

# Natural Attenuation of Chlorinated Aliphatics in Wetlands:

Linking  
Hydrology,  
Geochemistry,  
& Microbiology

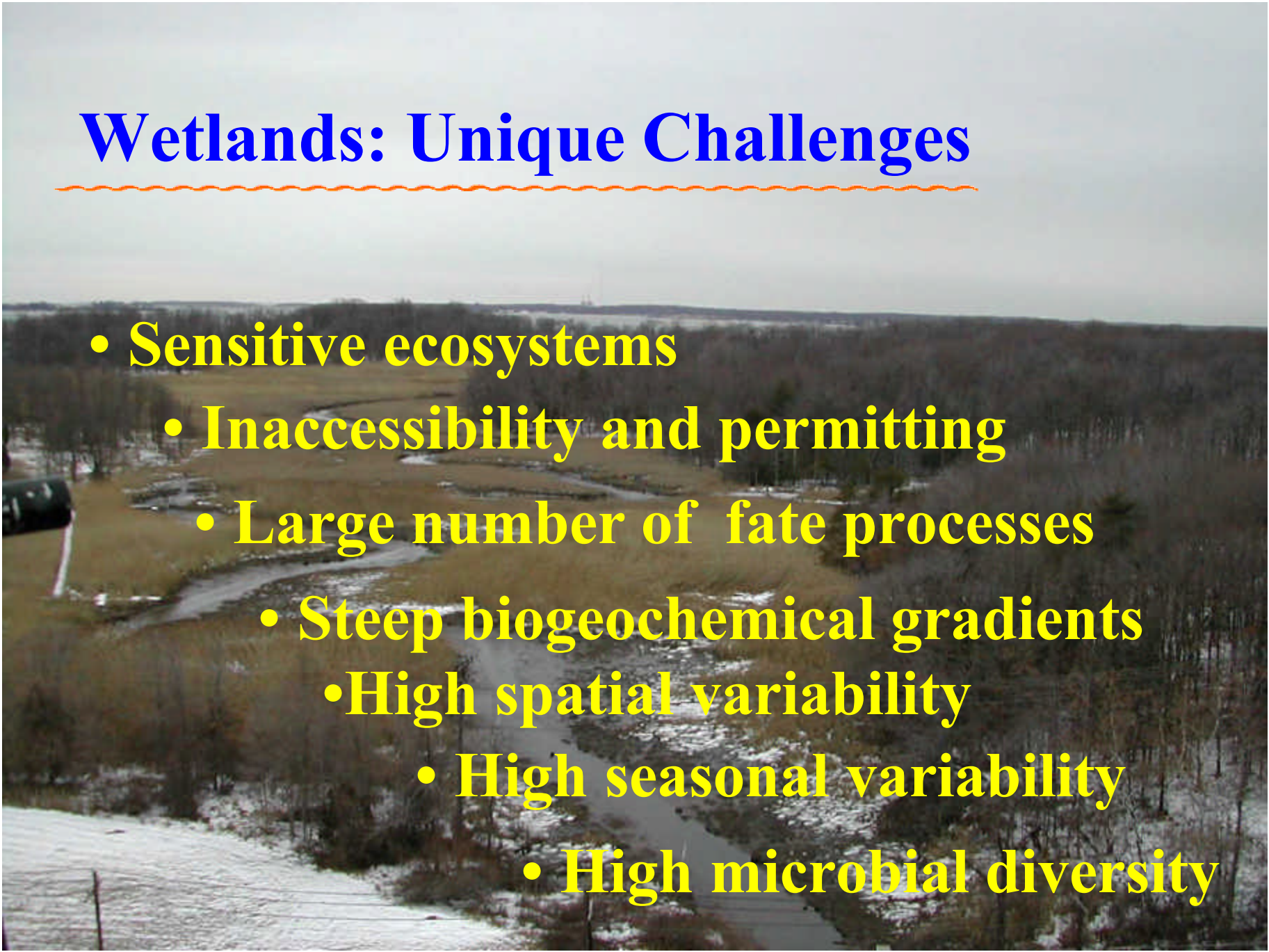
*Michelle M. Lorah*



# Wetlands: Unique Challenges

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- Sensitive ecosystems
  - Inaccessibility and permitting
  - Large number of fate processes
    - Steep biogeochemical gradients
    - High spatial variability
      - High seasonal variability
    - High microbial diversity



**WEST BRANCH CANAL CREEK  
ABERDEEN PROVING GROUND, MD**



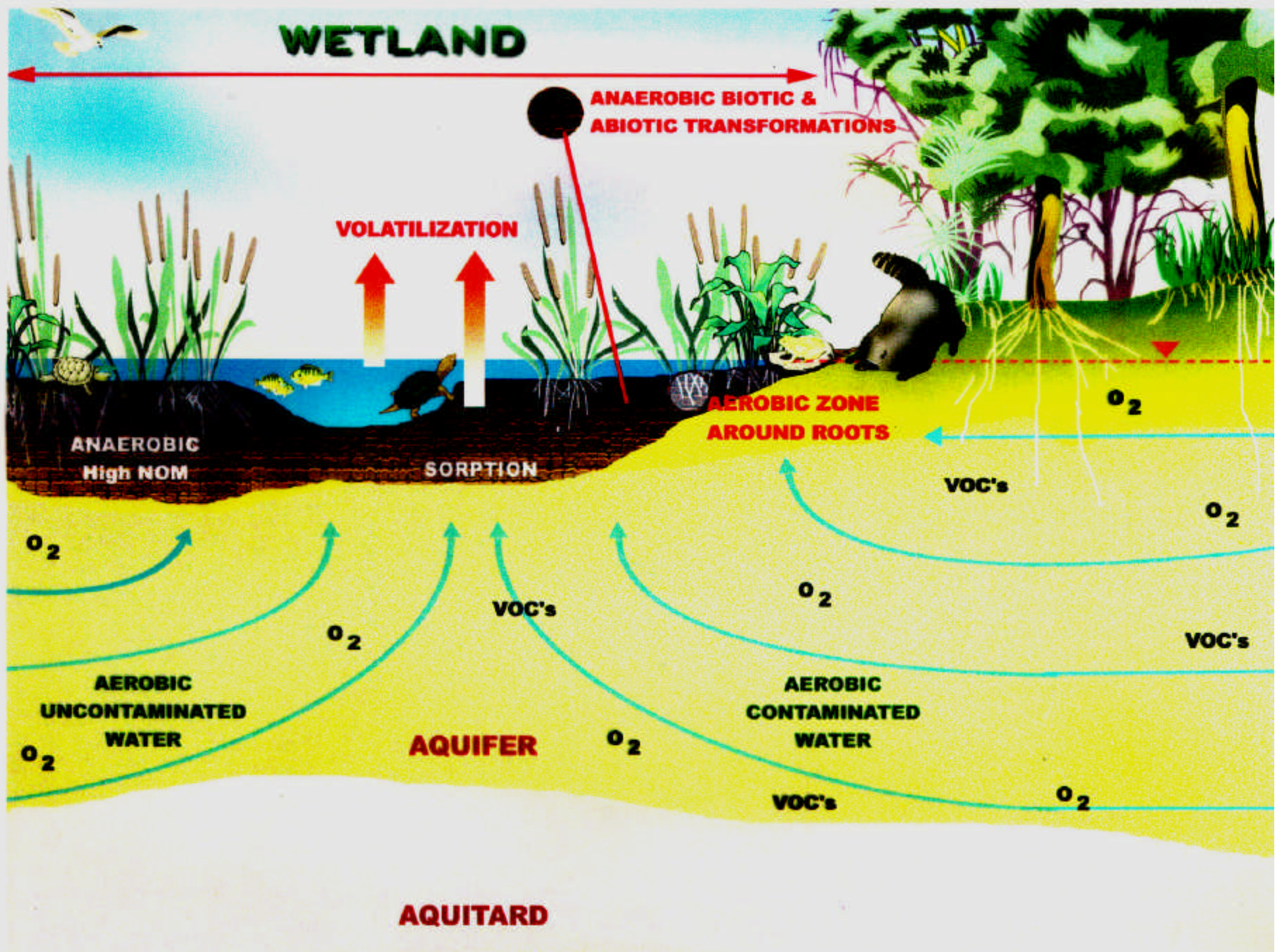
**Tidal Freshwater Wetland  
*Phragmites* dominated**

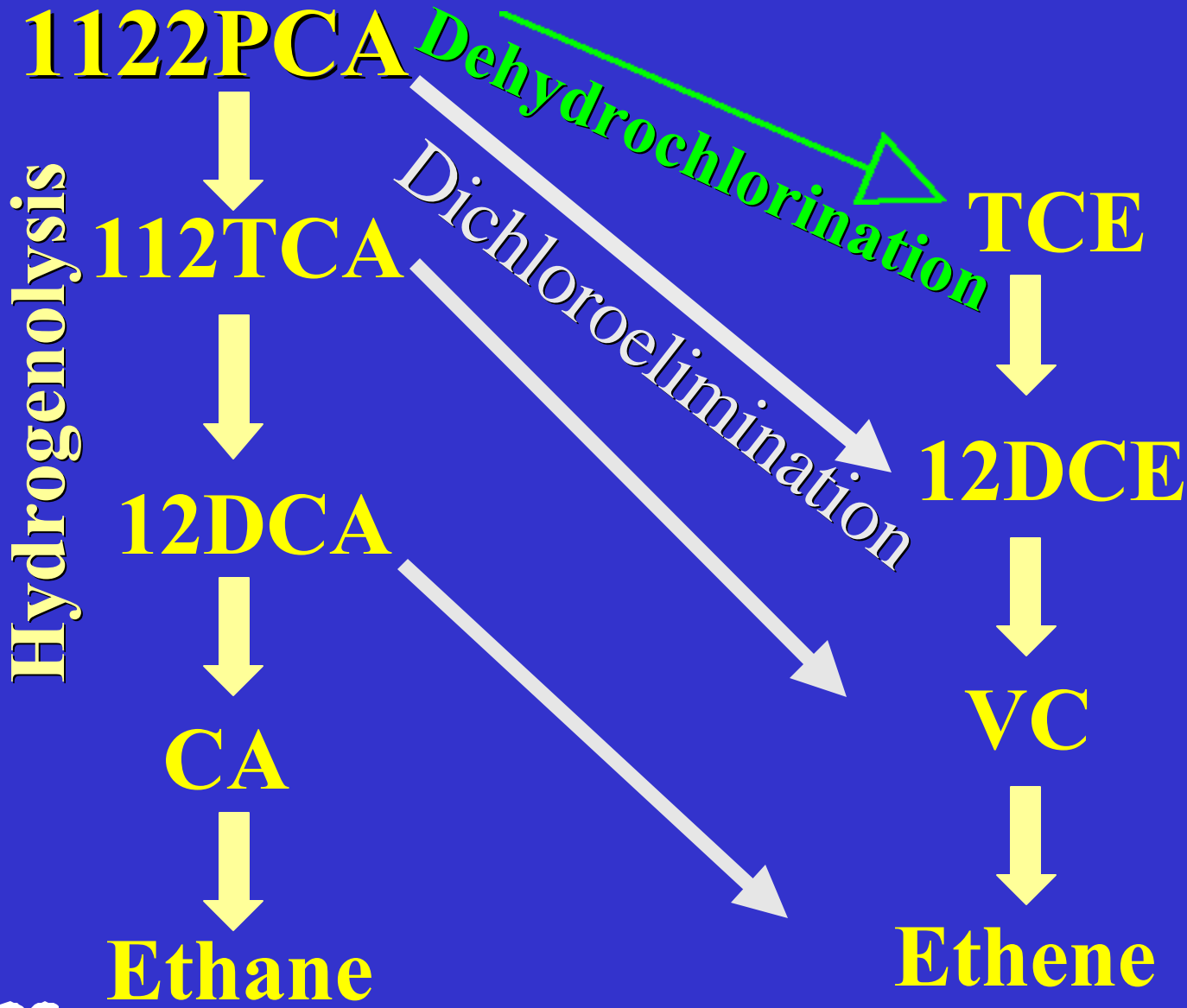


**Nested 3/4" Drive-Point Piezometers**

**Floating Walkways**

# WETLAND





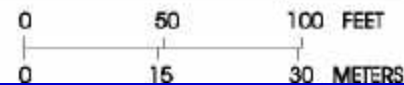
76°18'40"

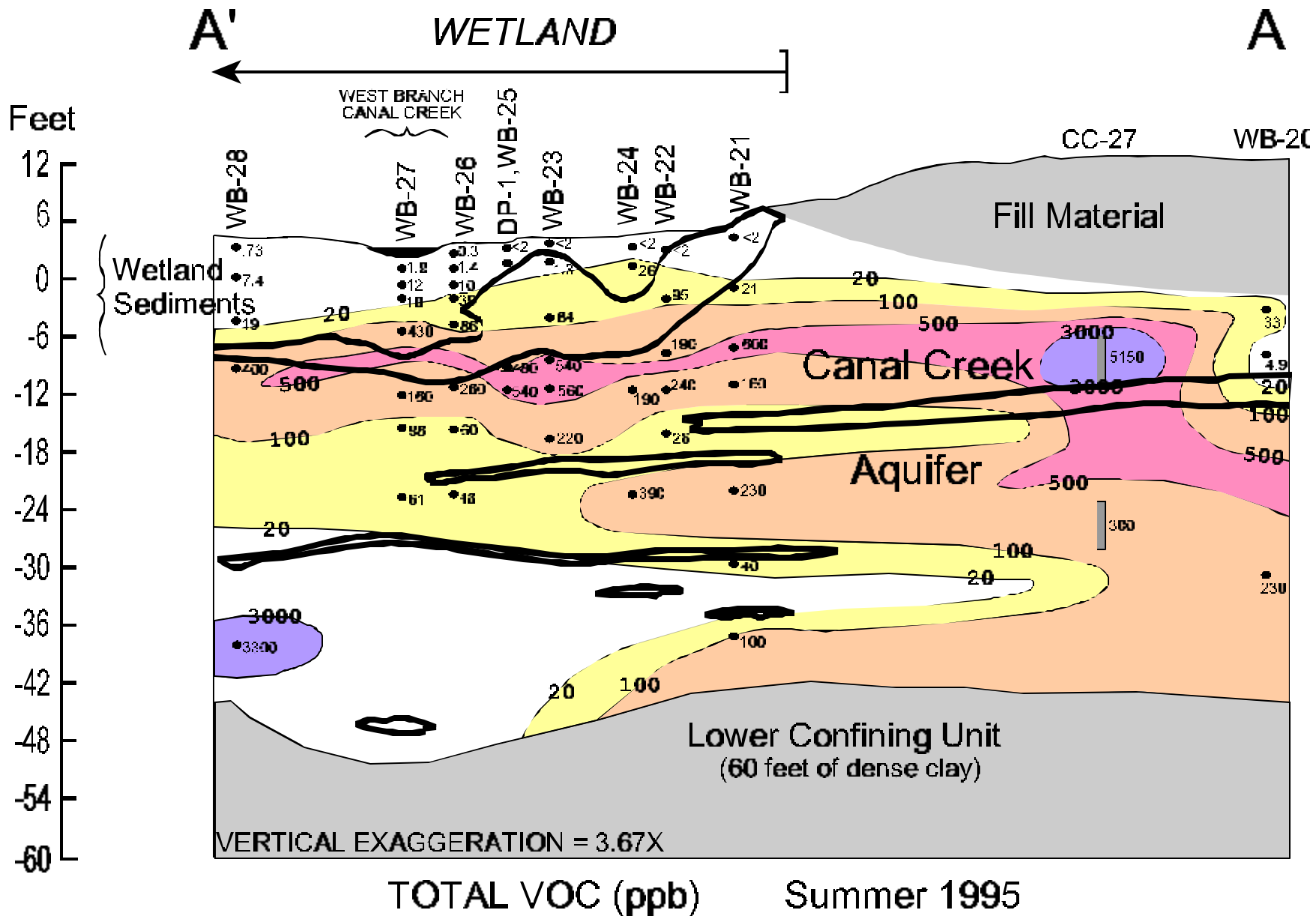
76°18'33"

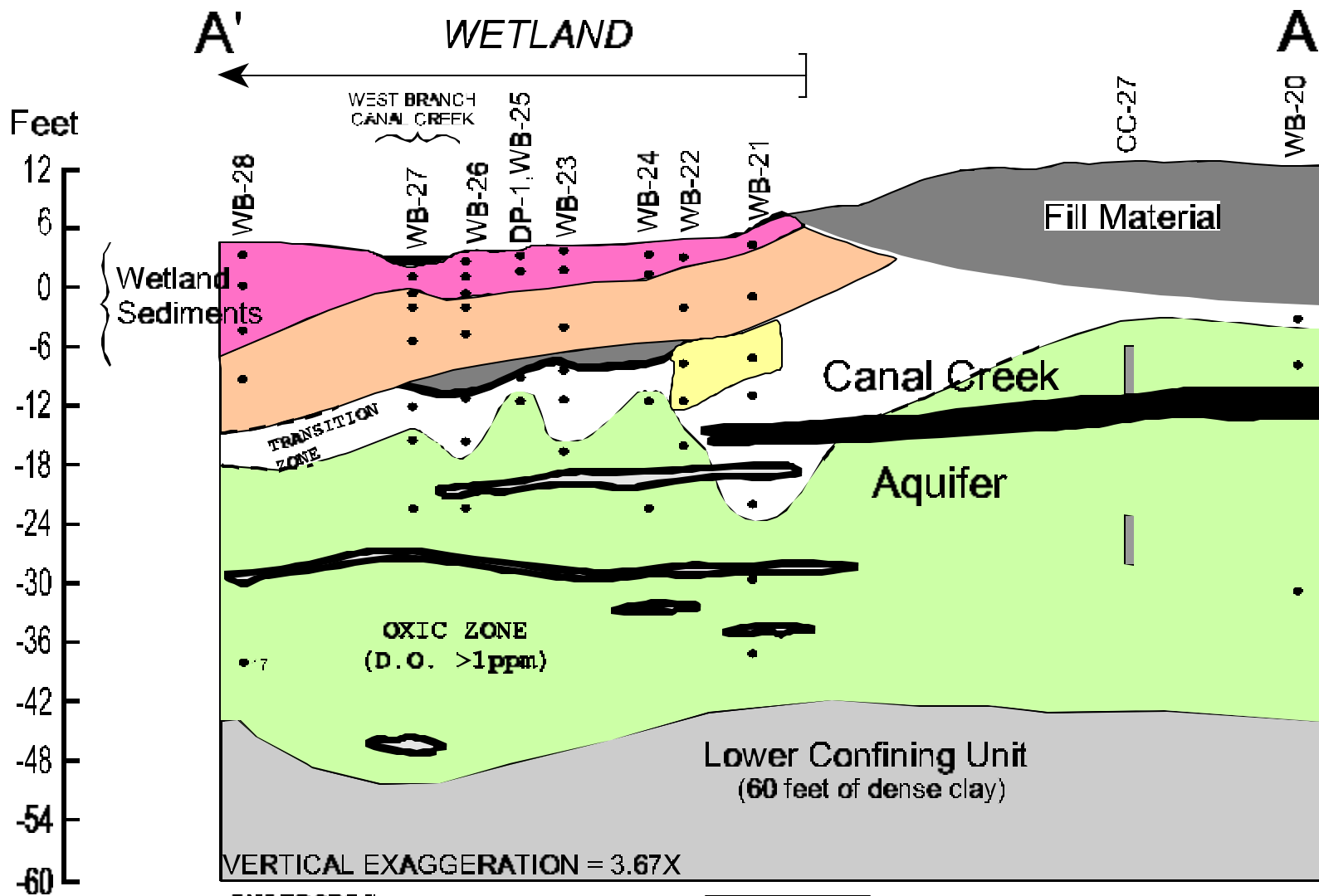


39°23'45"

# Aberdeen Proving Ground Site







**ANAEROBIC ZONES:**

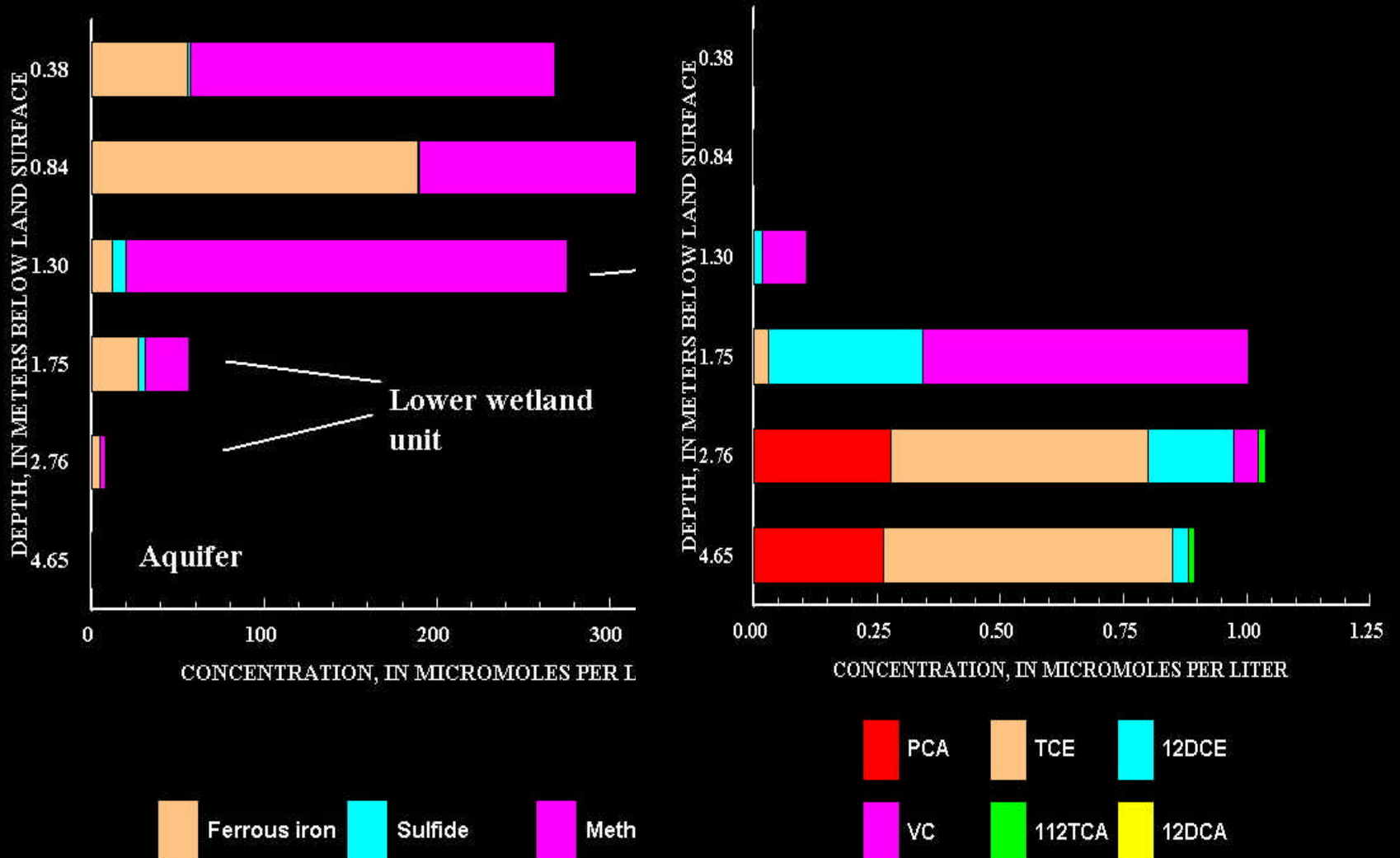
**>500 ppb**  
**METHANOGENIC**

**>1000 ppb**  
**IRON-REDUCING**

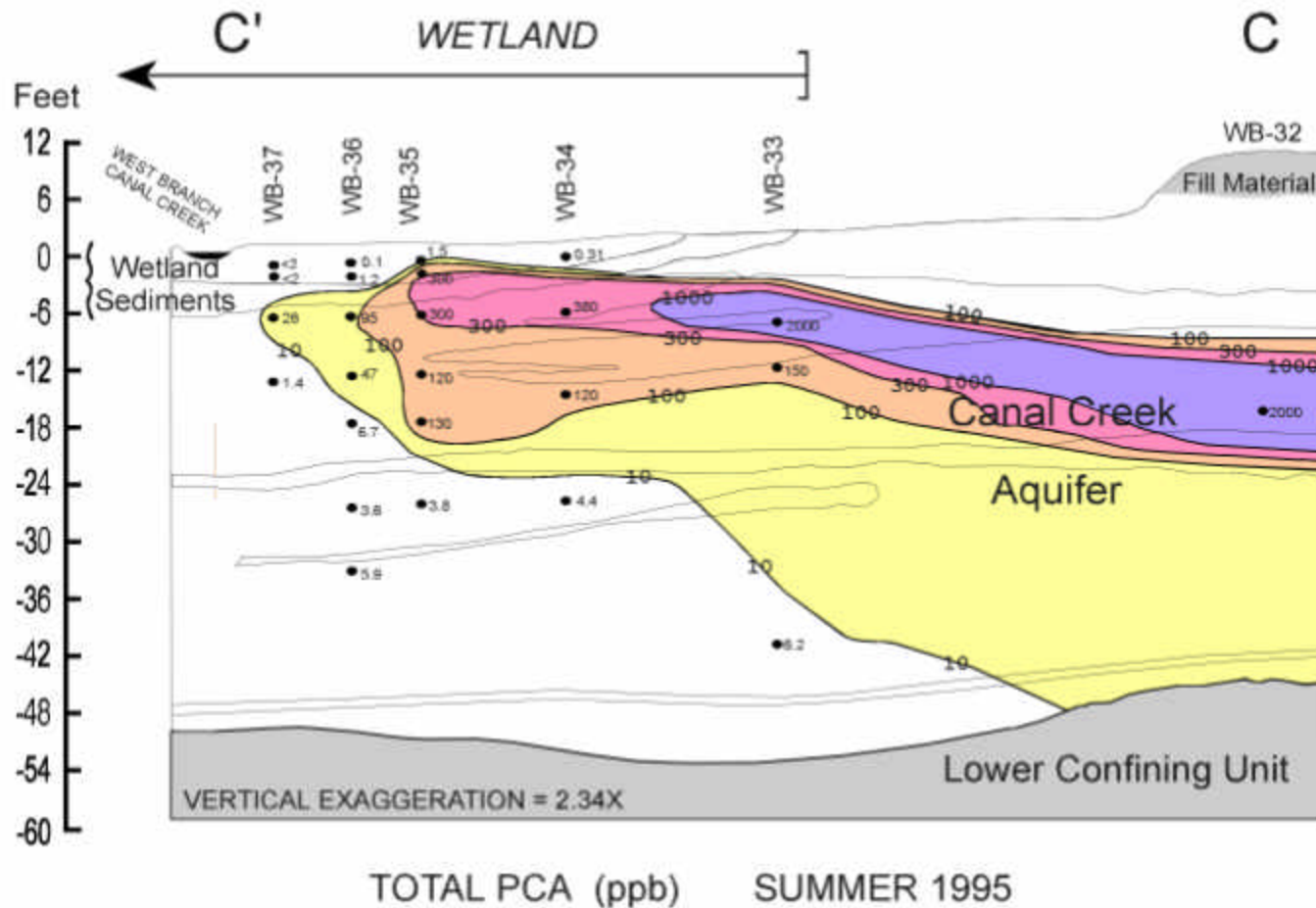
**>100 ppb**  
**SULFATE-REDUCING**



# Vertical Transformation Using Piezometers (WB26 May 1999)



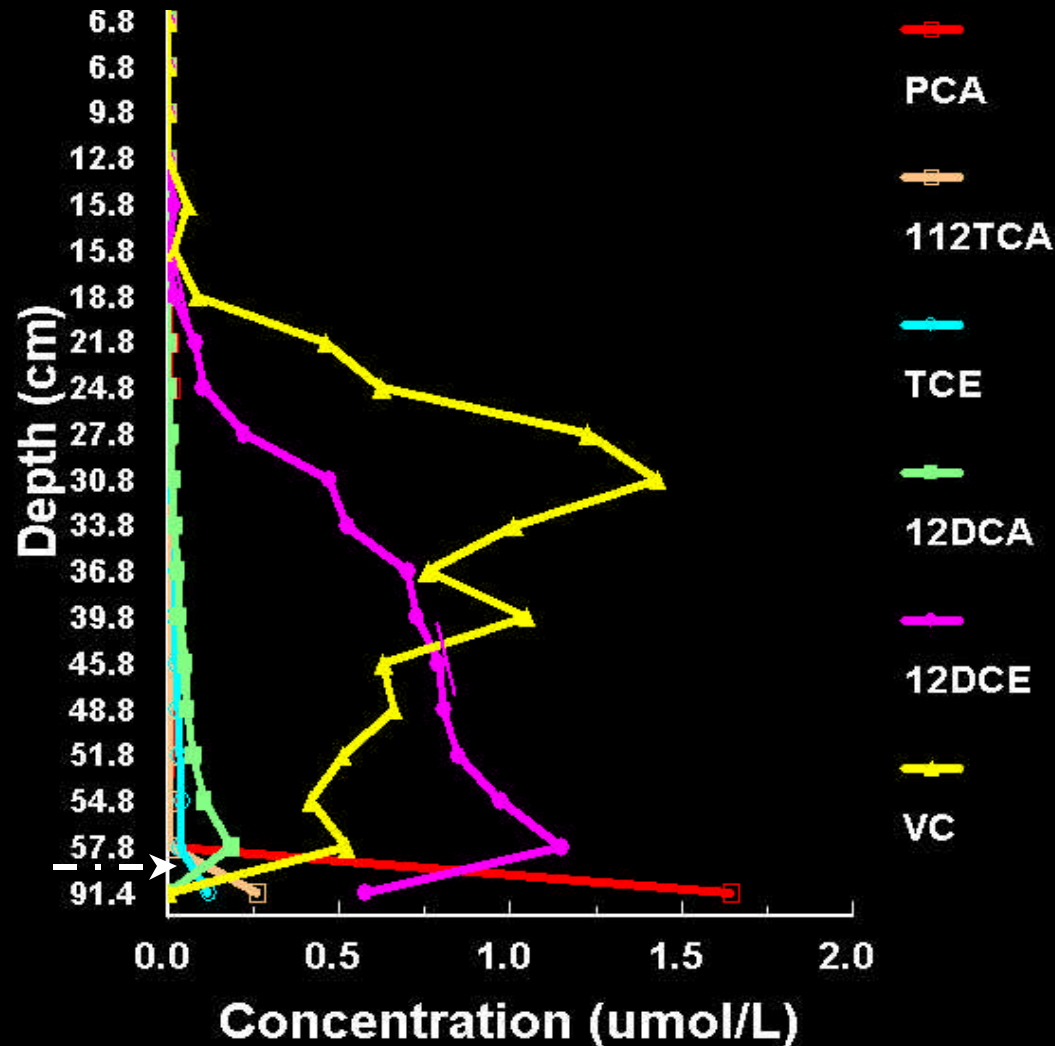
# Spatial Variability: A vs. C Transect



# PEEPERS

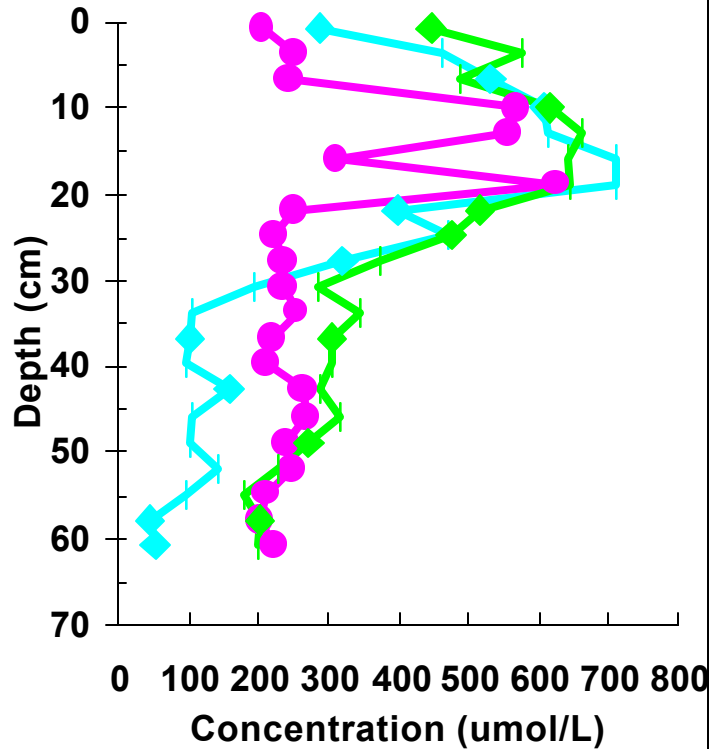


# Vertical Transformation Using Peepers P35, June 1996



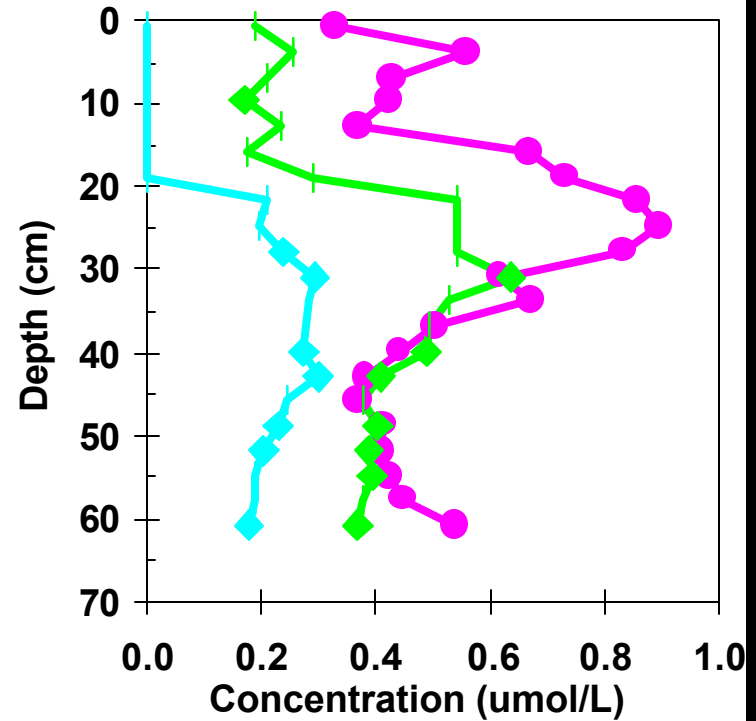
# Spatial Heterogeneity in Geochemistry

**CH<sub>4</sub>, Peeper Comparison, WB36, 5/01**



At Piezometers    At MLS    At Tube

**Total VOCs, Peeper Comparison, WB36, 5/01**



At Piezometers    At MLS    At Tube

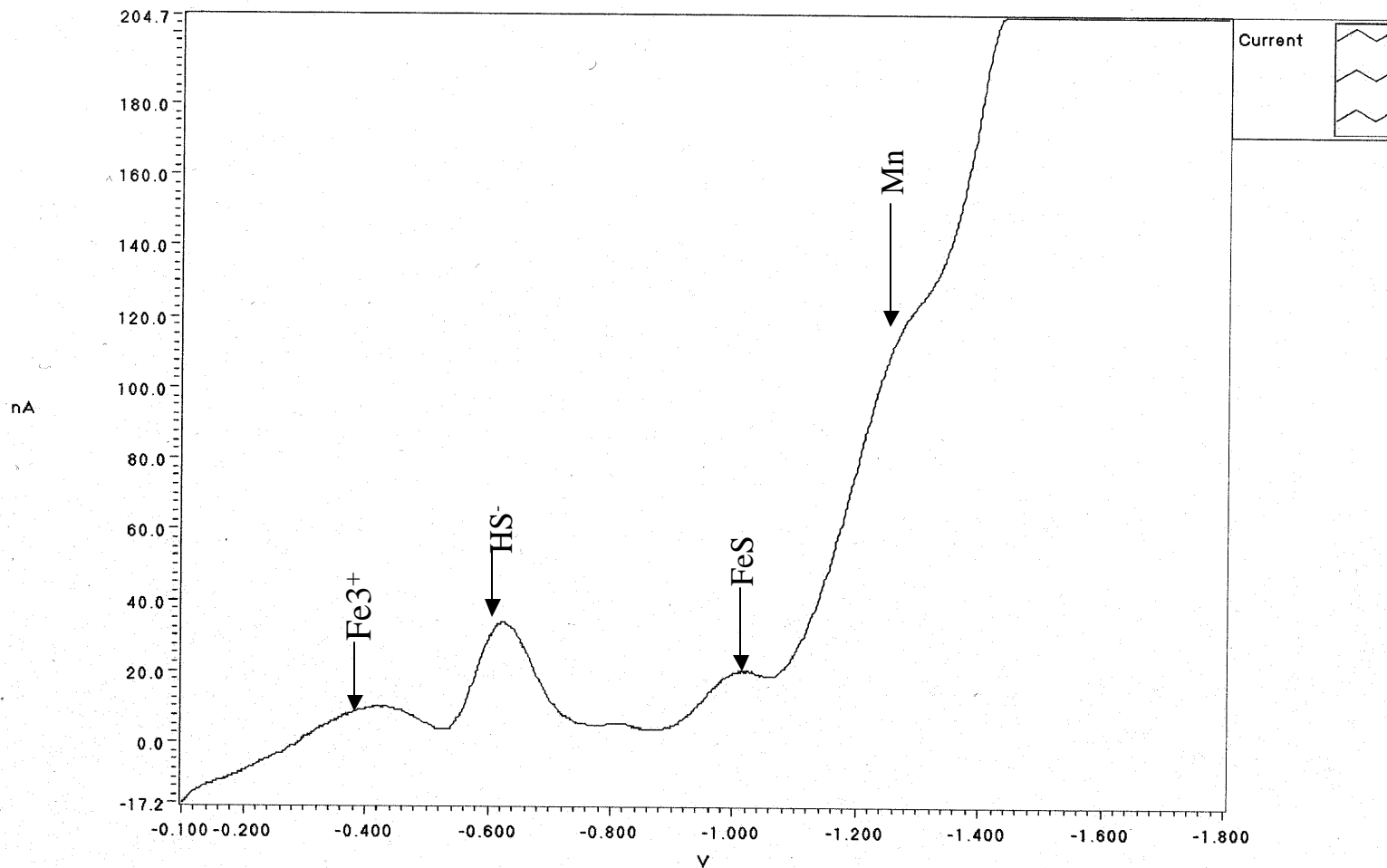
# AIS Model DLK-100A Electrochemical Analyzer Rev 3.2

File Name:

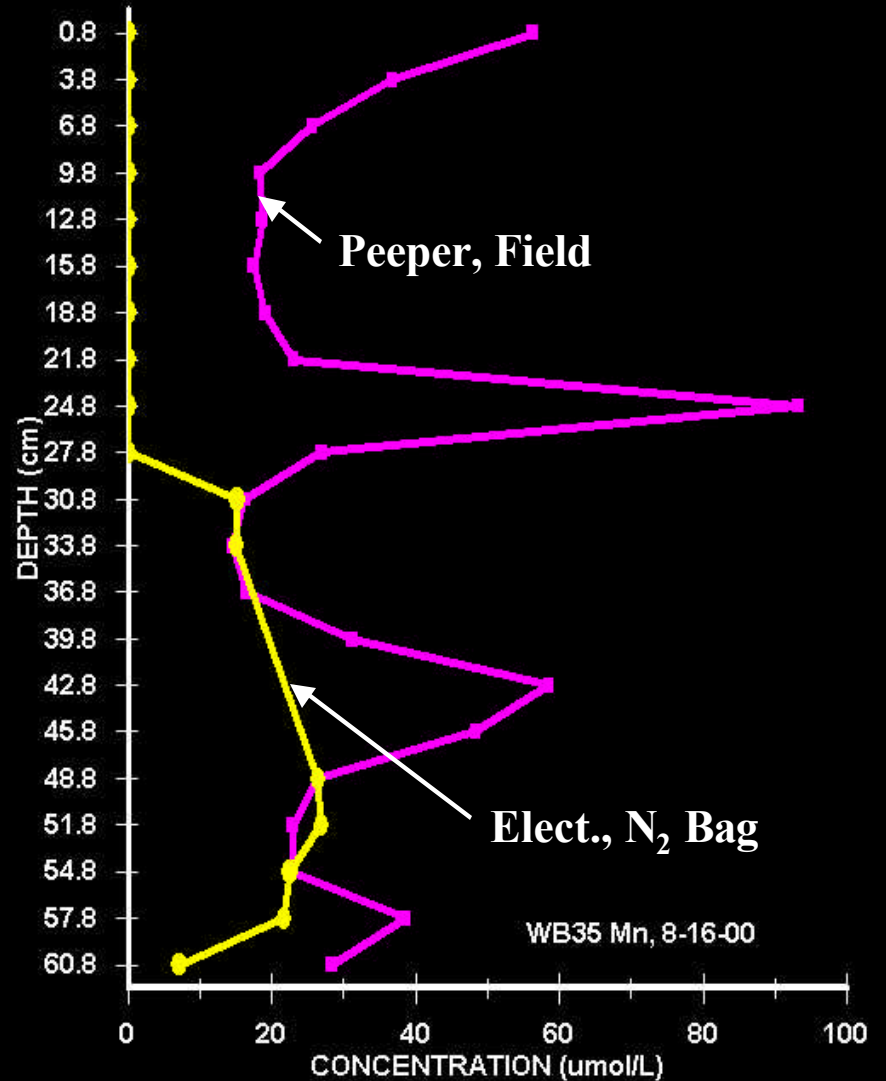
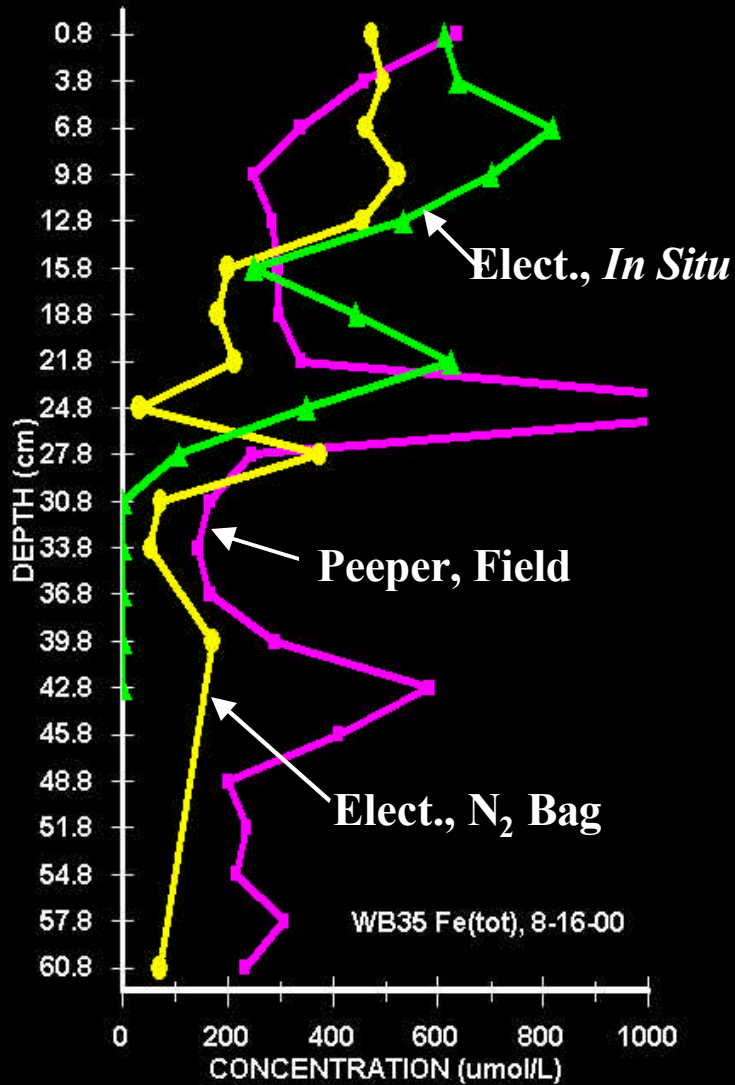
081502.660

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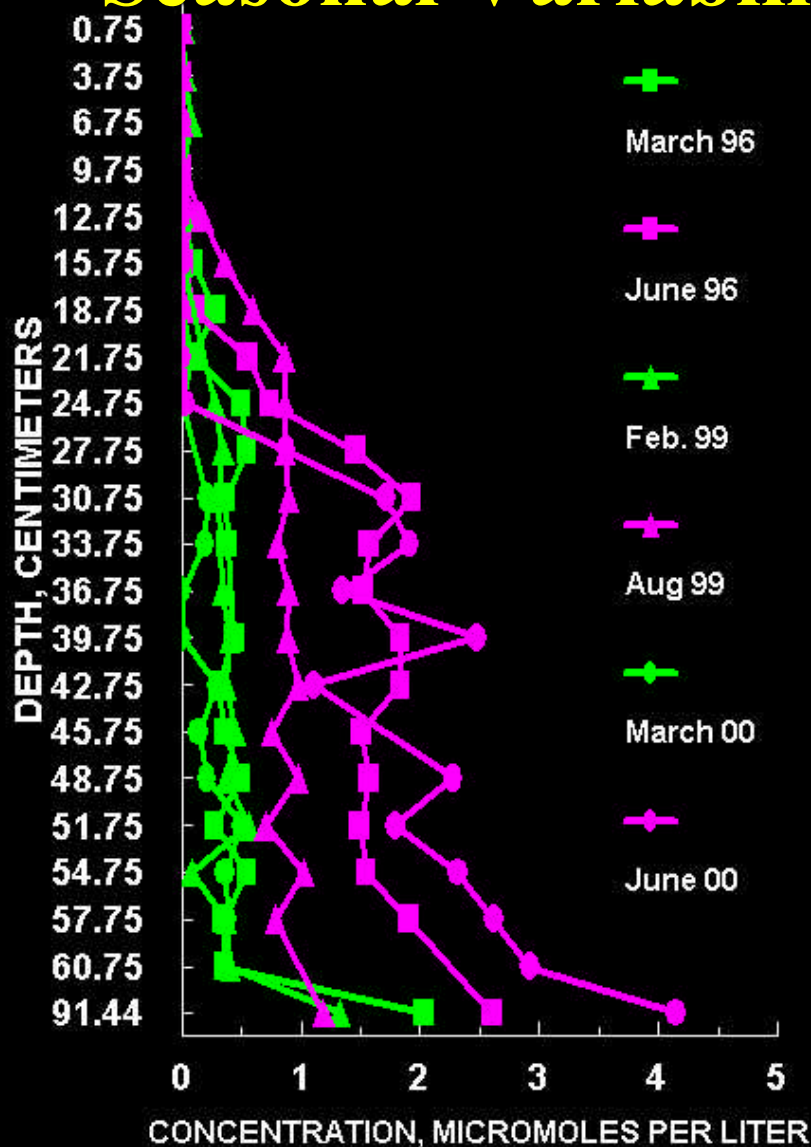
Technique	Initial Pot	Final Pot	Step Size	Pulse Ht	Range	Filter	Line Sync	Scan Rate	Samp Time	Points	Moving Avrg
Linear Sweep	-0.100V	-1.800V	-0.0017V	n/a	100nA	1ms	OFF	500.00mV/s	3.399E-3s	1000	ON, 19 Points



# Microelectrodes



# Seasonal Variability in Geochemistry



P35

Winter

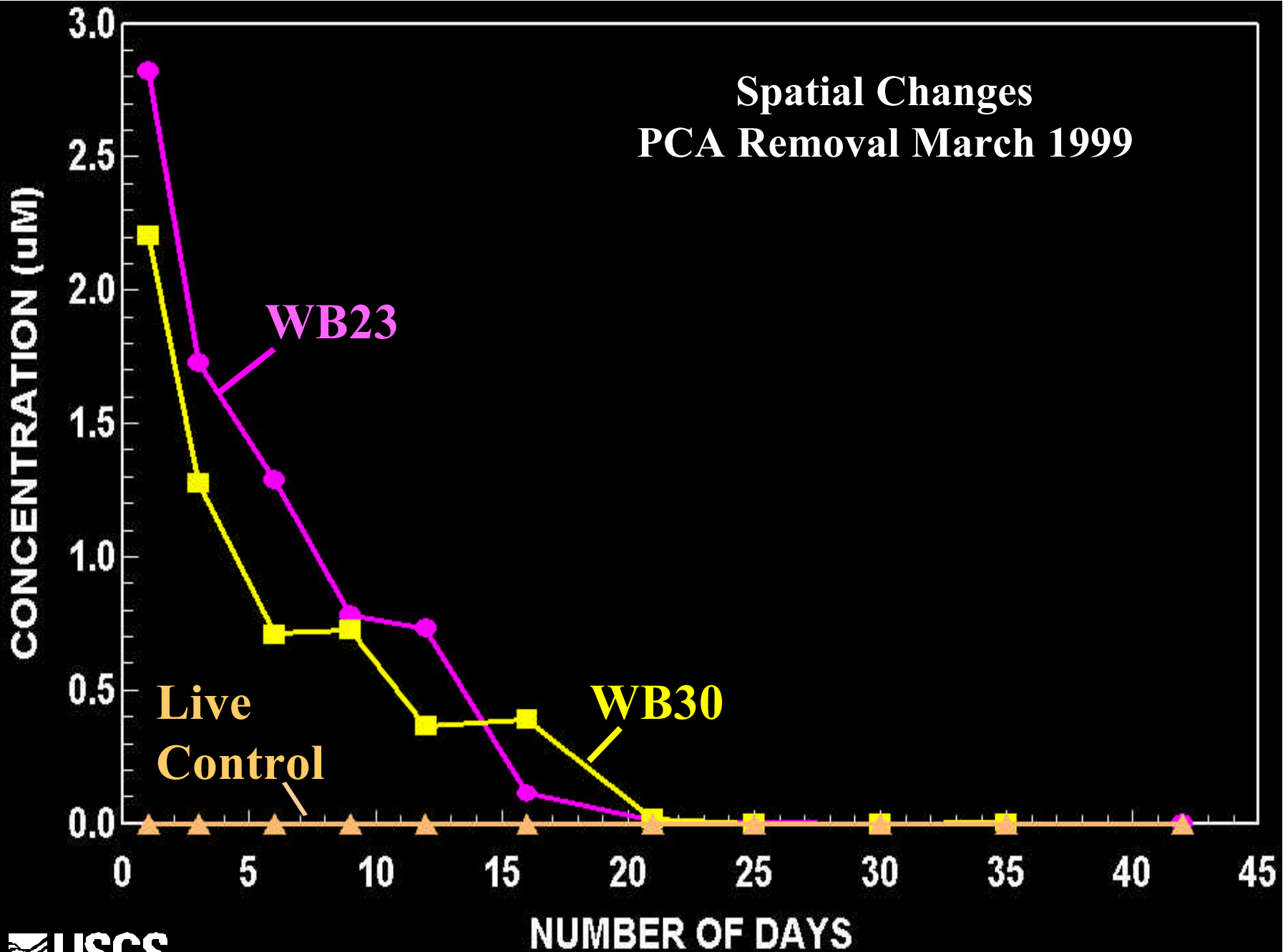
vs.

Summer

- VOCs highest in summer
- Cyclic change related to changing water levels
- Natural attenuation still efficient throughout year



# Spatial Changes PCA Removal March 1999



March-April 1999

% DAUGHTER COMPOUND

WB23 WB30

70  
60  
50  
40  
30  
20  
10  
0

112TCA

12DCA

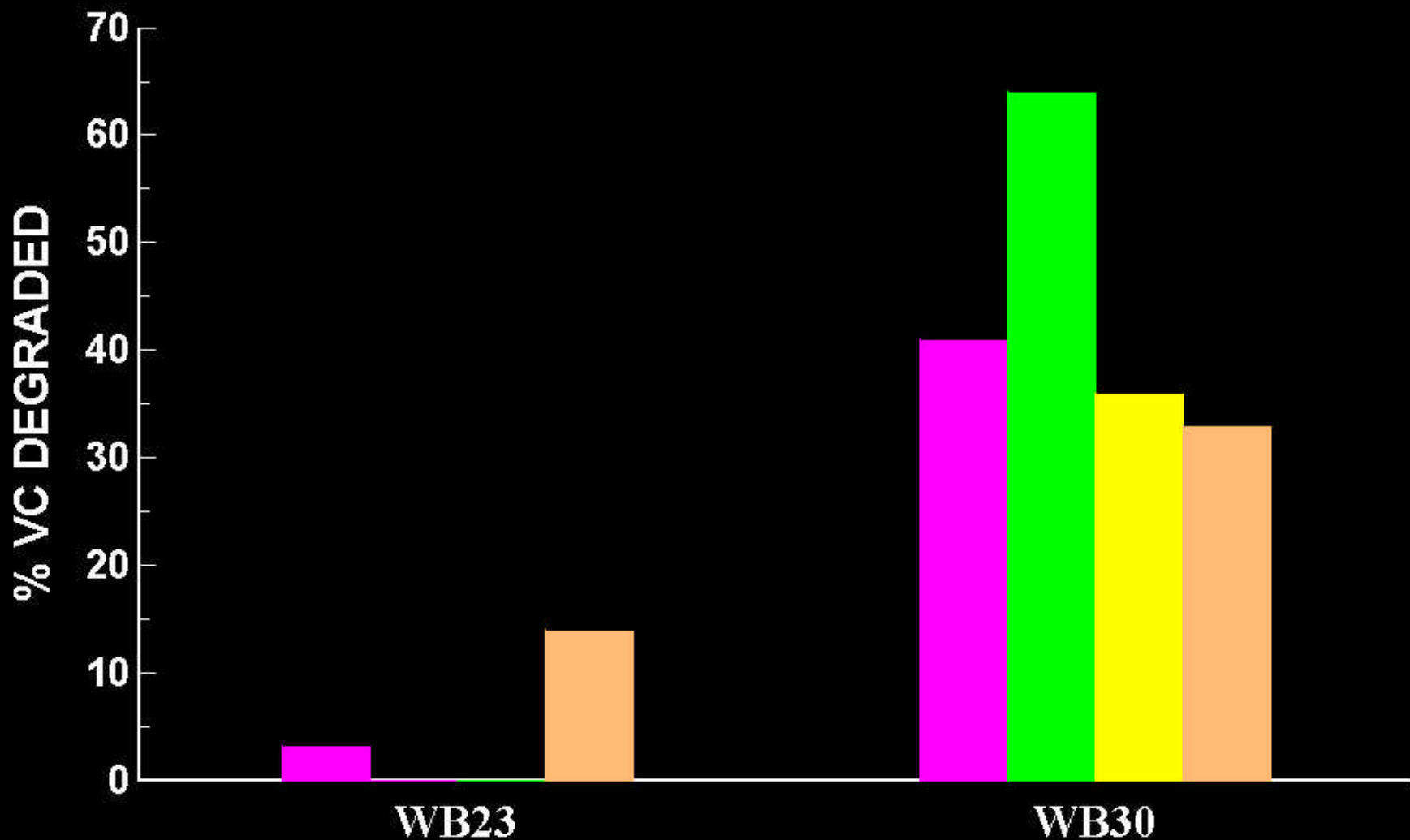
CA

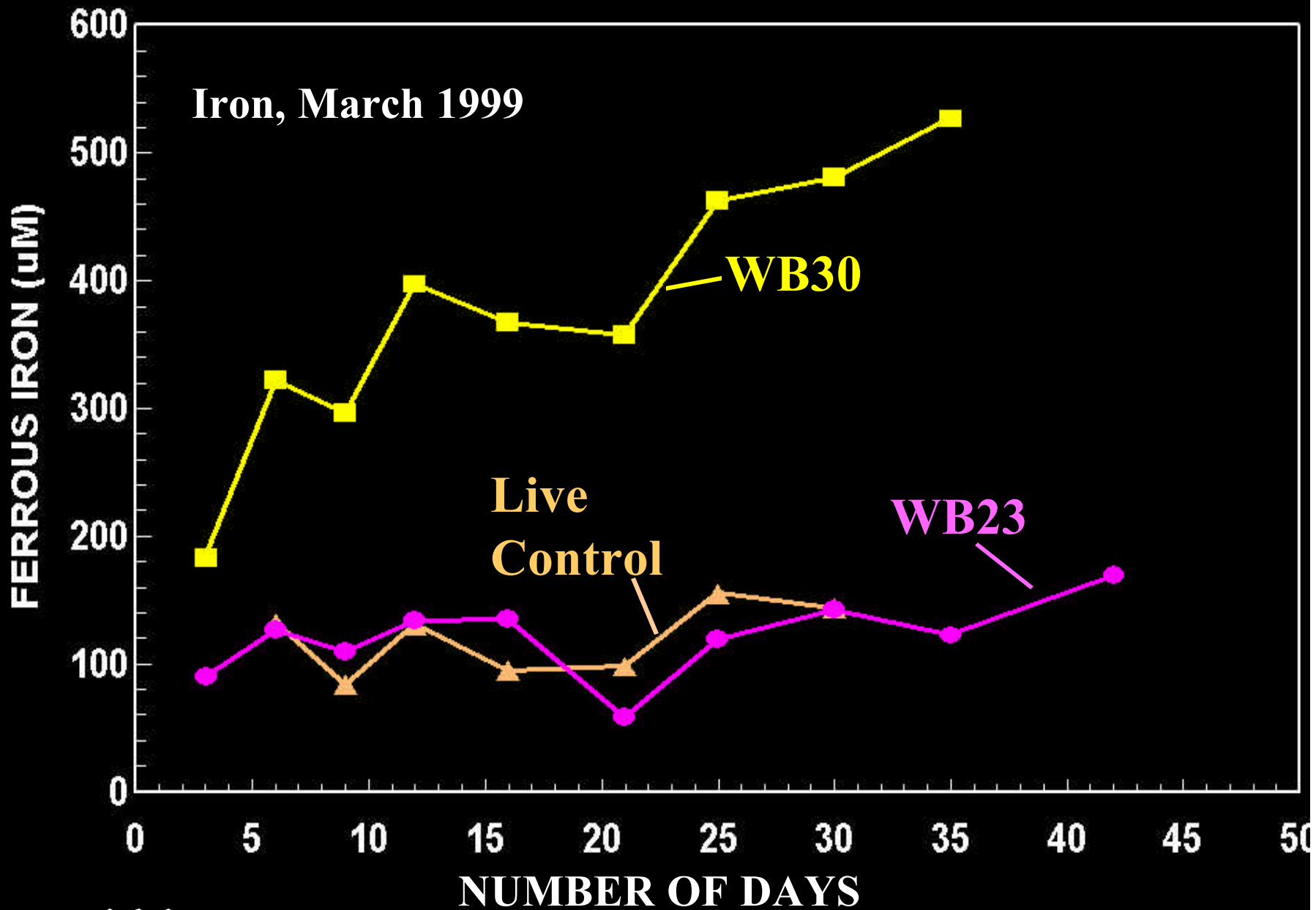
TCE

12DCE

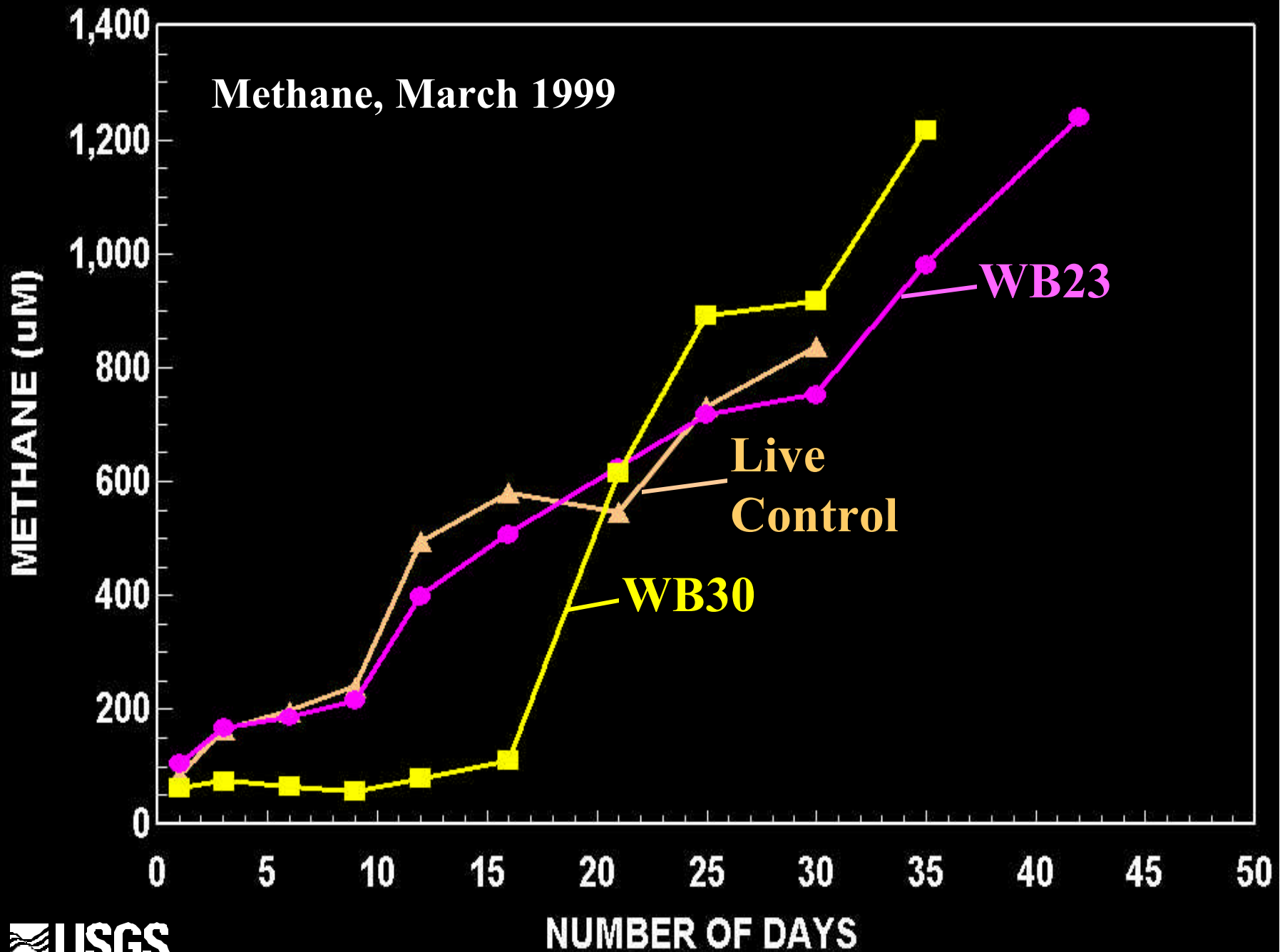
VC







# Methane, March 1999



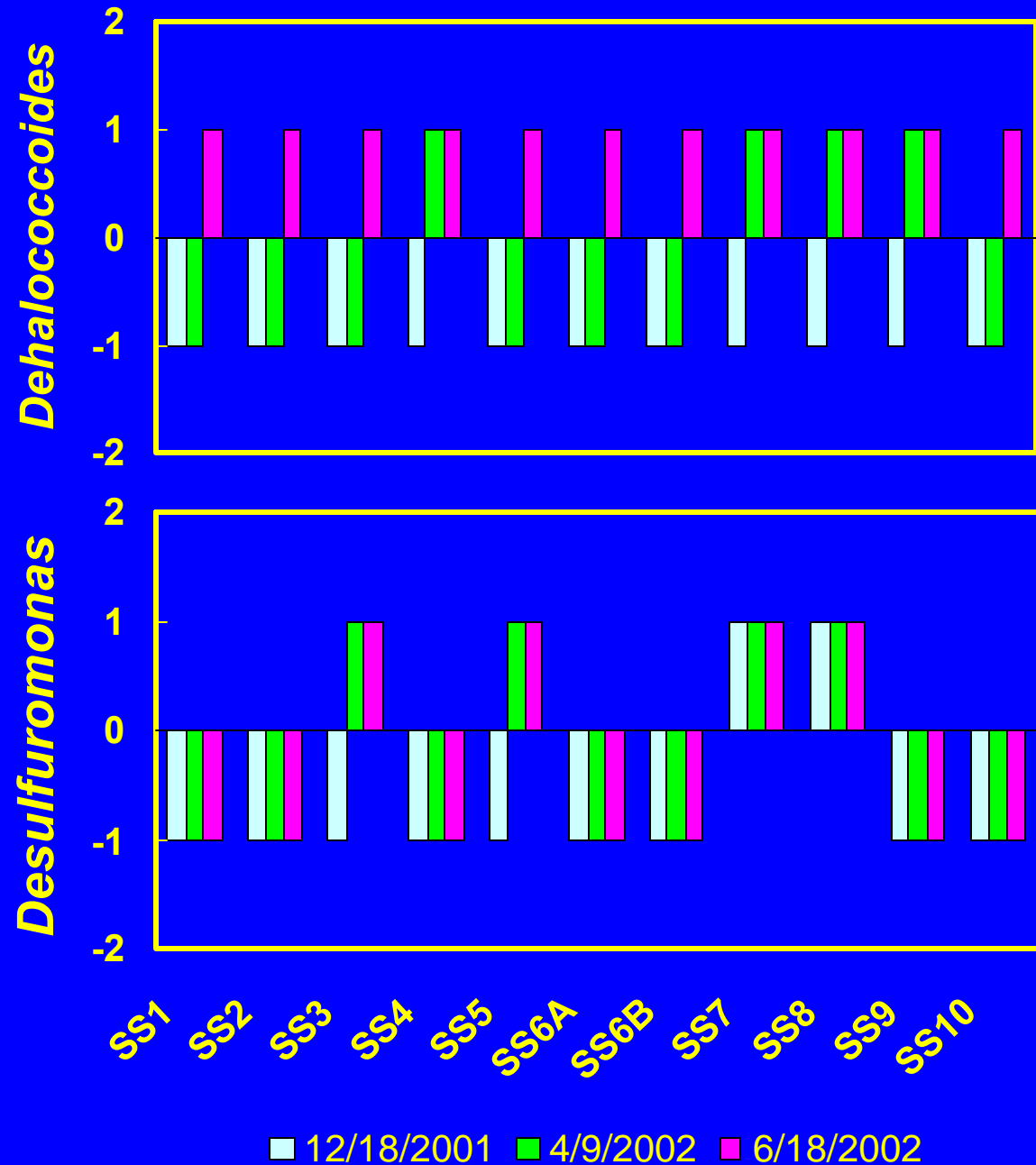
# Spatial Heterogeneity in Microbes

## Microcosm: WB23

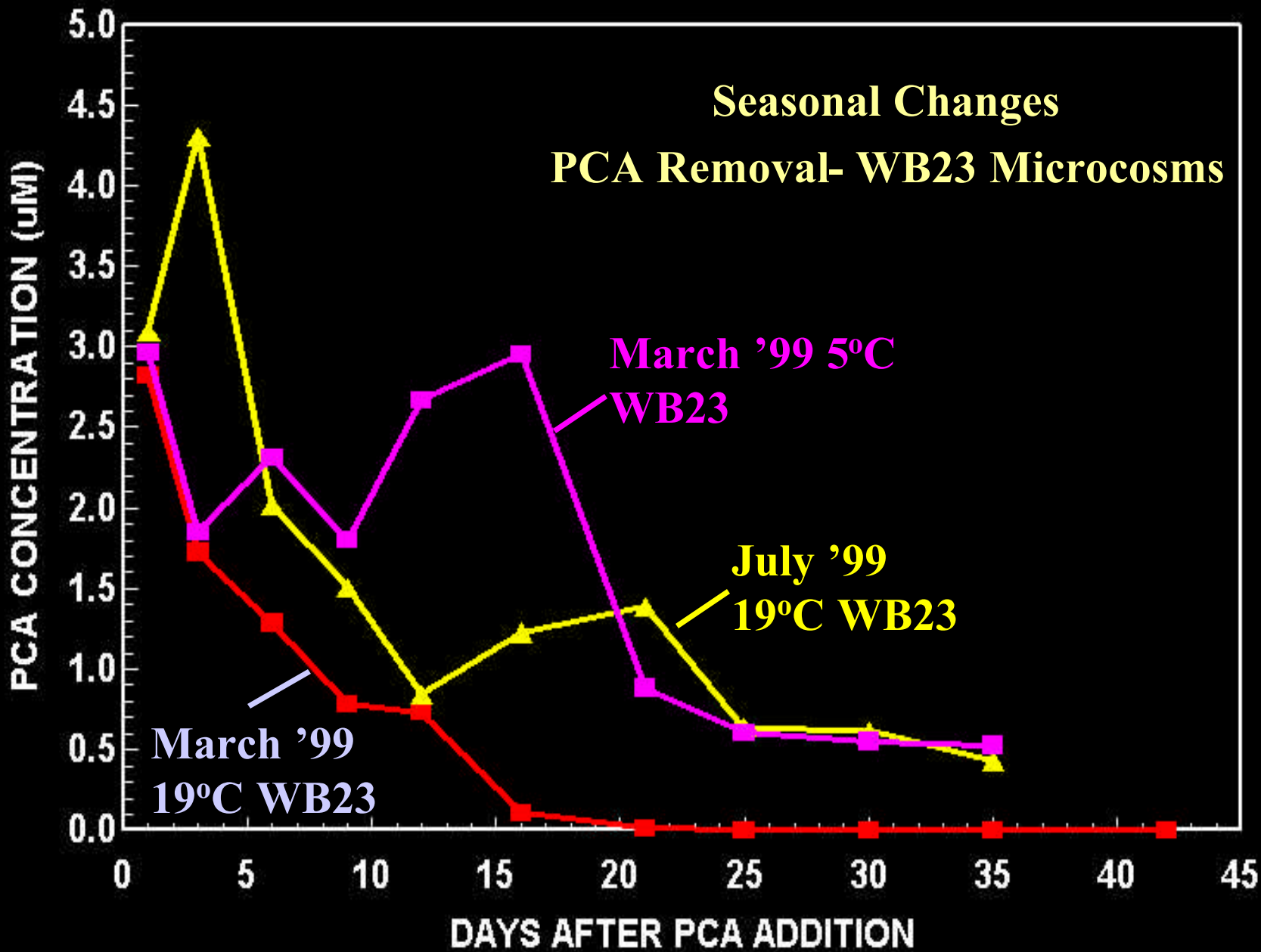
## WB30

<b>Day, bottle number</b>	<b><u>Microcosm 23TeCA.3/99</u></b>		<b><u>Microcosm 30TeCA.3/99</u></b>	
	<b>dcl-m<sup>b</sup></b>	<b>dcl-h</b>	<b>dcl-m</b>	<b>dcl-h</b>
<b>1, 1A</b>	-	-	+	+
<b>1, 1B</b>	-	-	+	-
<b>3, 2A</b>	-	-	+	-
<b>3, 2B</b>	-	-	+	-
<b>9, 4A</b>	-	-	+	-
<b>9, 4B</b>	-	-	-	-
<b>16, 6A</b>	-	-	na	na
<b>16, 6B</b>	-	-	+	+
<b>25, 8A</b>	-	-	-	+
<b>25, 8B</b>	-	-	+	-
<b>30, 9A</b>	-	-	-	-
<b>30, 9B</b>	-	-	+	-
<b>35, 10A</b>	-	-	na	na
<b>35, 10B</b>	-	-	+	+
<b><i>Desulfuromonas</i> strain BB1<sup>a</sup></b>	+	na	+	na
<b><i>Dehalococcoides</i> <i>ethenogenes</i><sup>a</sup></b>	na	+	na	+

# Seasonal Heterogeneity in Microbes



# Seasonal Changes PCA Removal- WB23 Microcosms

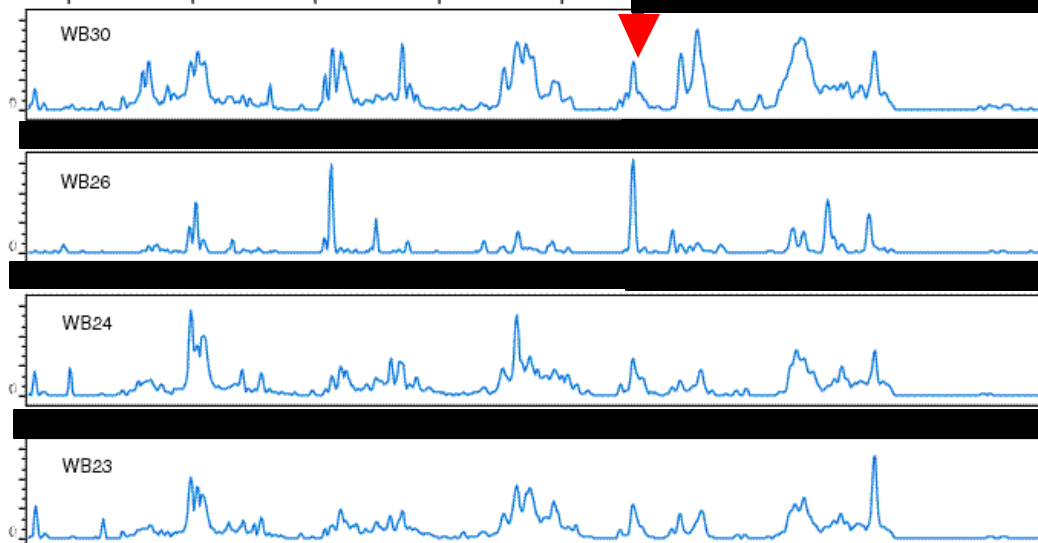




Slower  
summer  
microbial  
degradation  
related to  
plant growth?

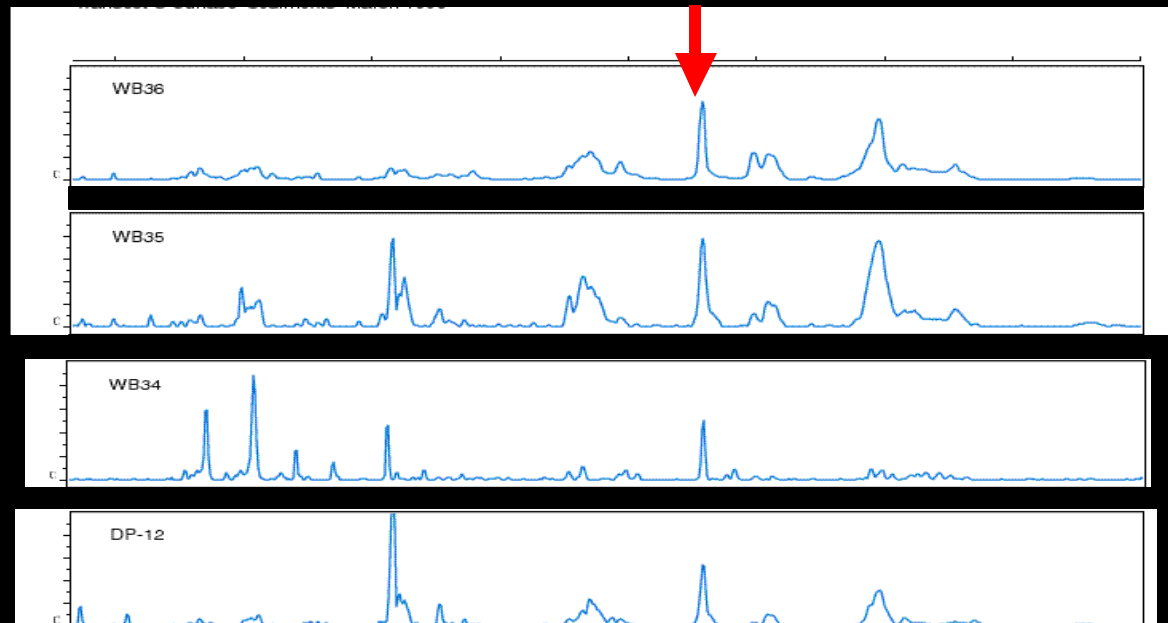


## TRANSECT A SURFACE SEDIMENT

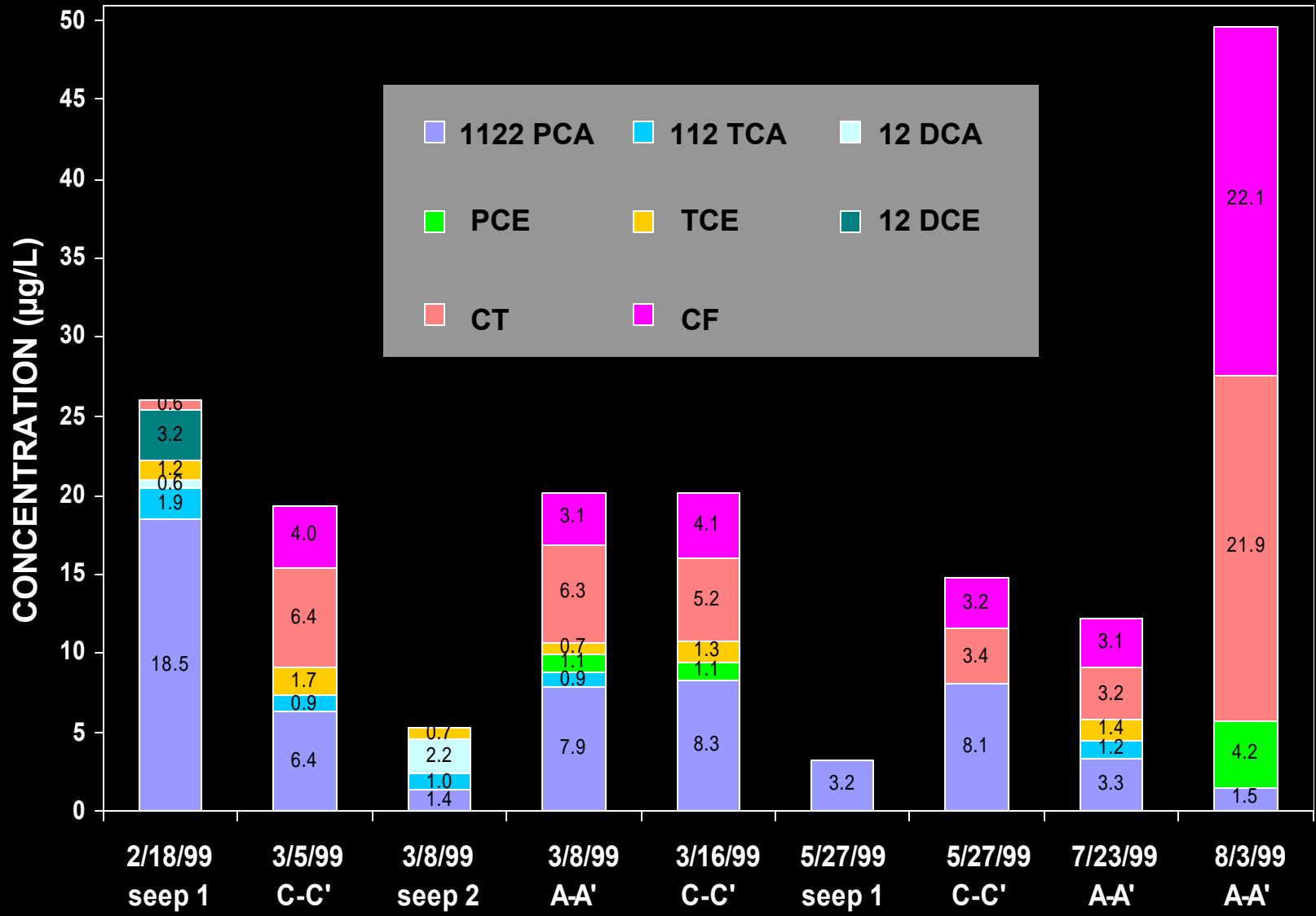


**Spatial  
Heterogeneity  
in Microbial  
Diversity**

## TRANSECT C SURFACE SEDIMENT



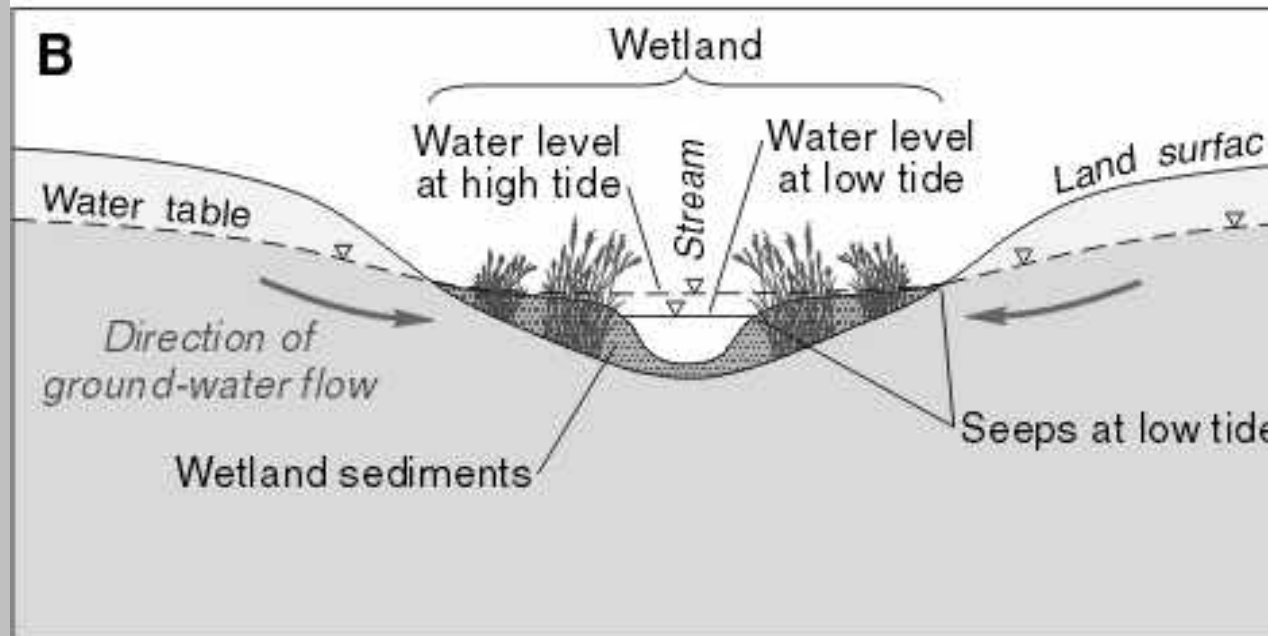
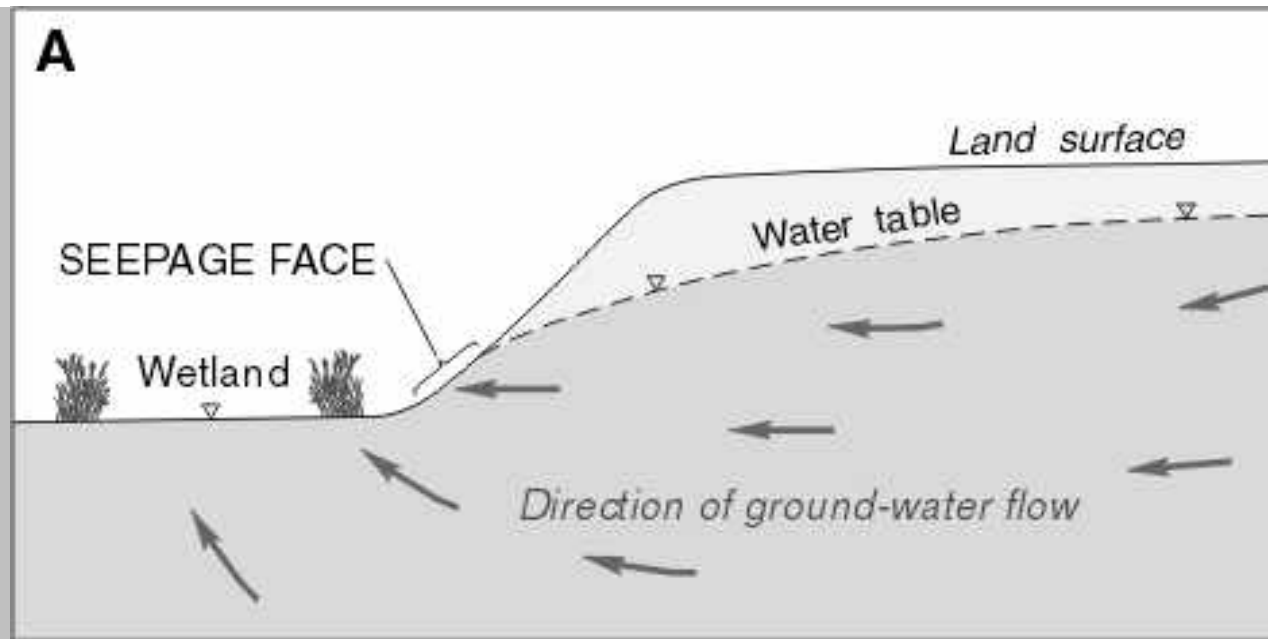
# VOCs in Surface Water at West Branch Canal Creek--FY99



## Delineate Seeps

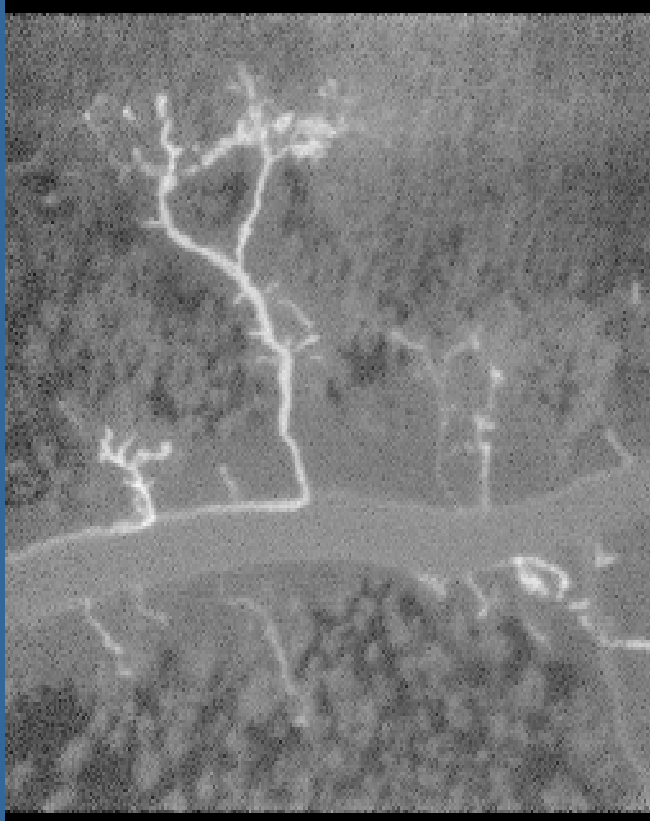
- Use aerial and ground TIR imaging surveys to identify seeps

- Evaluate the effectiveness of high-resolution TIR imaging in seep delineation



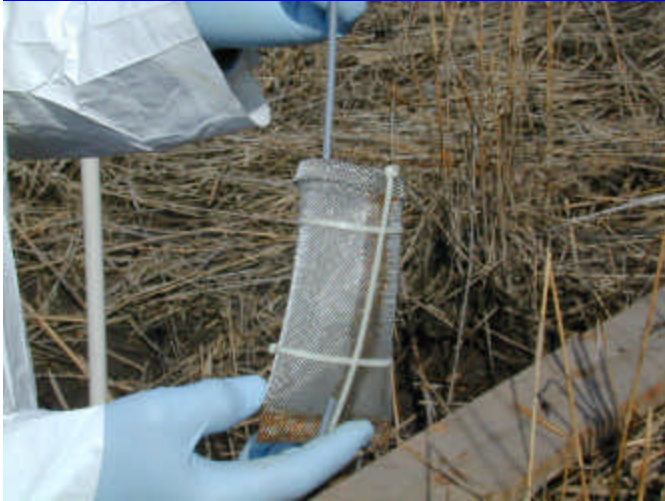
# Thermal Infrared Imaging Study

- Low altitude aerial TIR surveys during low tide by helicopter to identify suspected seeps
- FLIR SCR1000, fixed lens, TIR camera (digital video and still images) in collaboration with ATC
- Ground and boat TIR survey during low tide to confirm locations and scan areas not observable by helicopter

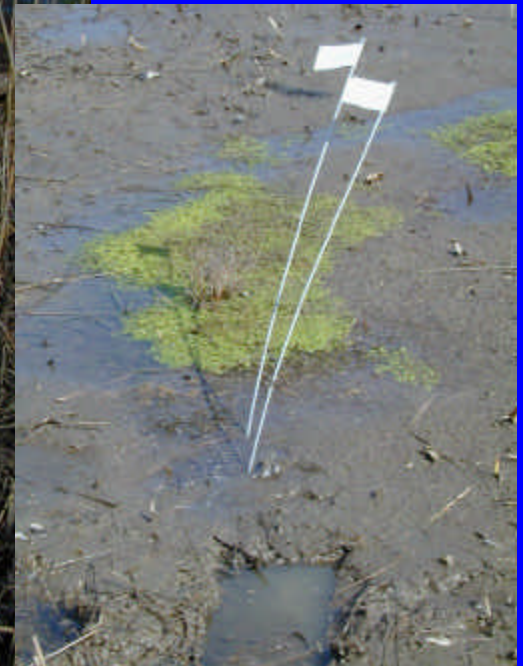




# Characterize Seeps



- Use Passive Diffusion Samplers to collect representative samples of shallow ground water
- Co-located surface-water samples



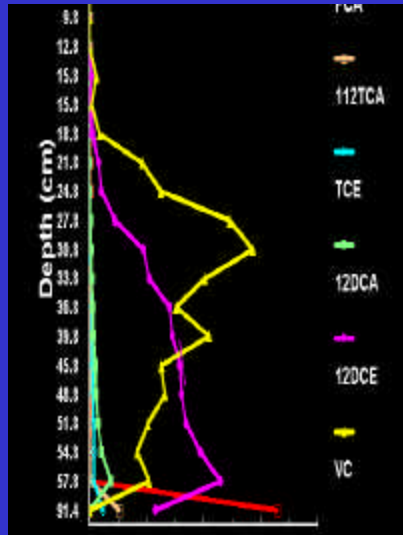
- Analyze for VOCs, methane



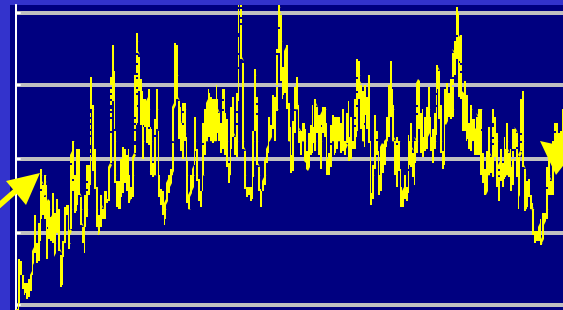
# Conclusions

• *Think multi-disciplinary*

• *Be creative*



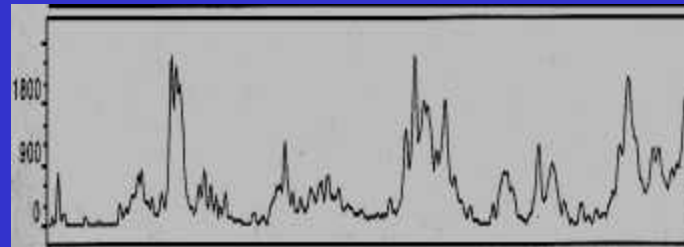
Chemistry



Hydrology



Vegetation



Microbiology

• *Define spatial and seasonal variability*



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*Mary A. Voytek*

*Tracey Spencer*

*Mastin Mount*

*Daniel Phelan*

*Lisa Olsen*

*U.S. Geological Survey*



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