ENVIRONMENT

PACE ANALYTICAL ENERGY SERVICES

Emerging Contaminants: 1,4 – Dioxane Considerations

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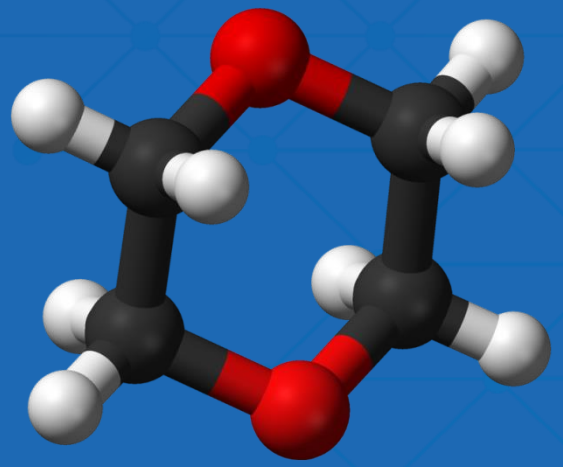
AGENDA

1. INTRODUCTION
2. 1,4 – DIOXANE – ID and Sources
3. IMPACTS
4. ANALYTICAL METHODS
5. COMPOUND SPECIFIC ISOTOPE ANALYSIS
6. CASE STUDY
7. TREATABILITY STUDIES
8. QUESTIONS

What is 1,4-DIOXANE



- 1,4-Dioxane is a synthetic industrial chemical
- It is completely miscible in water
- Unstable at high temperature (fire/explosion)
- A very likely contaminant at chlorinated sites
- A probable human carcinogen (animal studies)
- Detected in drinking water across the country

Where has 1,4-Dioxane Been Used

- As a stabilizer in chlorinated solvents
- As a cryoscopic laboratory solvent
- In consumer products: Varnish, Dyes, Paint Stripper
- In a number of industrial processes
  - Textile Manufacturing
  - Purification of Drugs
  - De-Icing
- Feed stock in shampoos and cosmetics

1,4-Dioxane in Drinking Water

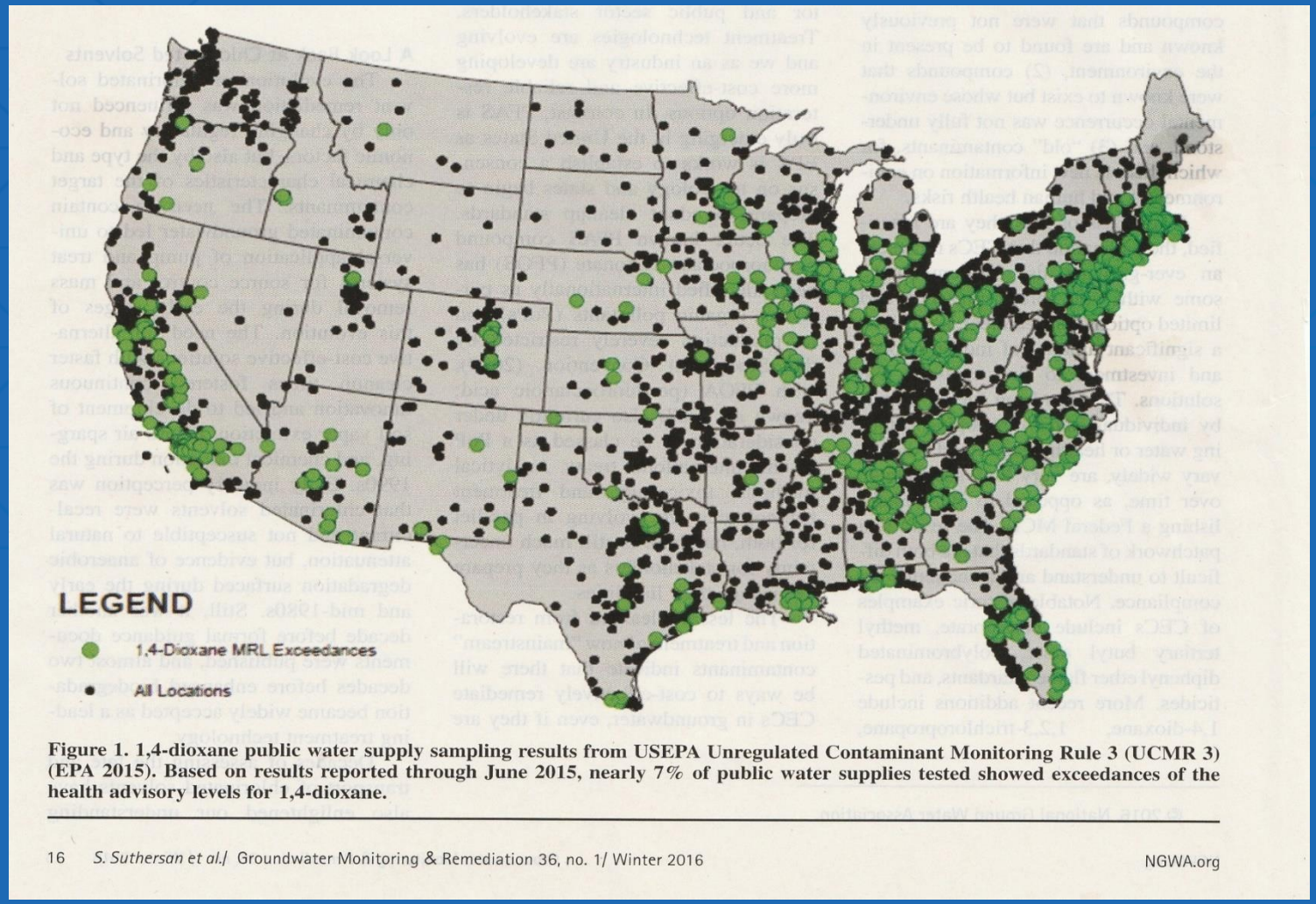


Figure 1. 1,4-dioxane public water supply sampling results from USEPA Unregulated Contaminant Monitoring Rule 3 (UCMR 3) (EPA 2015). Based on results reported through June 2015, nearly 7% of public water supplies tested showed exceedances of the health advisory levels for 1,4-dioxane.

Unregulated Contaminant Monitoring Rule

- UCMR program established to monitor WW influent/ effluent
- 1,4-Dioxane fell in UCMR 3 (2012-2016)
  - 1,1 –DCA
  - Hex Chrome
  - PFOS/PFOA
  - 1,2,3 – TCP
- Currently in UCMR 4 (2017-2021)
  - Manganese, TOC, selected pesticides

Environmental Impacts of 1,4-Dioxane

- Released to the environment from multiple users
    - To consumers in products, DW and reservoirs*
- Mildly retarded by sorption to soil
- Moves rapidly in subsurface soil
- Migrates rapidly in groundwater
- Relatively resistant to degradation

Plume Characteristics

1,4-Dioxane plumes generally dilute (365ug/L median)

Typically lack an easily targeted source zone

Back diffusion

Often co-located with chlorinated solvents

- 1,1,1-TCA most often (70%)
- 1,1-DCE nearly as often (69%)
- With TCE at (52%)

Plume may be much longer than chlorinated, but can be shorter, possibly due to later introduction

Characterization Methodology

Concentration	8260 SIM @ .5ug/L
	8270 SIM @ .1ug/L
	522 @ .07ug/L
Mobile Lab	SPME 8270 SIM @ .2ug/L

qPCR to determine microbial type and quantity

1 D CSIA evaluate biodegradation - Carbon

2 D CSIA evaluation of sources – Carbon/Hydrogen

TO-17 in air to evaluate vapor intrusion

Treatment Options For 1,4-Dioxane

Dissolved oxygen correlates with 1,4-D attenuation

But 1,4-D attenuation inhibited by presence of CVOCs

Strategy - Treatment Train

- Removal of inhibiting compounds, CVOCs
- Followed by bioaugmentation with 1,4-D degraders

Use biomarkers to assess aerobic degradation - CB1190

MNA may be more effective than previously thought

Treatment Options For 1,4-Dioxane, cont'd

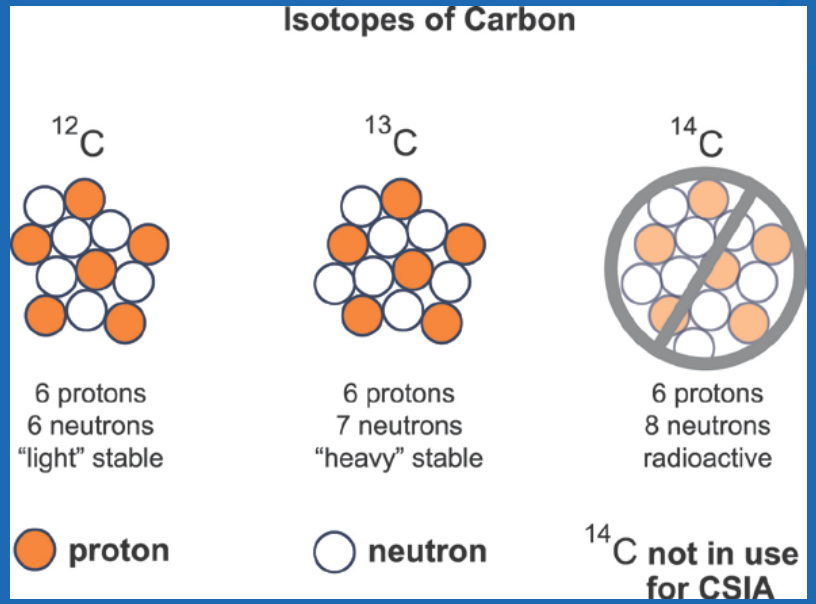
Where have we seen the most progress

- Oxidation
  - UV/H_2O_2
- ISCO
  - Sodium/ Potassium persulfate
  - O_3
- Phytoremediation
- Thermal
  - ERH, SEE, TCH
- MNA
  - CSIA

COMPOUND SPECIFIC ISOTOPE ANALYSIS (CSIA)

CSIA methodology measures the ratio of stable isotopes of an element of a particular compound

- For 1,4 -Dioxane, evaluation of carbon and hydrogen isotopes is protocol
- For chlorinated compounds, evaluation of carbon and chlorine isotopes is protocol



CASE STUDY

Large confidential site, industrial area near LAX

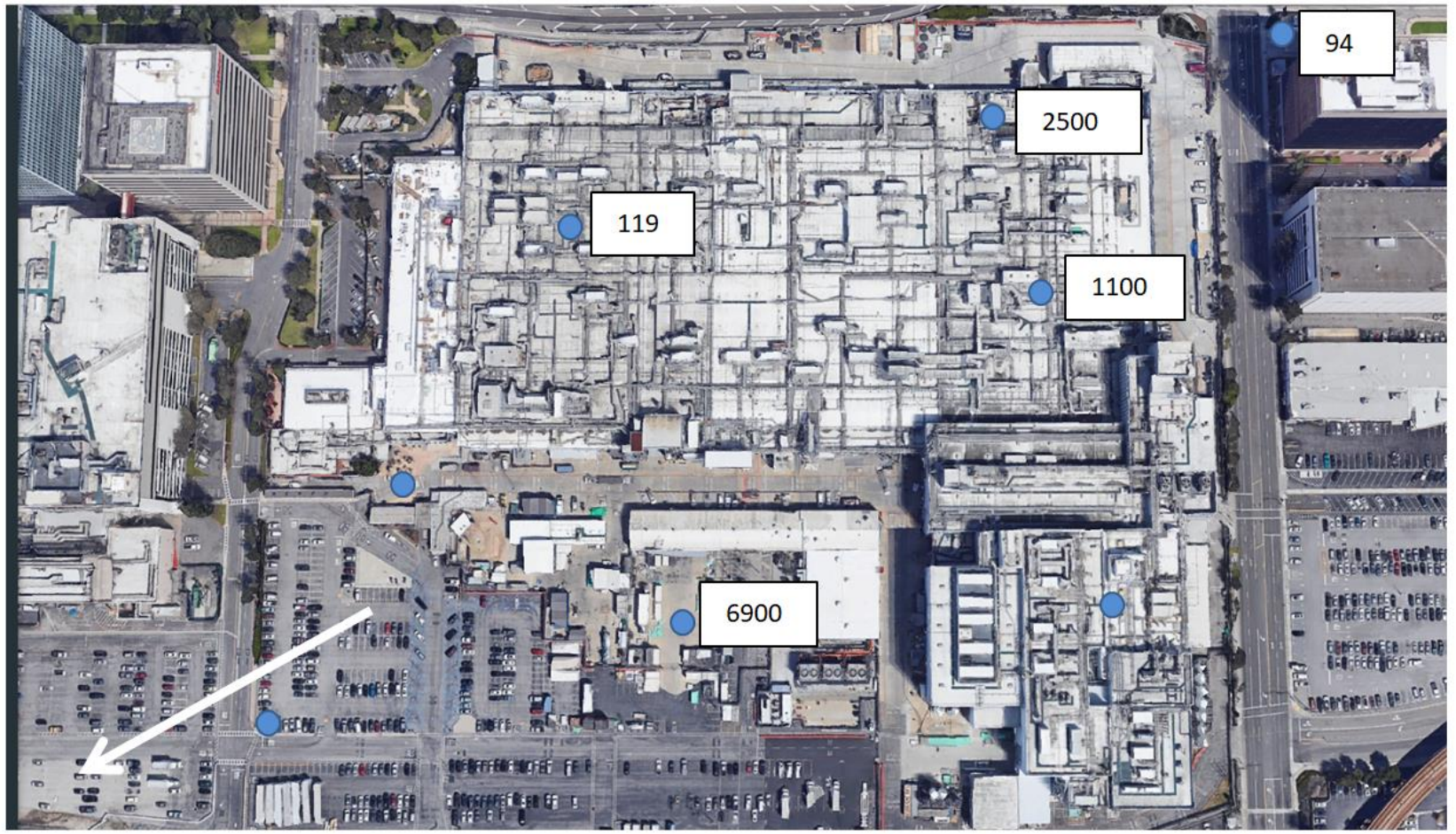
Multiple CVOC plumes including TCA and 1,4-D

RP suspected other sources of 1,4-Dioxane

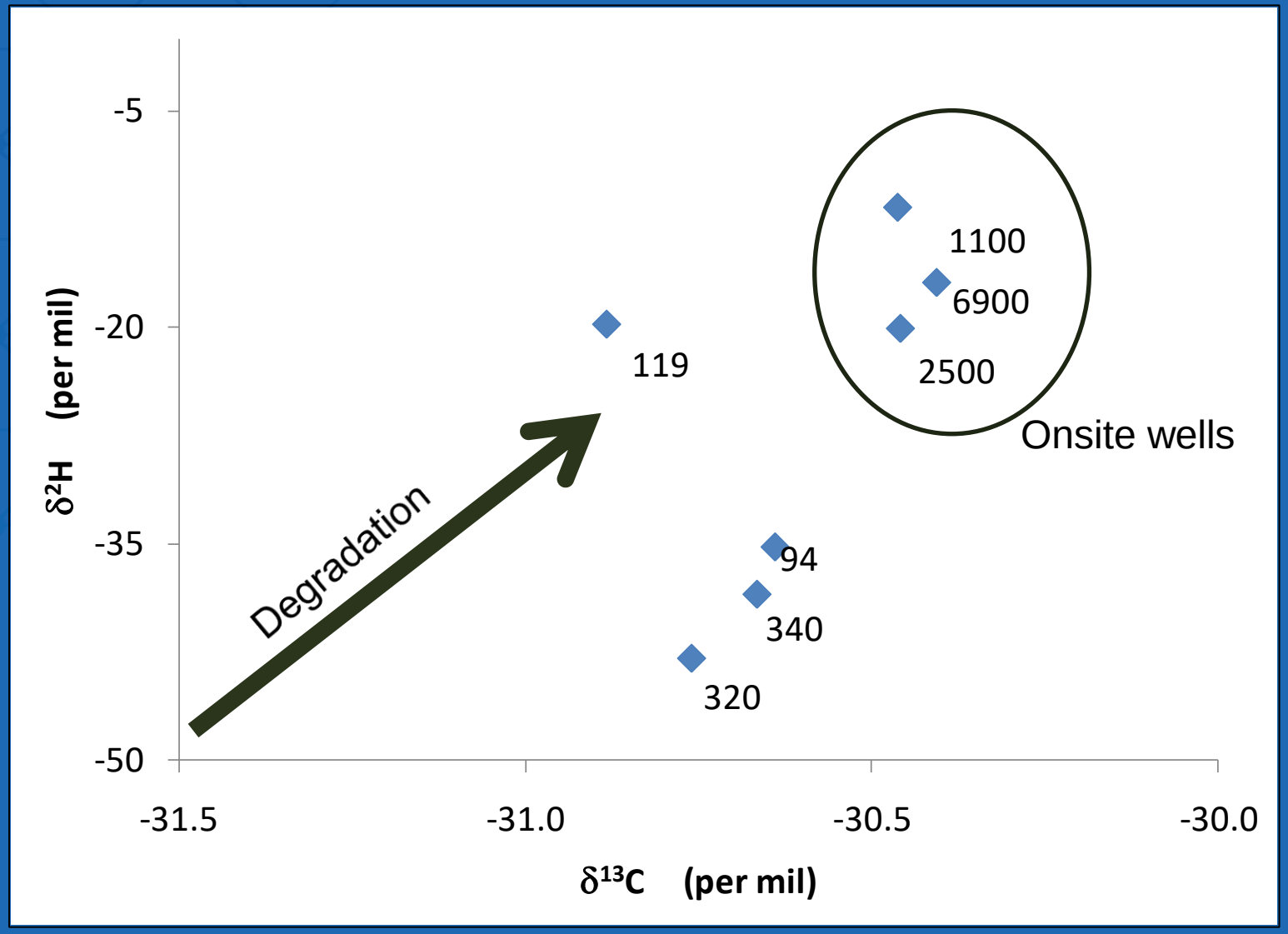
7 samples at strategic wells, 2 D CSIA Carbon/Hydrogen

One line of evidence for multiple source argument

CASE STUDY



CASE STUDY


-5
-20
-35
-50
δ²H (per mil)
-31.5
-31.0
-30.5
-30.0
δ¹³C (per mil)
119
1100
6900
2500
Onsite wells
94
340
320
Degradation

CASE STUDY – 1,4 – Dioxane Treatability

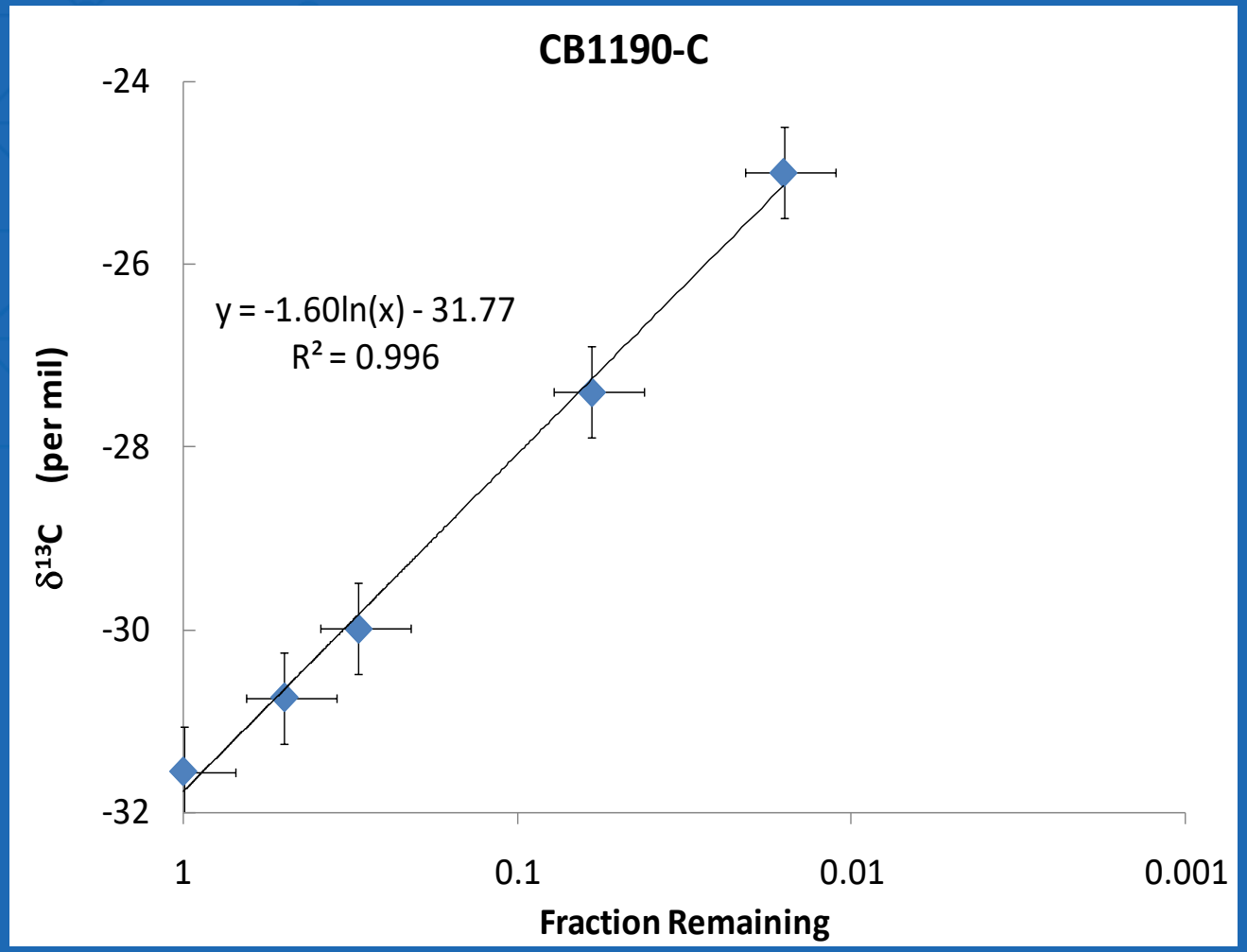
https://www.siremlab.com/treatability-testing/

Treatability studies mimics subsurface environment in a closed system.

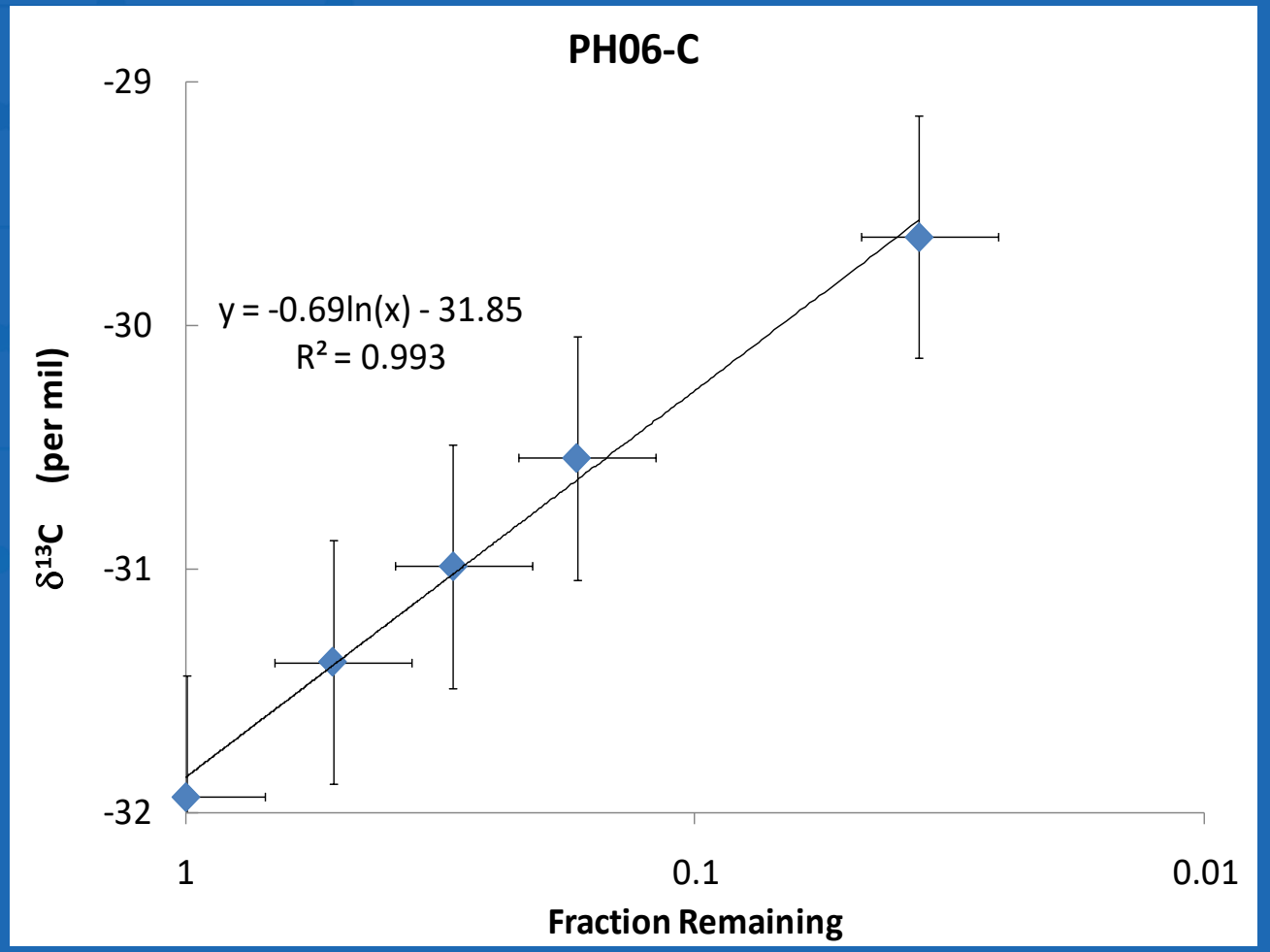
Basically, a laboratory “pilot study”

Can measure degradation of controlled contaminant

CASE STUDY – 1,4 – Dioxane Treatability



CASE STUDY – 1,4 – Dioxane Treatability



Summary

1,4-Dioxane has been widely used in the US

- Has been found in our Drinking Water
- Probably at many CVOC sites not yet evaluated

1,4-D is a probable human carcinogen

State and Federal clean up levels are developed

Methods available to evaluate & monitor activity

Effective treatments are becoming available

Pace will deliver unmatched value and customer service. We will develop our talents and innovative culture to become the clear choice for our customers, employees and business partners.

THANK YOU