Idaho National Engineering and Environmental Laboratory

Landfill Gas Effects on Vegetation and on Water Balance

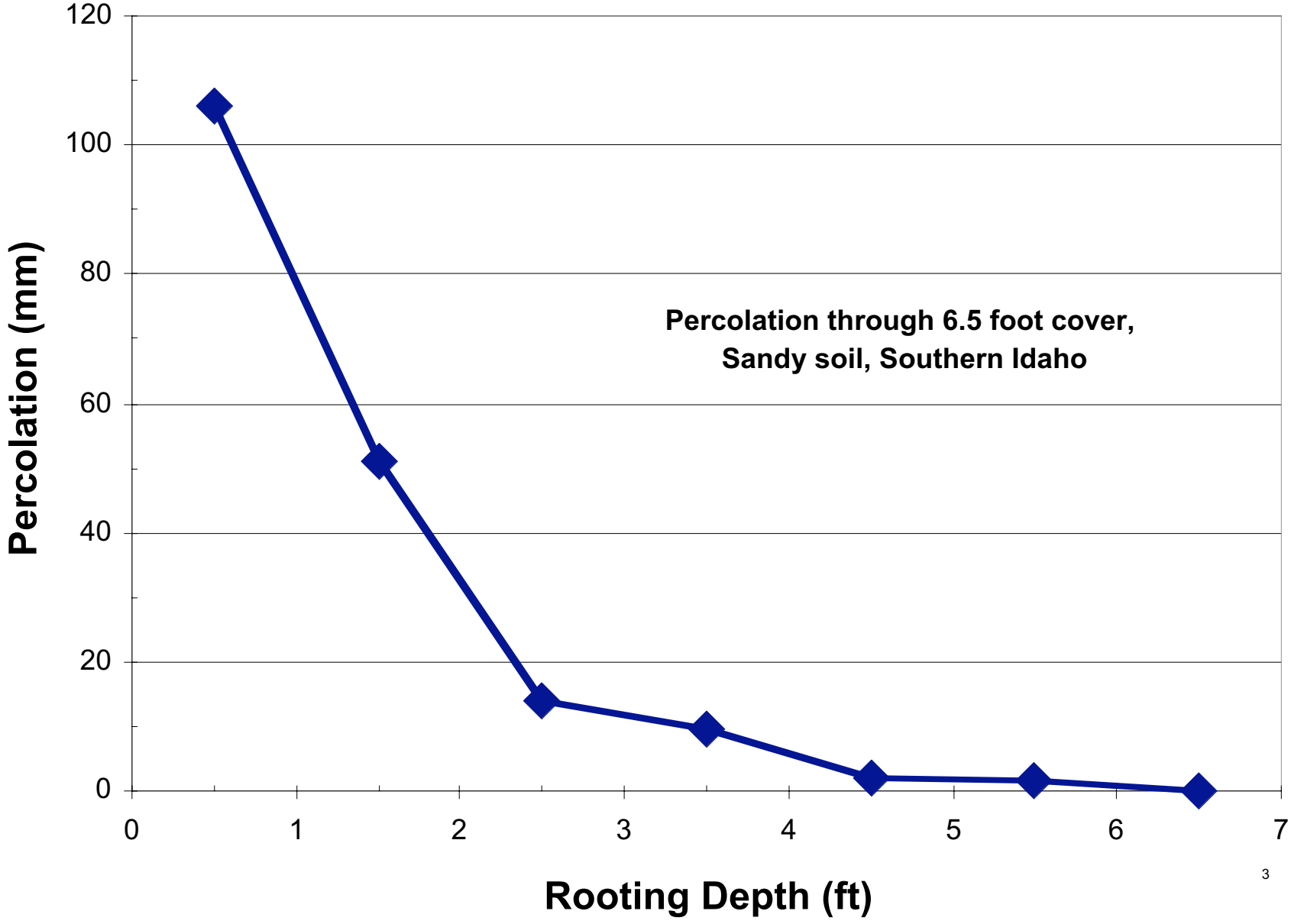
Mark D. Ankeny and
Gregory J. Stormberg

October 16, 2003

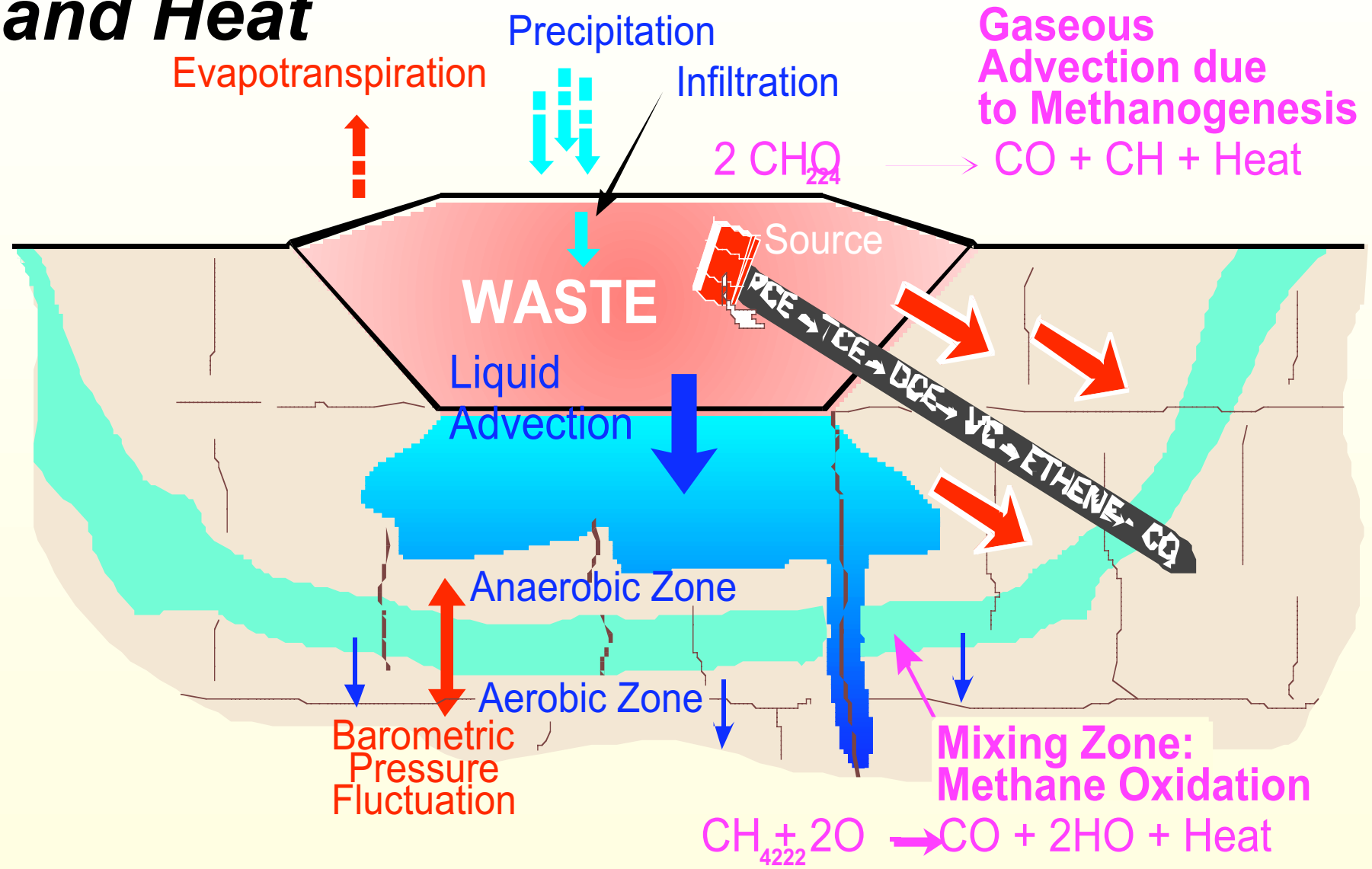
Outline

- *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

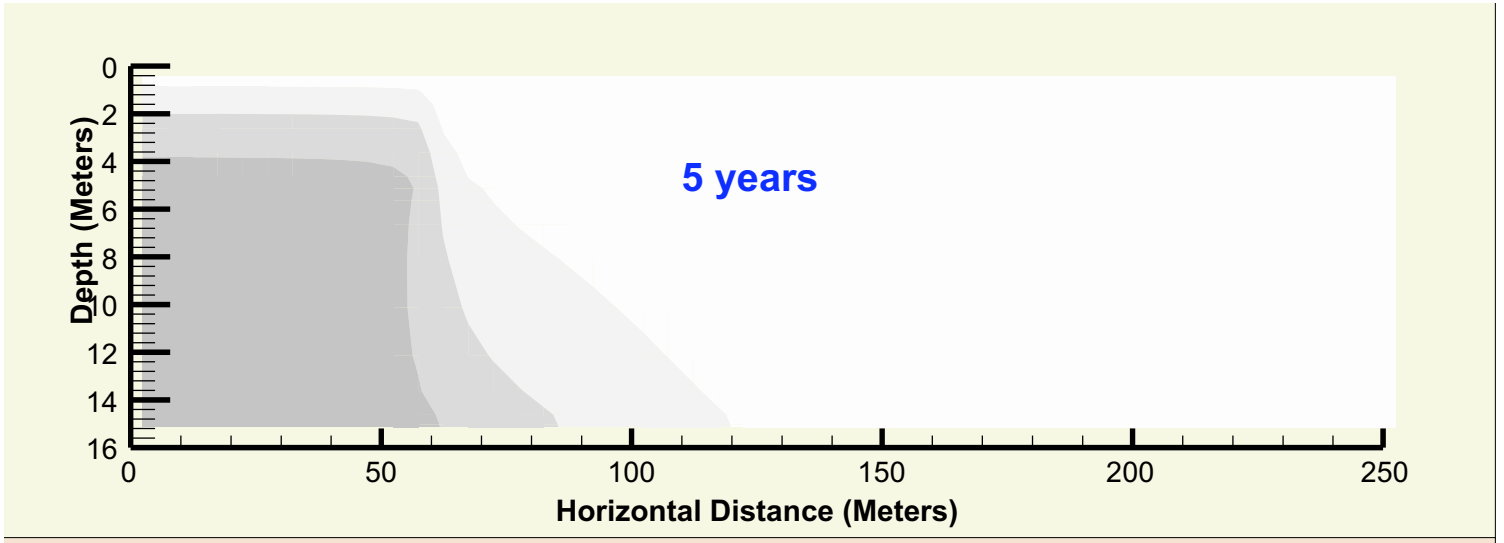


Landfills Generate a lot of Water, Gases and Heat

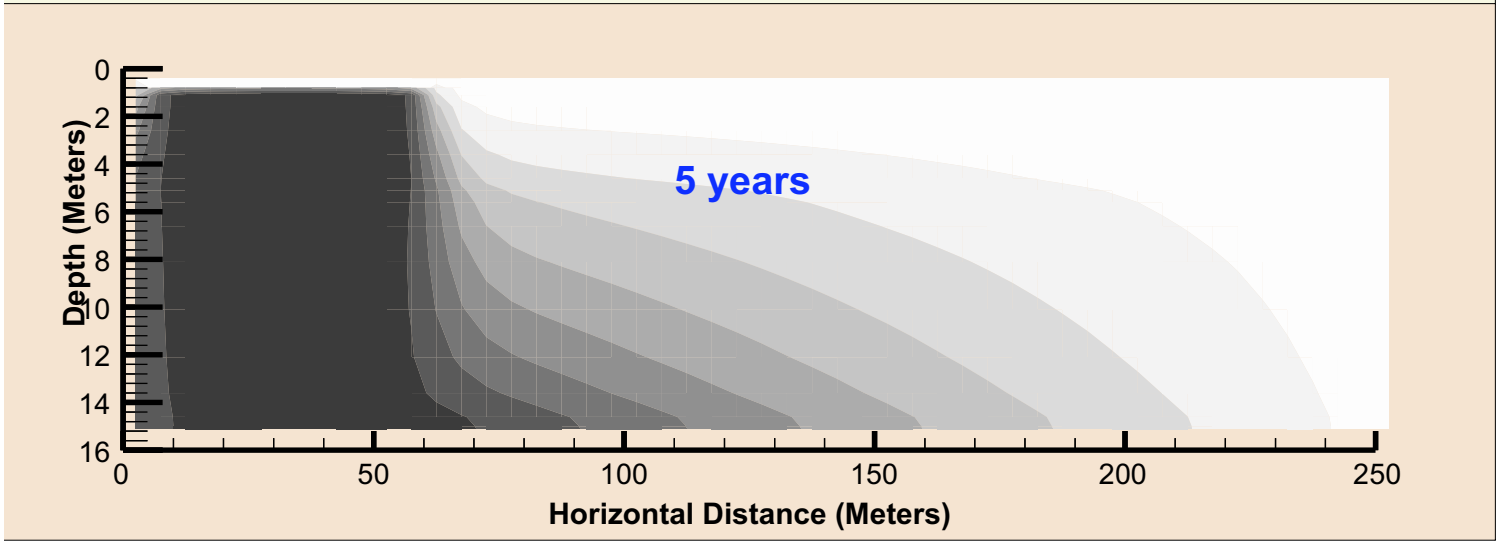


Landfill Cover Gas Movement: Up and Down

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

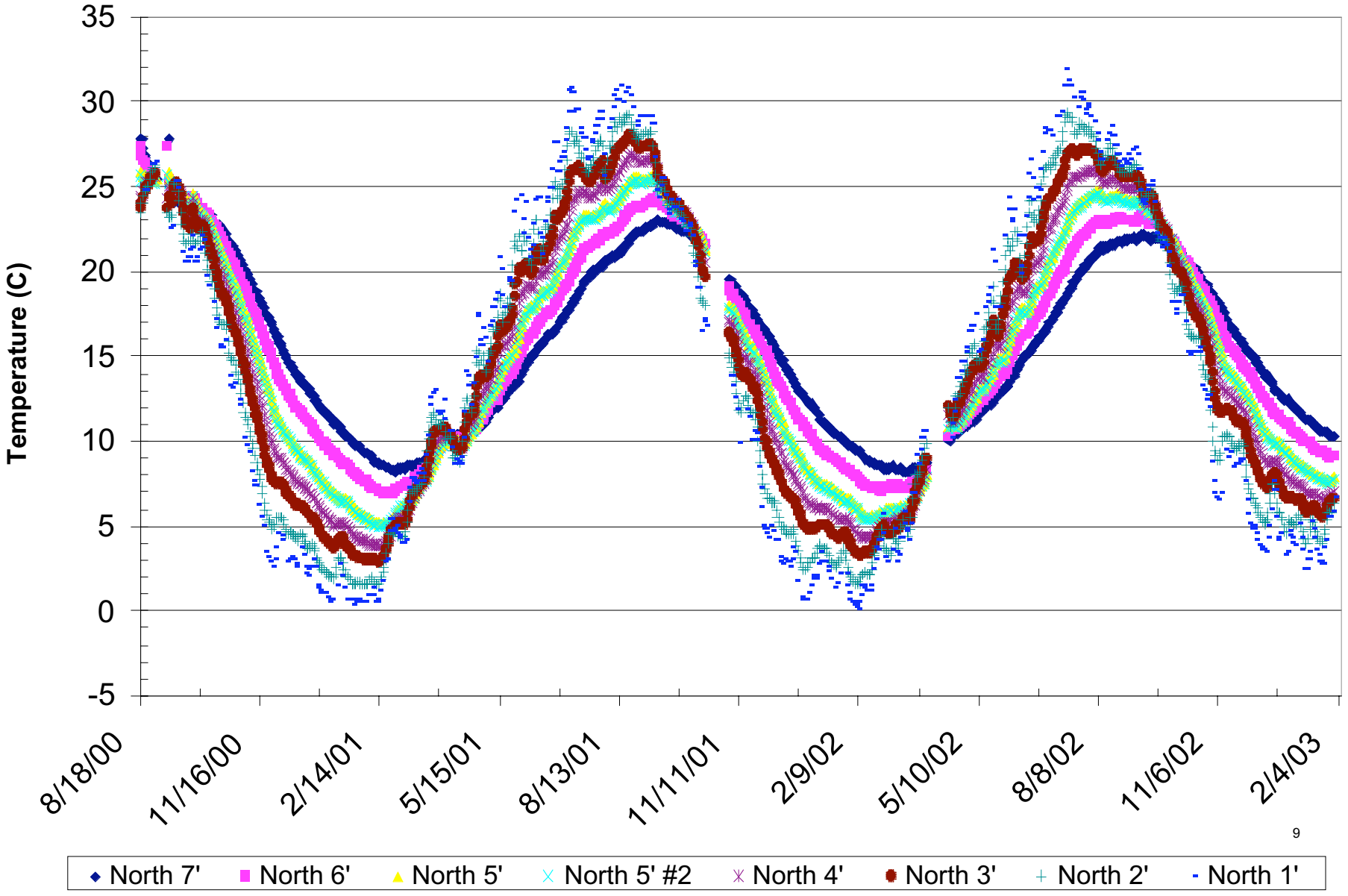
$$272\ m^3\ CH_4 * \frac{1mol}{0.0224\ m^3/mol} * 1\ m^2 * \frac{36\ g\ H_2O}{1mol\ CH_4} * \frac{1\ kg}{1000\ g} * \frac{0.001\ m^3}{1\ kg} = \frac{0.437\ m^3\ water}{1\ m^2\ landfill\ surface}$$

44 cm of new water in the profile

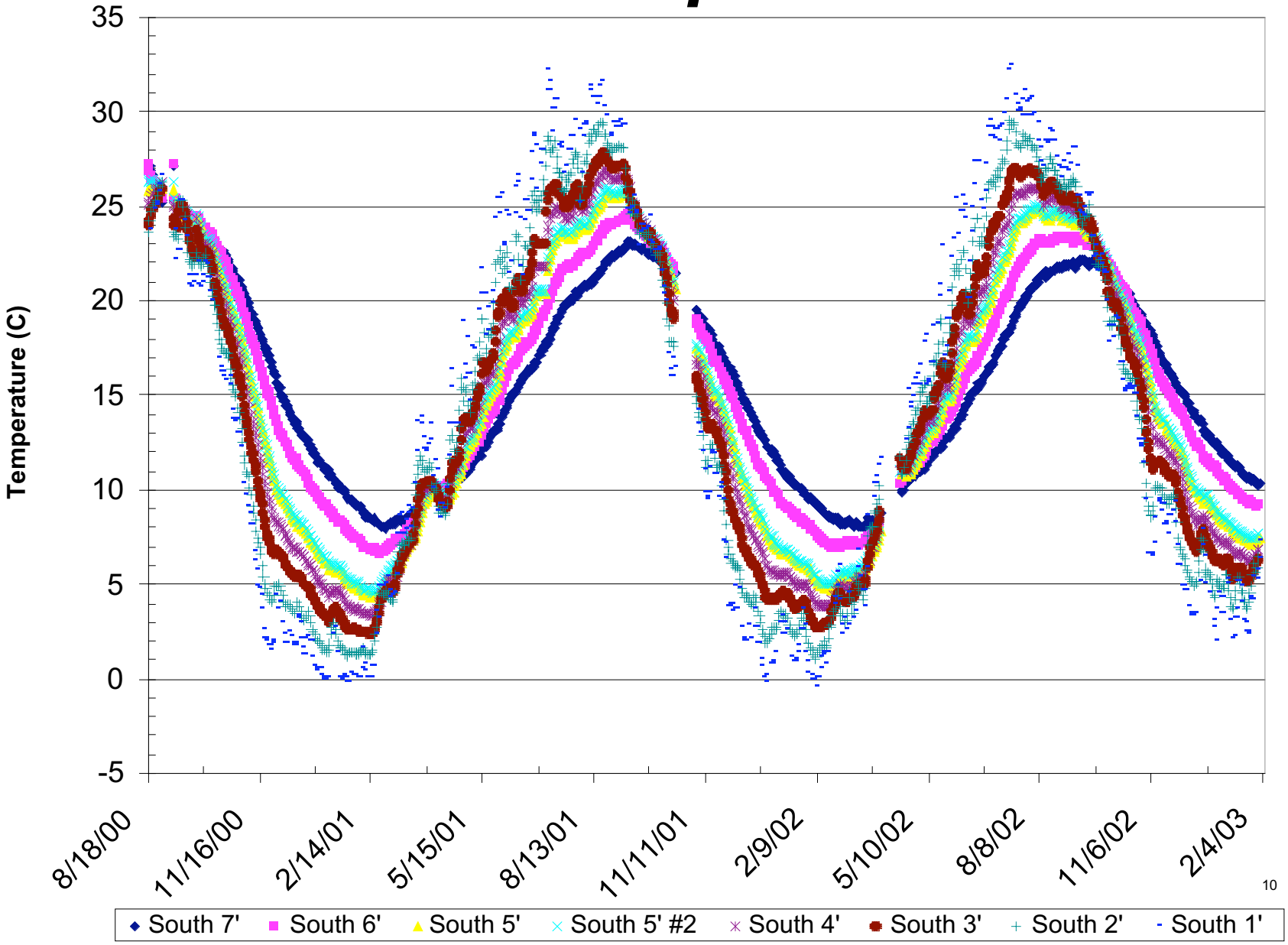
And loss of water holding capacity

Southwest Idaho

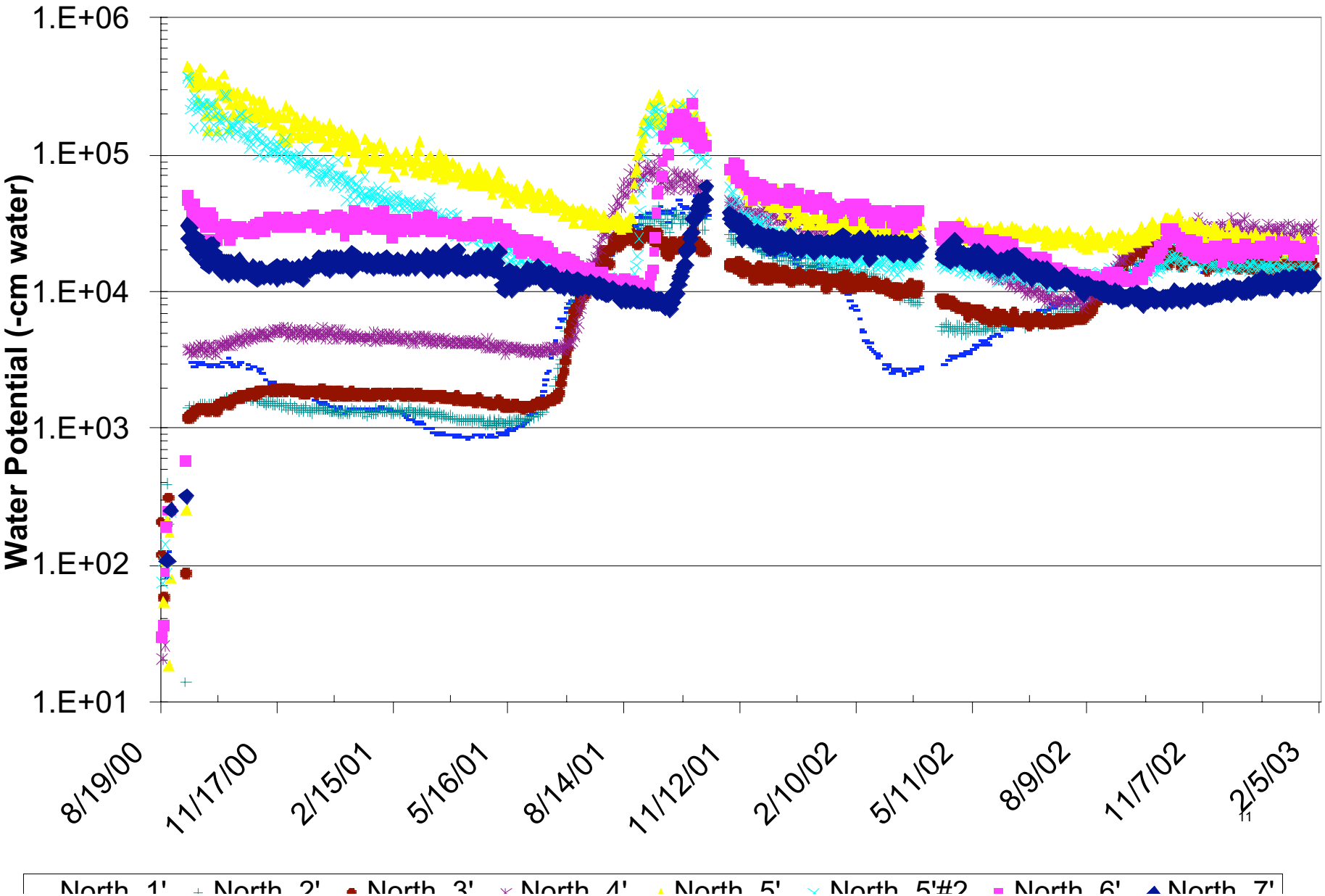
North Profile Temperatures



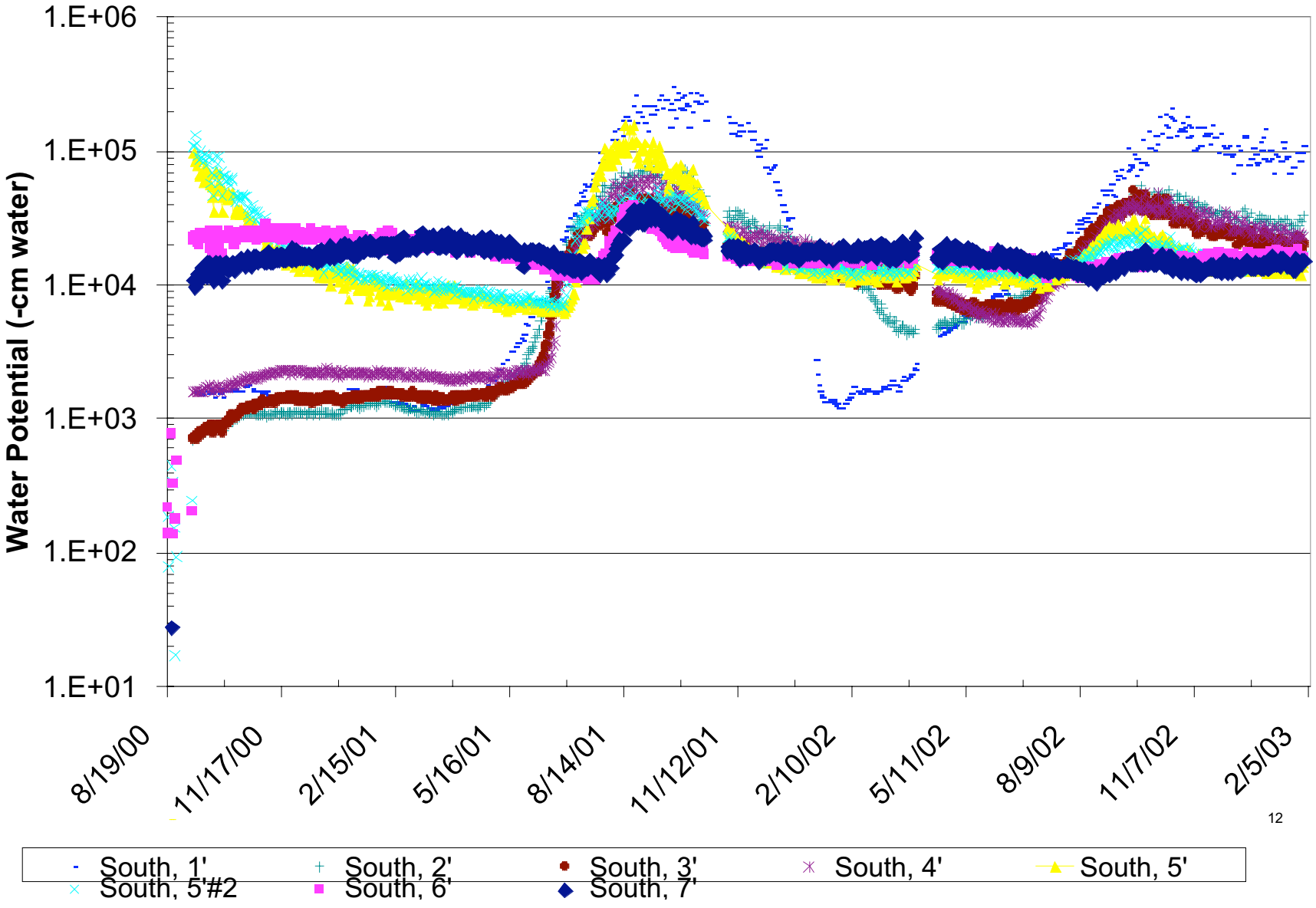
South Profile Temperatures



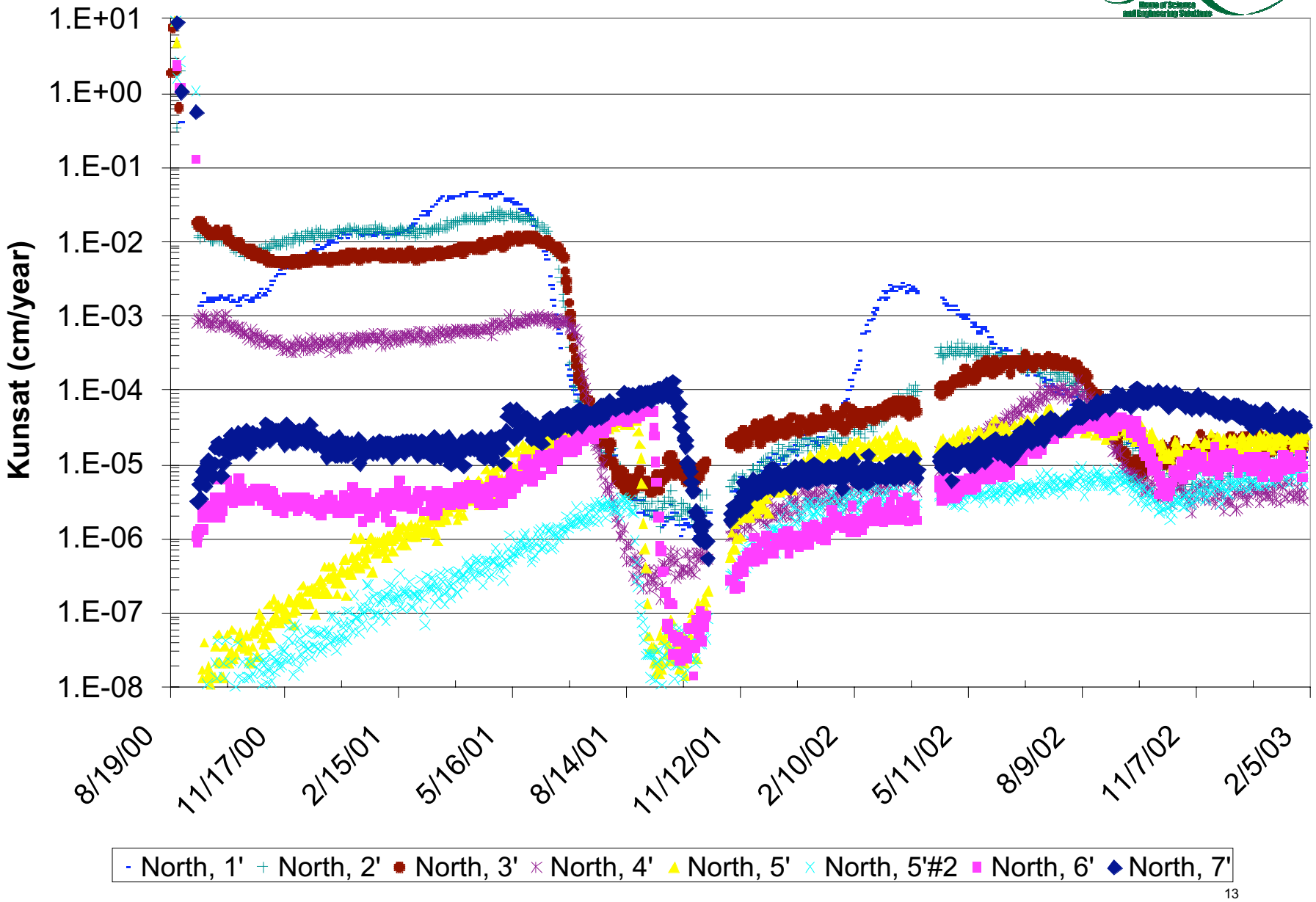
North Profile Water Potentials



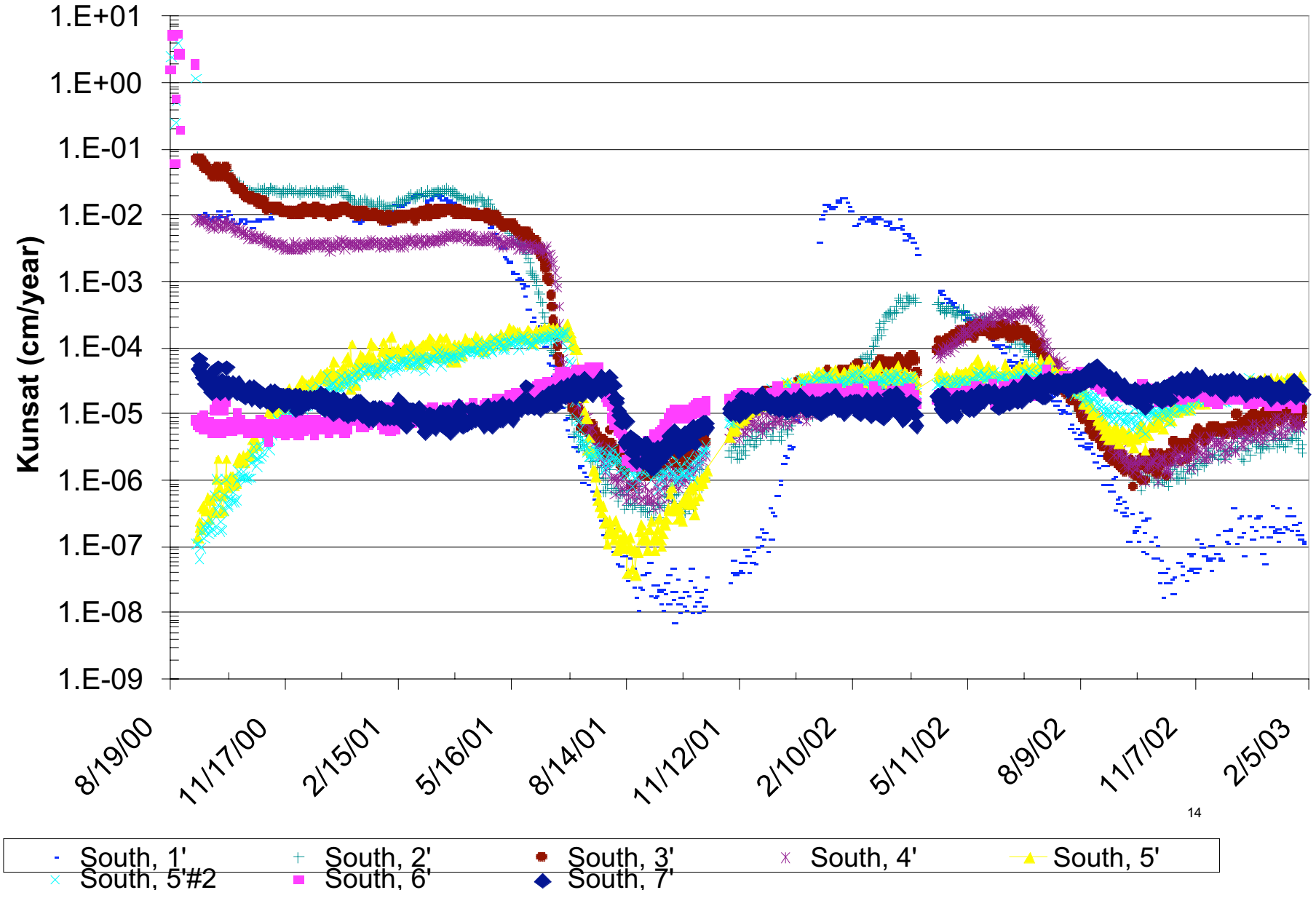
South Profile Water Potentials



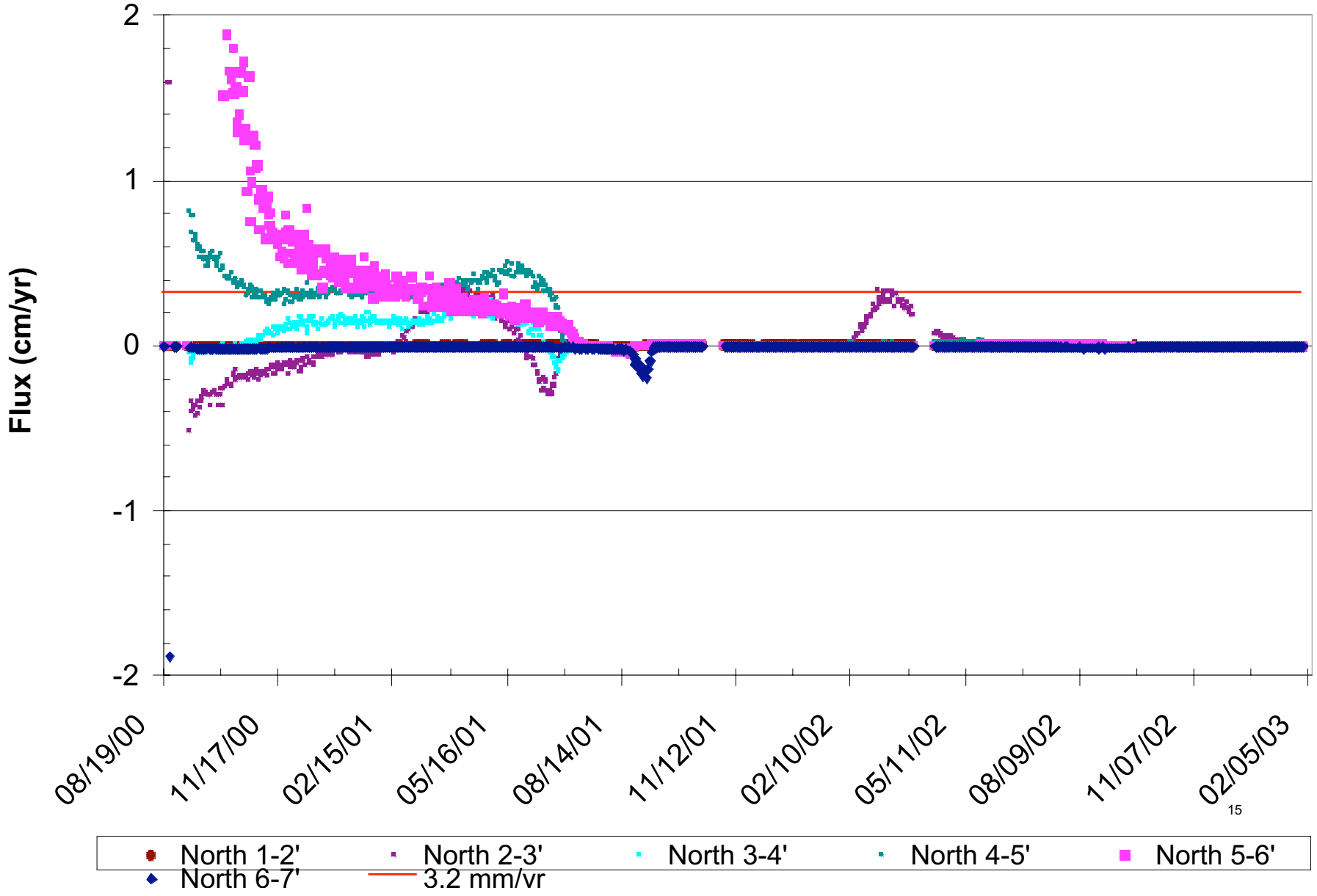
North Profile Unsaturated K's



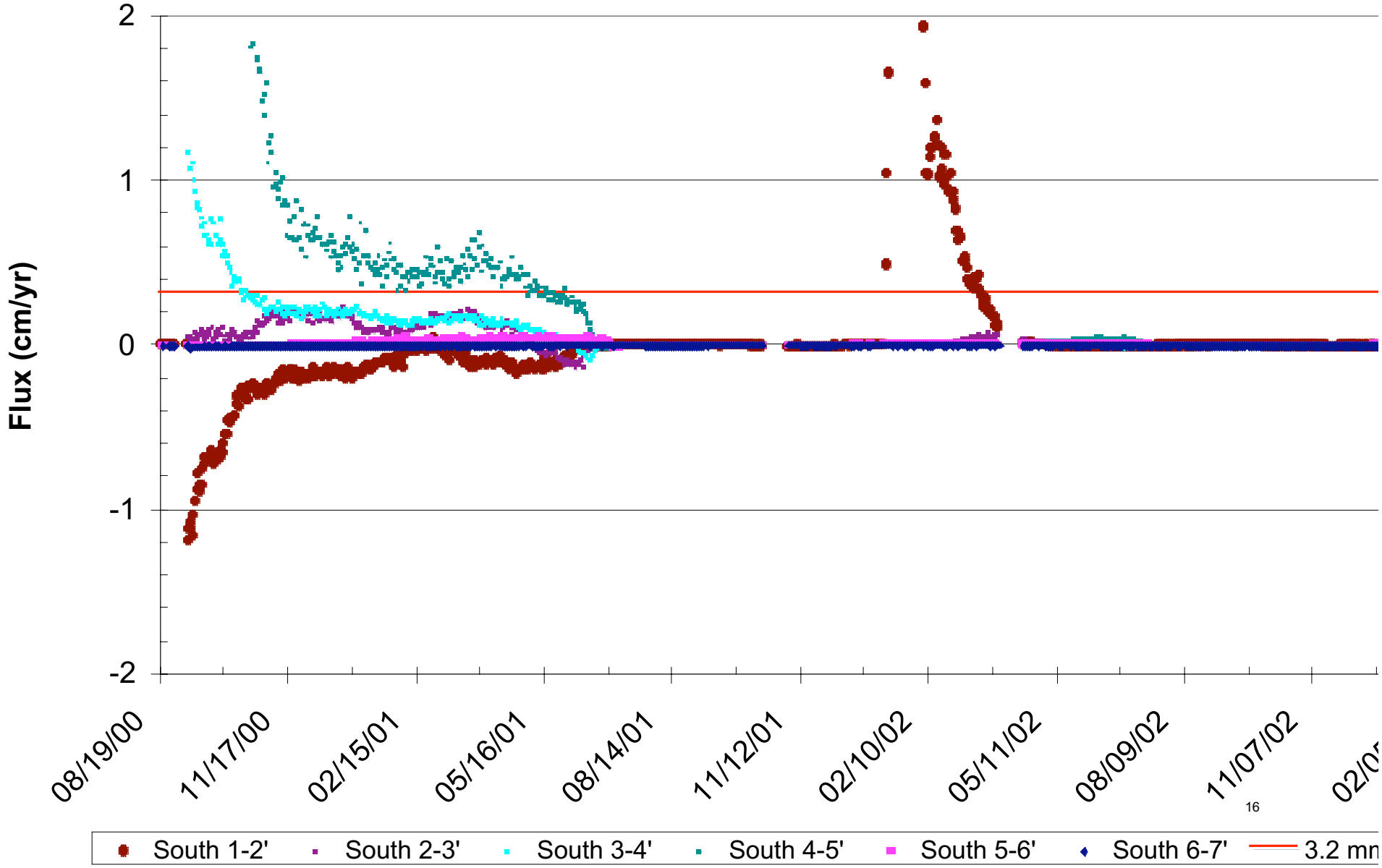
South Profile Unsaturated K's



North Profile Water Fluxes by Depth



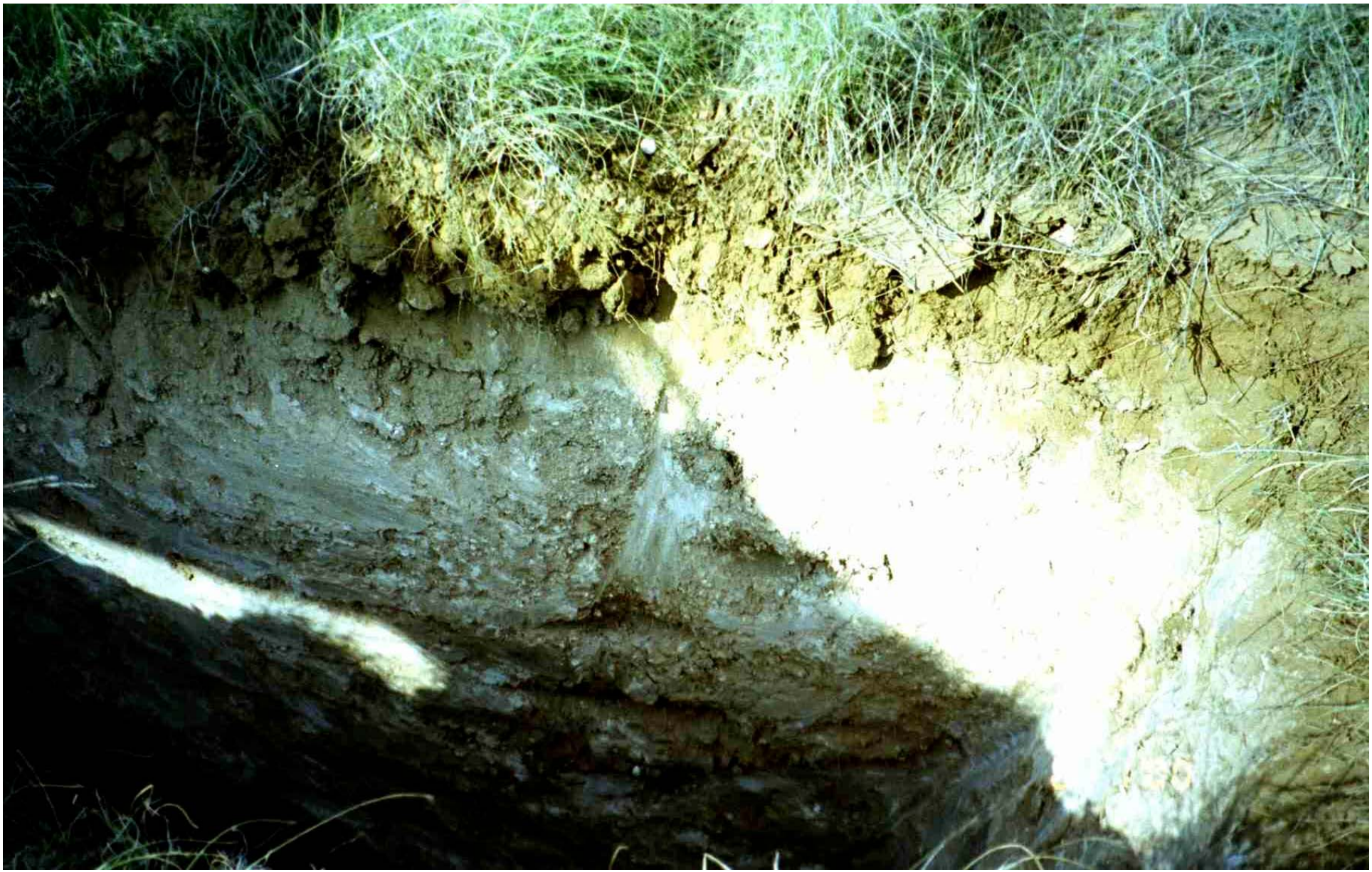
South Profile Water Fluxes by Depth



Native Site: Grama Grass, TX

Native Site: Dry to 8 feet +

Native Soil Profile



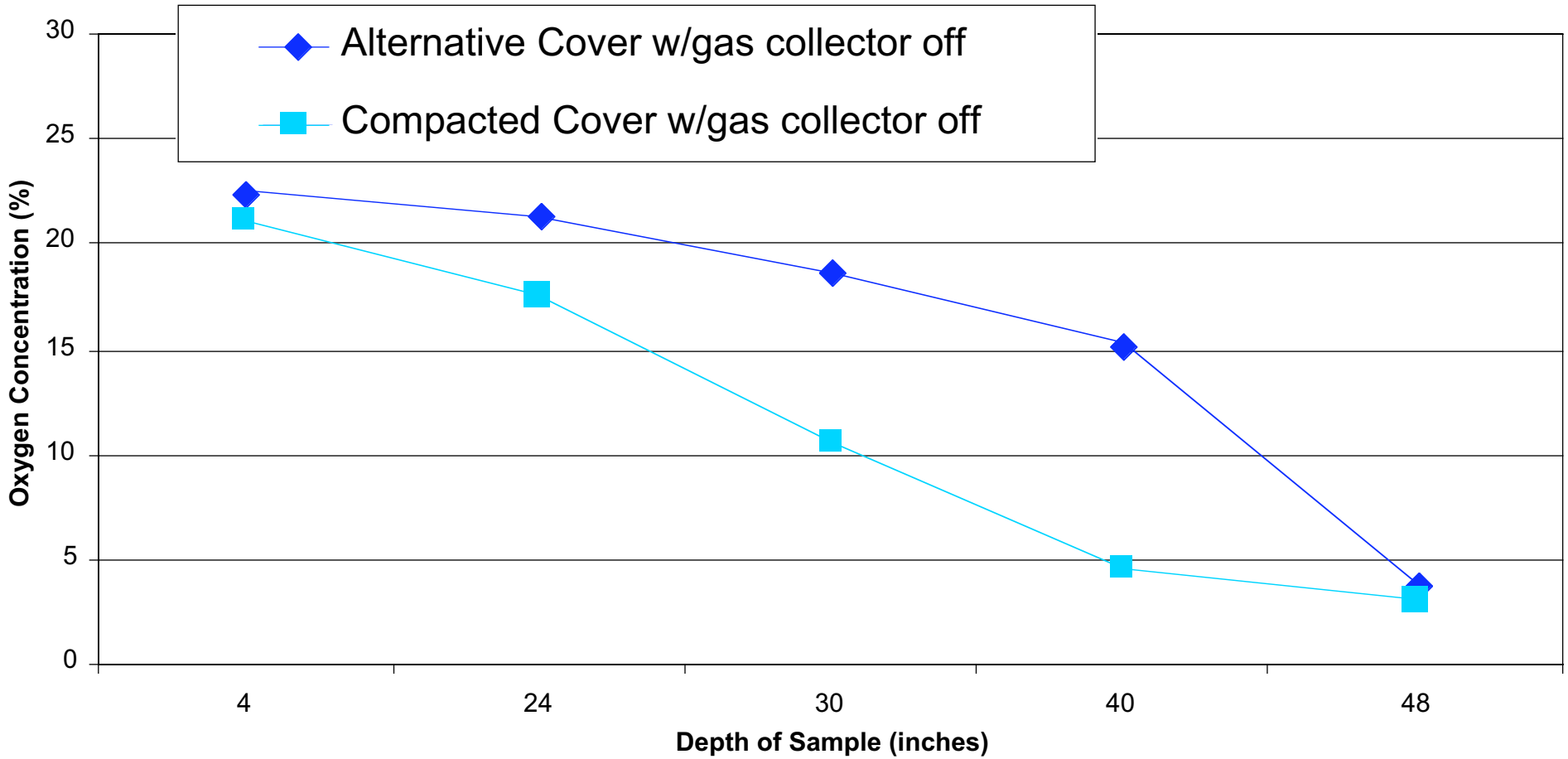
Engineered Cover: ~ 95% Proctor

Engineered Cover . No roots below two feet. Anaerobic

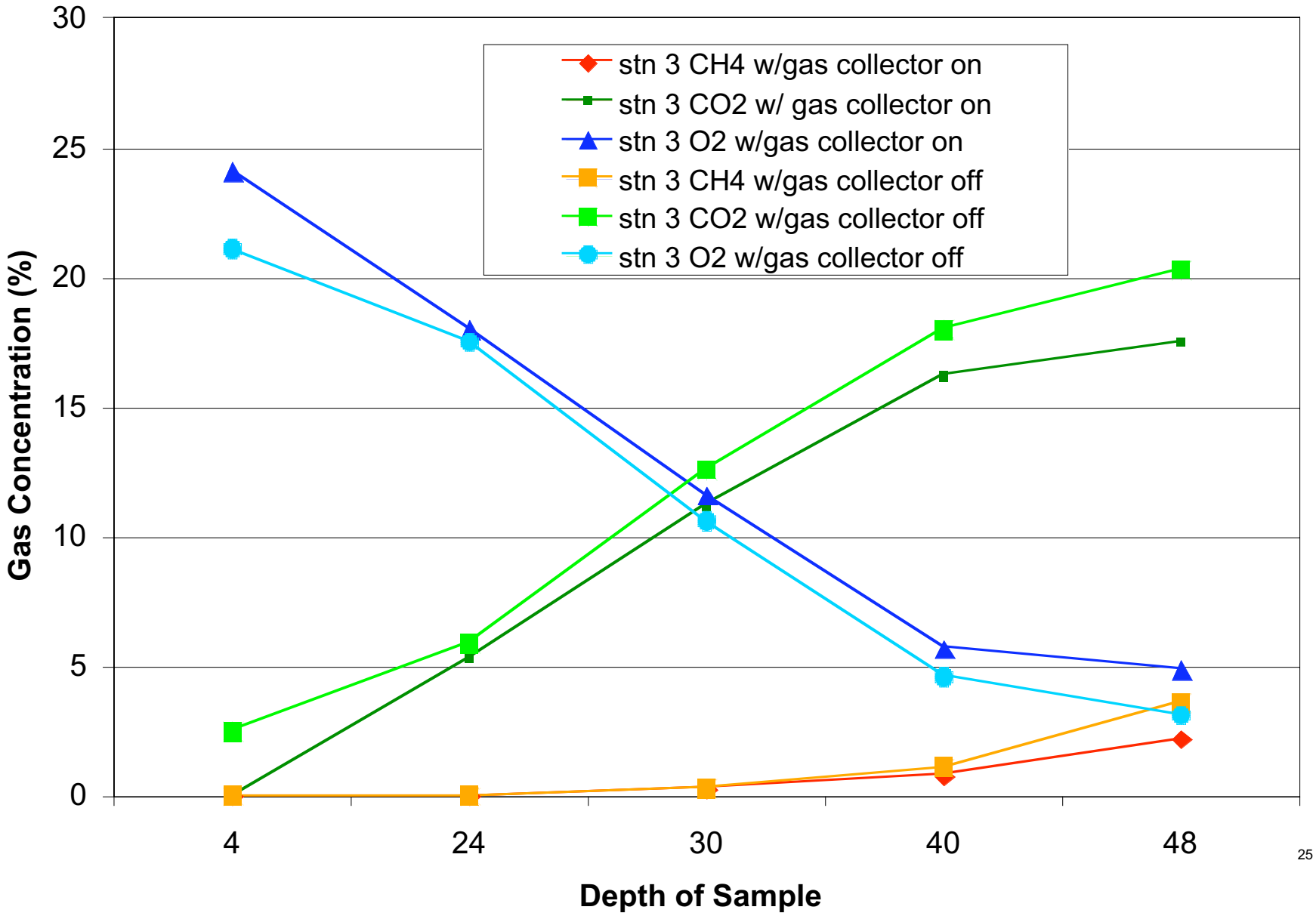
Soil Cover: ~90% Proctor

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

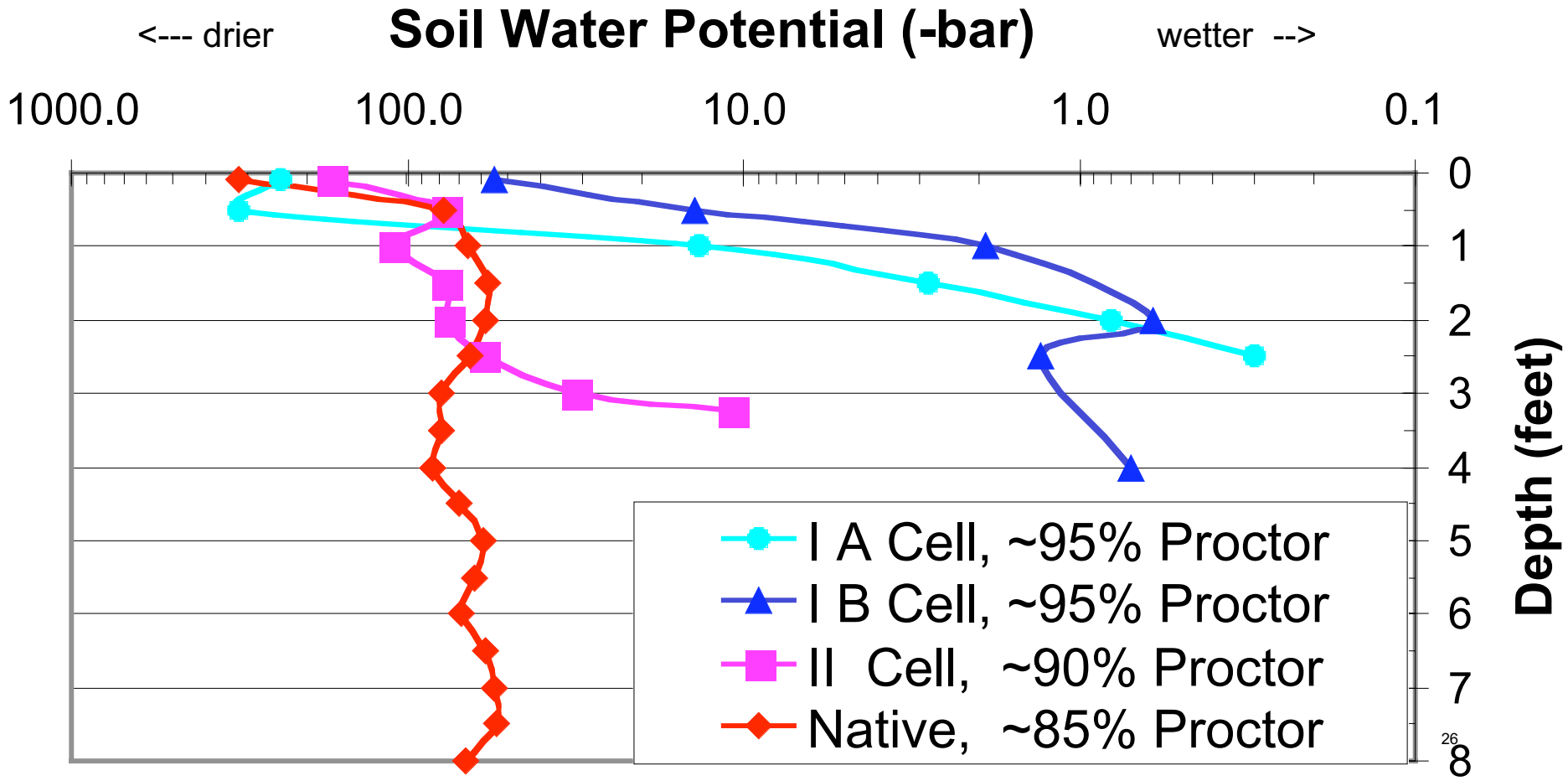
Compaction Can Lead to Reducing Conditions



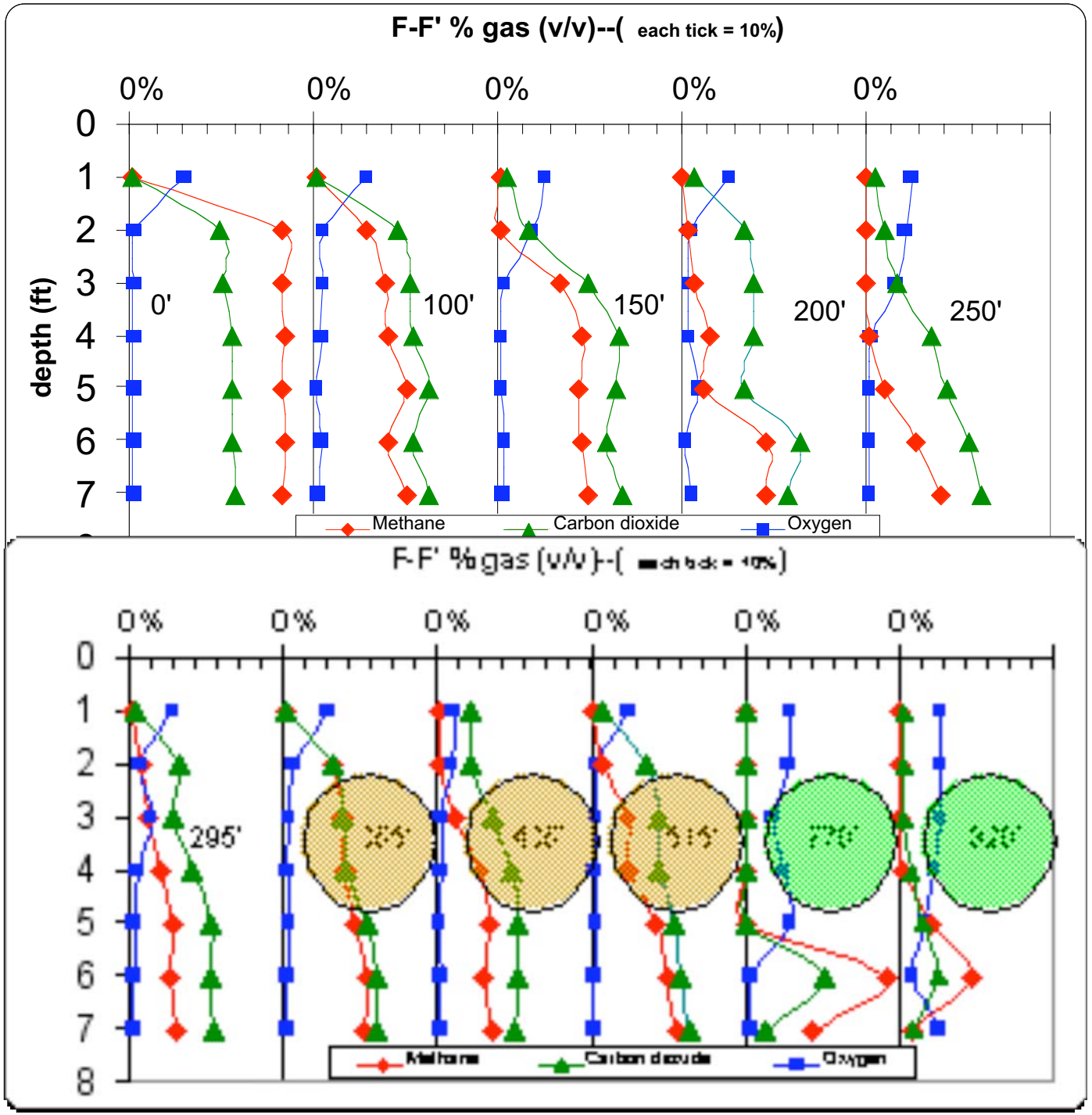
Engineered Cover Gas Profiles



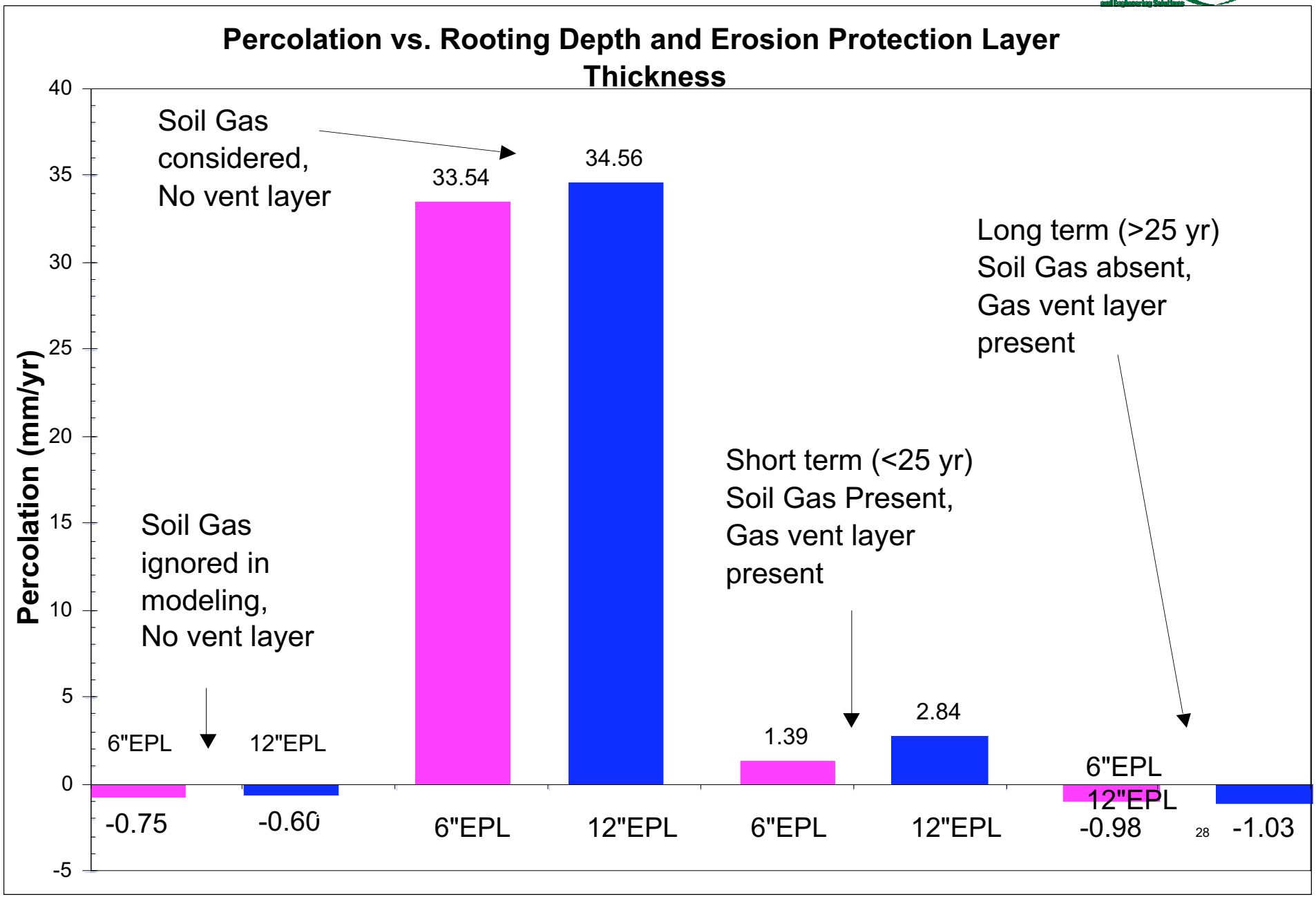
More Compaction, Less Oxygen, Increased Percolation: TX



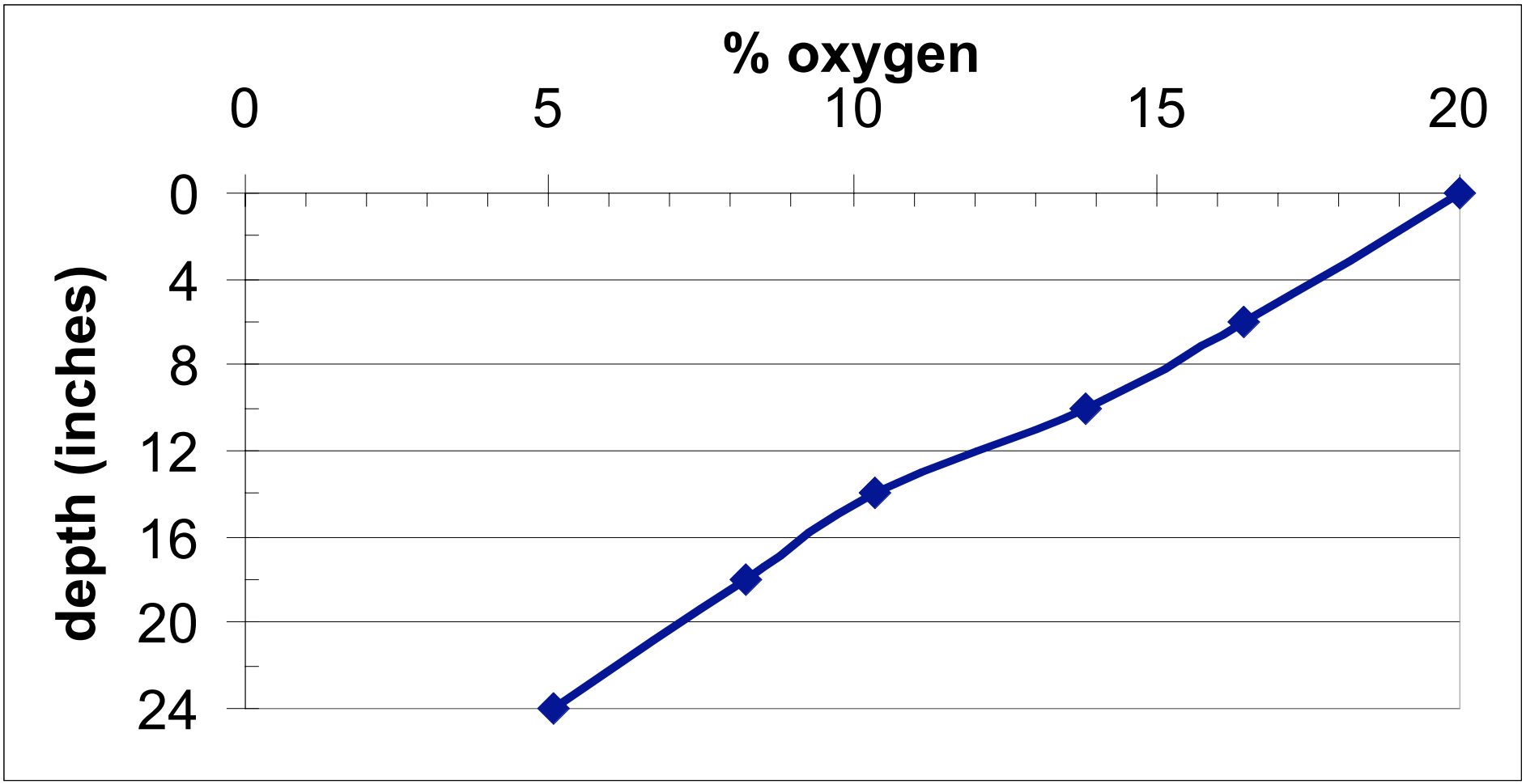
Landfill Gases Can Shut Down Plants: CO



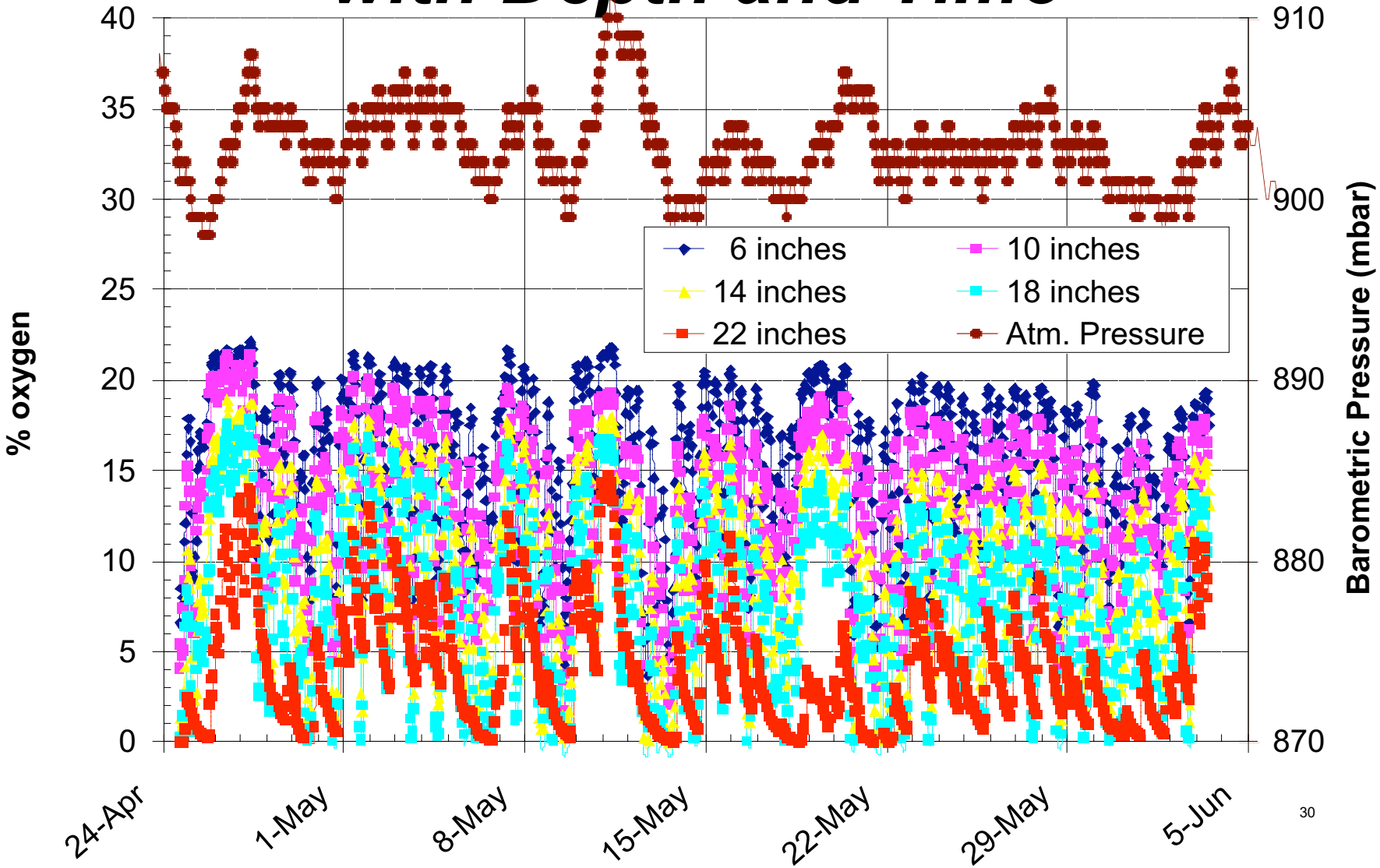
Percolation as Affected by Gas: CO



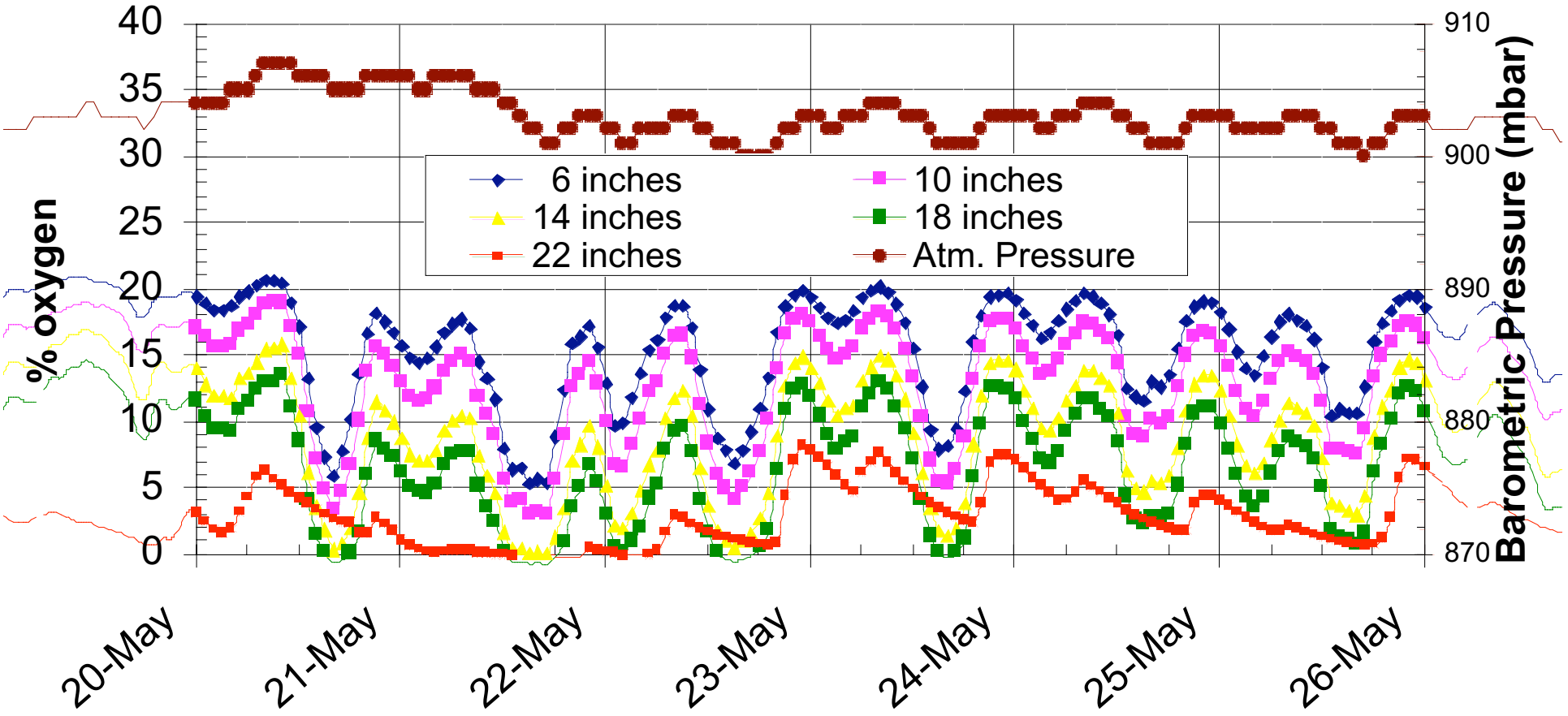
Average Oxygen Concentrations in Landfill Cover Profile: Southern CA



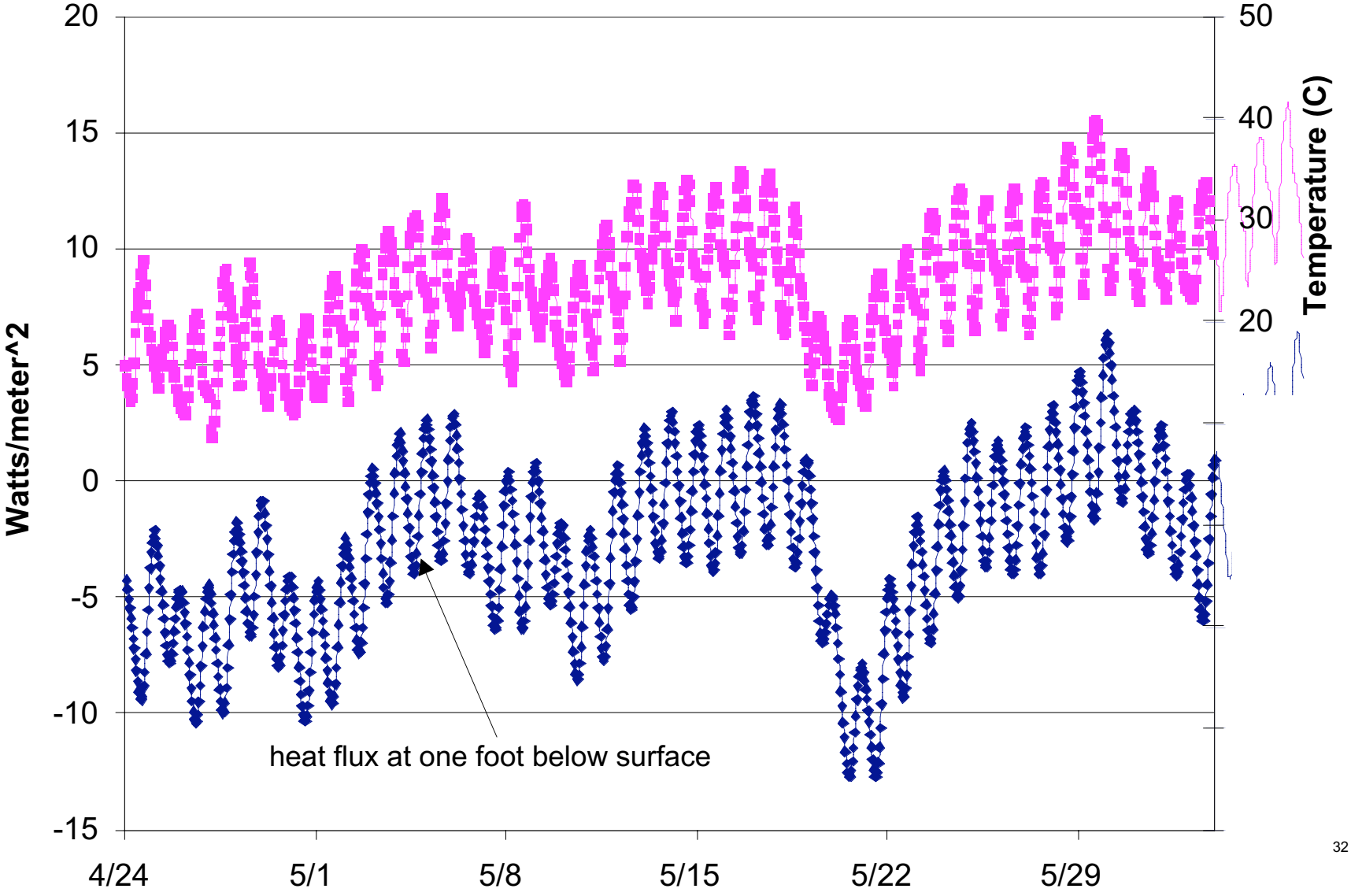
Anaerobic Conditions Change with Depth and Time



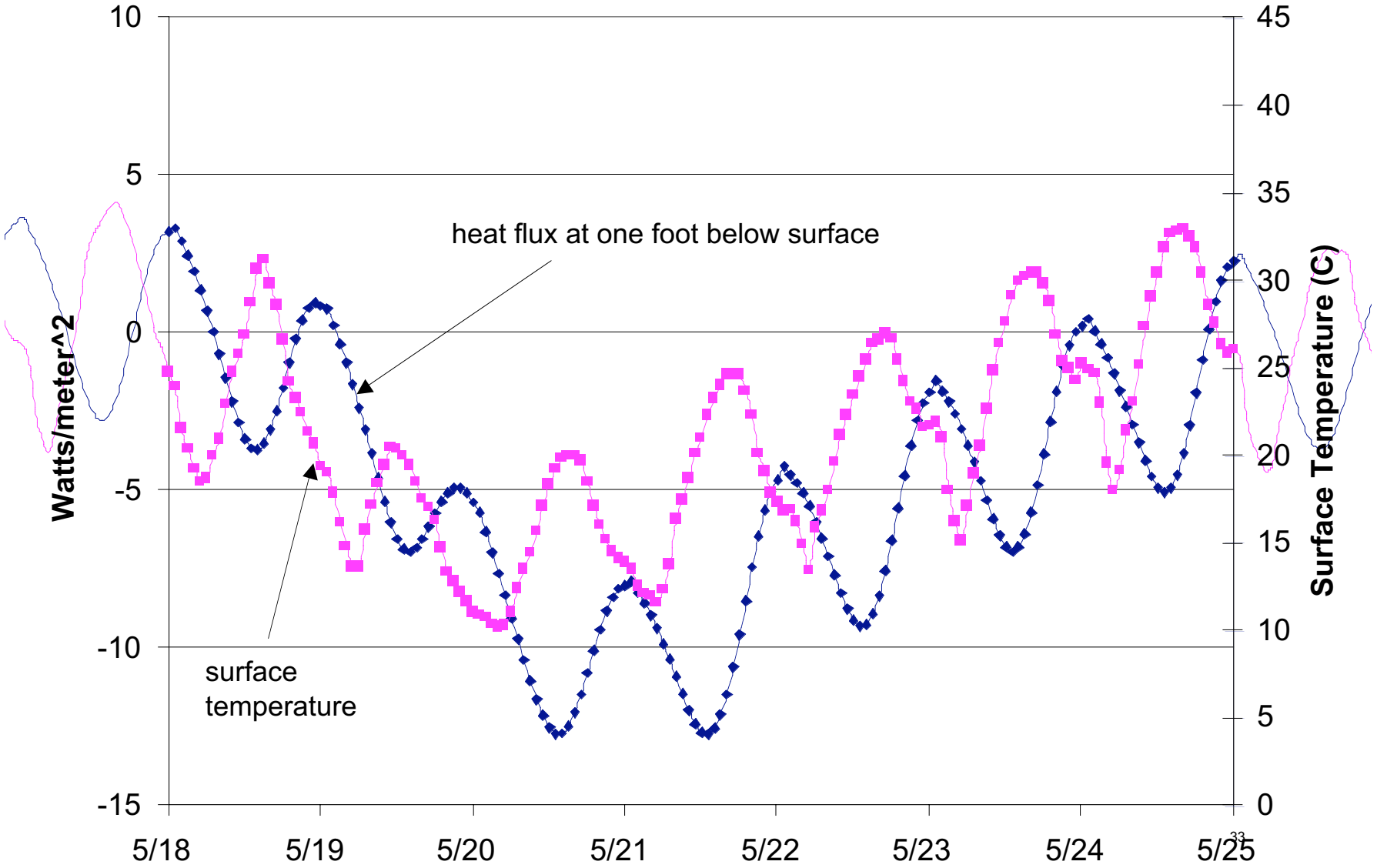
Cover Gas Profiles Vary Diurnally



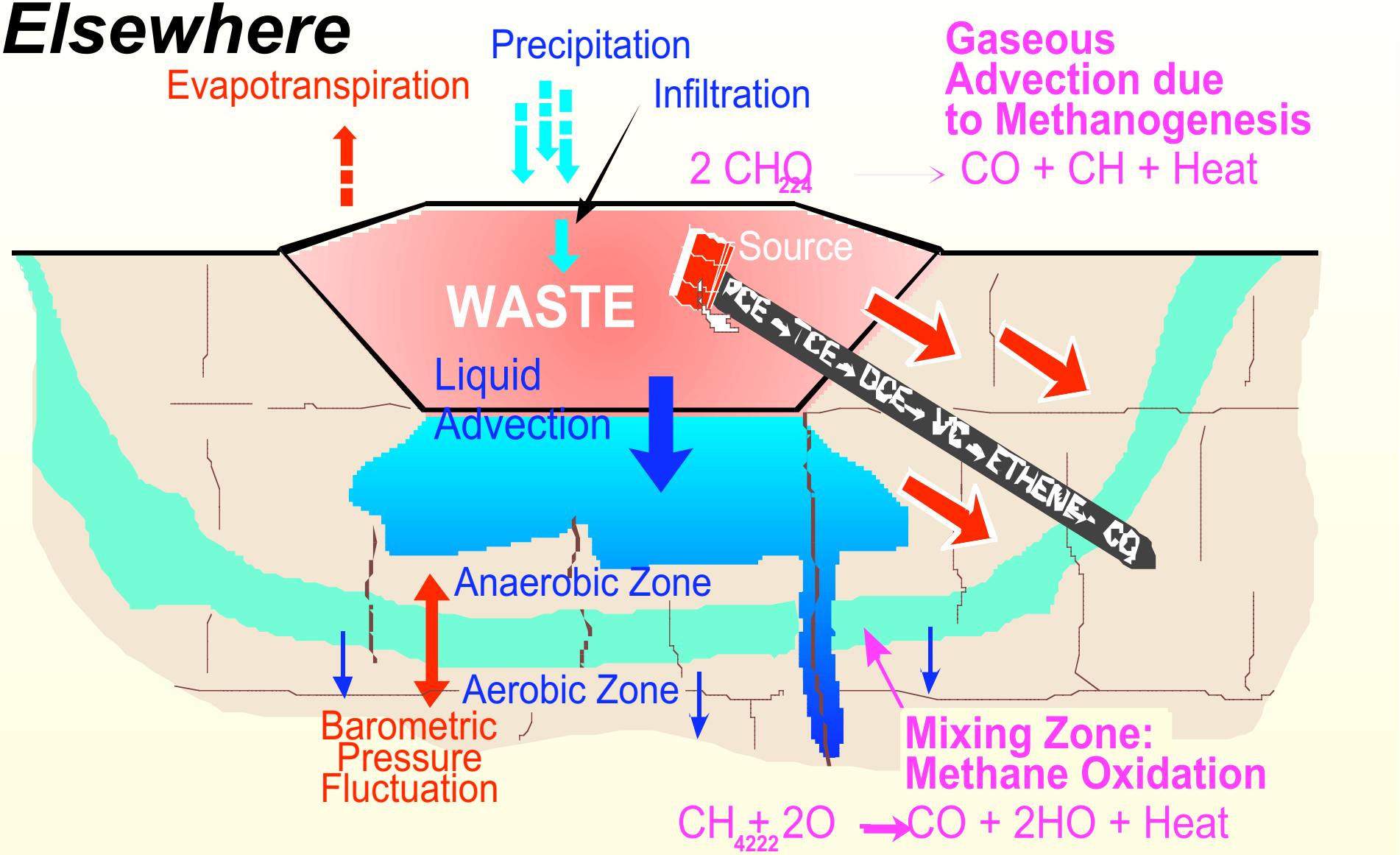
Landfills Also Emit a lot of Heat



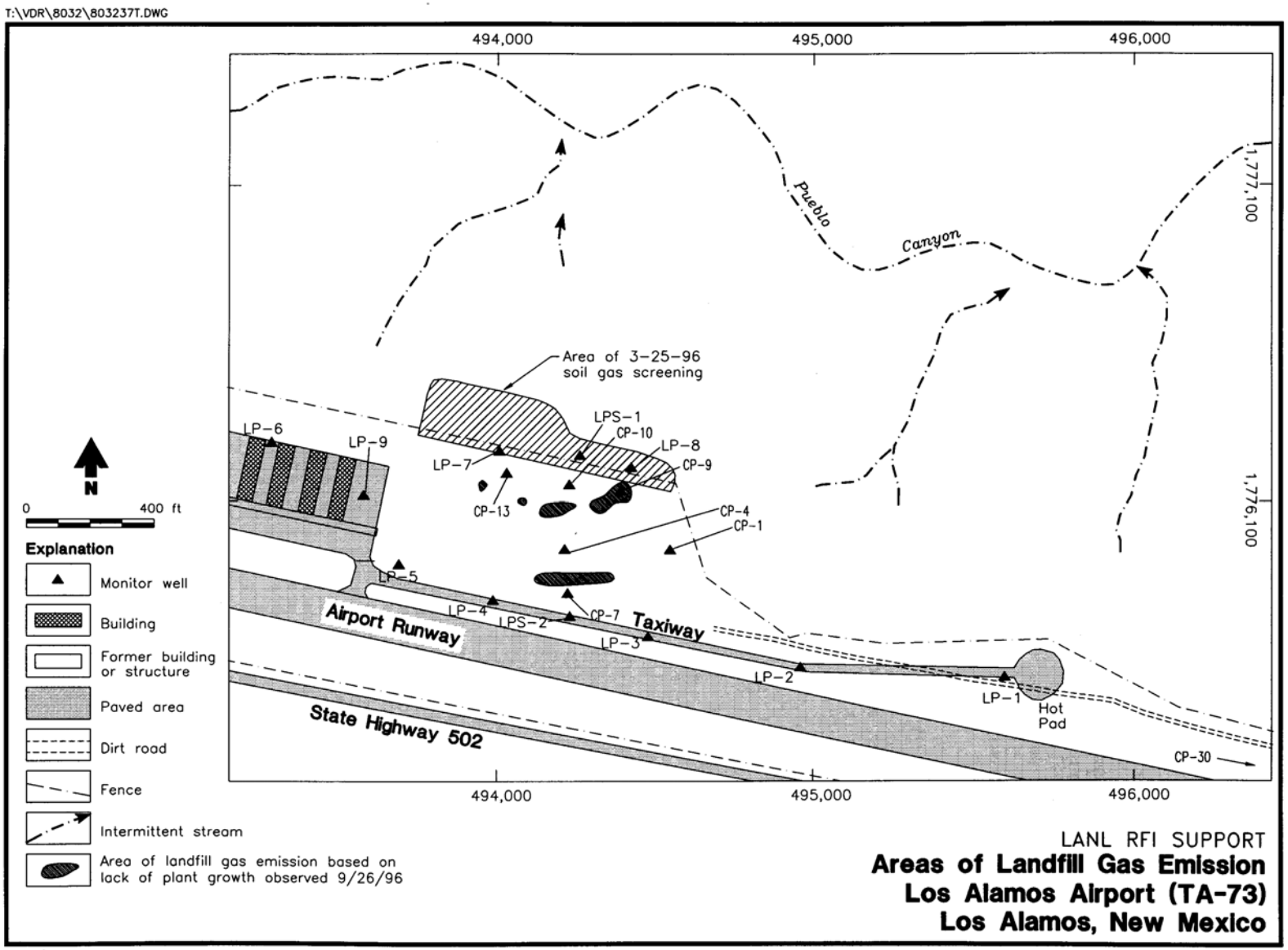
Heat Flux Varies with Time and Depth



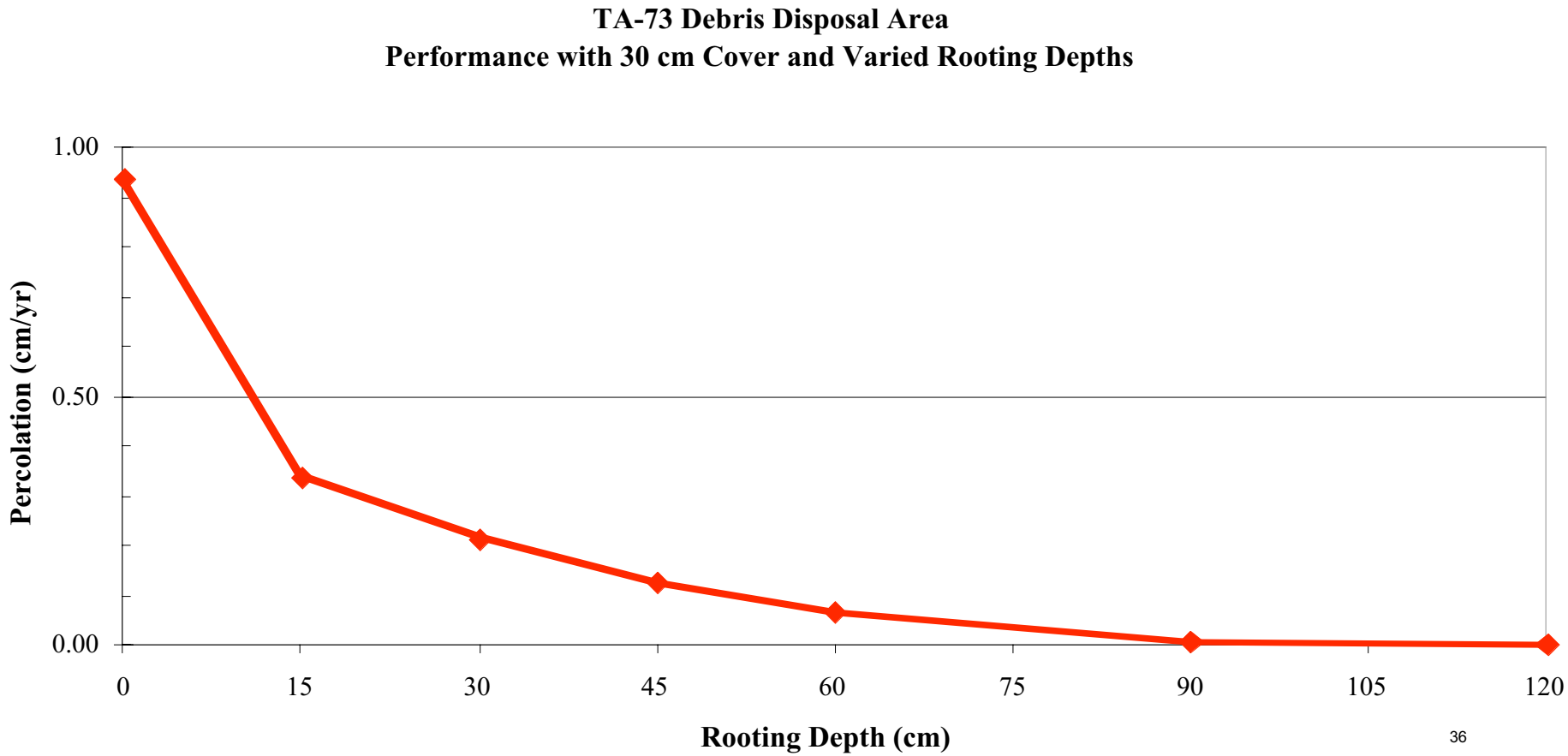
A Cover Could Create Problems Elsewhere



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

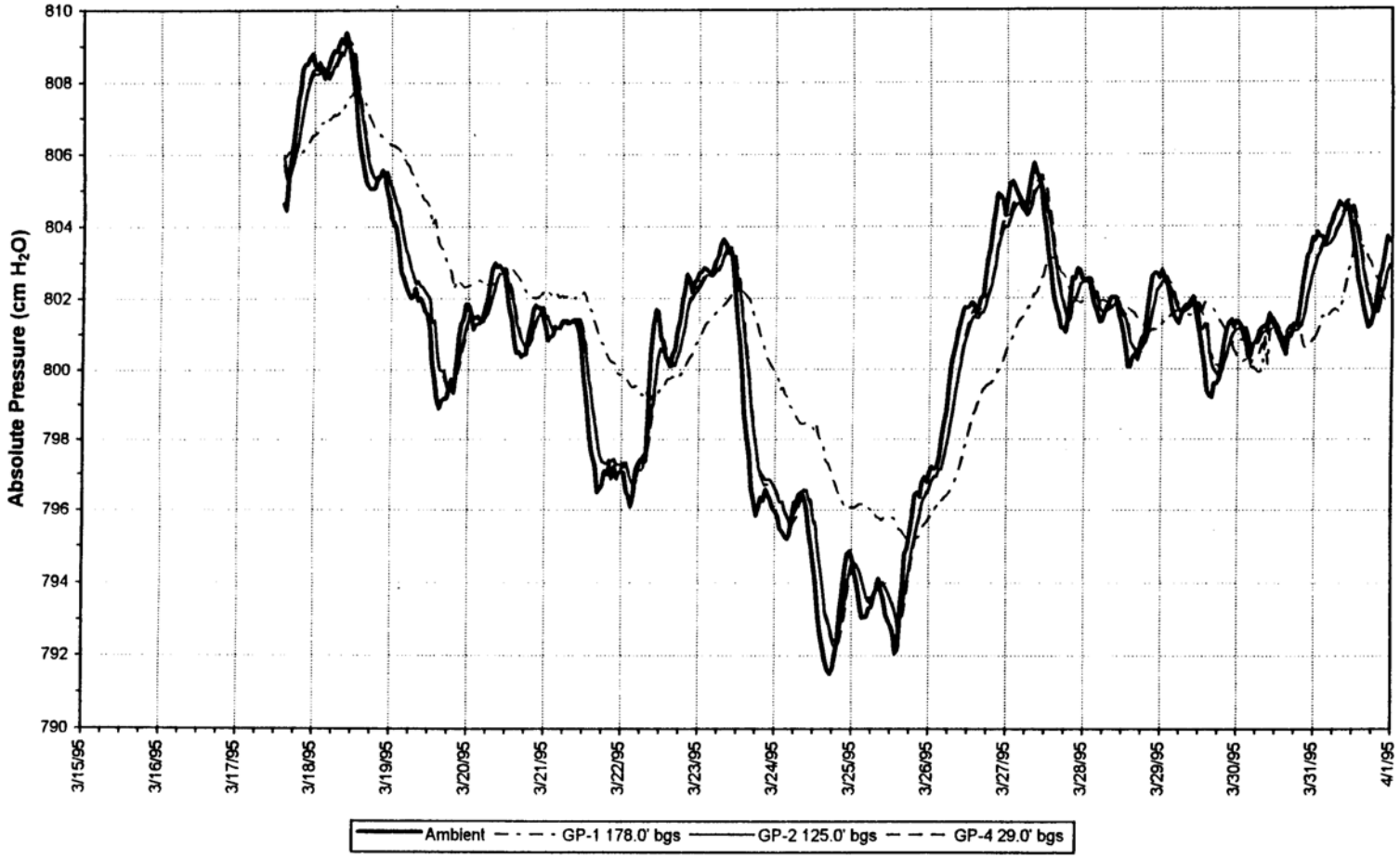


Percolation on a Finer-Textured Soil

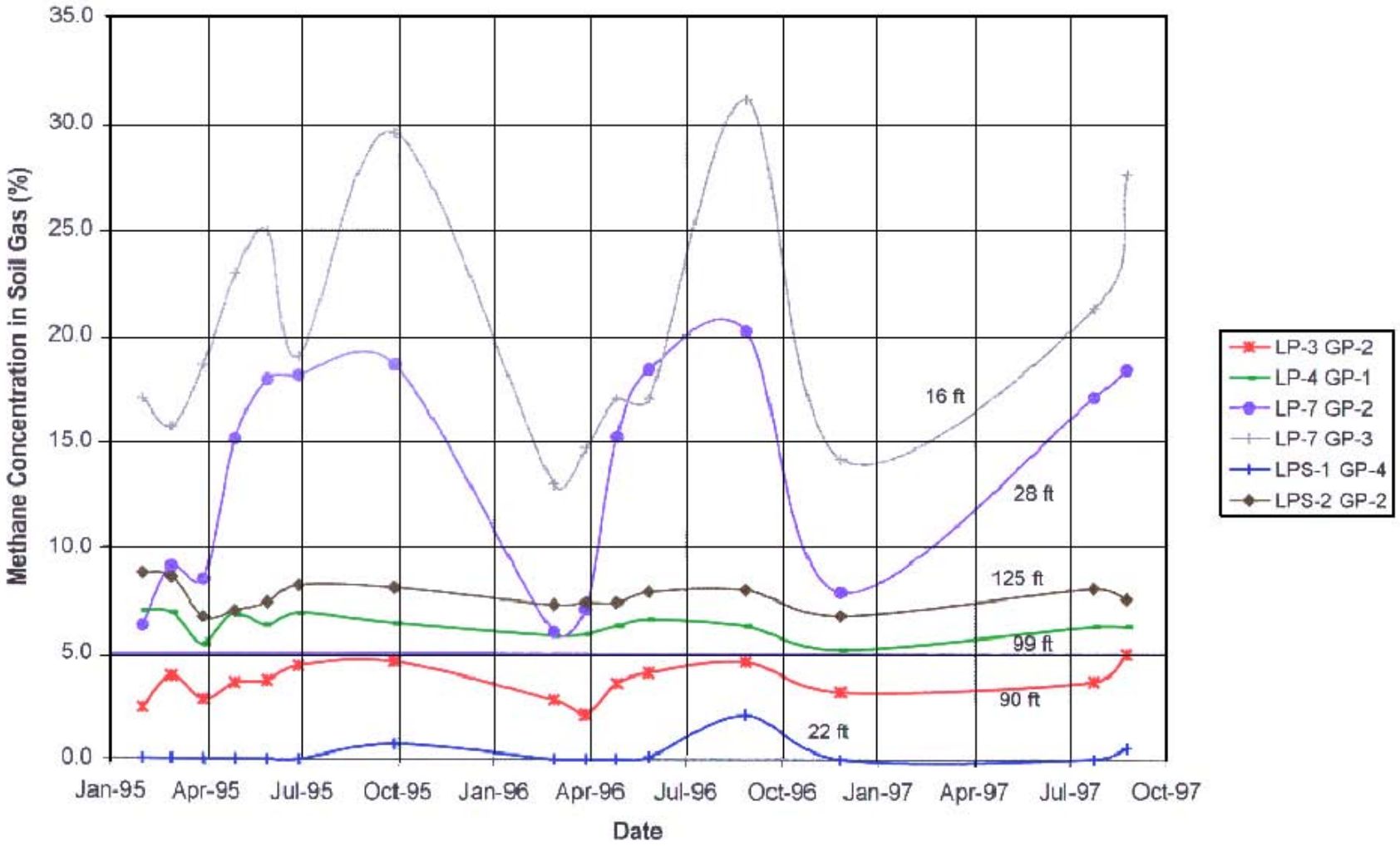


No Oxygen, No Roots, No T in ET

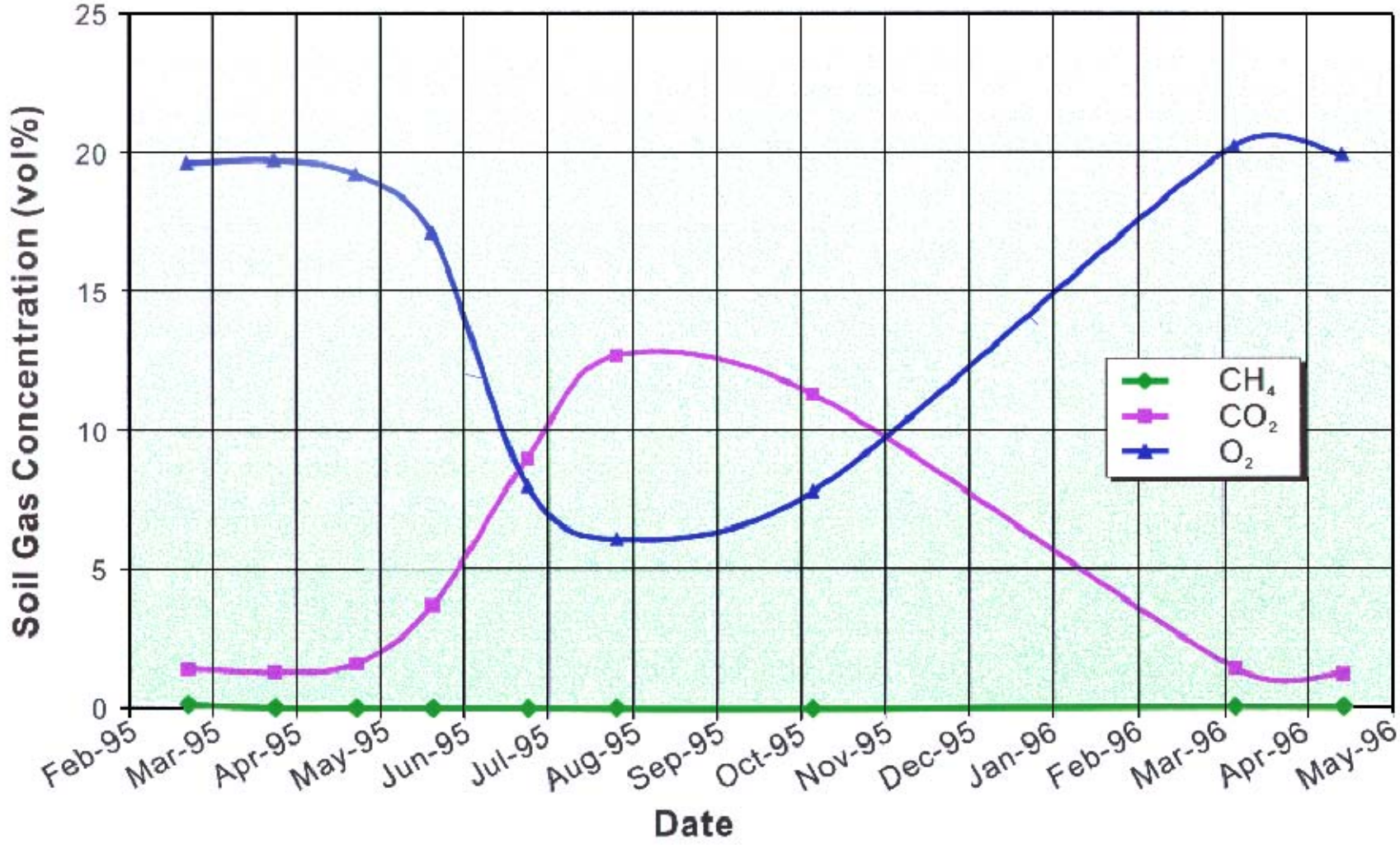
Barometric Pressure Patterns Vary Over Time



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*