
*Idaho National Engineering and Environmental Laboratory*

# *Effects of Landfill Gas on Vegetation and on Cover Performance*

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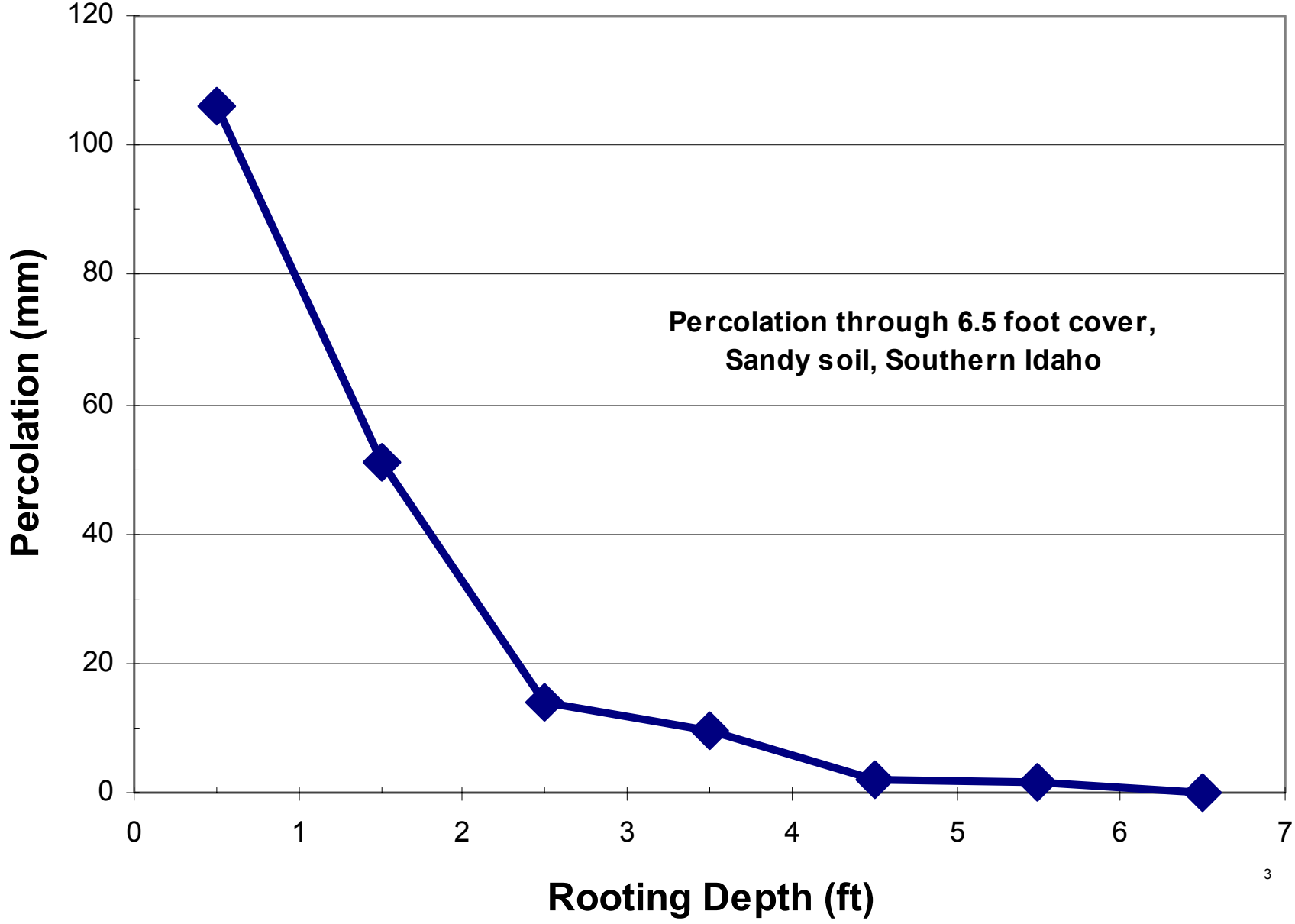
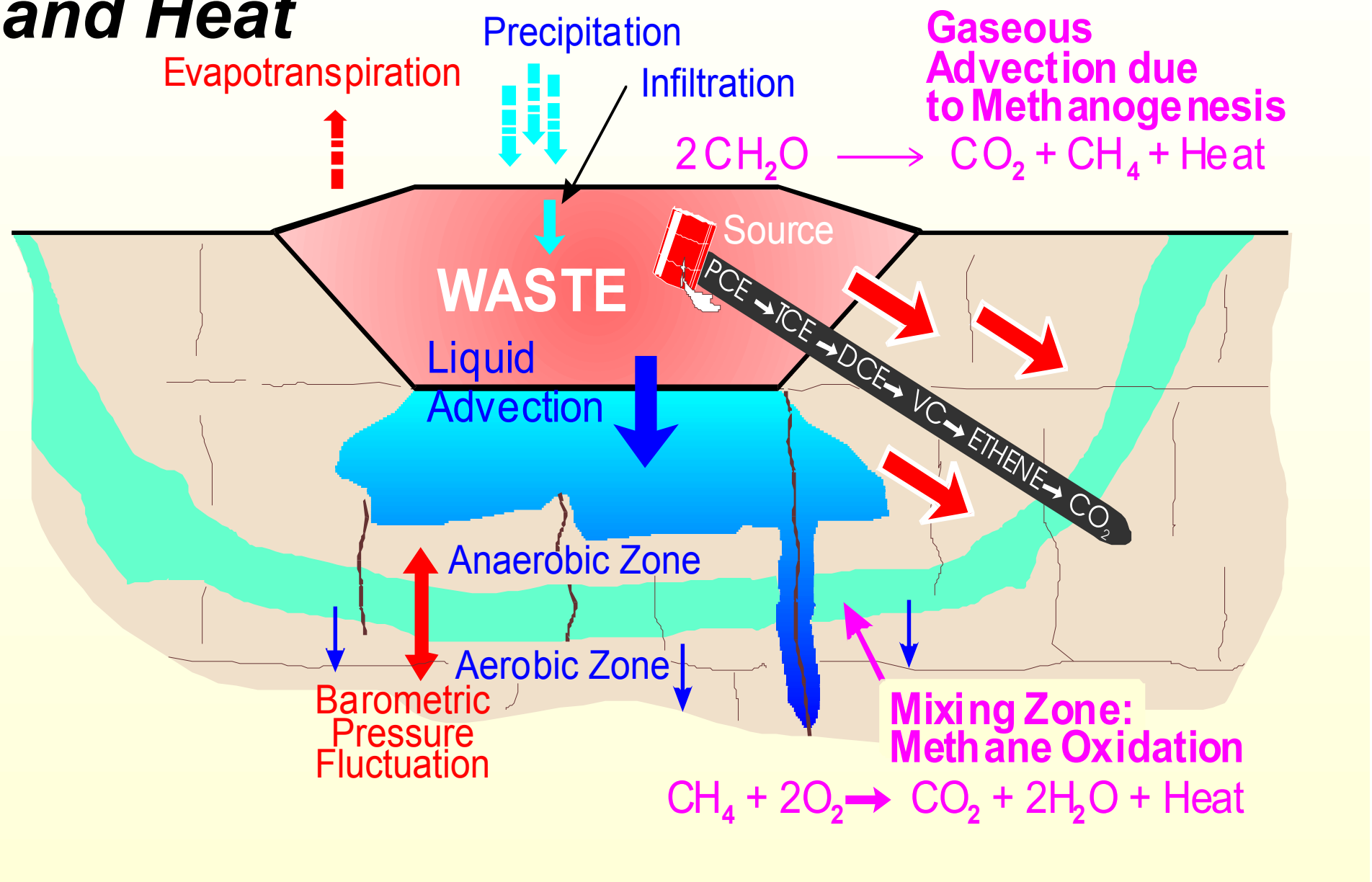
# Outline

- *The problem: landfill gases affect plants*
- *Overview of the landfill cover/waste interaction*
- *Simple system example without gas: Boise, ID*
- *Landfill/analogue example with gas: Lubbock, TX*
- *CA, NM, CO landfill gas/vegetation data & modeling*

# The Problem: Percolation as a Function of Rooting Depth

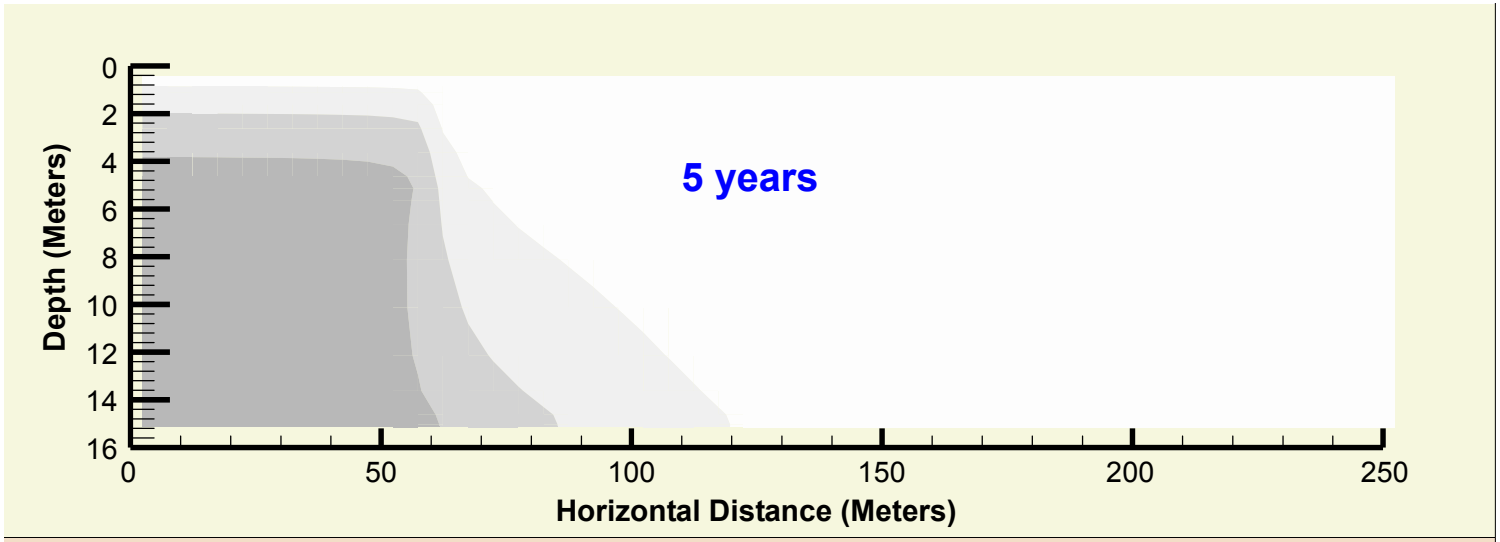


# *Landfills Generate a lot of Water, Gases and Heat*

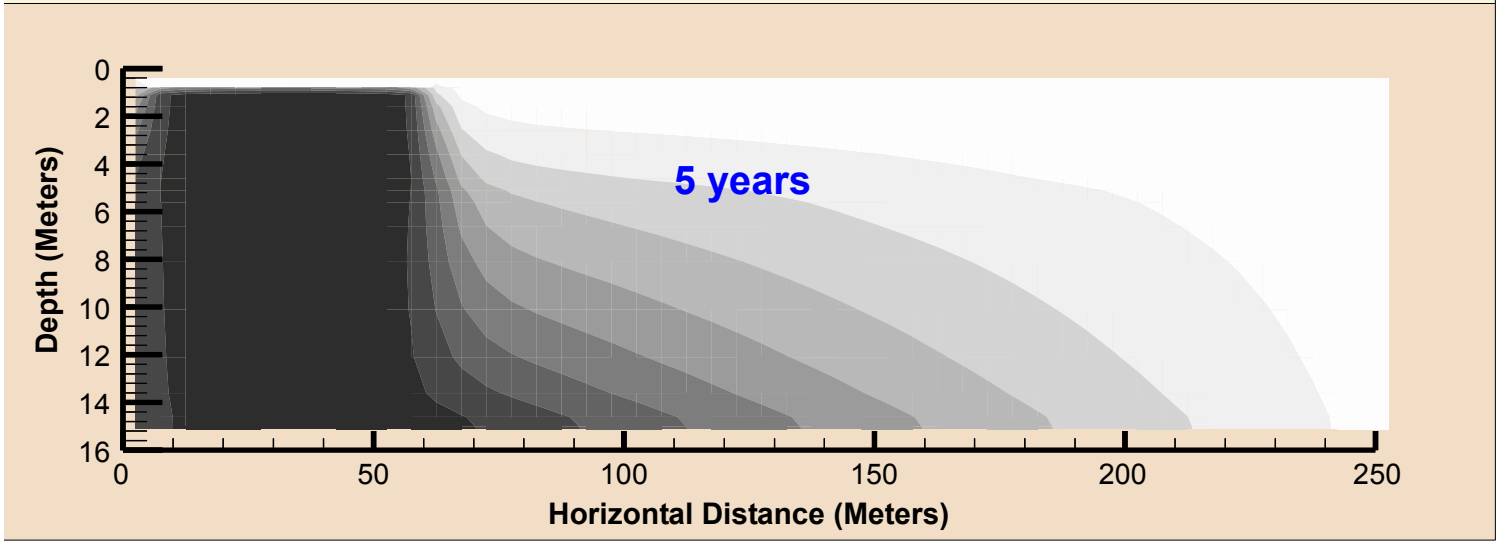


# *Landfill Cover Gas Movement: Up and Down*

**High K Cover**




**Low K Cover**



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

$$CH_4 + 2O_2 \rightarrow HCO_3^- + H_2O + H^+ + 580kJ/mol$$

$$CH_4 + 2NO_3^- \rightarrow HCO_3^- + N_2 + H_2O + OH^- + 469kJ/mol$$

$$CH_4 + FeO(OH) \rightarrow CO_2 + Fe^{2+} + 2H_2O + H^+ + 171kJ/mol$$

$$CH_4 + SO_4^{2-} \rightarrow HCO_3^- + HS^- + H_2O + 61kJ/mol$$

# Methane Generation and Oxidation

$$0.4\ Mg/m^3 * \frac{170\ m^3\ methane}{1\ Mg\ waste} * 4m = 272\ m^3\ methane/m^2\ of\ landfill\ surface$$

An equal volume of CO2 also will be generated

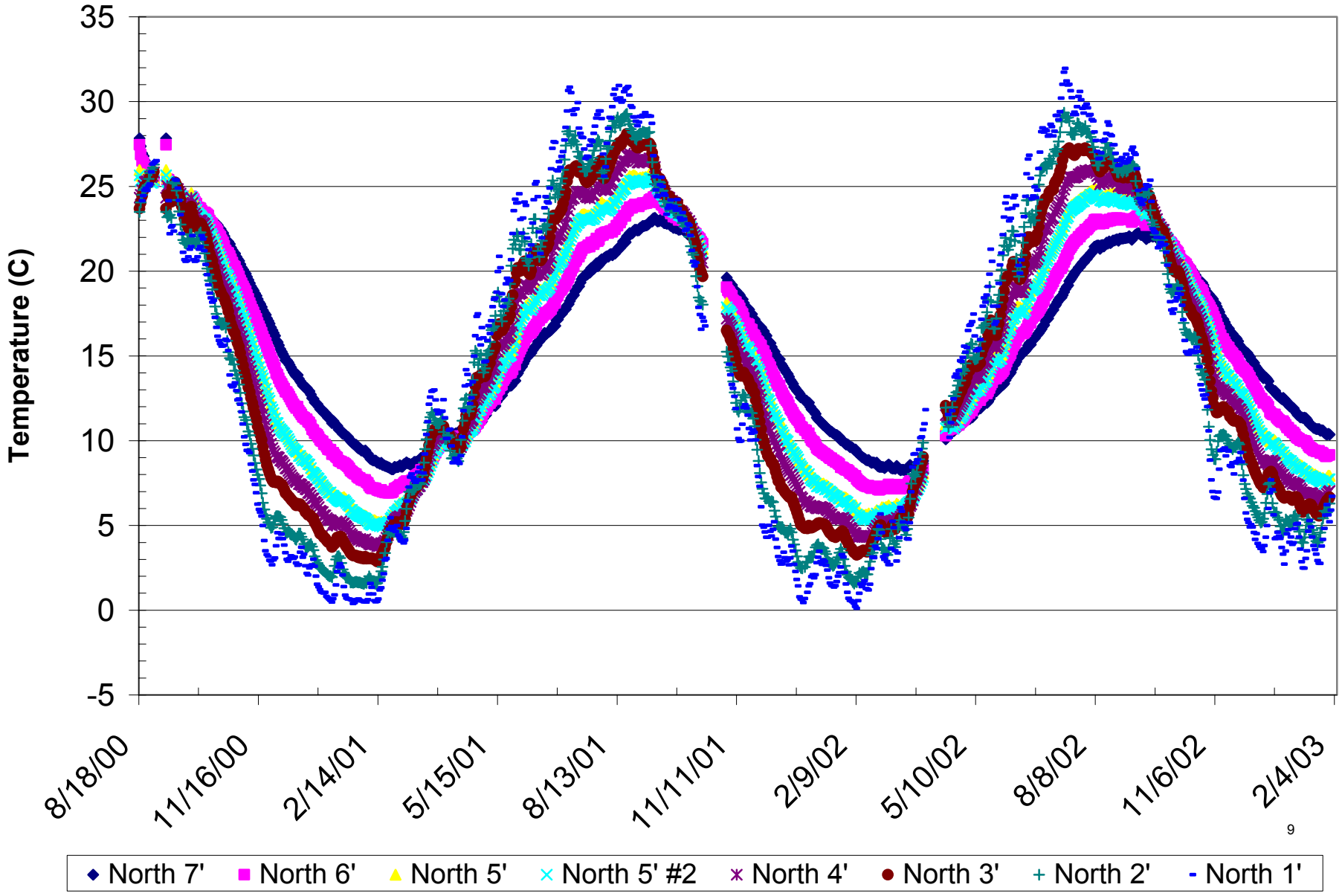
$$272\ m^3\ CH_4 * \frac{1mol}{0.0224\ m^3/mol} * 1\ m^2 * \frac{36\ g\ H_2O}{1mol\ CH_4} * \frac{1\ kg}{1000\ g} * \frac{0.001\ m^3}{1\ kg} = \frac{0.437\ m^3\ water}{1\ m^2\ landfill\ surface}$$

44 cm of new water in the profile

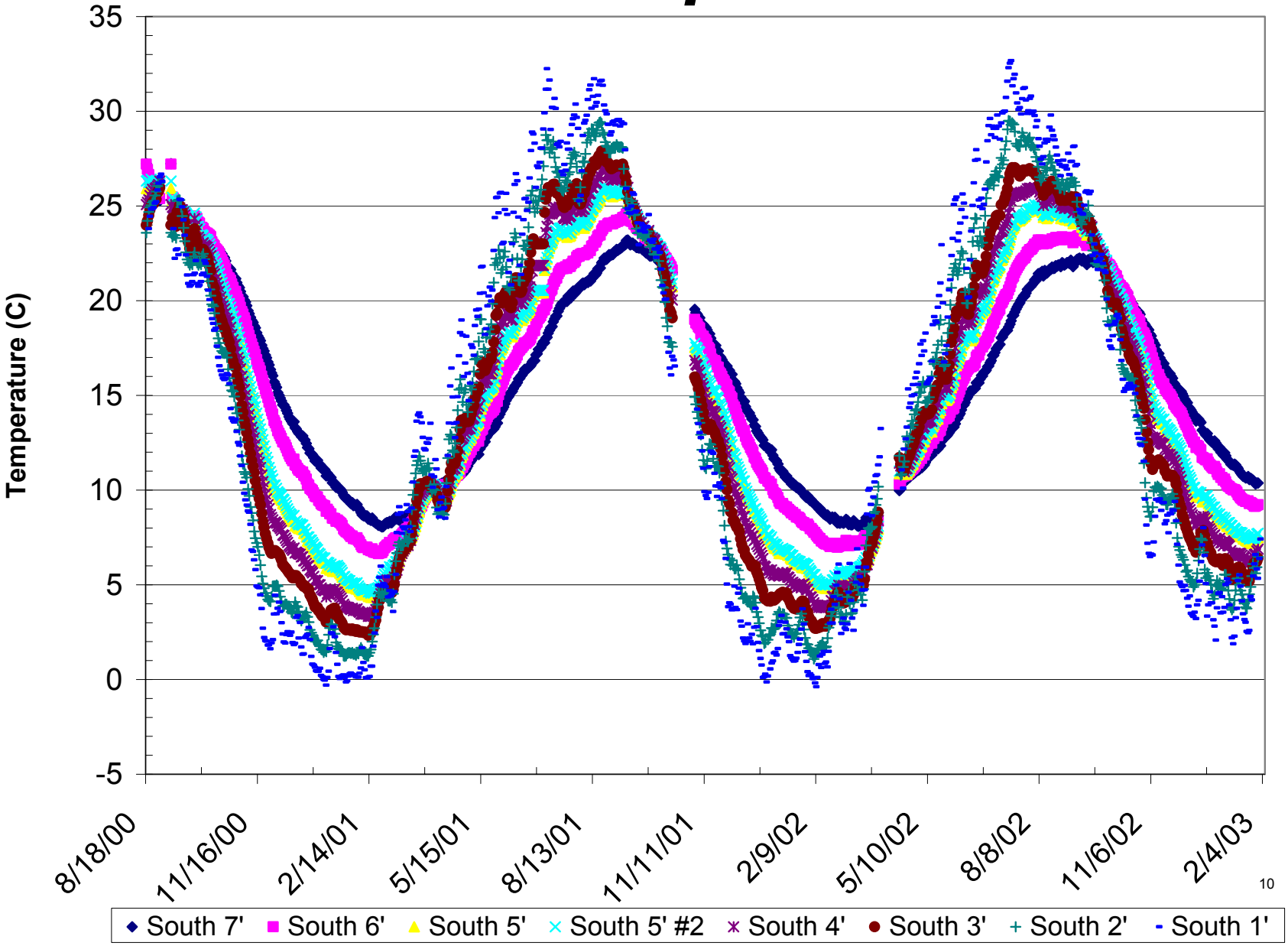
And loss of water holding capacity

# Southwest Idaho

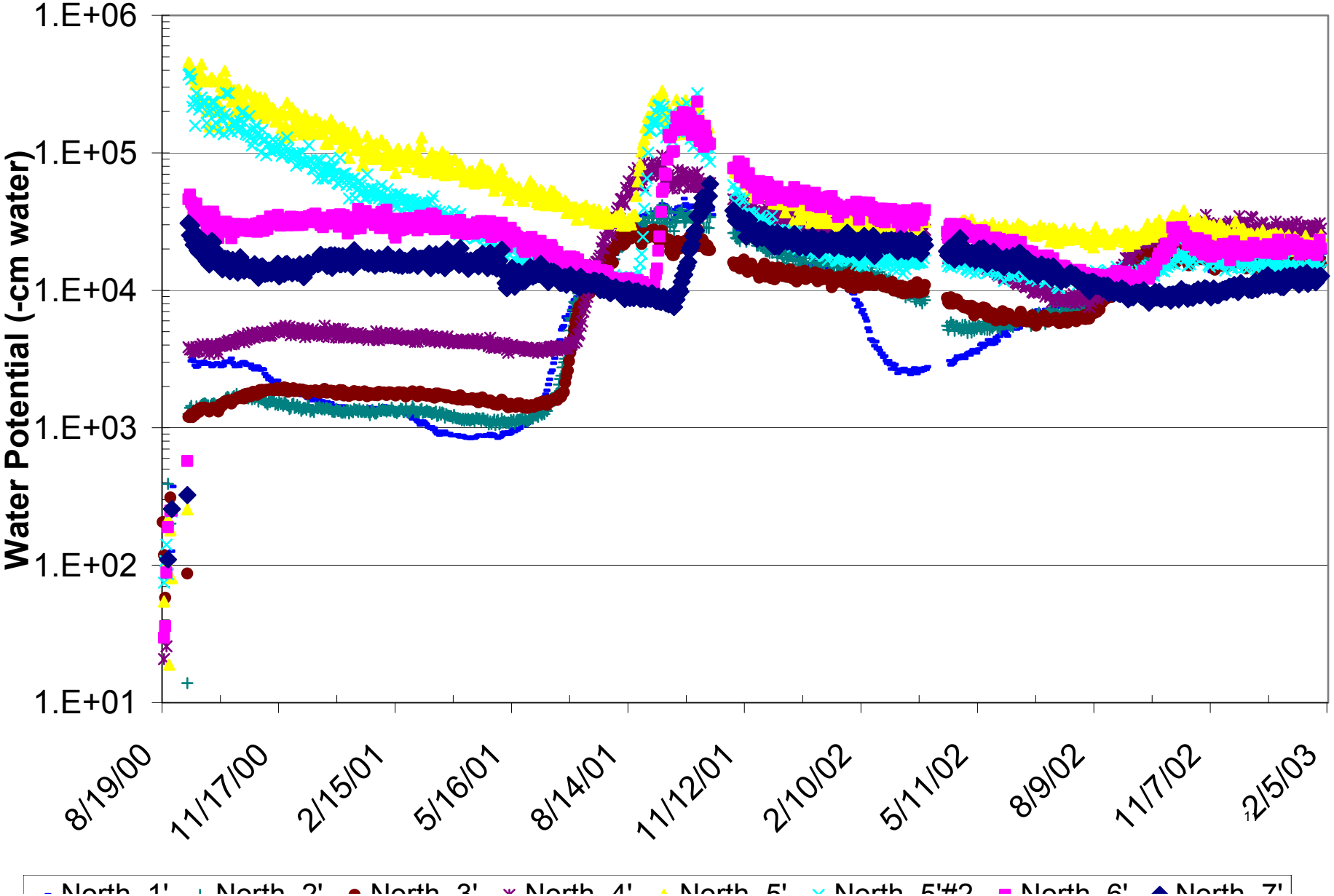
# North Profile Temperatures



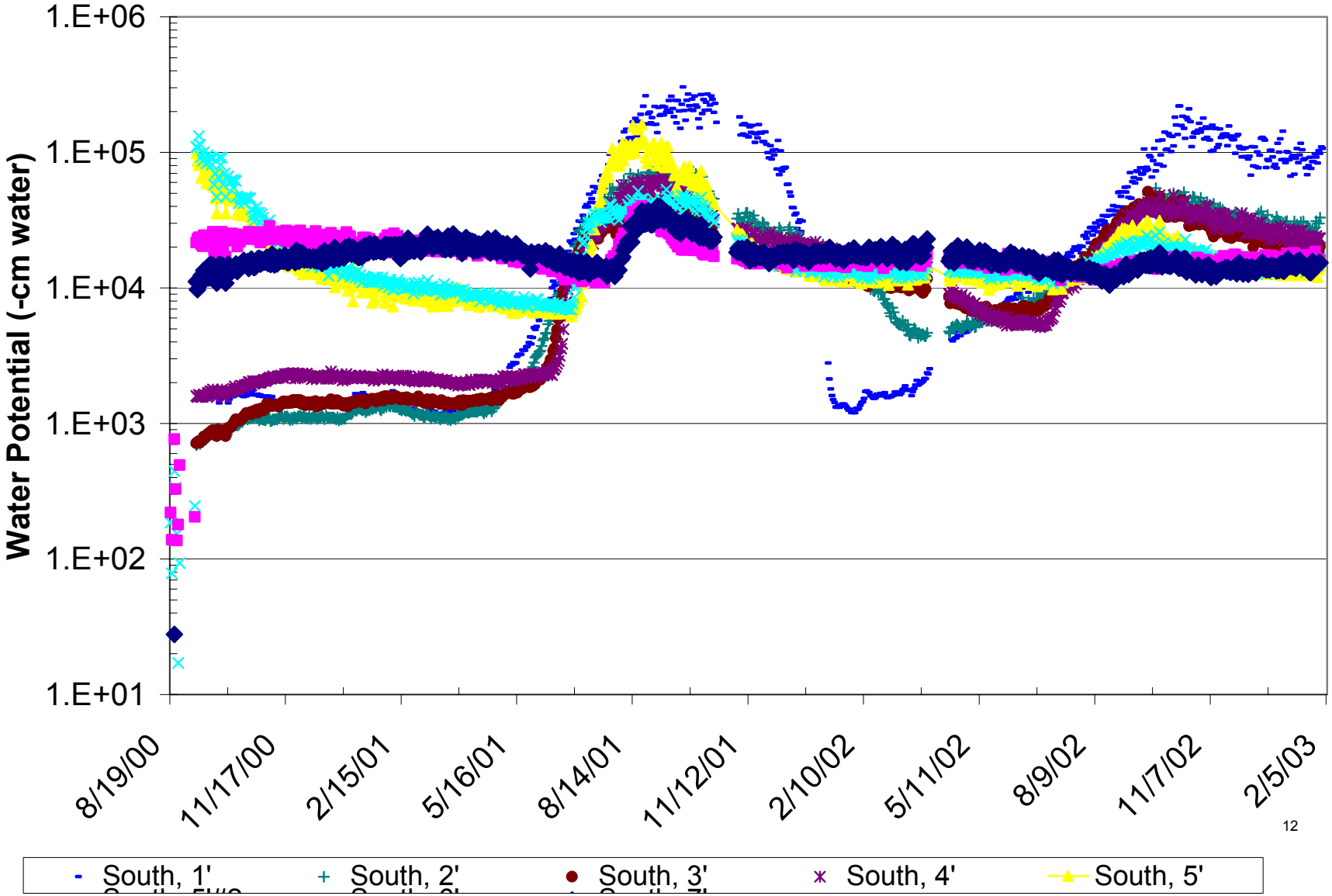
# South Profile Temperatures



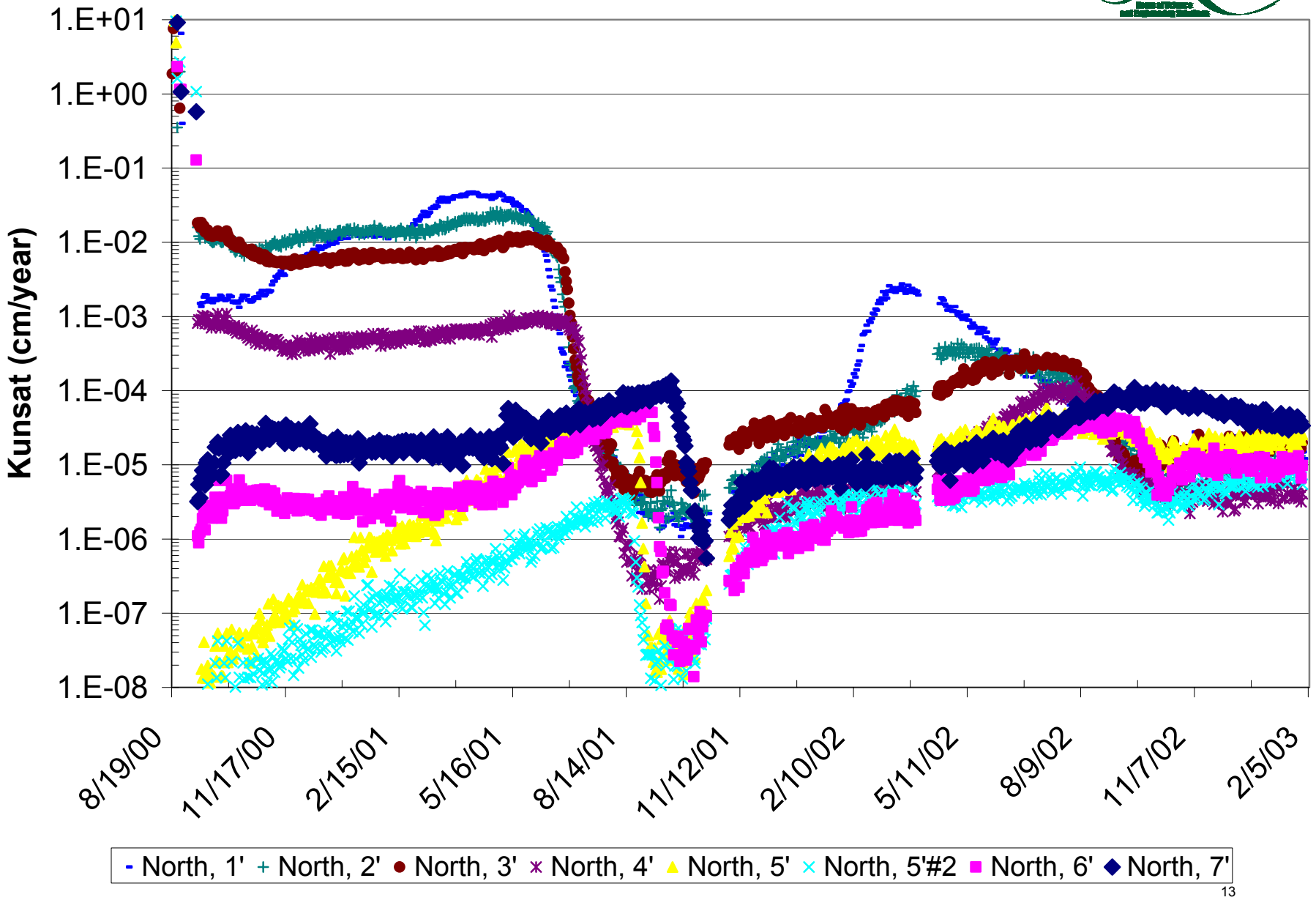
# North Profile Water Potentials



# South Profile Water Potentials



# North Profile Unsaturated K's



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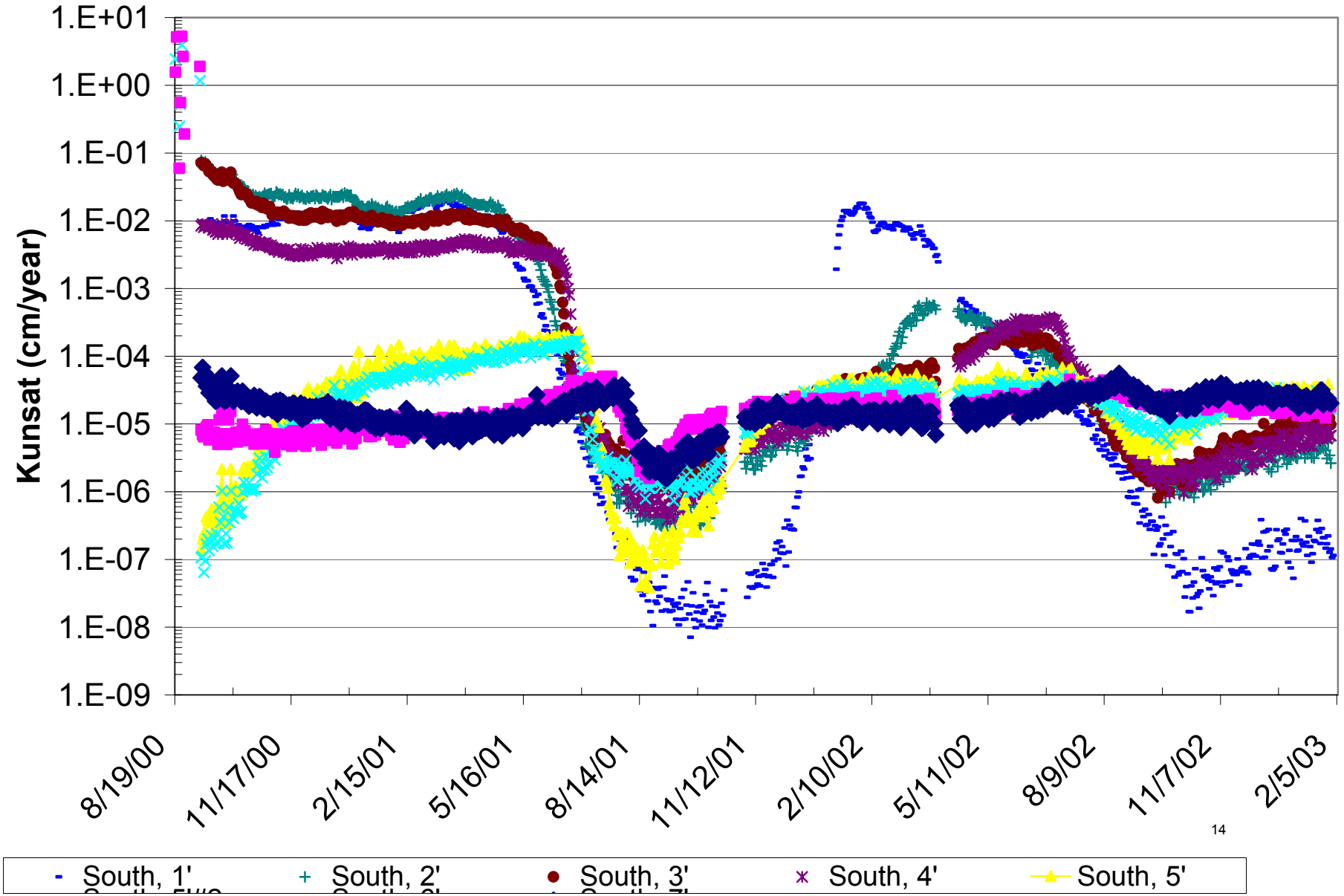
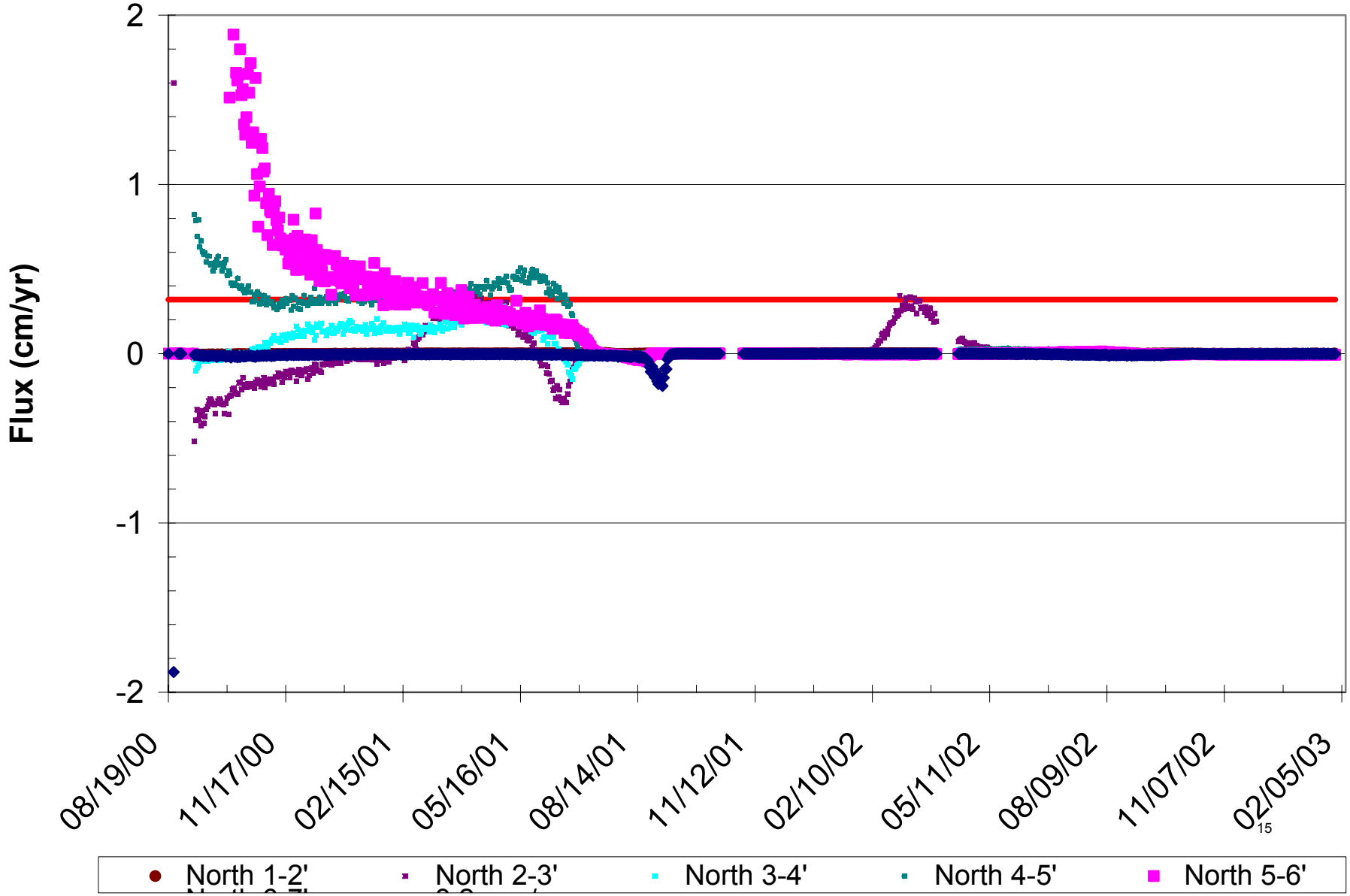
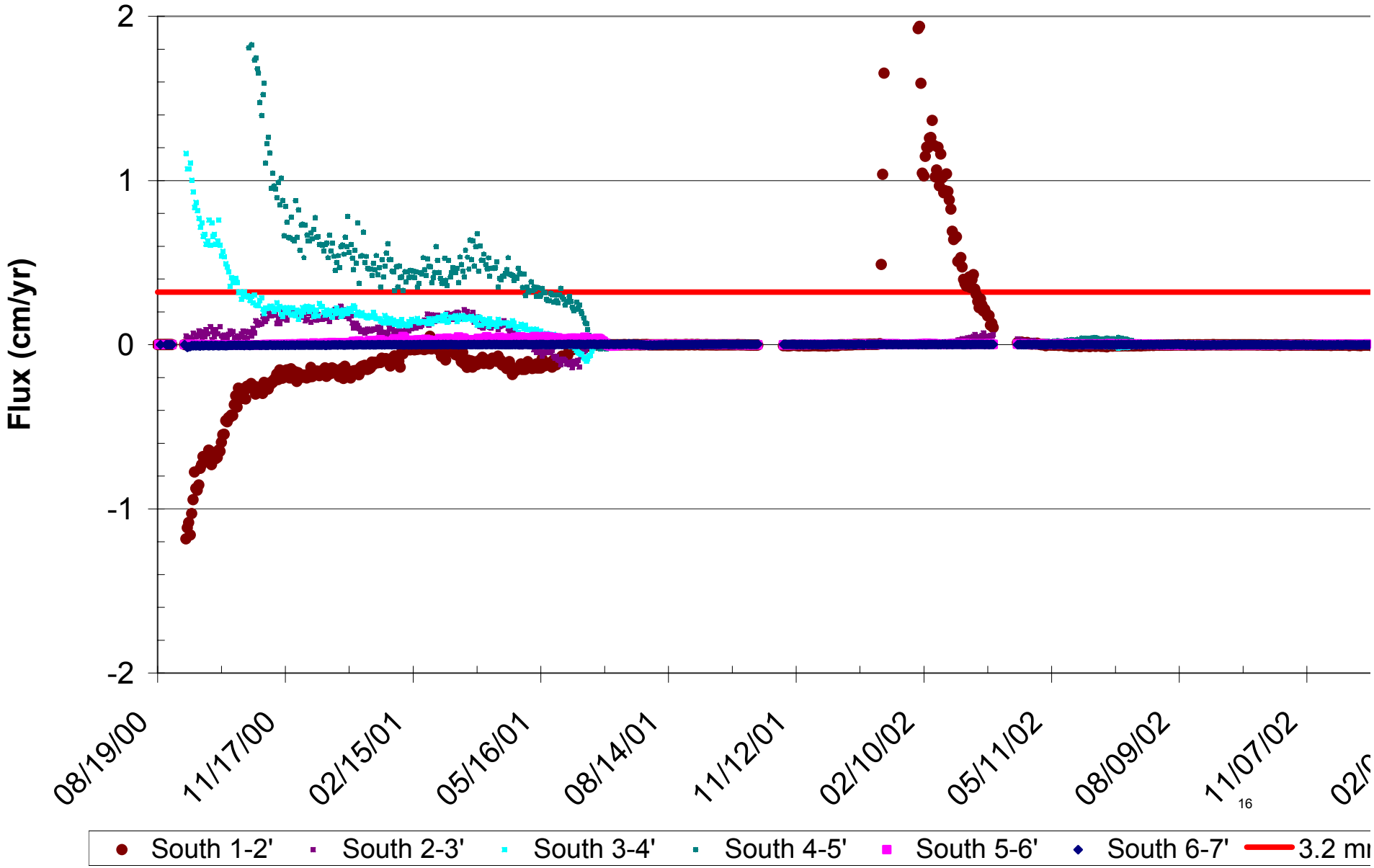


# North Profile Water Fluxes by Depth



# South Profile Water Fluxes by Depth



# *Native Site: Grama Grass, TX*

# *Native Site: Dry to 8 feet +*

# Native Soil Profile

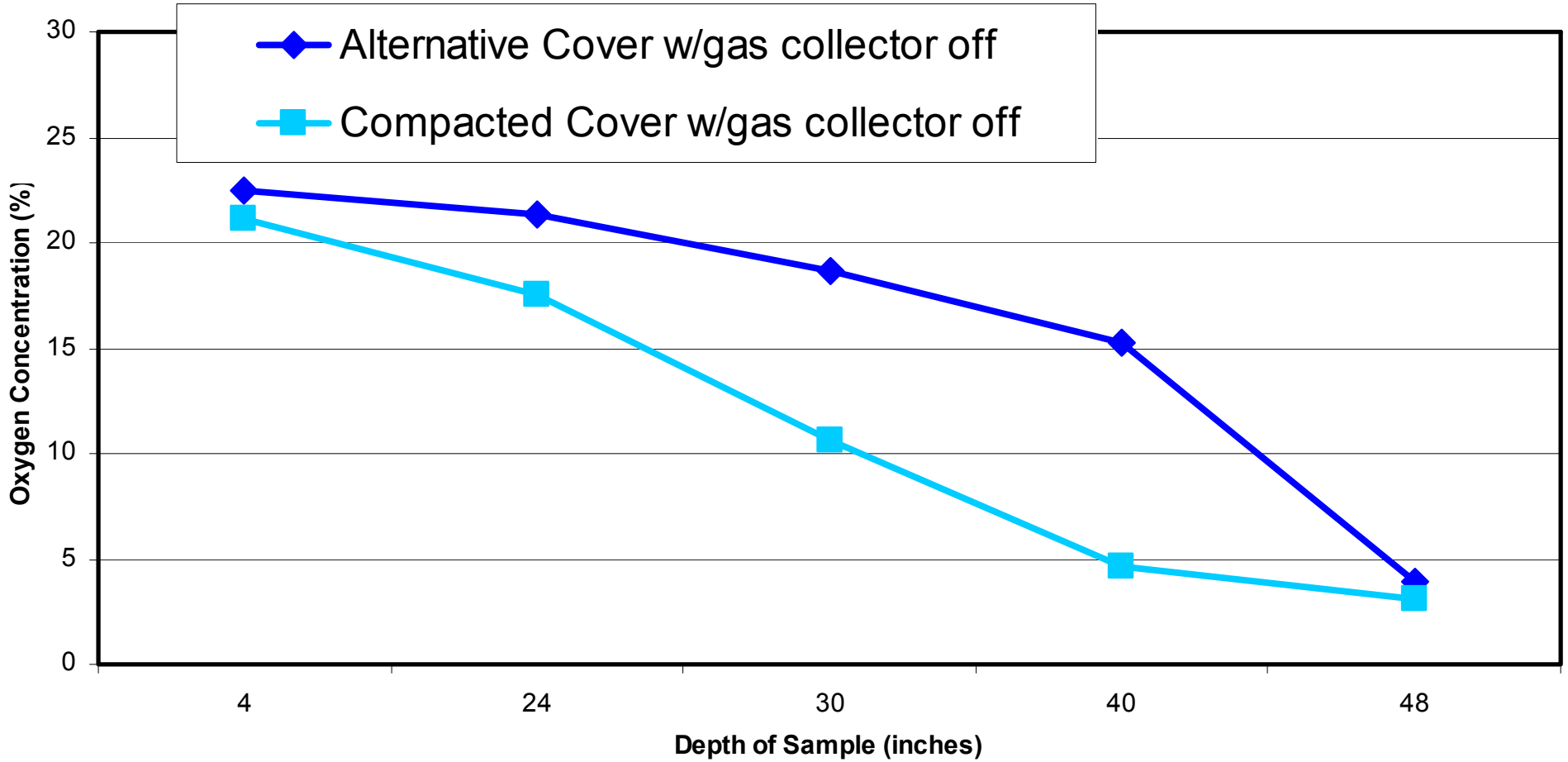
# *Engineered Cover: ~ 95% Proctor*

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

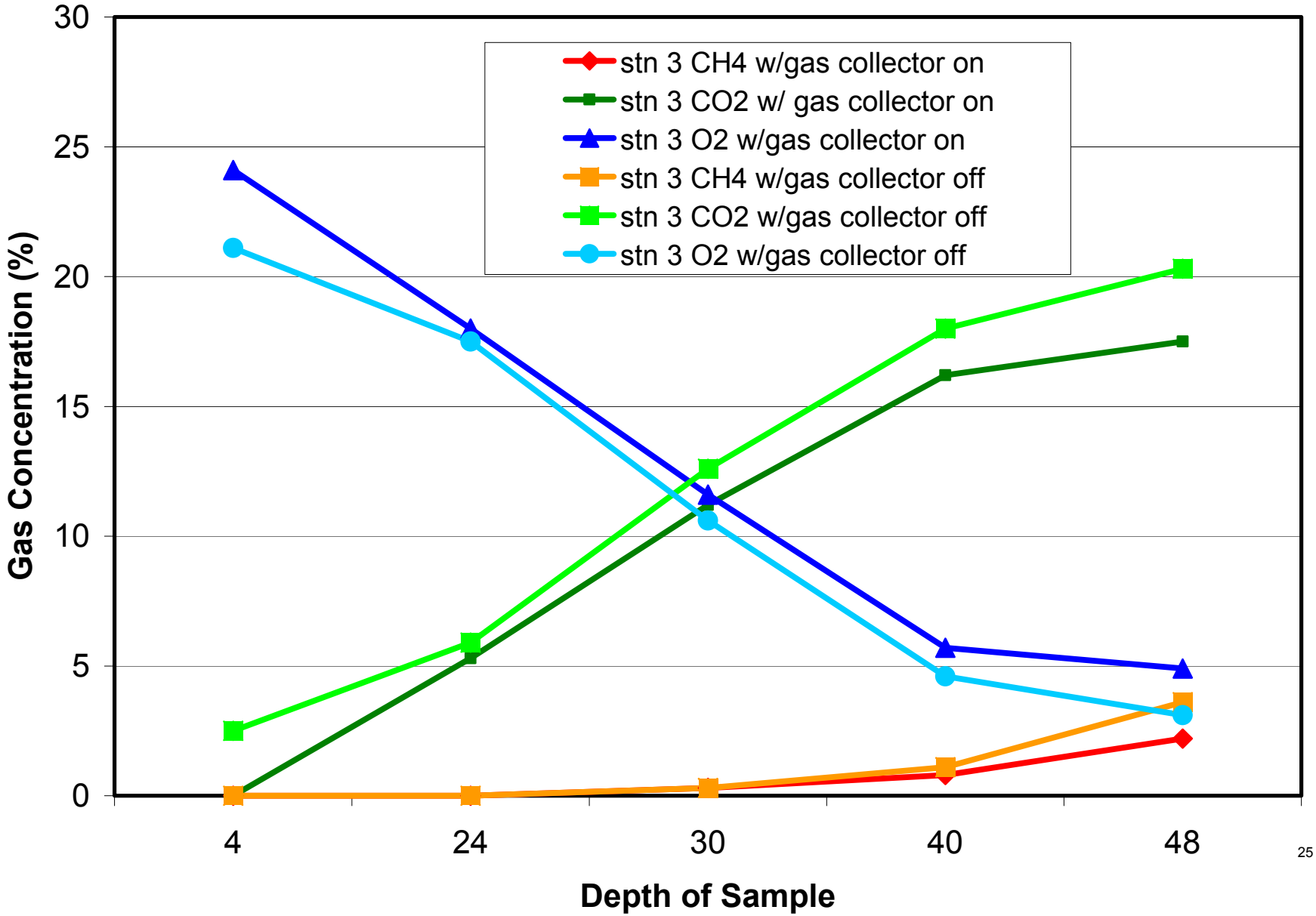
# Soil Cover: ~90% Proctor

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

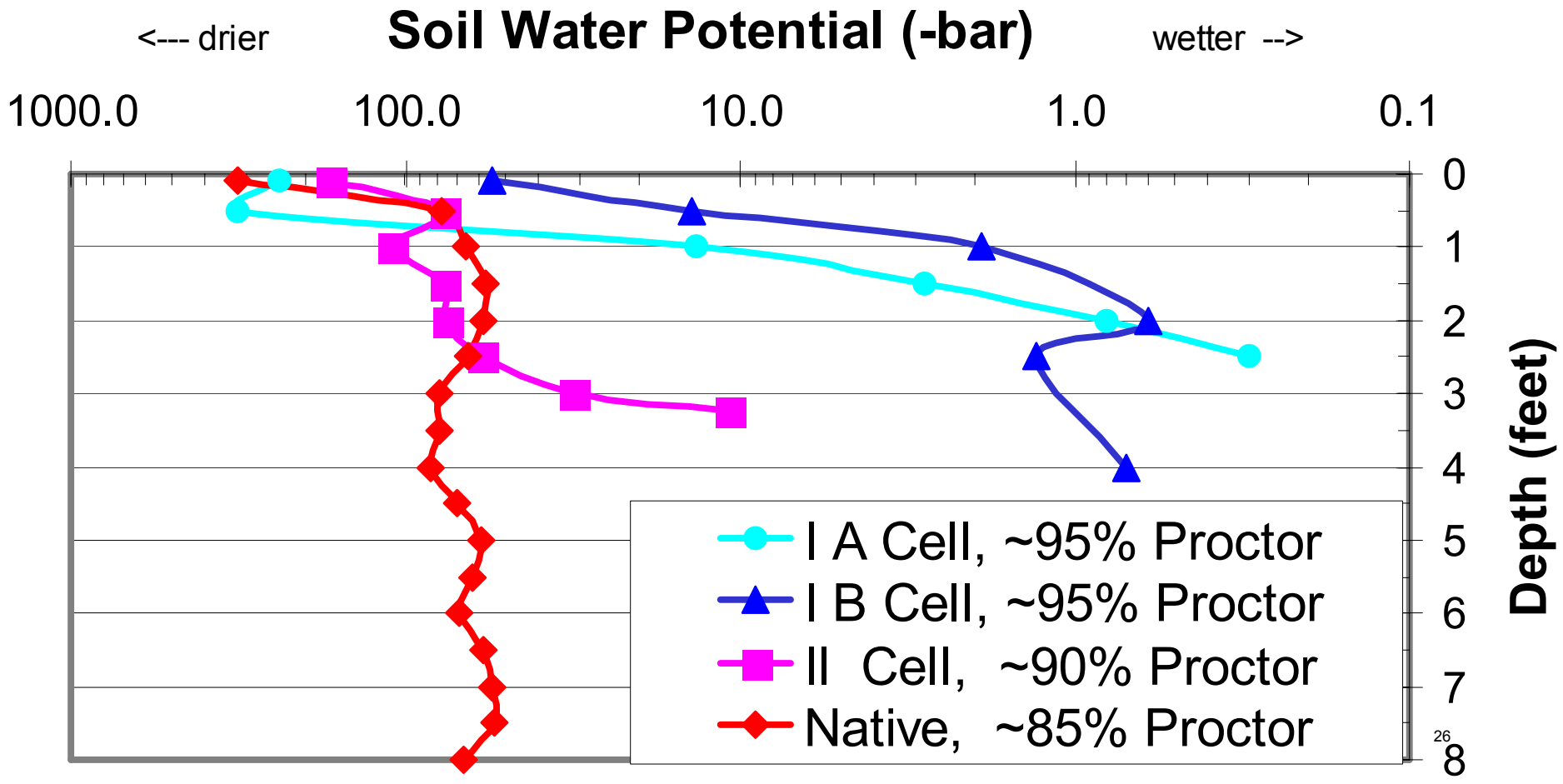
# Compaction Can Lead to Reducing Conditions



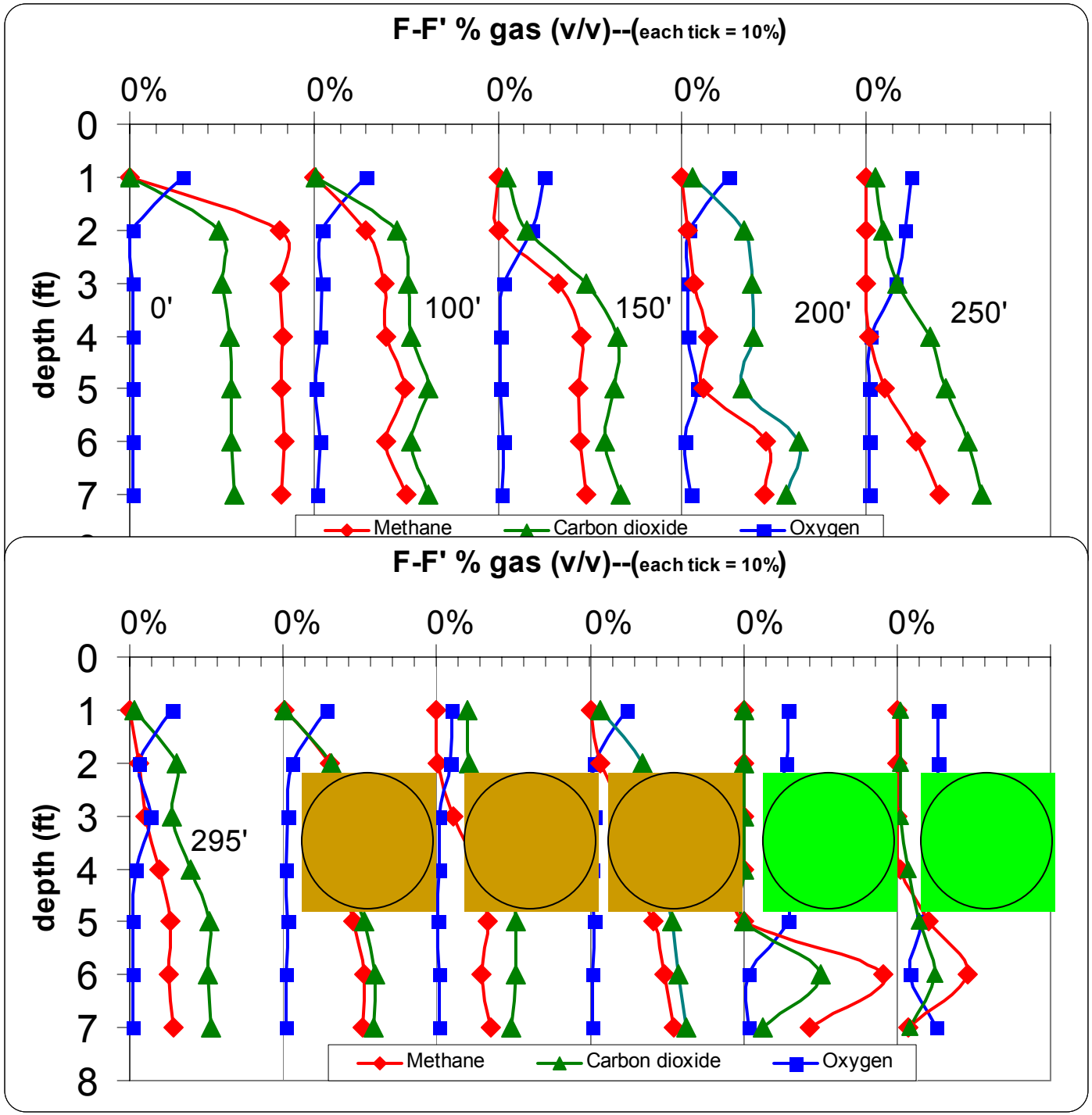
# Engineered Cover Gas Profiles



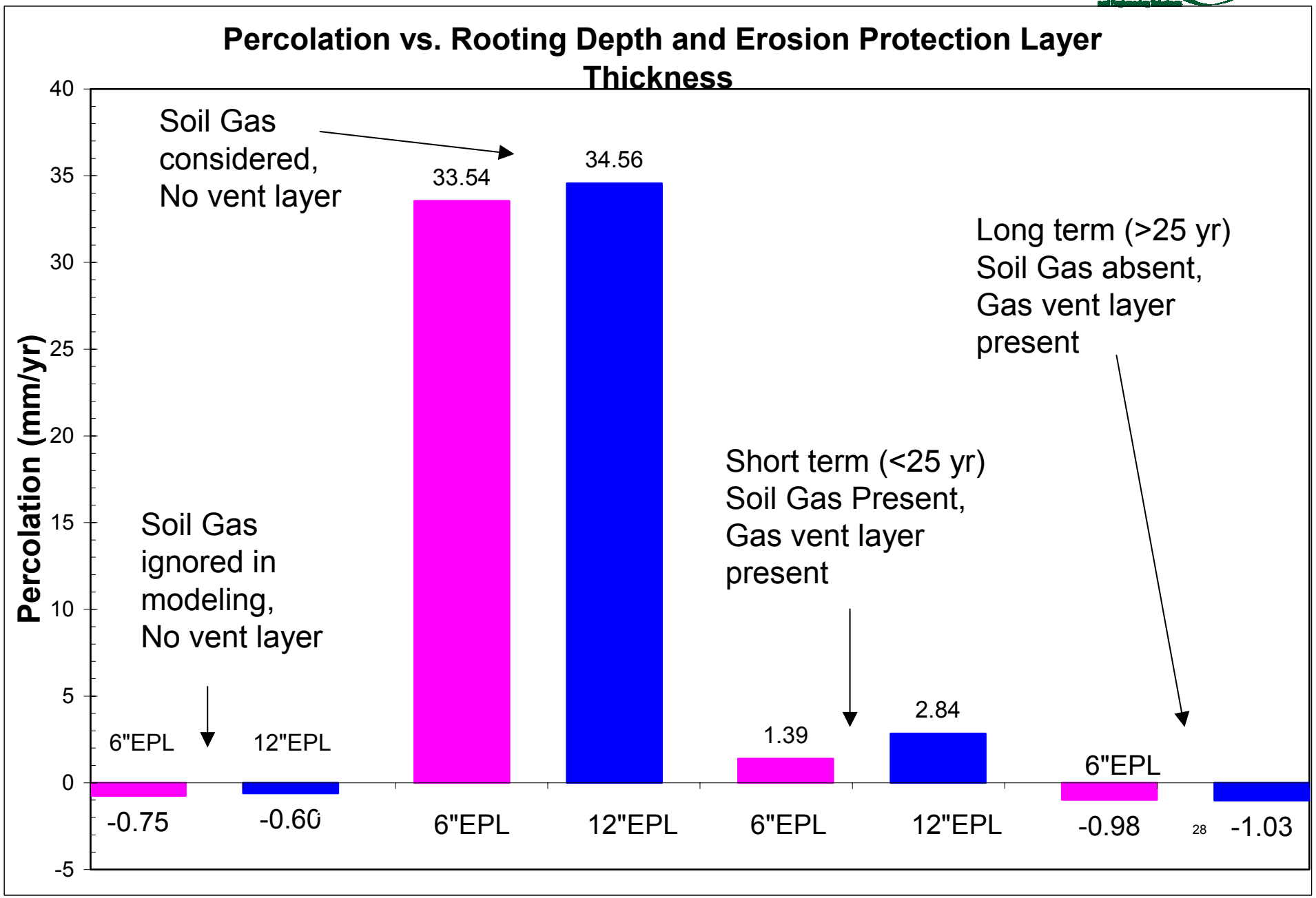
# More Compaction, Less Oxygen, Increased Percolation: TX



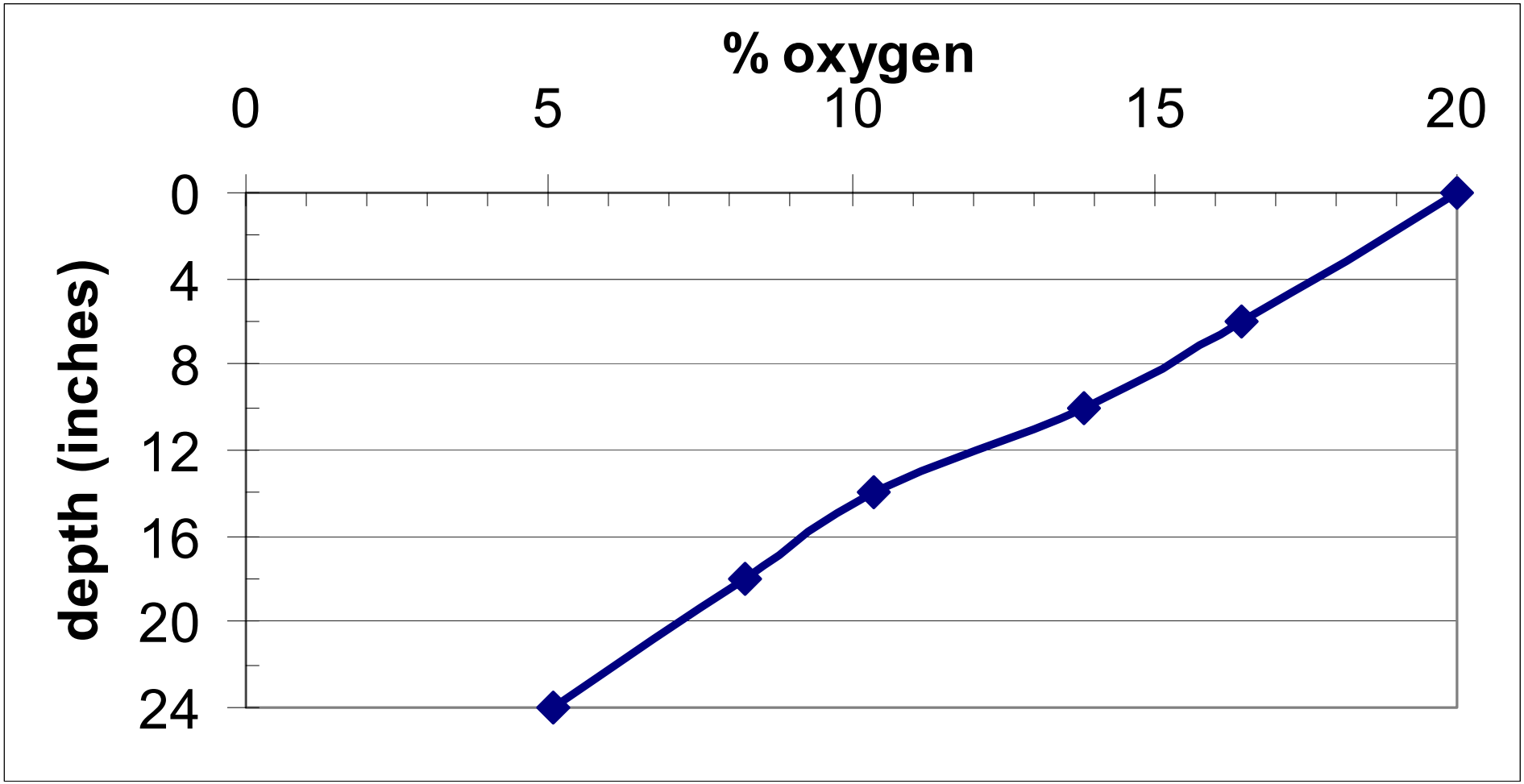
# *Landfill Gases Can Shut Down Plants: CO*



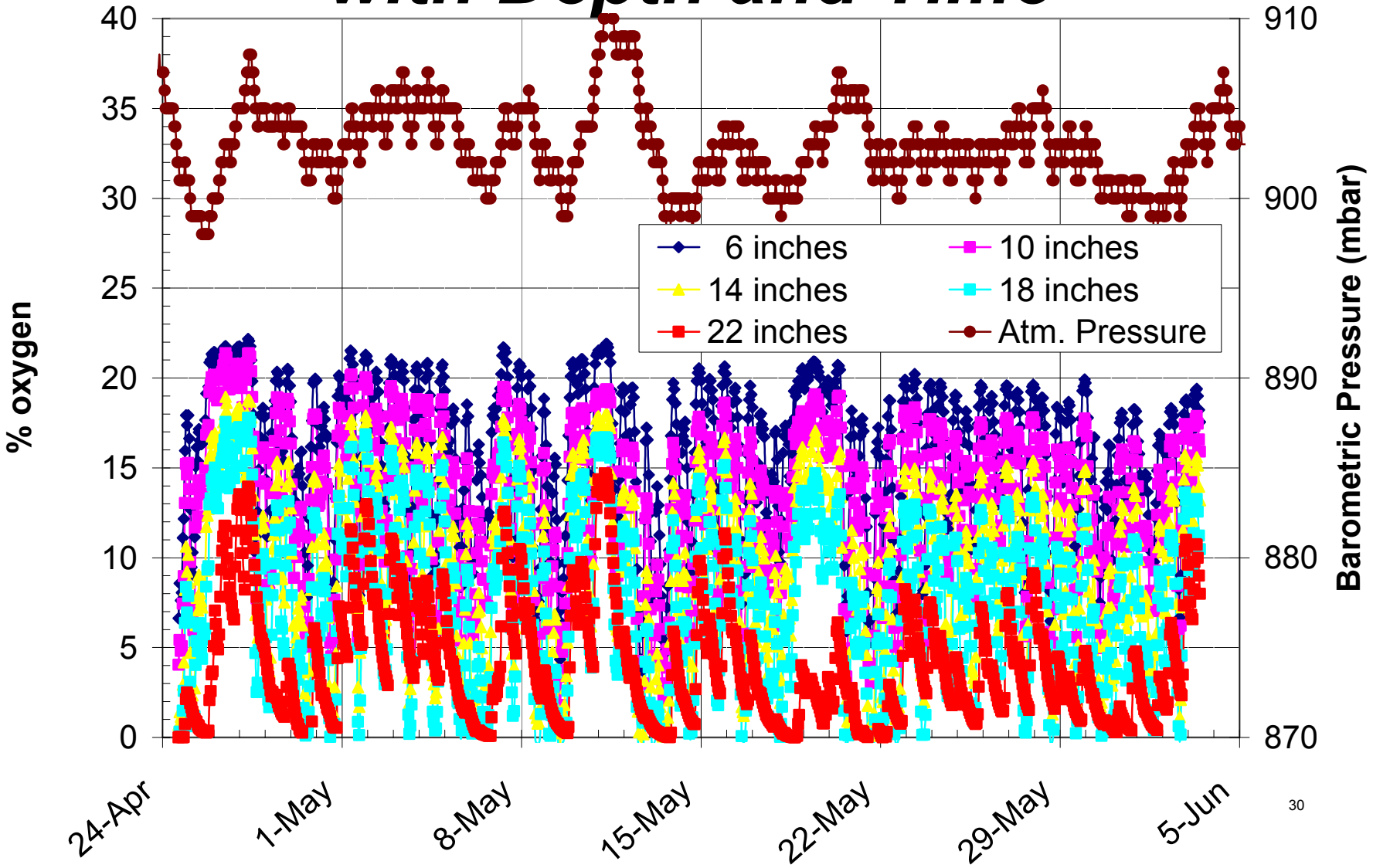
# Percolation as Affected by Gas: CO



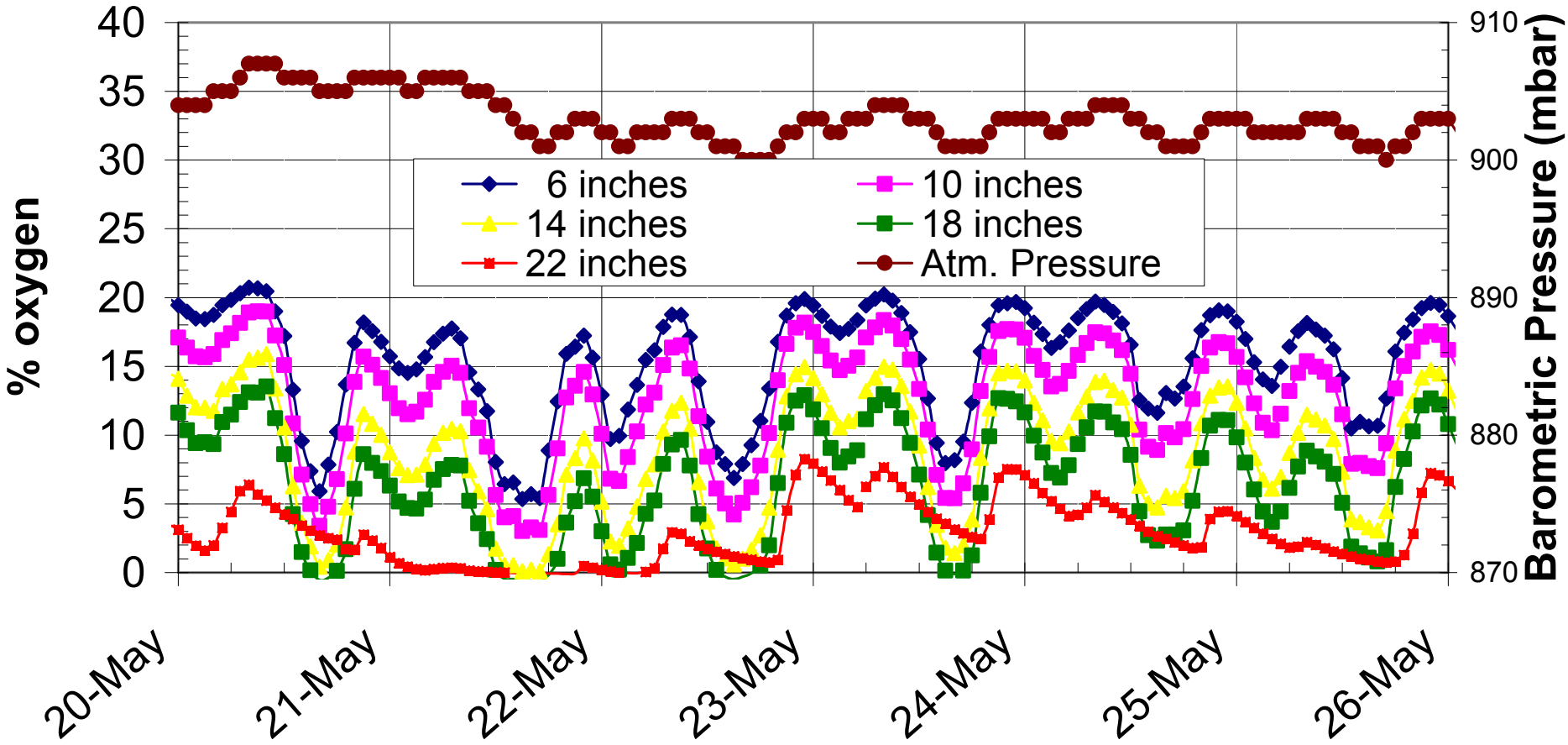
# Average Oxygen Concentrations in Landfill Cover Profile: Southern CA



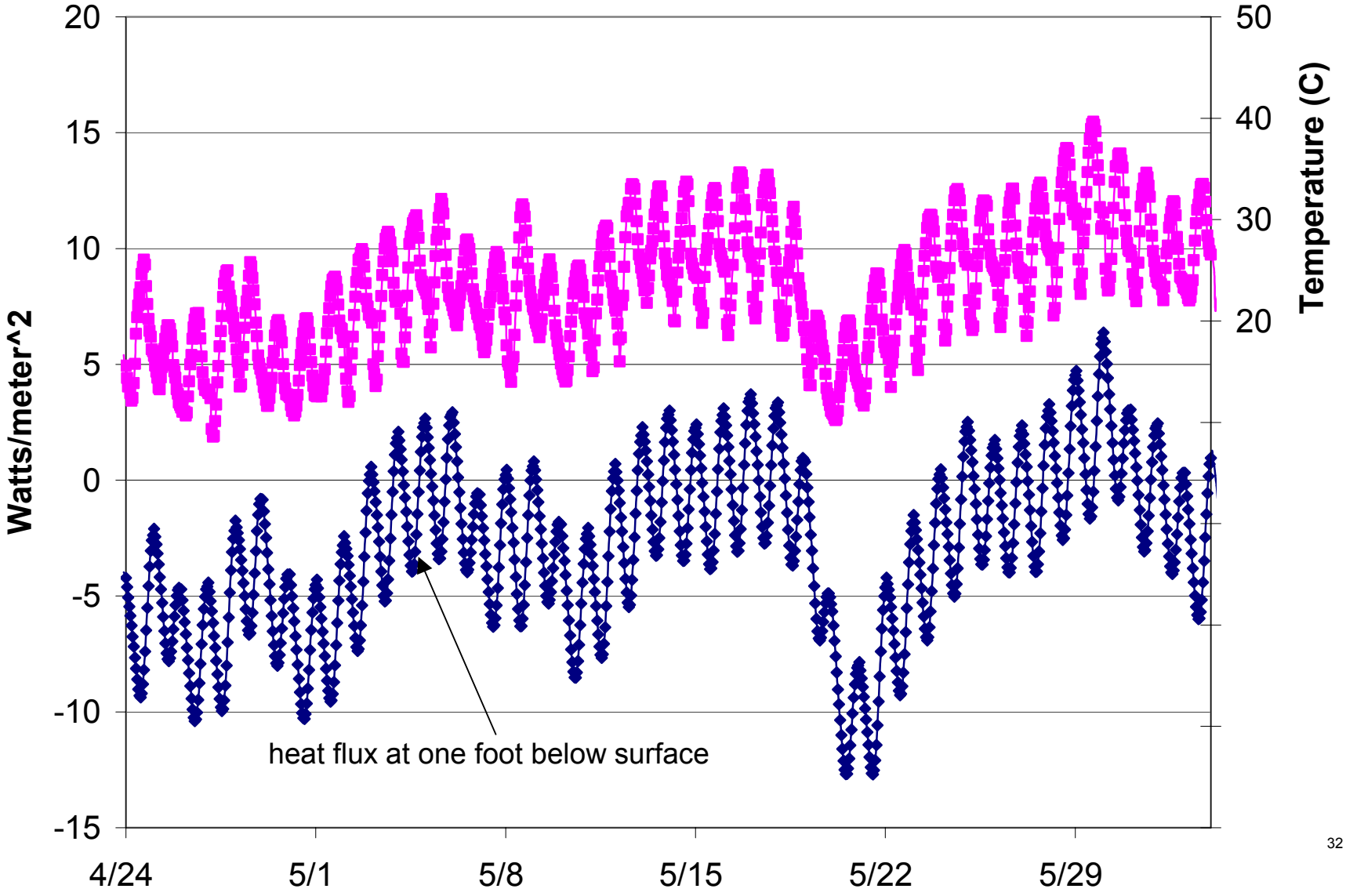
# Anaerobic Conditions Change with Depth and Time



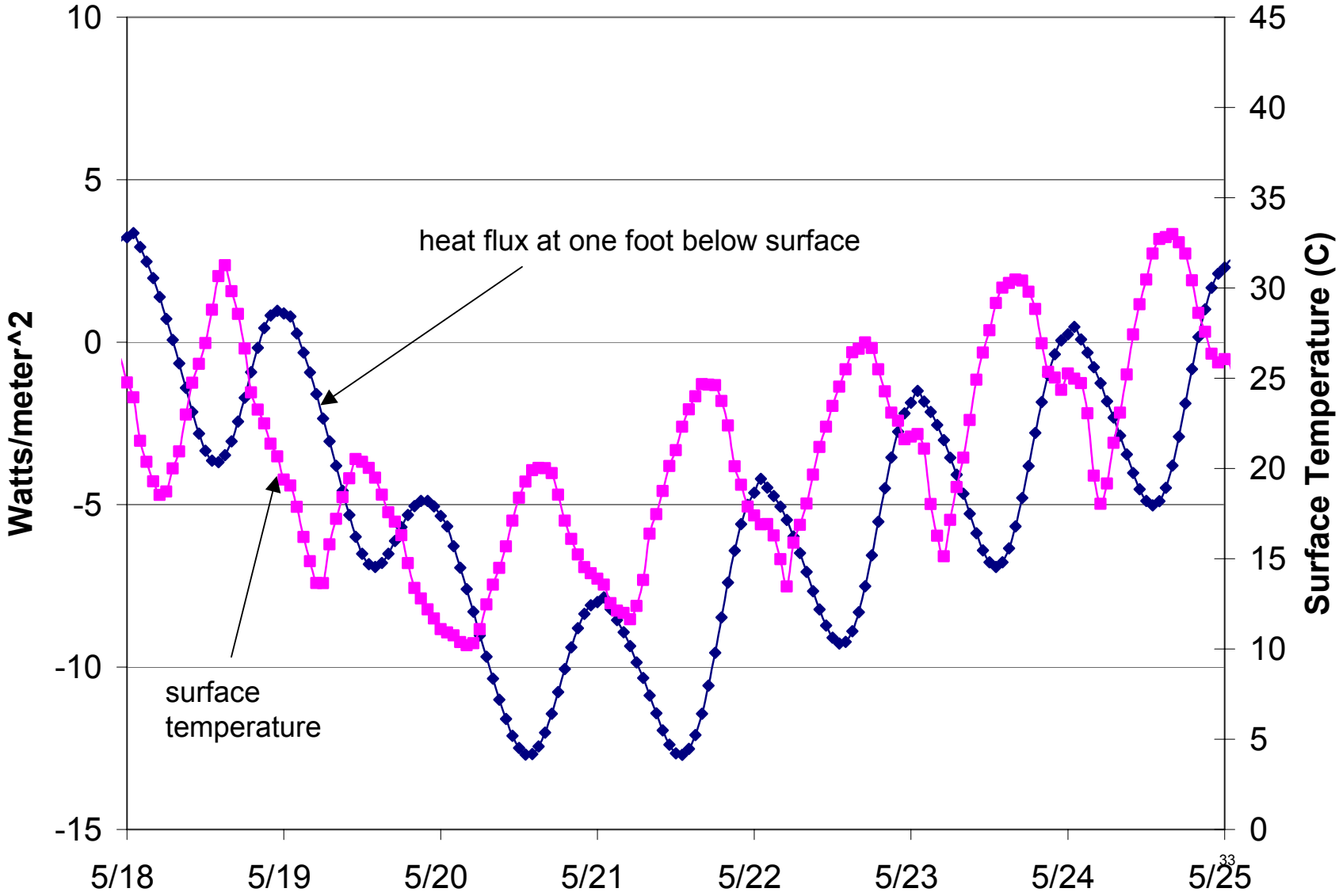
# Cover Gas Profiles Vary Diurnally



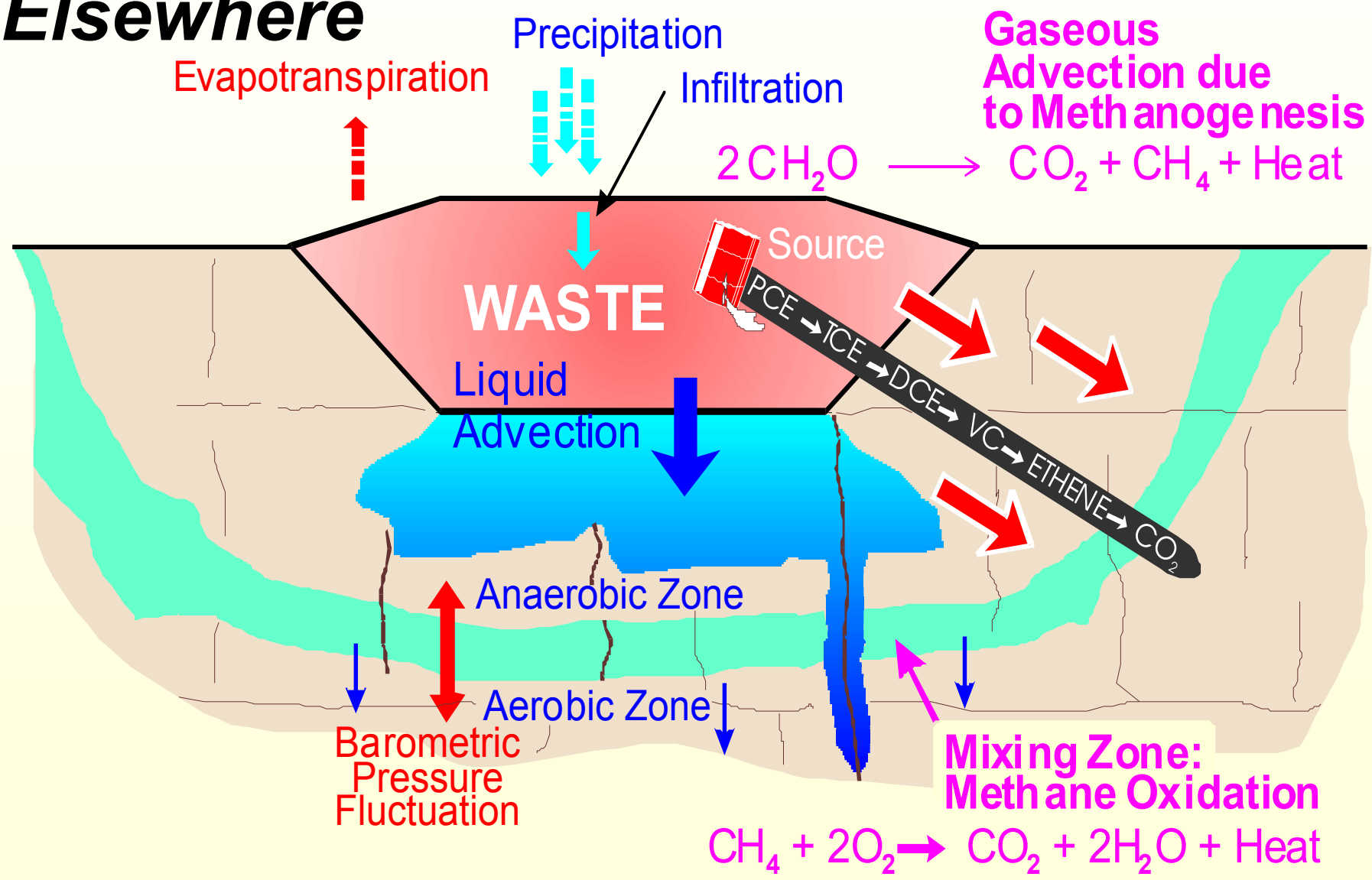
# Landfills Also Emit a lot of Heat



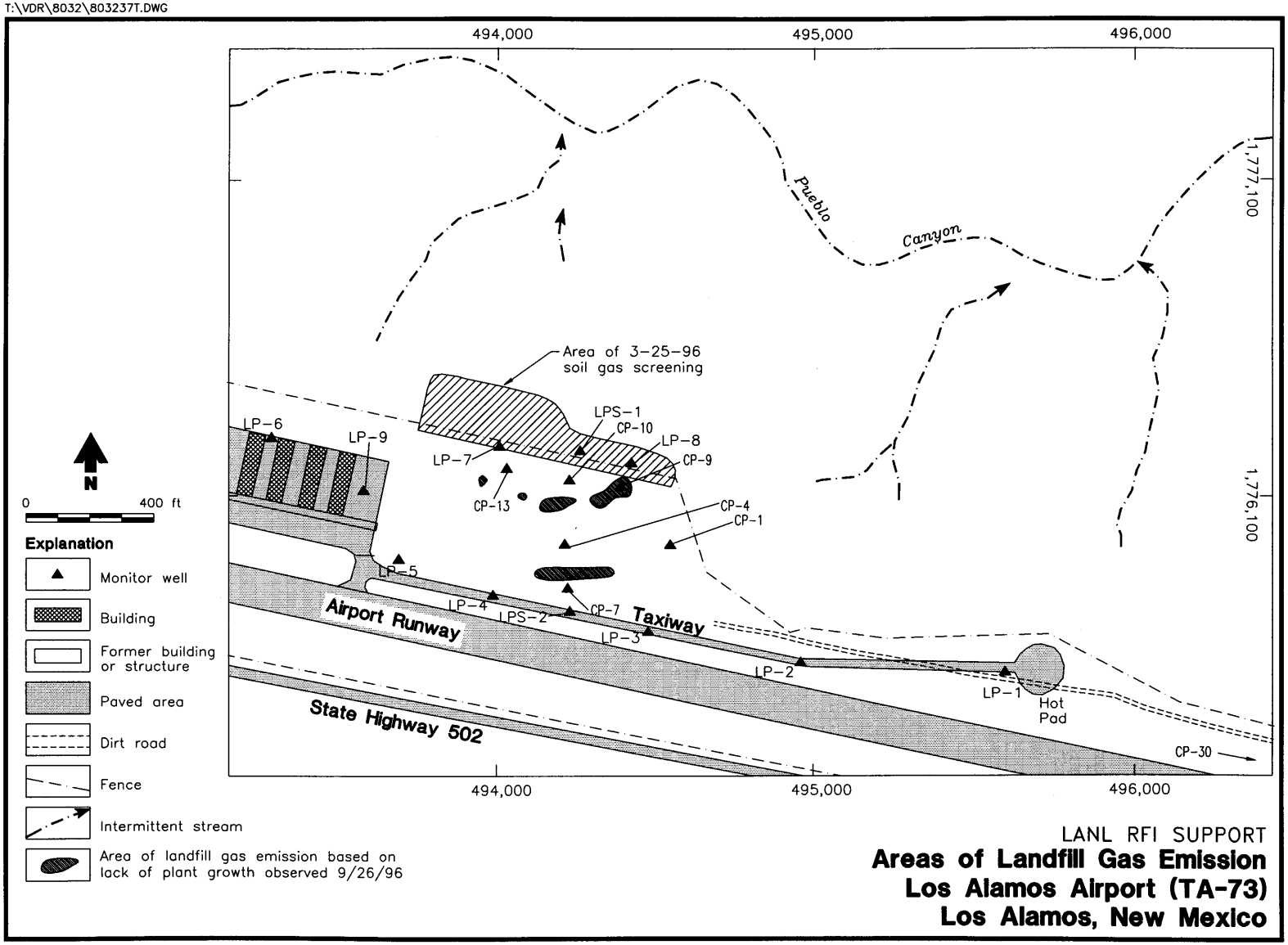
# Heat Flux Varies with Time and Depth



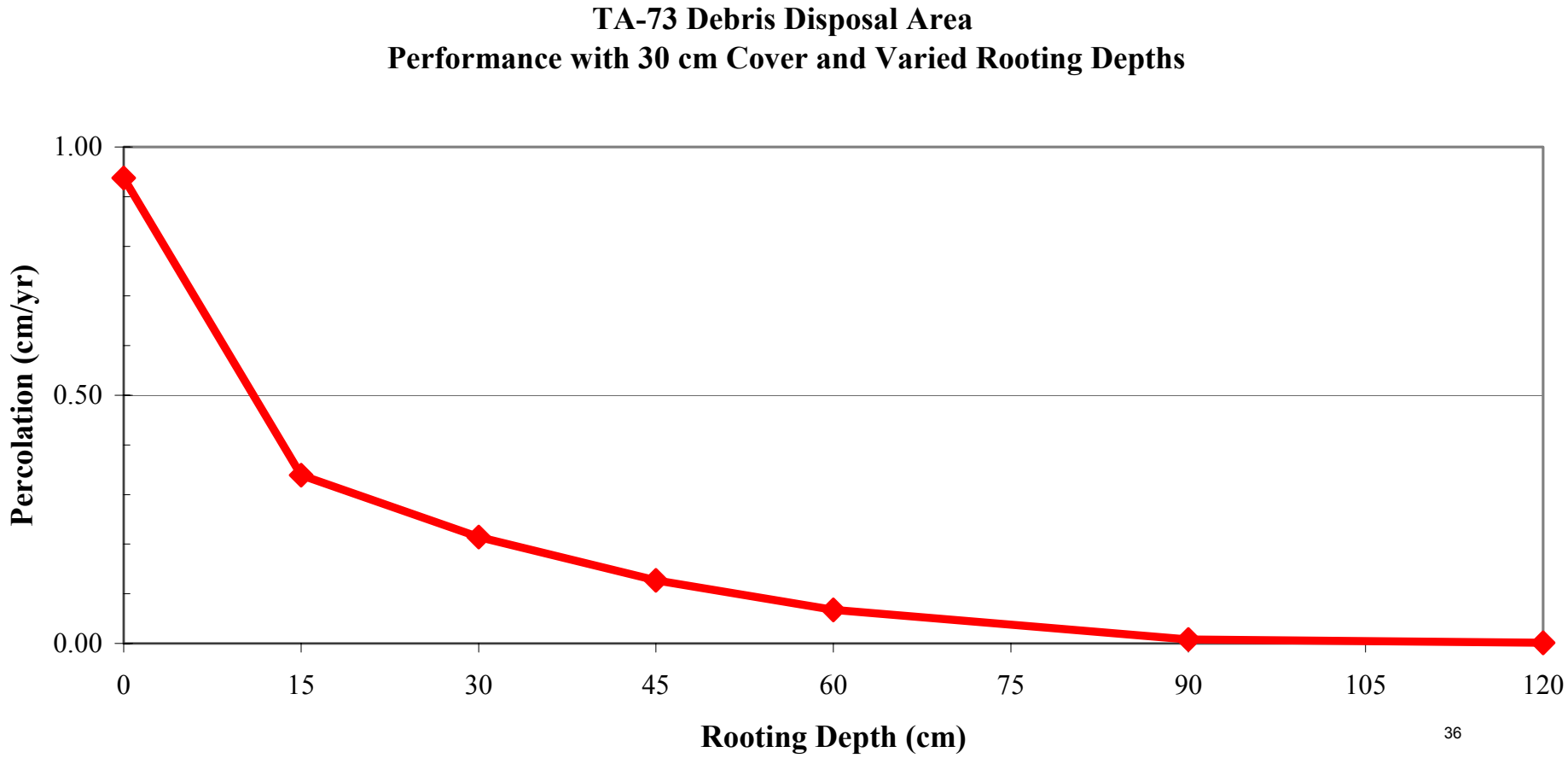
# A Cover Could Create Problems Elsewhere



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

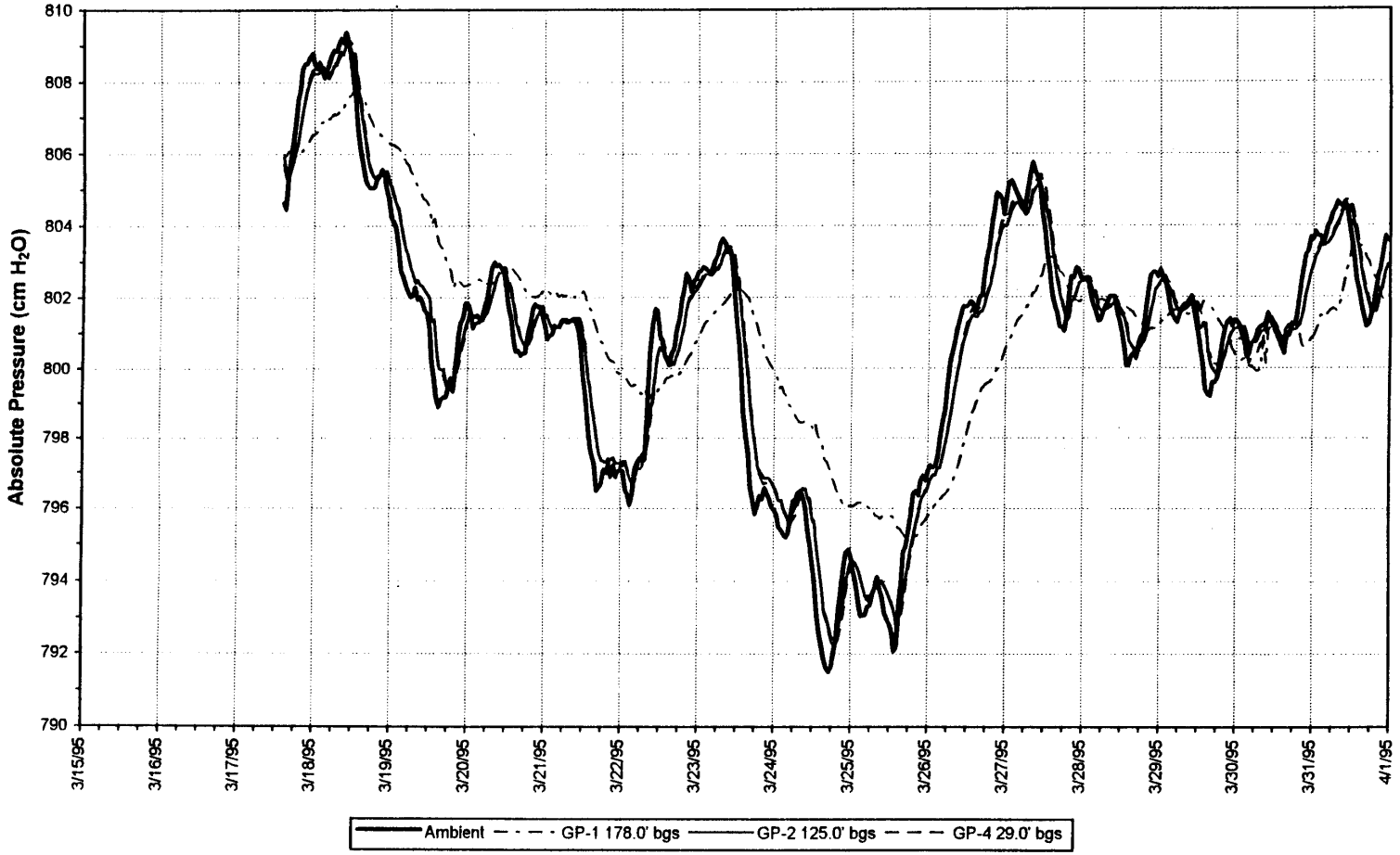


# Percolation on a Finer-Textured Soil

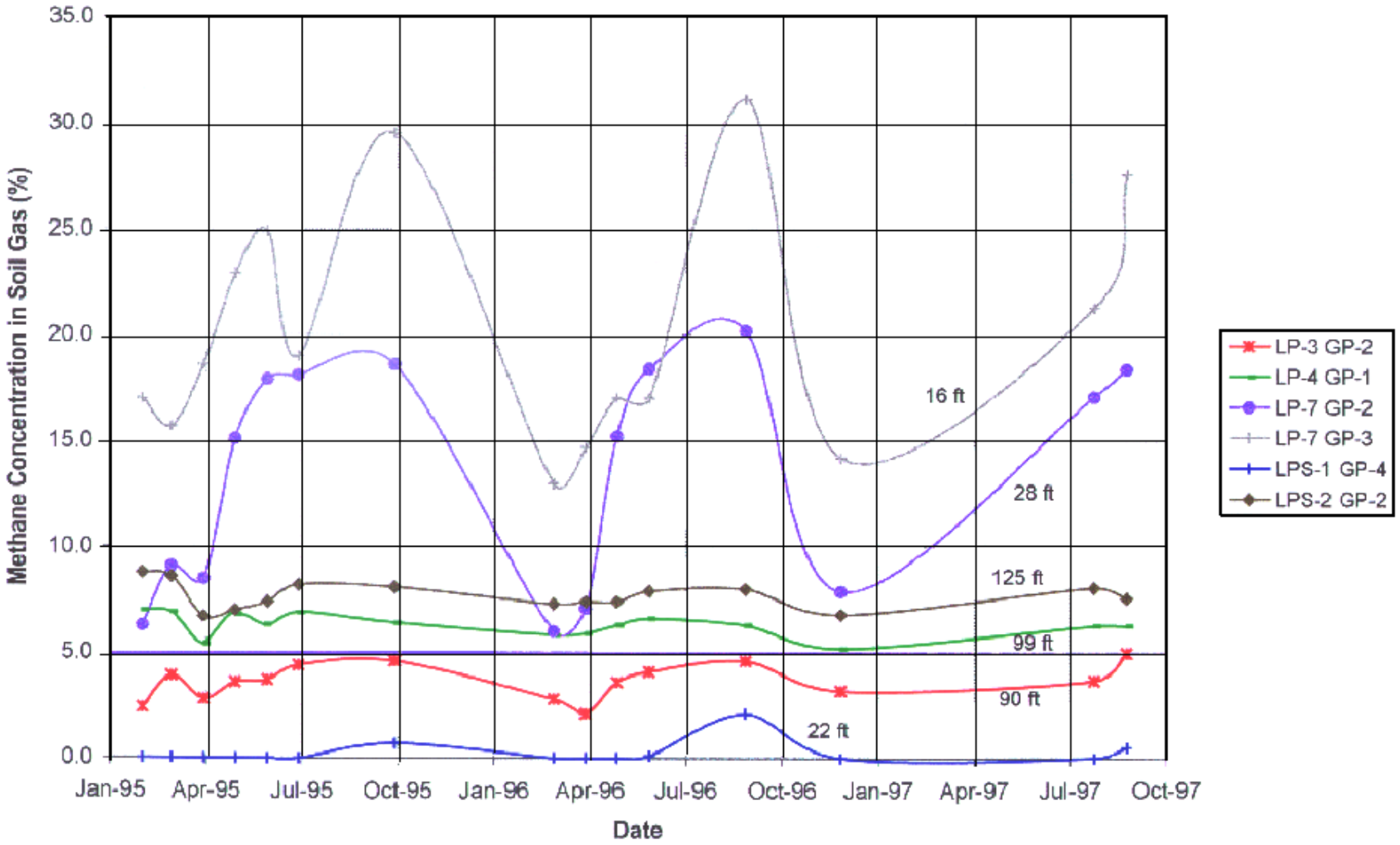


# *No Oxygen, No Roots, No T in ET*

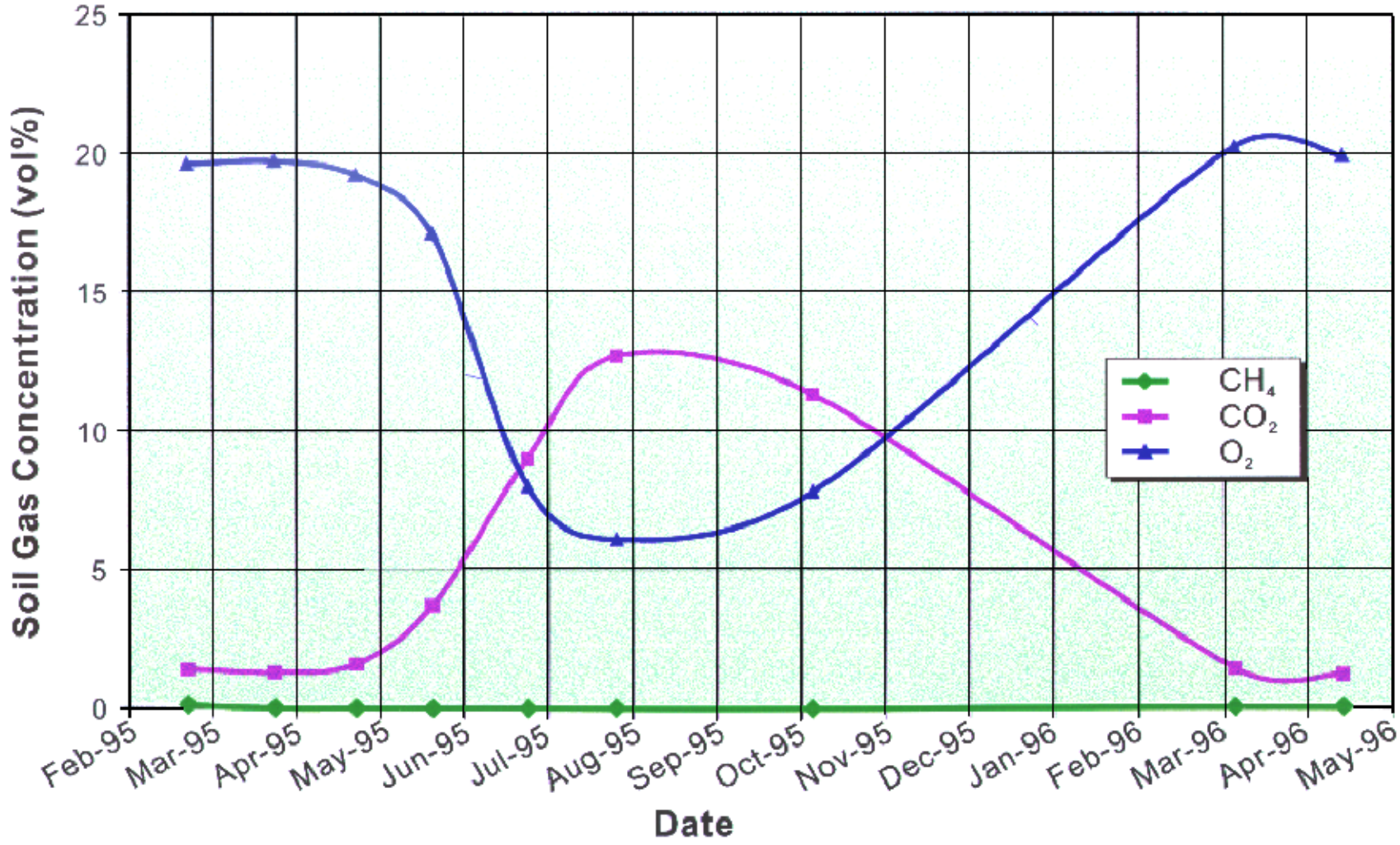
# Barometric Pressure Patterns Vary Over Time



# Methane Often Peaks in Summer



# *Seasonal Changes in Gas Profiles are Common*



# *Summary*

- *Plant roots need oxygen*
- *Compaction reduces aeration and can reduce performance*
- *We can understand and monitor gas-free vegetated landfill covers*
- *We do not yet understand all of the gas-vegetation-energy balance-water balance processes*
- *Our lack of understanding will likely lead to failed alternative landfill covers*