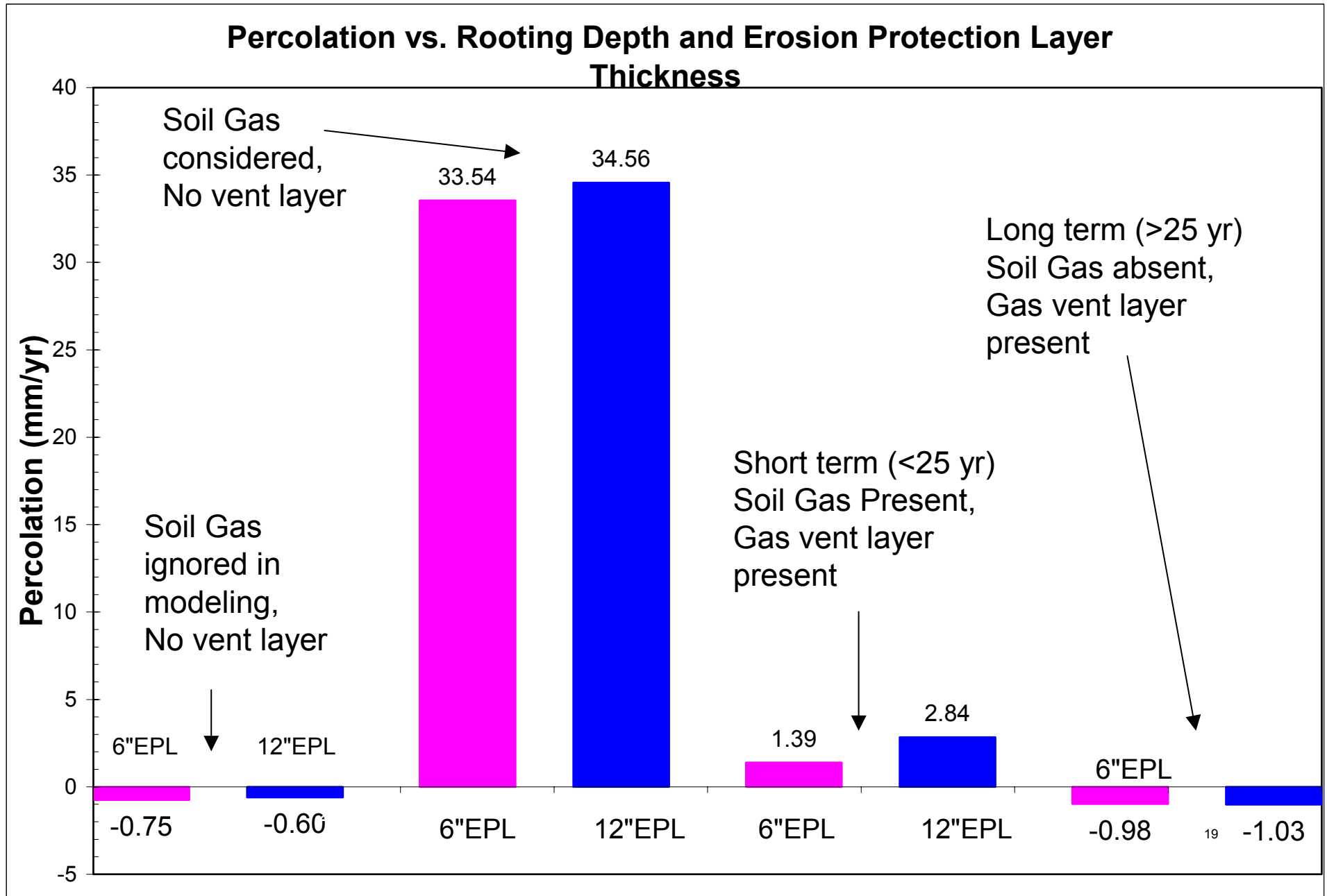
# *Oxygen decreases rapidly with depth over relatively new waste*



# Landfill Gases Can Shut Down Plants: CO

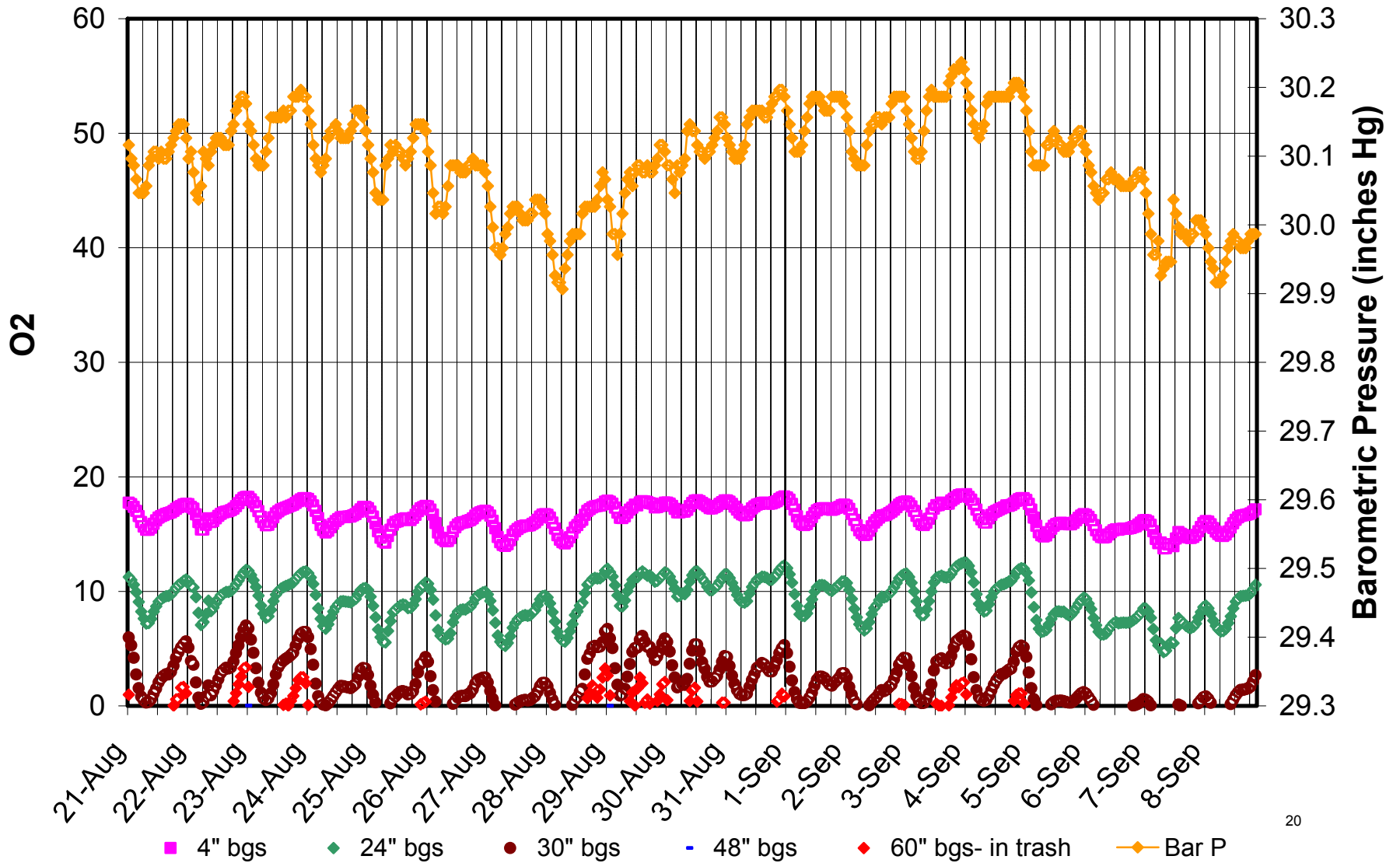


# Percolation as Affected by Gas: CO

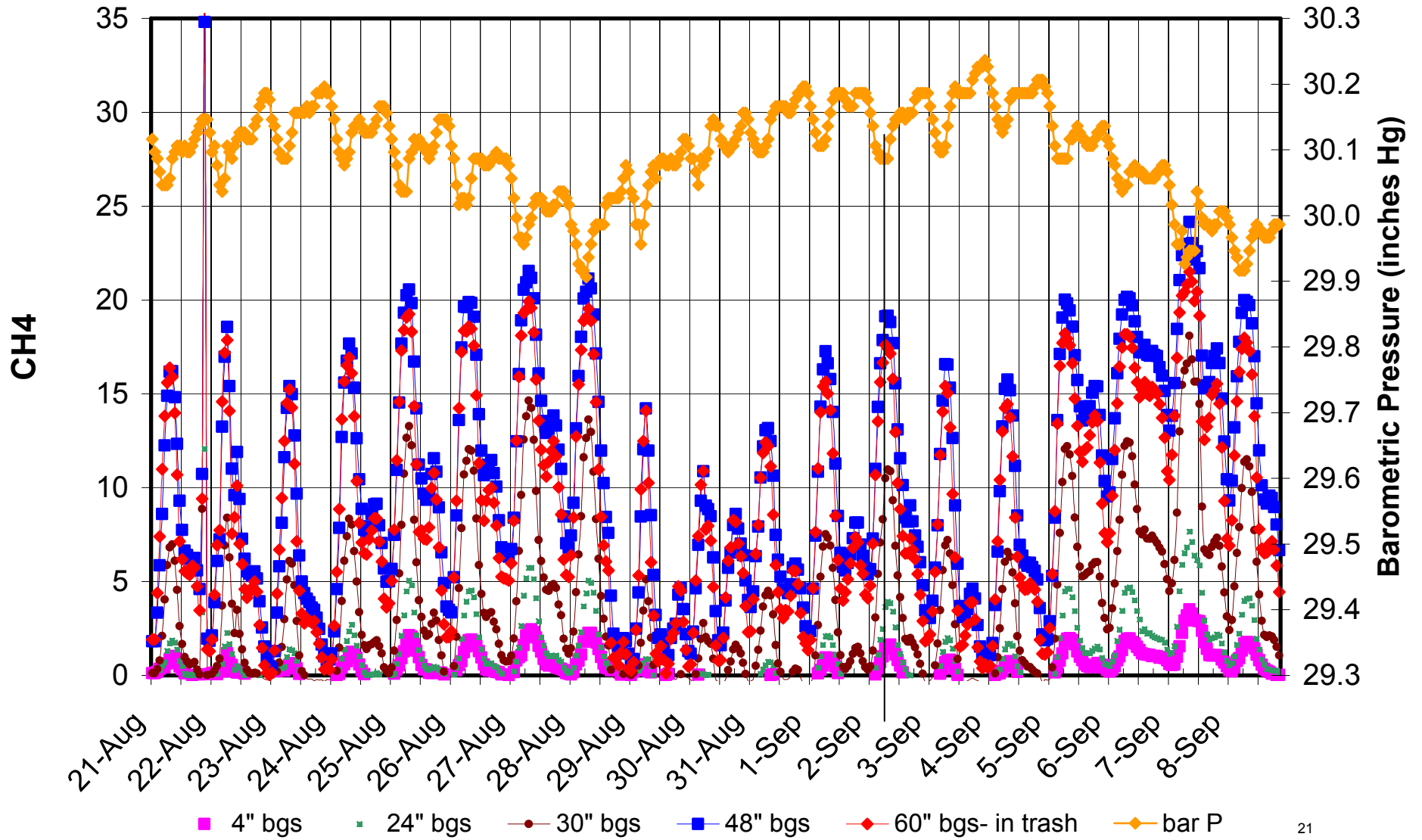


# Redox Conditions are a function of both Depth and Time

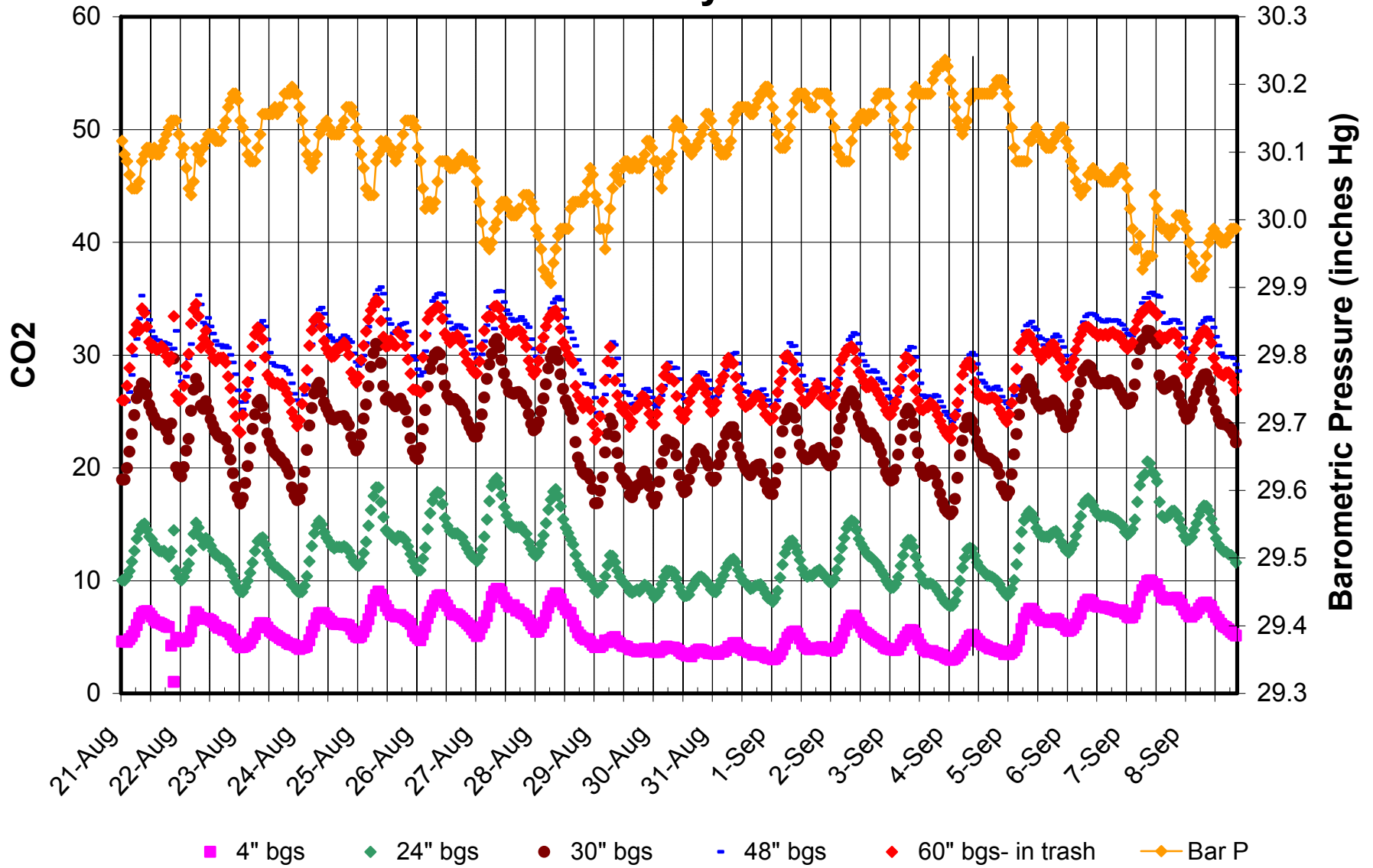
## O2 Percentage by Volume



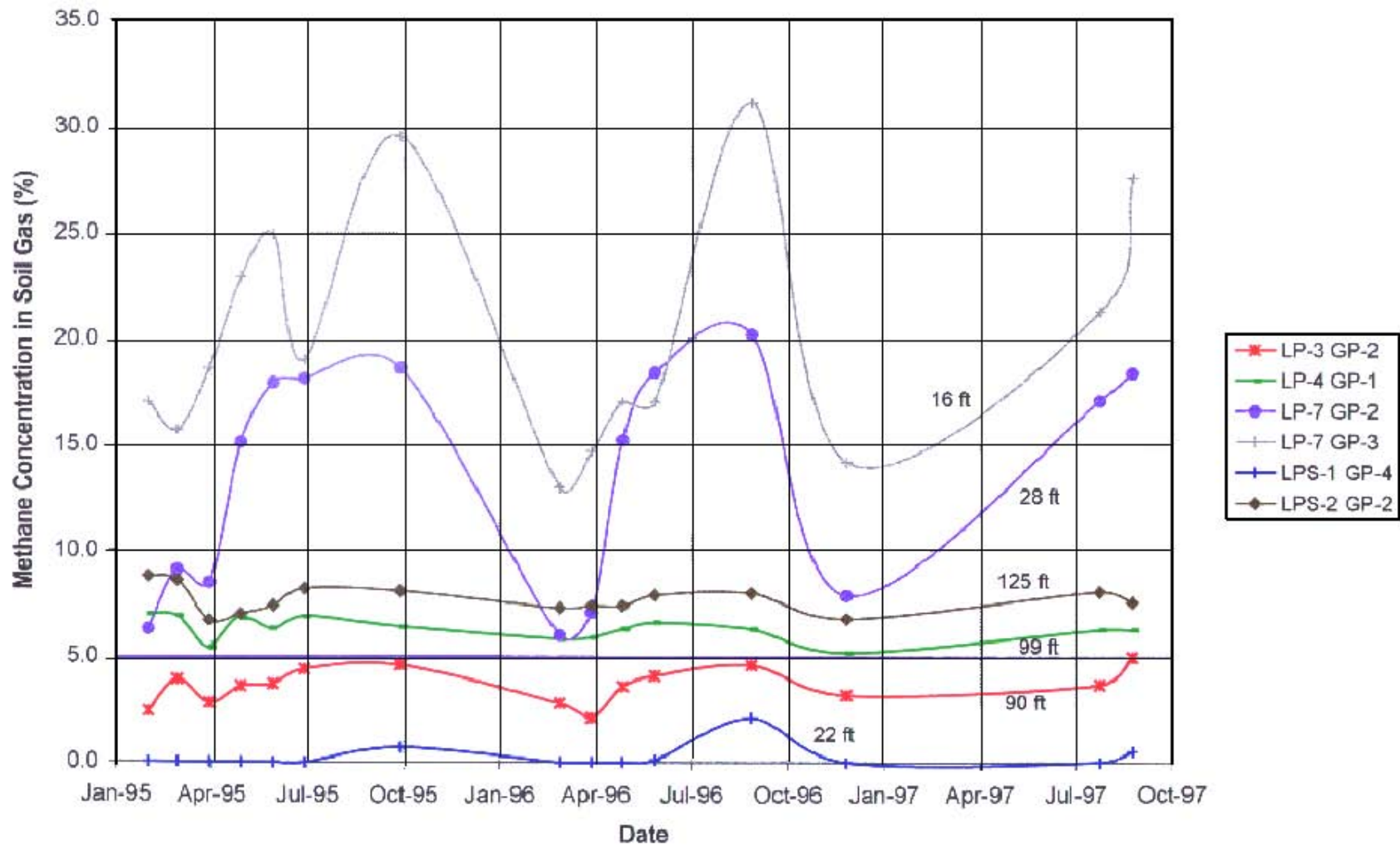
# CH4 Percentage by Volume



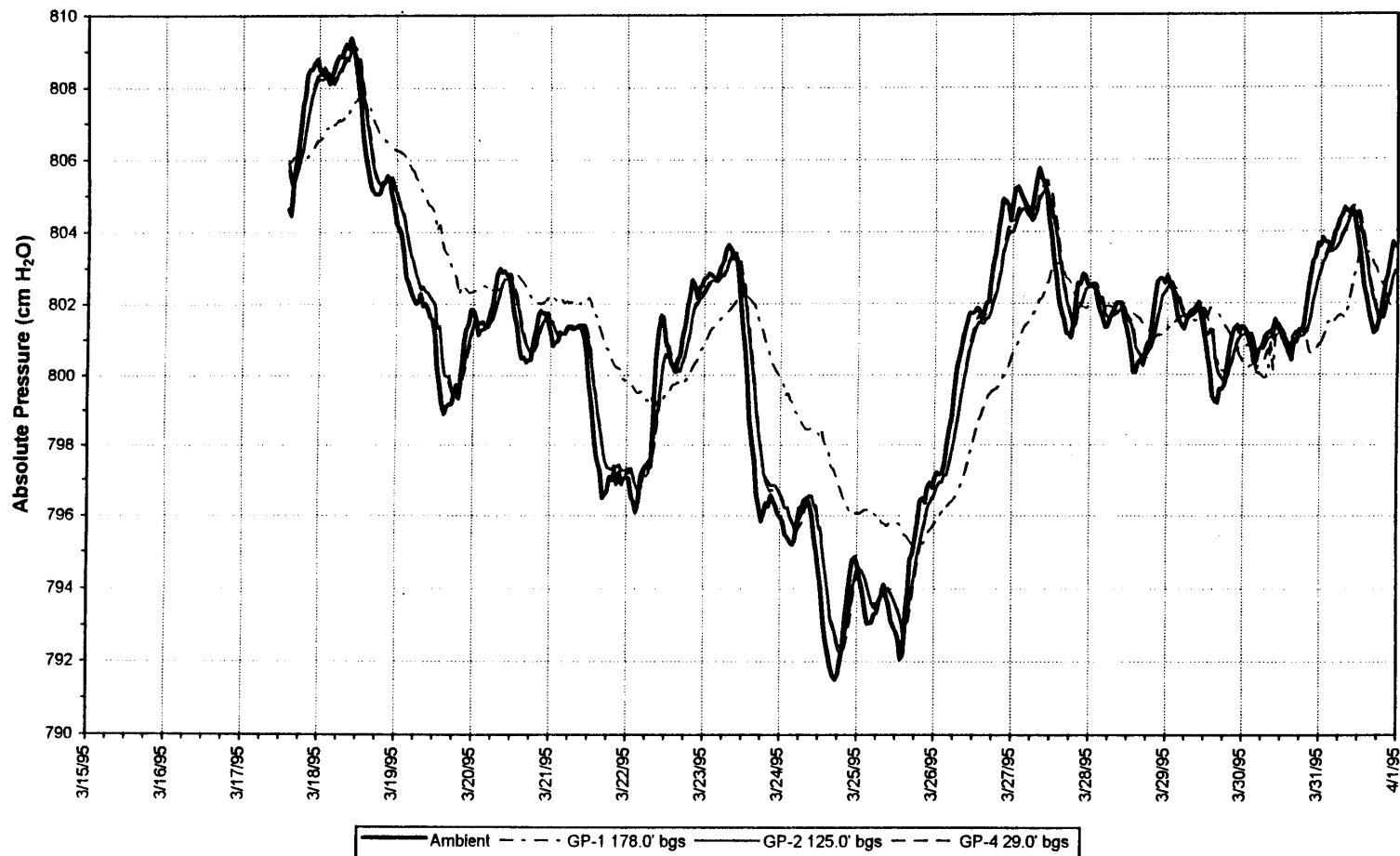
# CO2 % by volume



# Seasonal Changes in Gas Profiles are Common



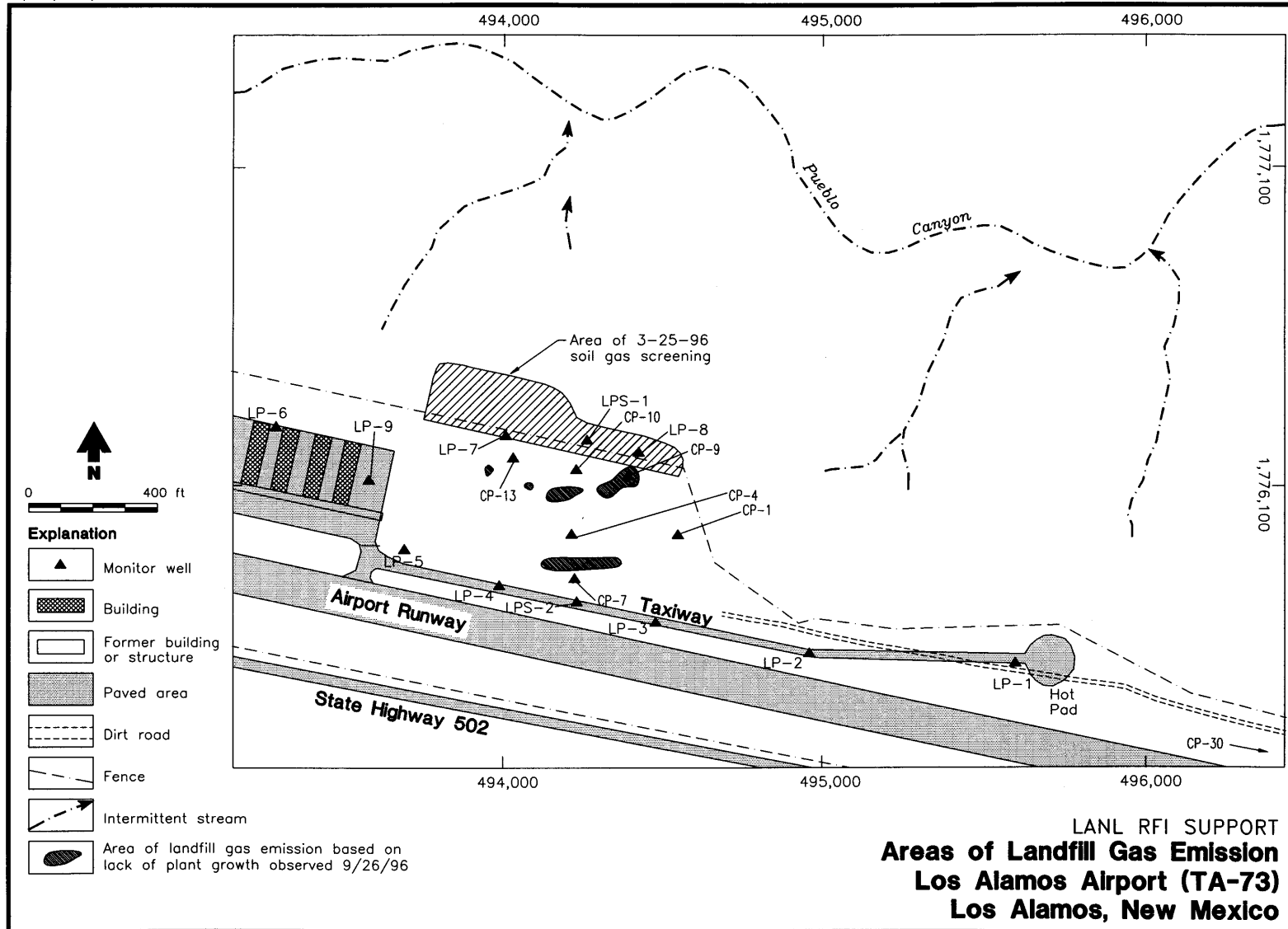
# Barometric Pressure Patterns Vary Over Time





# Areas of Landfill Gas Emission at Los Alamos Airport (TA-73)

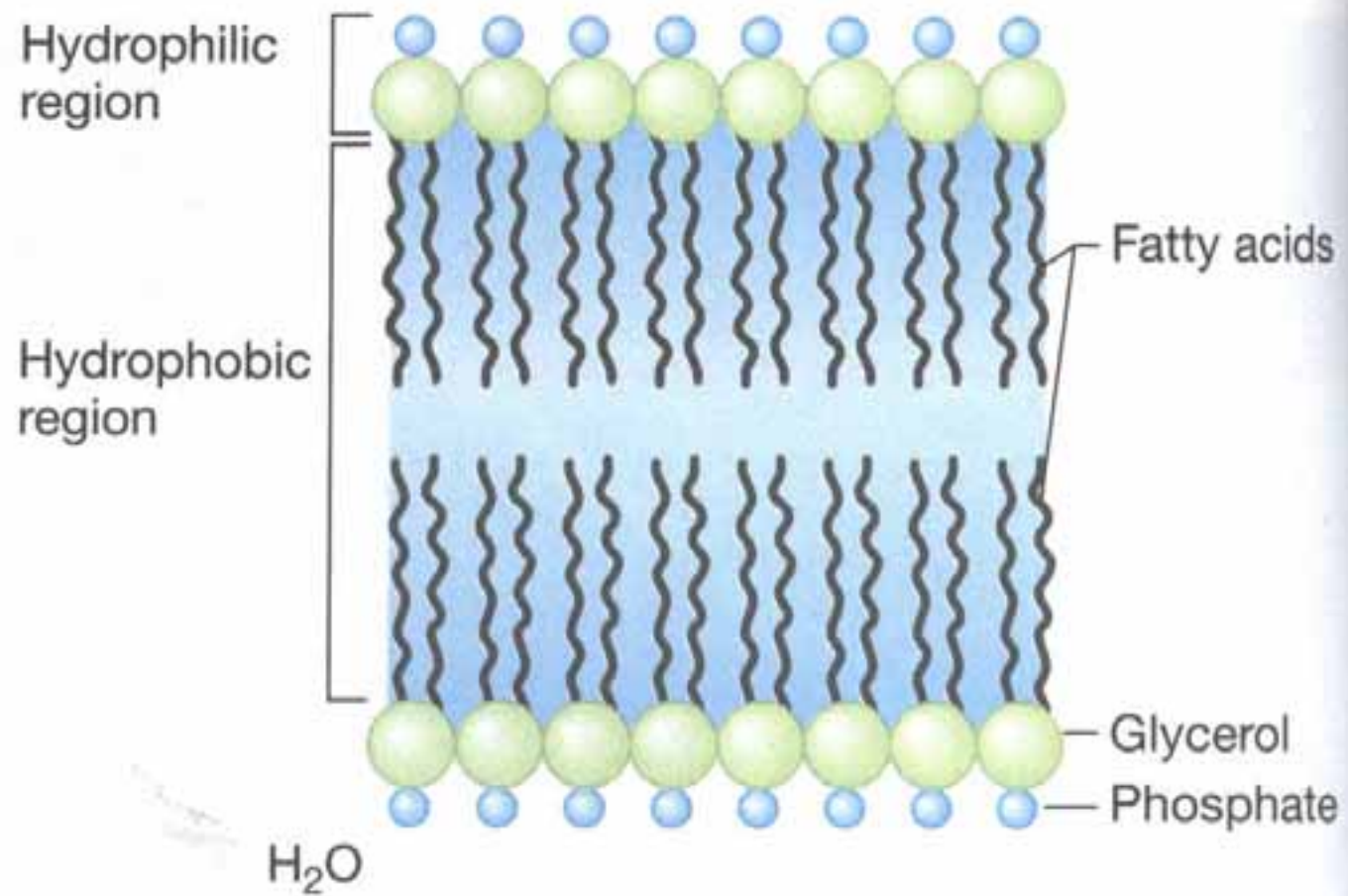
T:\VDR\8032\803237T.DWG



# ***Phospholipids***

- *Essential components of every living cell and are useful biomarkers because:*
  - *they have great structural diversity with high biological specificity.*
- *Used as a proxy for microbial biomass*
  - *Phospholipids are quickly consumed when an organism dies*
  - *Not found in storage products*
  - *Make up a relatively constant proportion of the biomass*

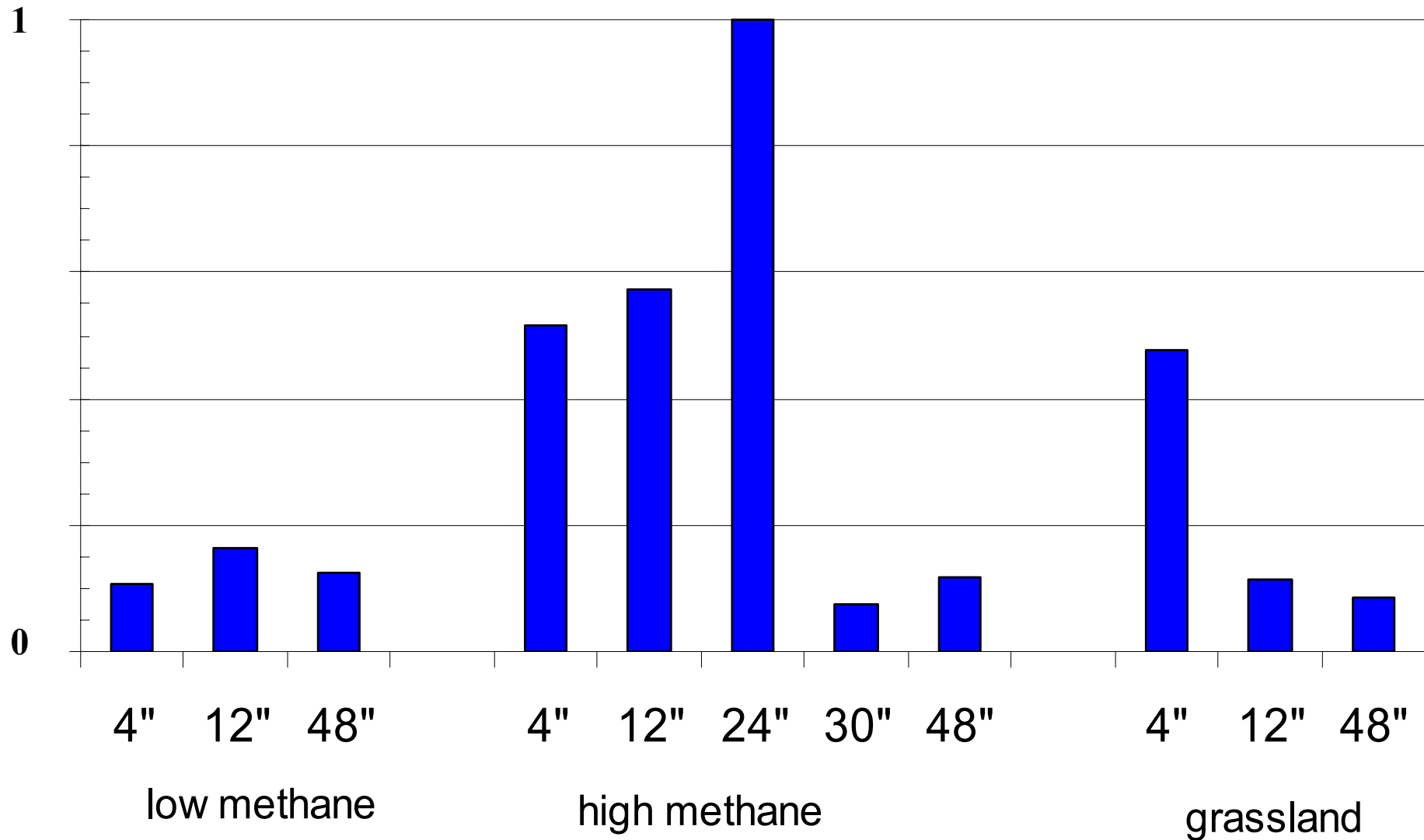
# ***Structure of the lipid bi-layer***

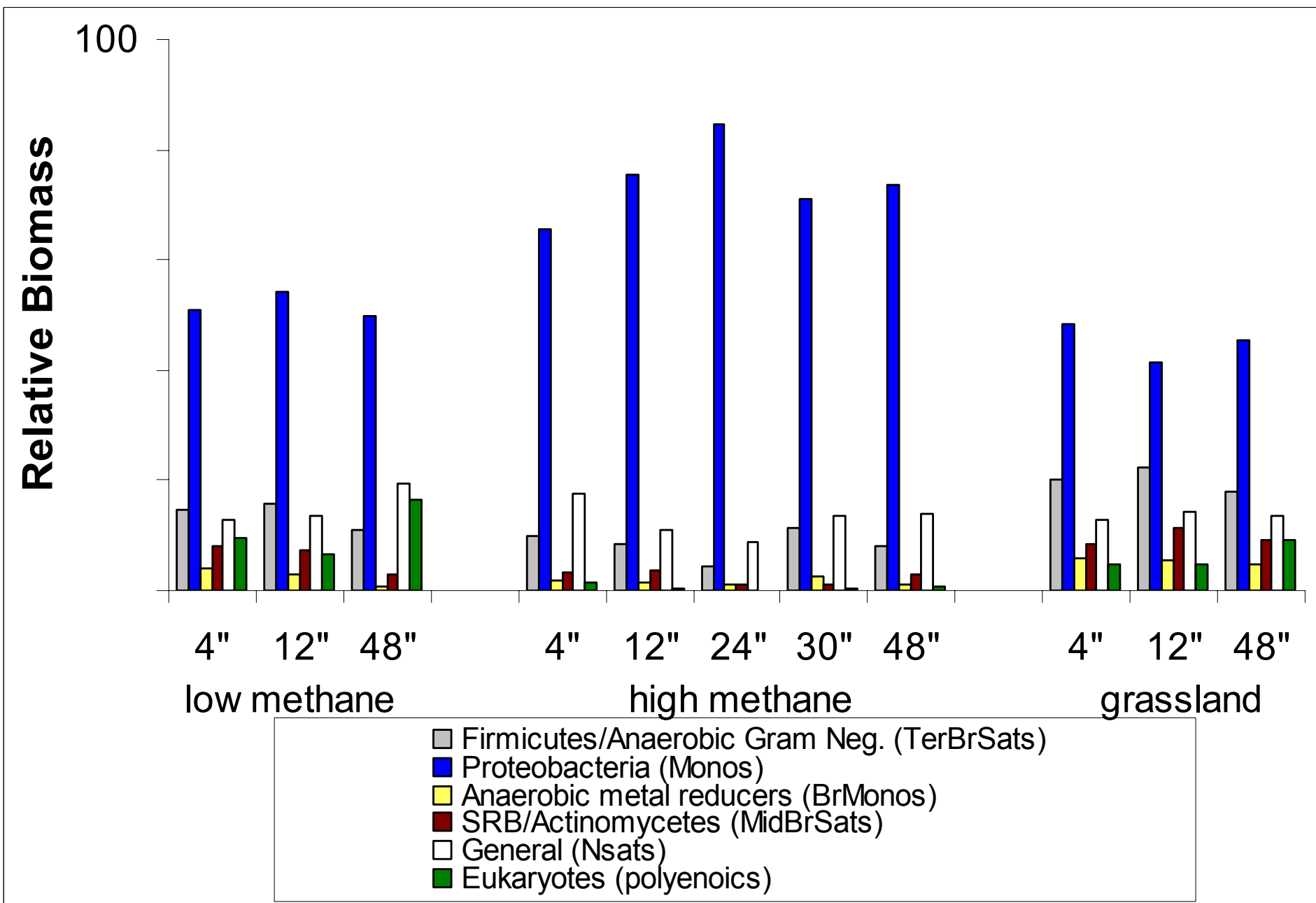


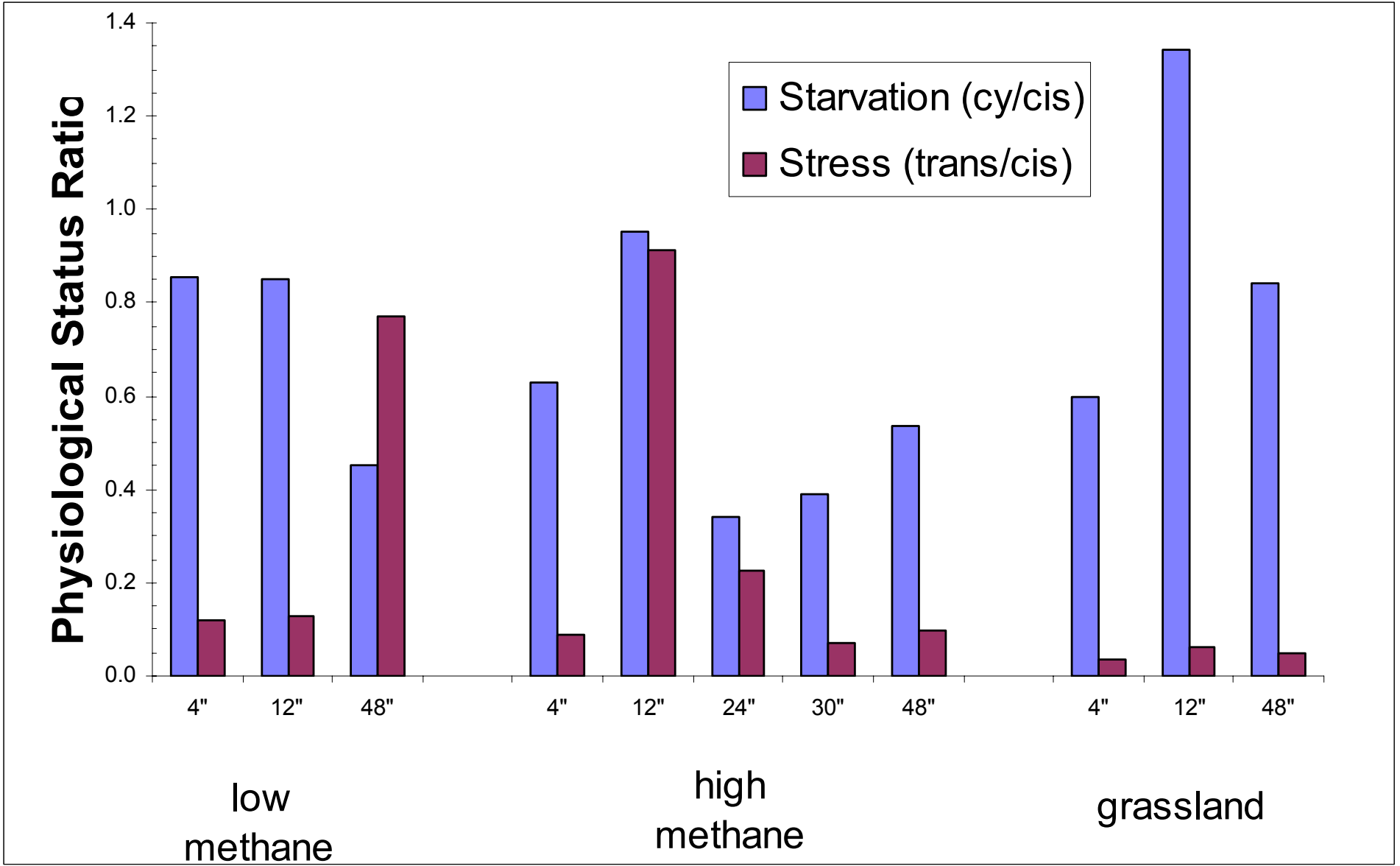
# Interpretation

<b>Fatty Acid</b>	<b>Microbial Group</b>
15:0i, 17:0i, 15:0a, etc..	Gram positive bacteria
cy17:0, cy19:0, 18:1 $\Delta$ 11c	Gram negative bacteria (also cy19:0 gm+)
10 Me18:0, 10 Me17:0, 10 Me16:0	Actinomycetes
18:2 $\omega$ 6,9, 18:1 $\omega$ 9c	Fungi
20:4 $\omega$ 6	Protozoan
16:1 $\omega$ 5	Arbuscular mycorrhizal fungi
18:1 $\omega$ 8c	Methanotrophs

# *Relative Biomass*







# *Summary*

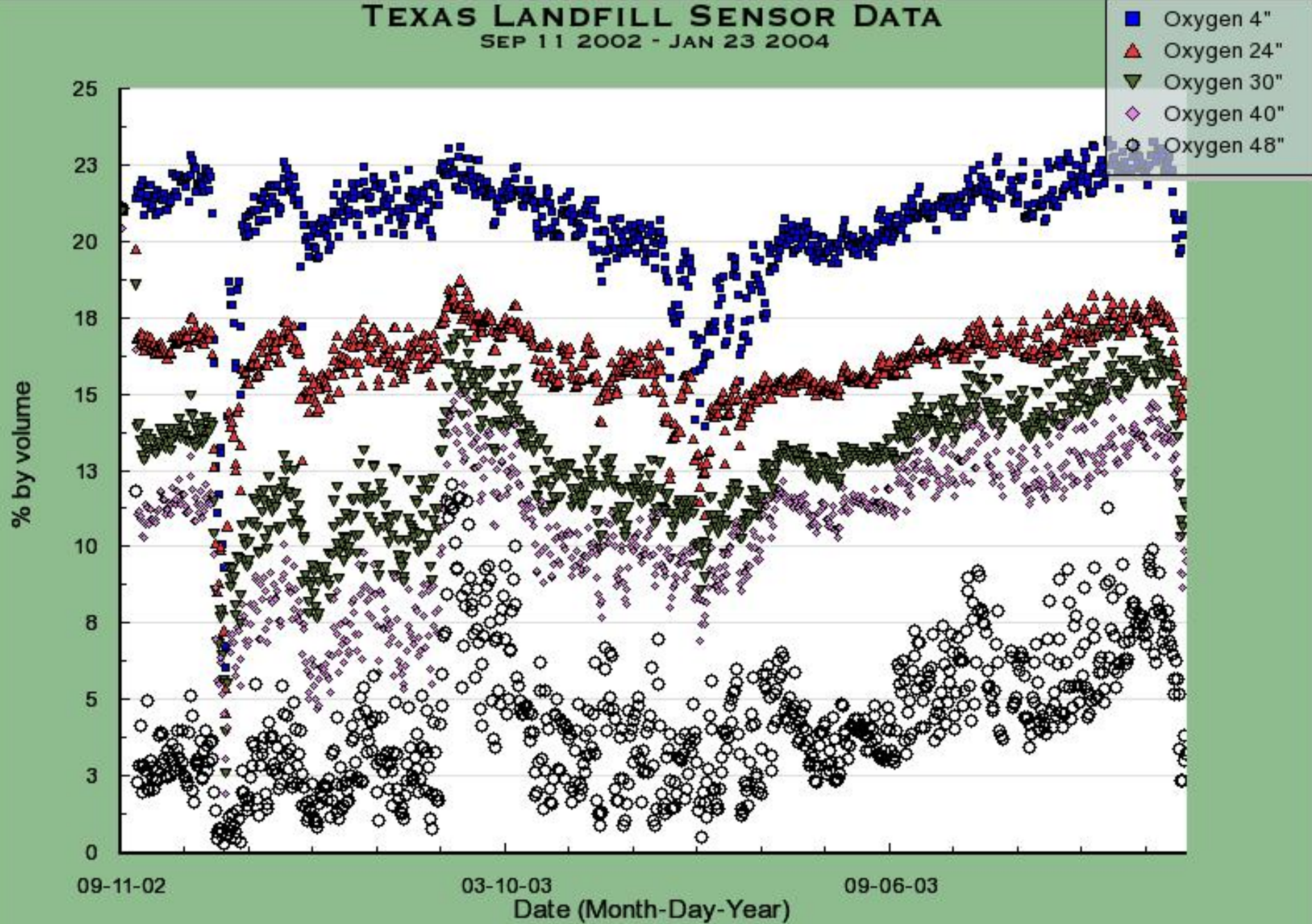
- *Covers and waste interact.*
- *Joint presence of methane and oxygen can result in methane oxidation, water production, and total biomass increases*
- *The interaction can reduce both total vegetation, root mass, and rooting depth.*
- *Reduced transpiration from decreased surface vegetation, reduced root penetration, and water formation in the cover are not likely to improve performance*



***No Oxygen, No  
Roots, No T in ET***

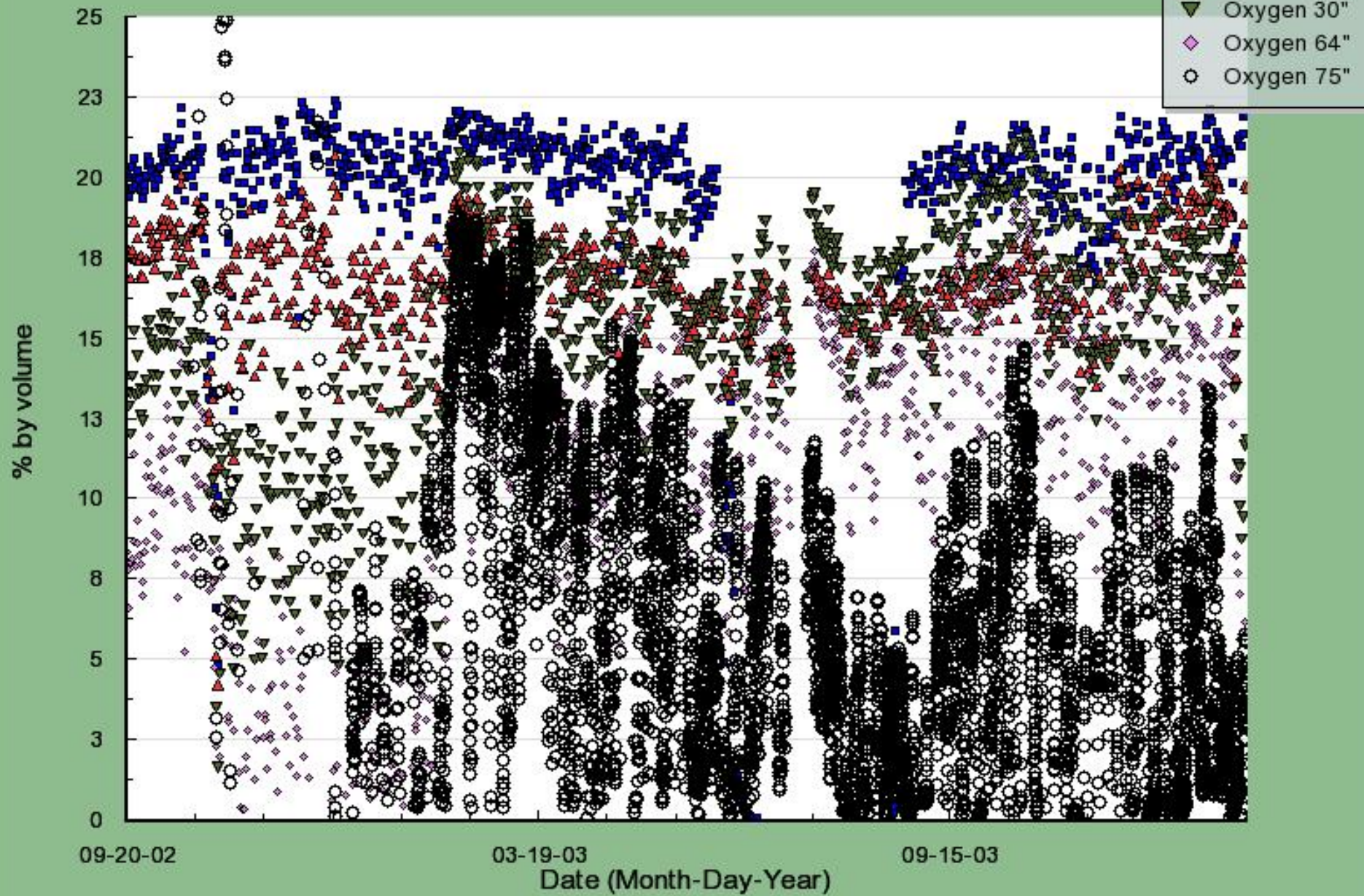
# TEXAS LANDFILL SENSOR DATA

SEP 11 2002 - JAN 23 2004



# TEXAS LANDFILL SENSOR DATA

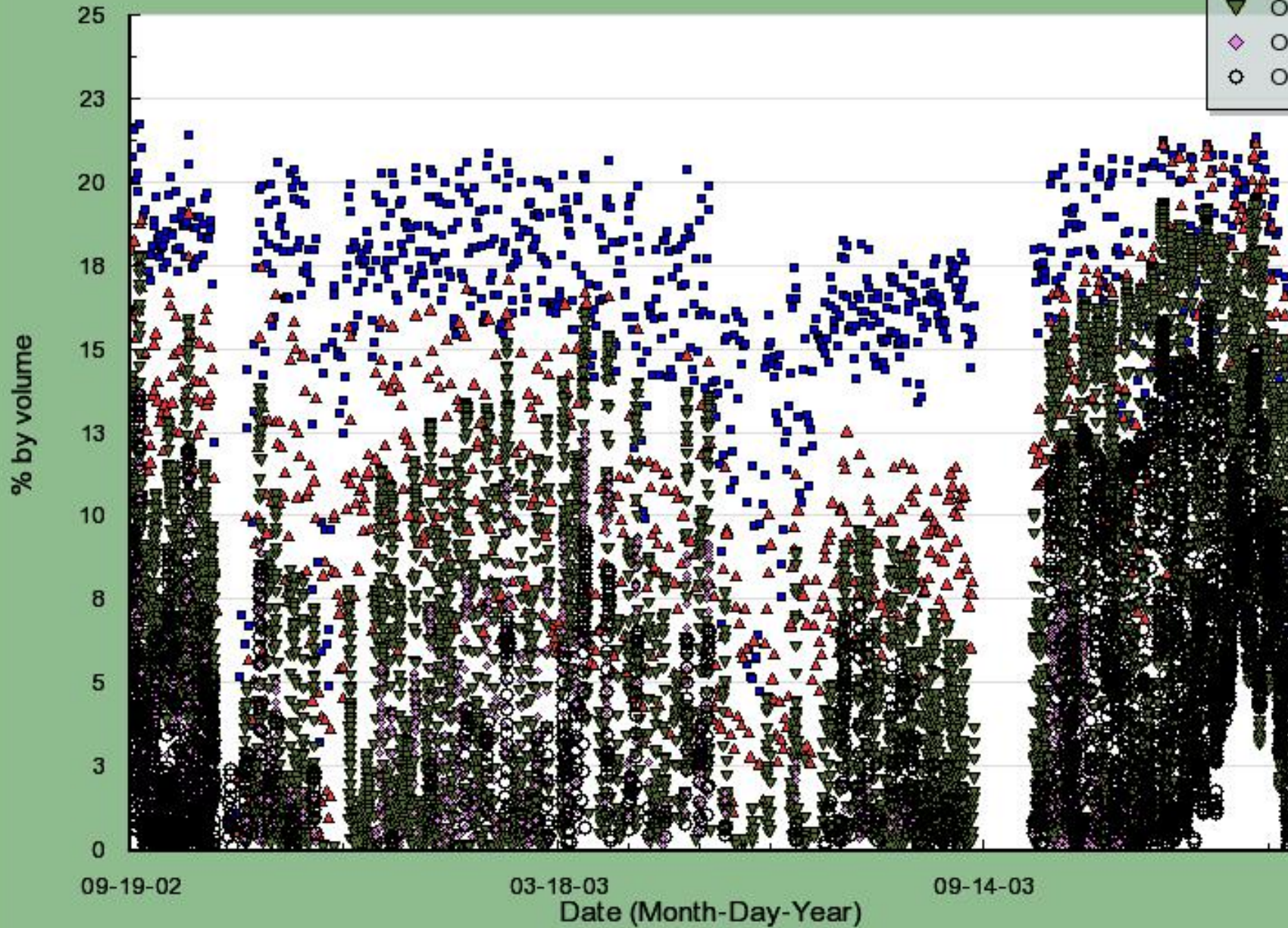
SEP 20 2002 - JAN 23 2004



# TEXAS LANDFILL SENSOR DATA

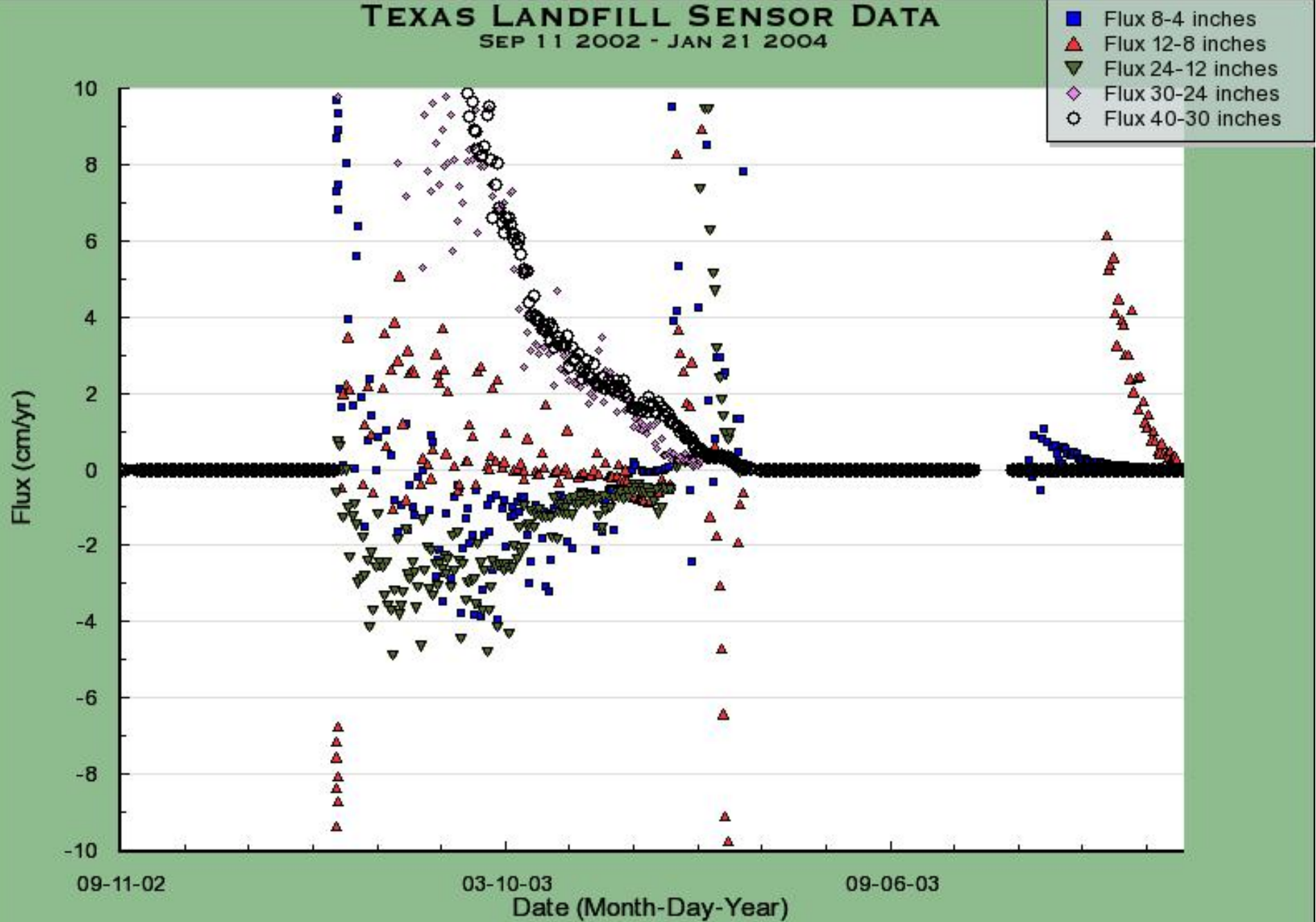
SEP 19 2002 - JAN 23 2004

- Oxygen 4"
- ▲ Oxygen 24"
- ▼ Oxygen 30"
- ◆ Oxygen 48"
- Oxygen 60"



# TEXAS LANDFILL SENSOR DATA

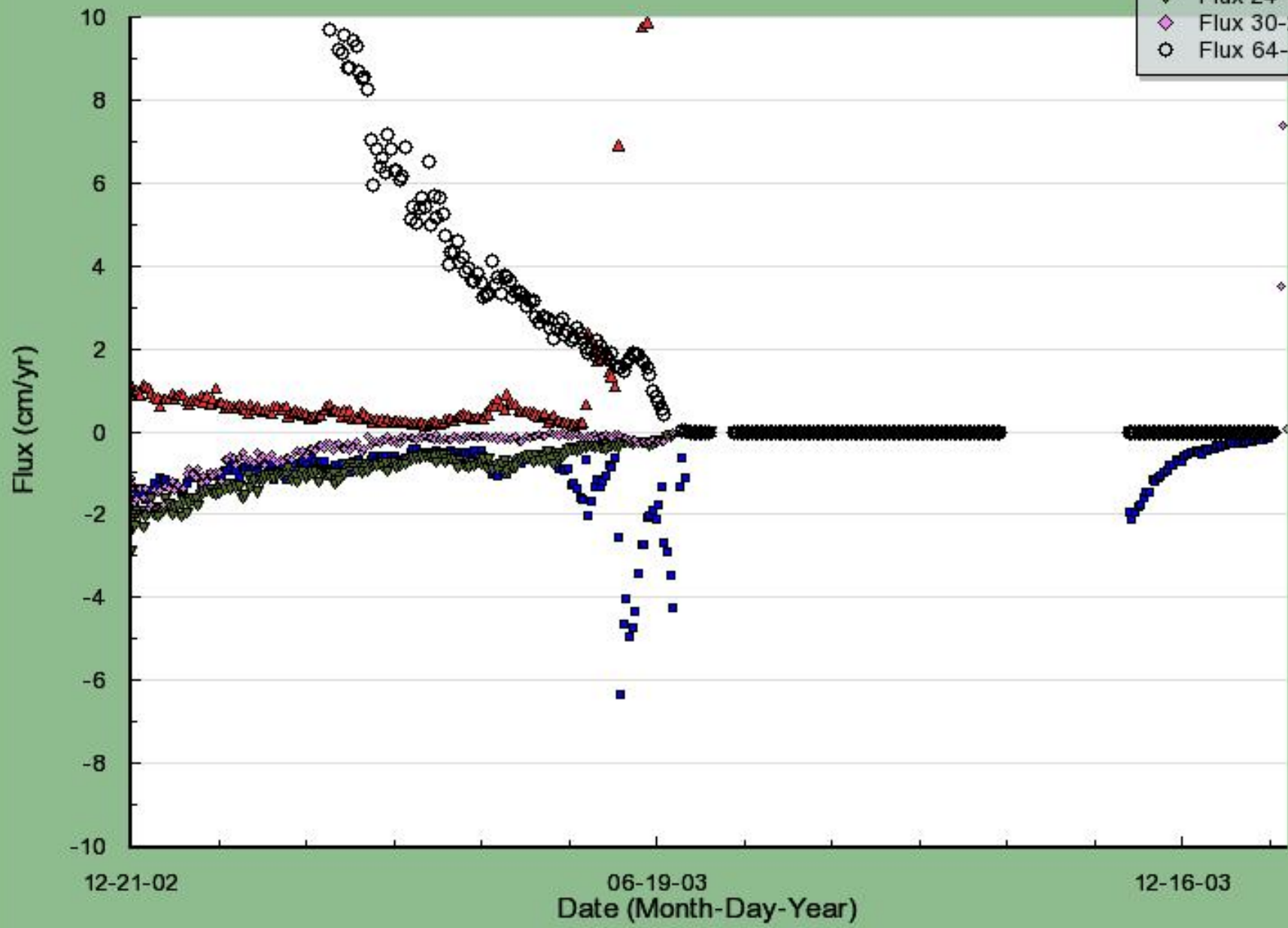
SEP 11 2002 - JAN 21 2004



# TEXAS LANDFILL SENSOR DATA

DEC 21 2002 - JAN 21 2004

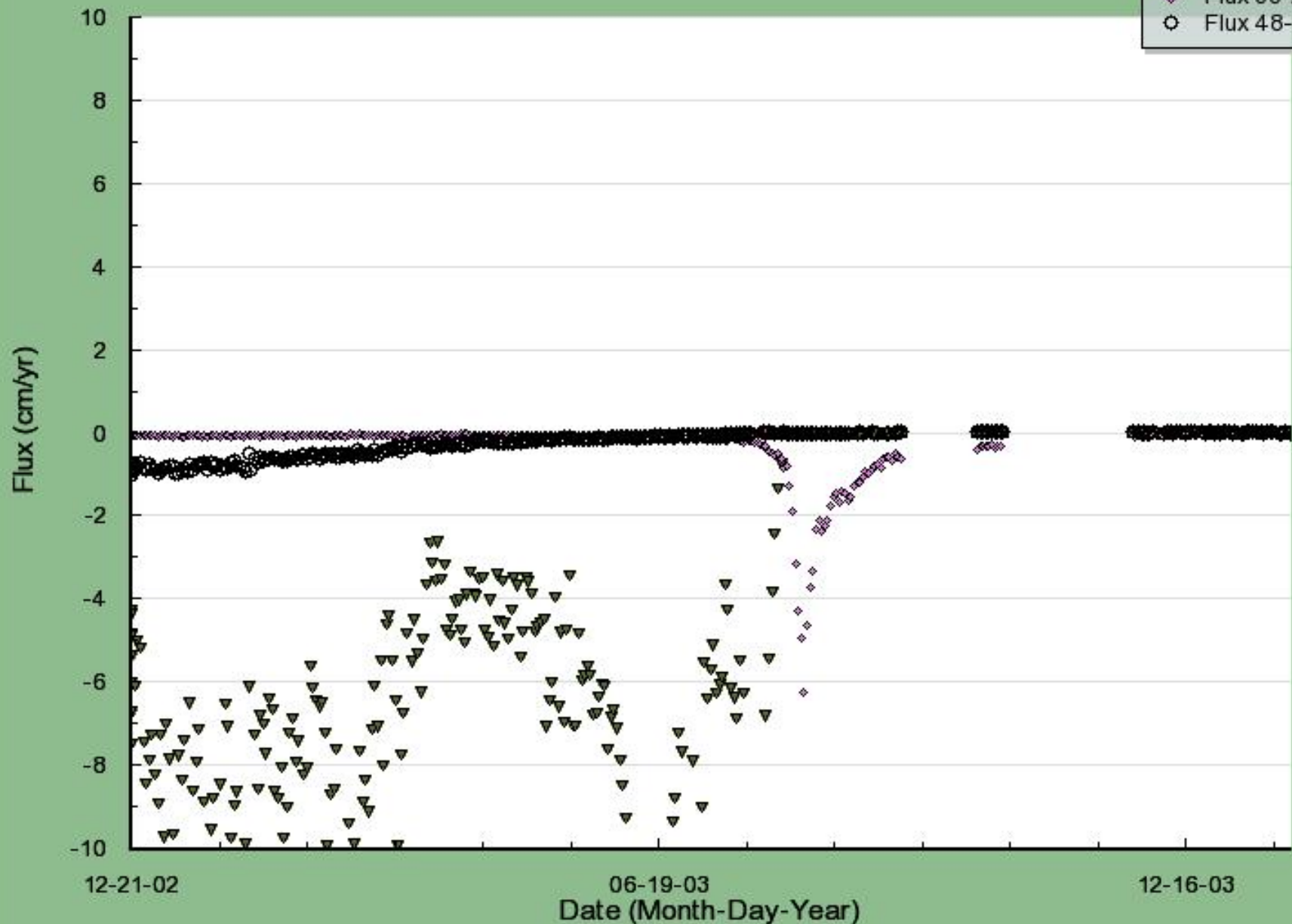
- Flux 8-4 inches
- ▲ Flux 12-8 inches
- ▼ Flux 24-12 inches
- ◆ Flux 30-24 inches
- Flux 64-30 inches



# TEXAS LANDFILL SENSOR DATA

DEC 21 2002 - JAN 21 2004

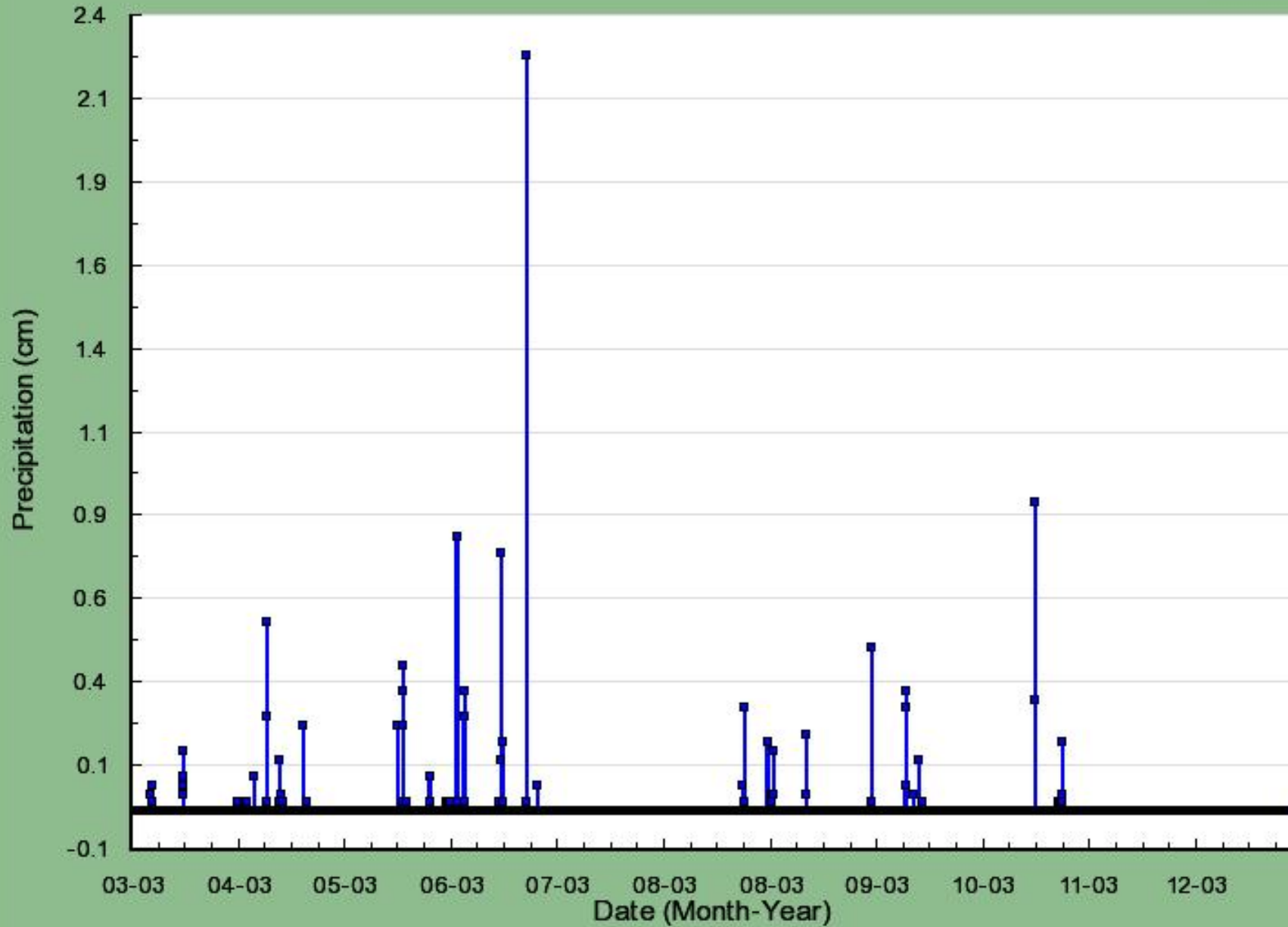
- ▲ Flux 12-8 inches
- ▼ Flux 24-12 inches
- ◇ Flux 30-24 inches
- Flux 48-30 inches



# TEXAS LANDFILL SENSOR DATA

MAR 14 2003 - JAN 14 2004

■ Precipitation

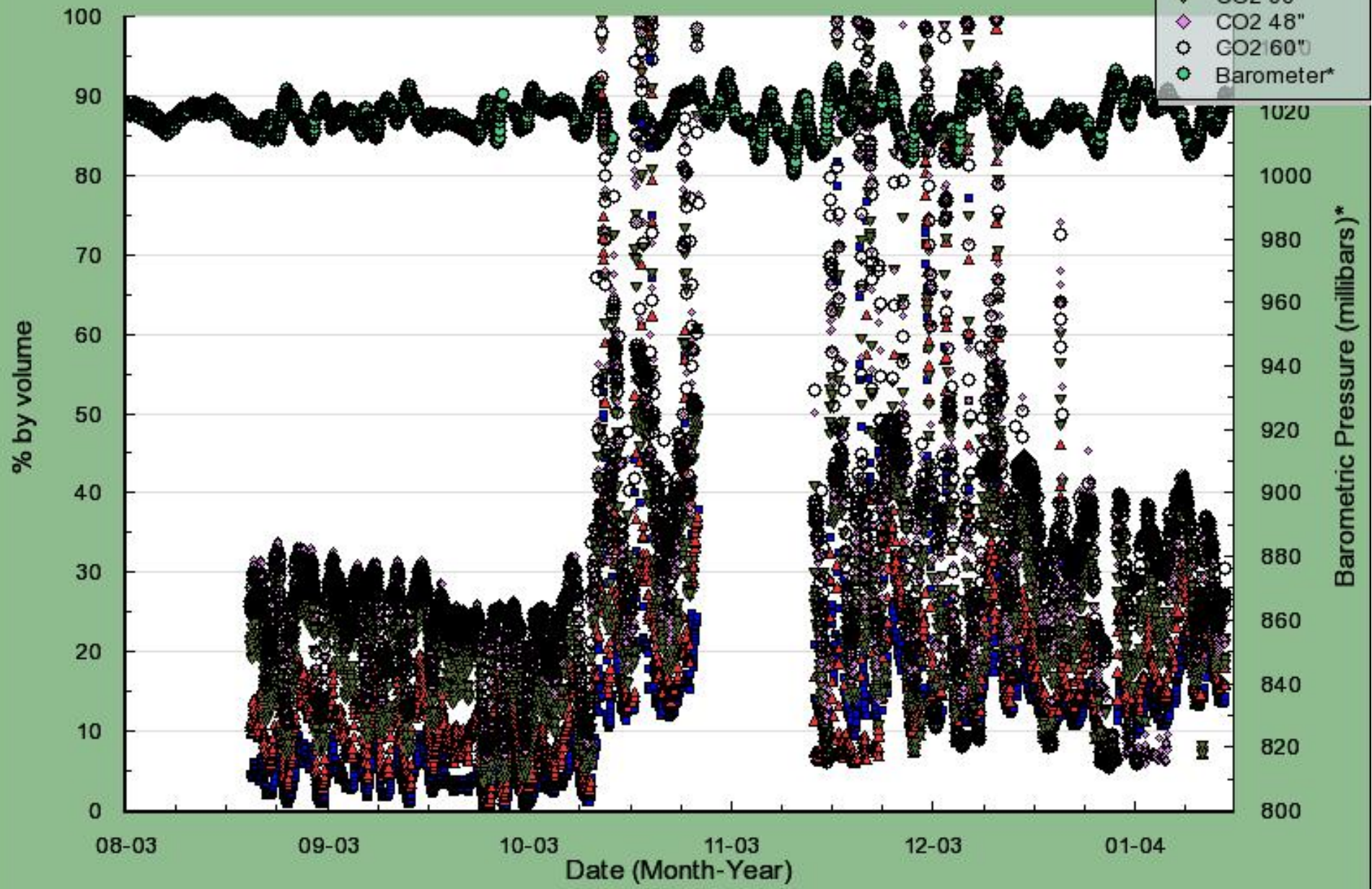




# TEXAS LANDFILL SENSOR DATA

AUG 23 2003 - JAN 23 2004

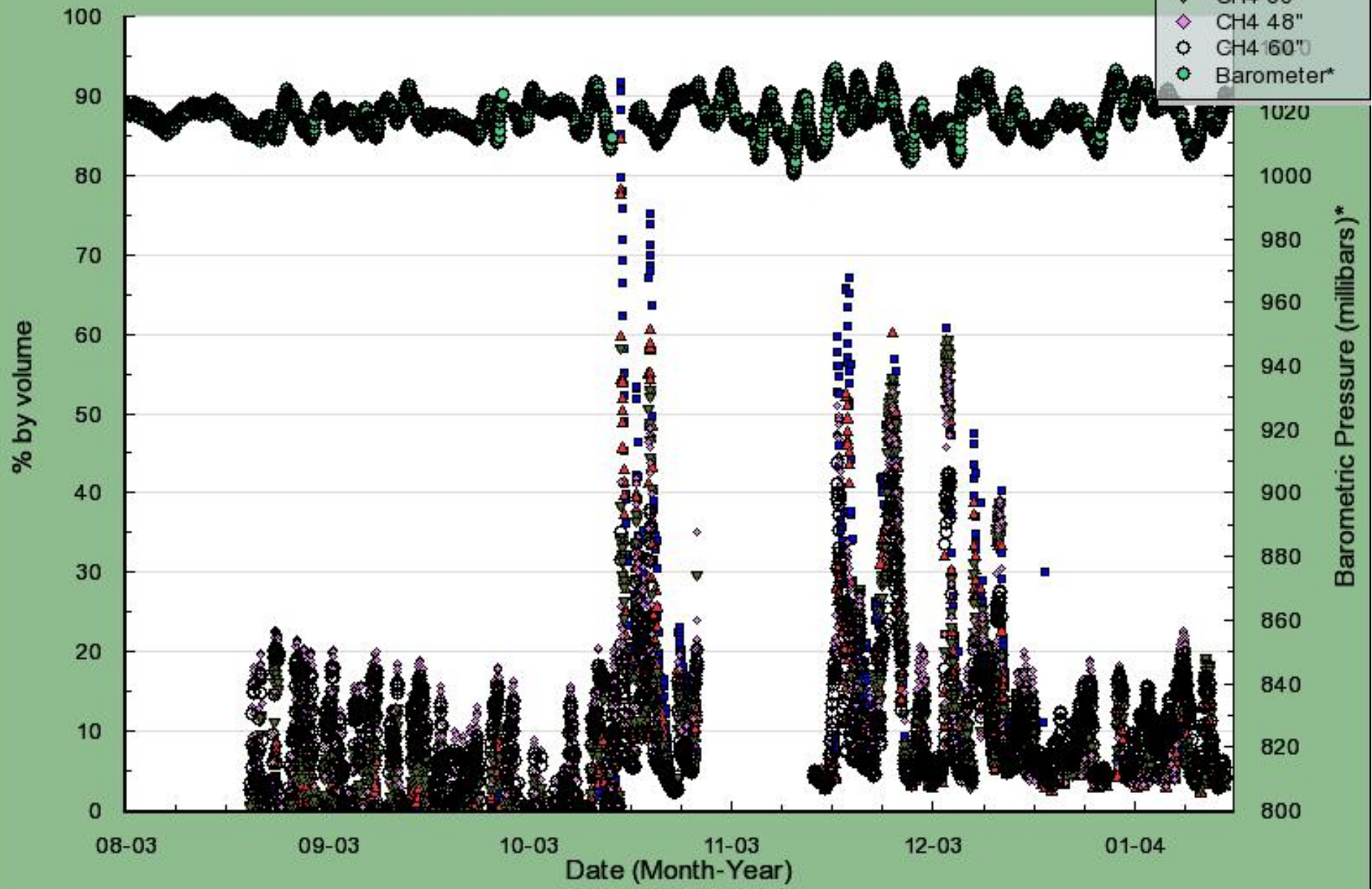
- CO2 4"
- ▲ CO2 20"
- ▼ CO2 30"
- ◆ CO2 48"
- CO2 60"
- Barometer\*



# TEXAS LANDFILL SENSOR DATA

AUG 23 2003 - JAN 23 2004

- CH4 4"
- ▲ CH4 20"
- ▼ CH4 30"
- ◆ CH4 48"
- CH4 160"
- Barometer\*



# A Cover Could Create Problems Elsewhere

