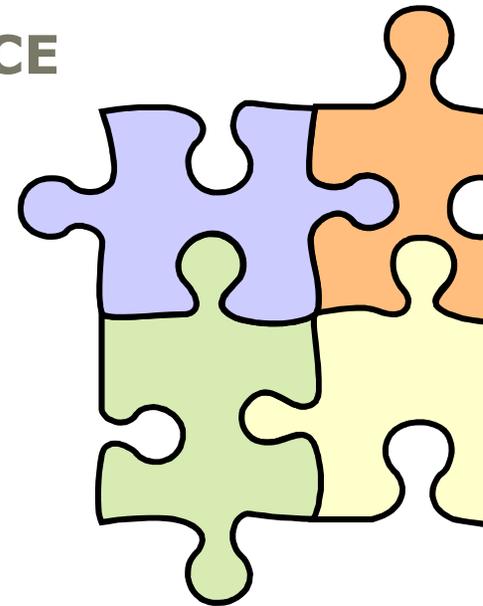


CONFIRMATION OF A CONCEPTUAL SITE MODEL USING COMPOUND SPECIFIC ISOTOPE ANALYSIS

INTERNATIONAL PETROLEUM ENVIRONMENTAL CONFERENCE
NEW ORLEANS, LOUISIANA
NOVEMBER 10, 2016

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BACKGROUND

Former industrial site dating back to 1917

Redeveloped as warehouse/light industrial

Numerous investigations conducted in 1980s and 1990s, not under regulatory oversight

Since 2009, investigations performed under regulatory oversight



BACKGROUND

Location

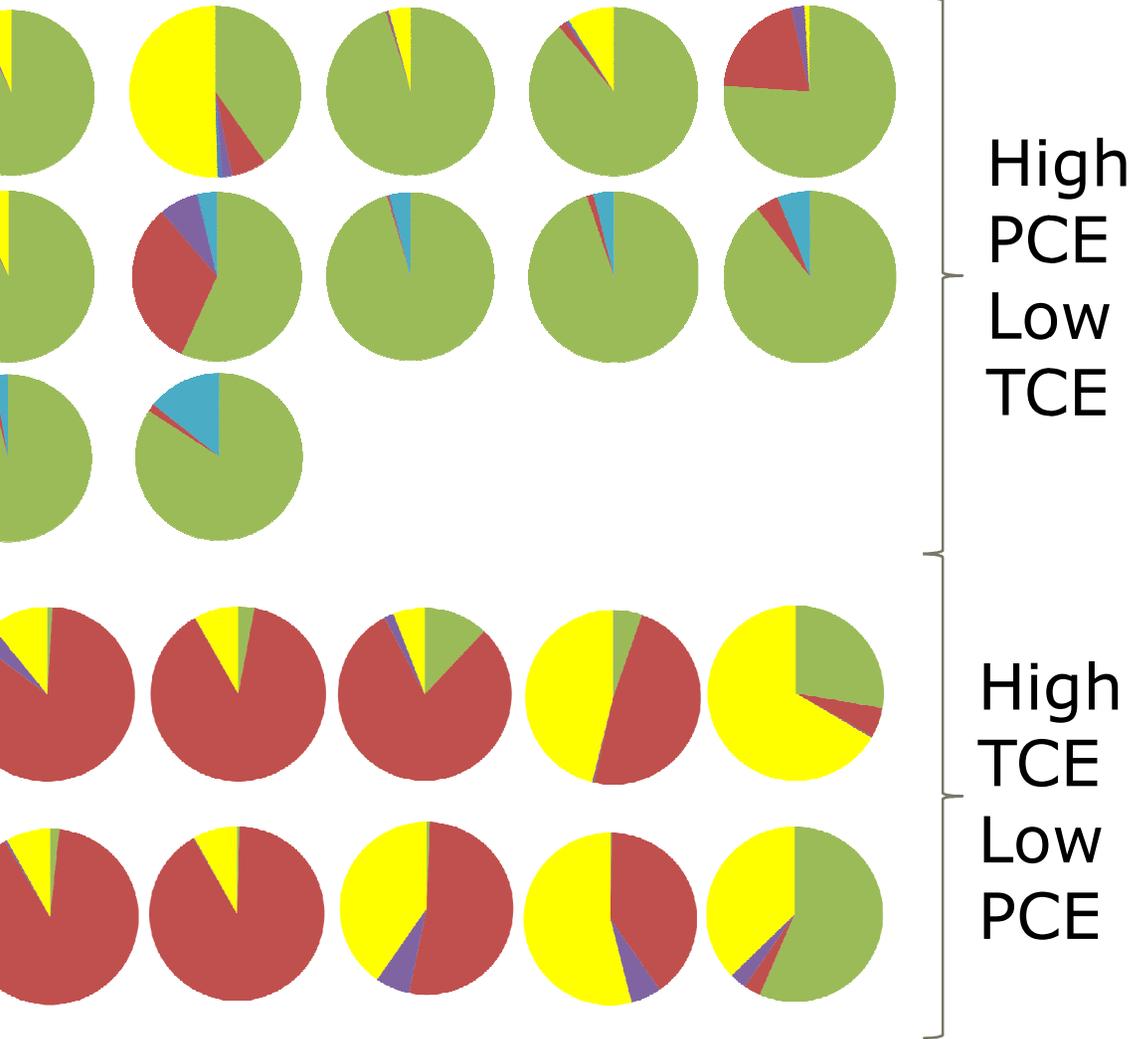
Hydrogeology

Lithology

Comparison of volatile organic compounds (VOCs) present in soil/soil vapor and groundwater identified very different contaminant profiles



DISTRIBUTION OF VOCS



■ TCE
 ■ cis-1,2-DCE
 ■ Vinyl Chloride
 ■ Other

trachloroethene TCE – Trichloroethene, cis-1,2-DCE – cis-1,2-Dichloroethene

OBJECTIVES AND PHASED SAMPLING

evaluate disconnect between soil vapor and groundwater

address data gaps discussed with regulatory agency regarding potential on-site sources of VOCs

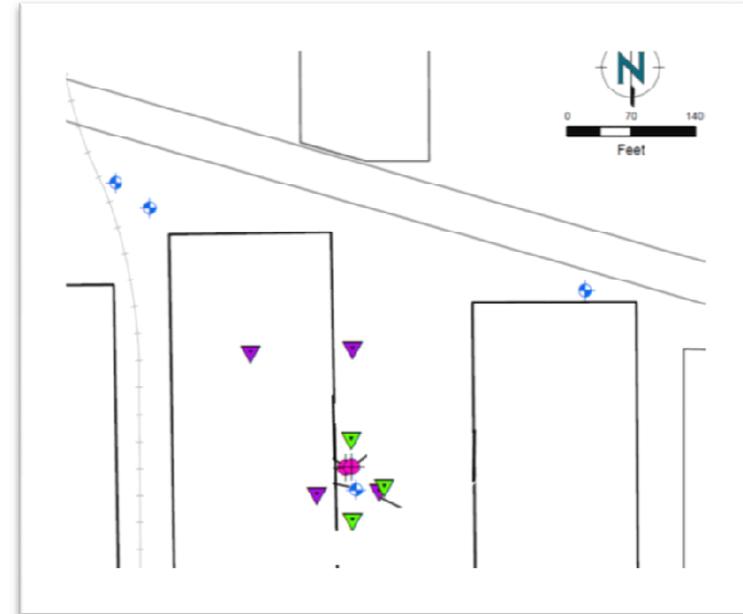
phased sampling approach

Groundwater

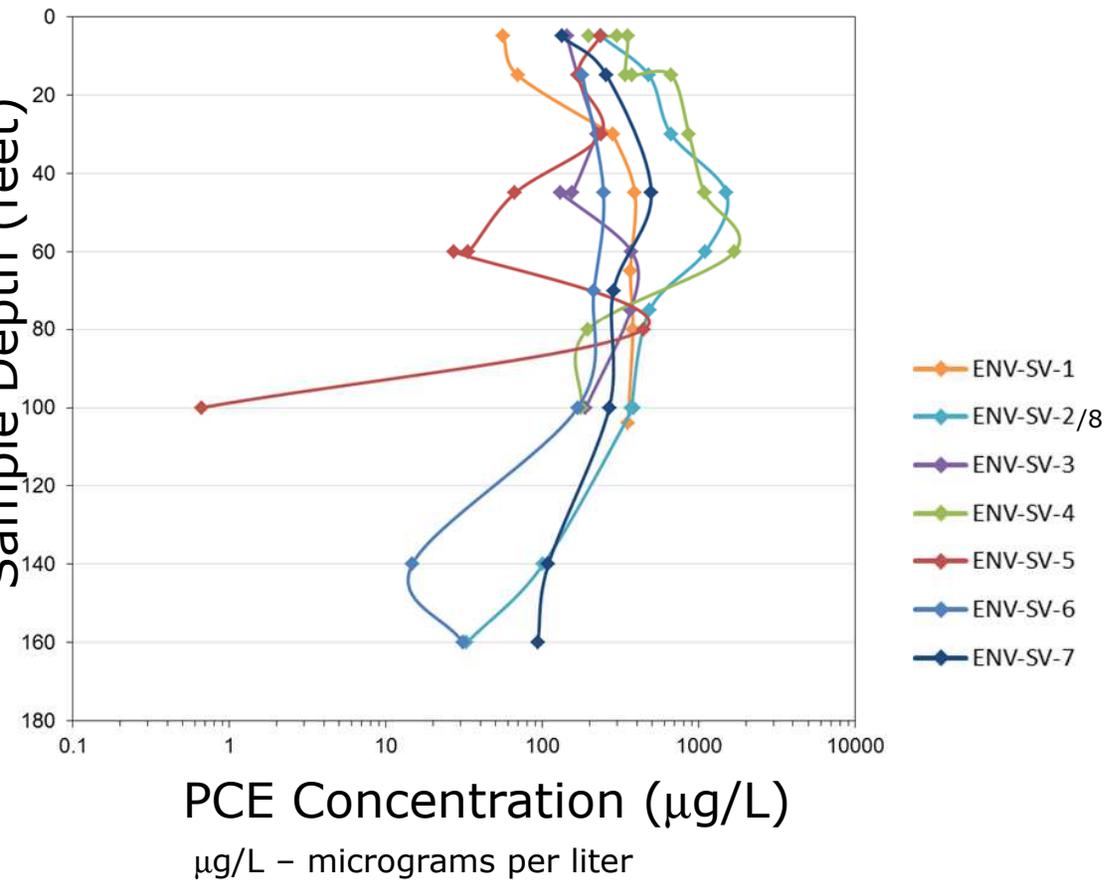
Soil Vapor

Soil

Compound Specific Isotope Analysis (CSIA) – soil vapor and groundwater samples



OIL VAPOR SAMPLING



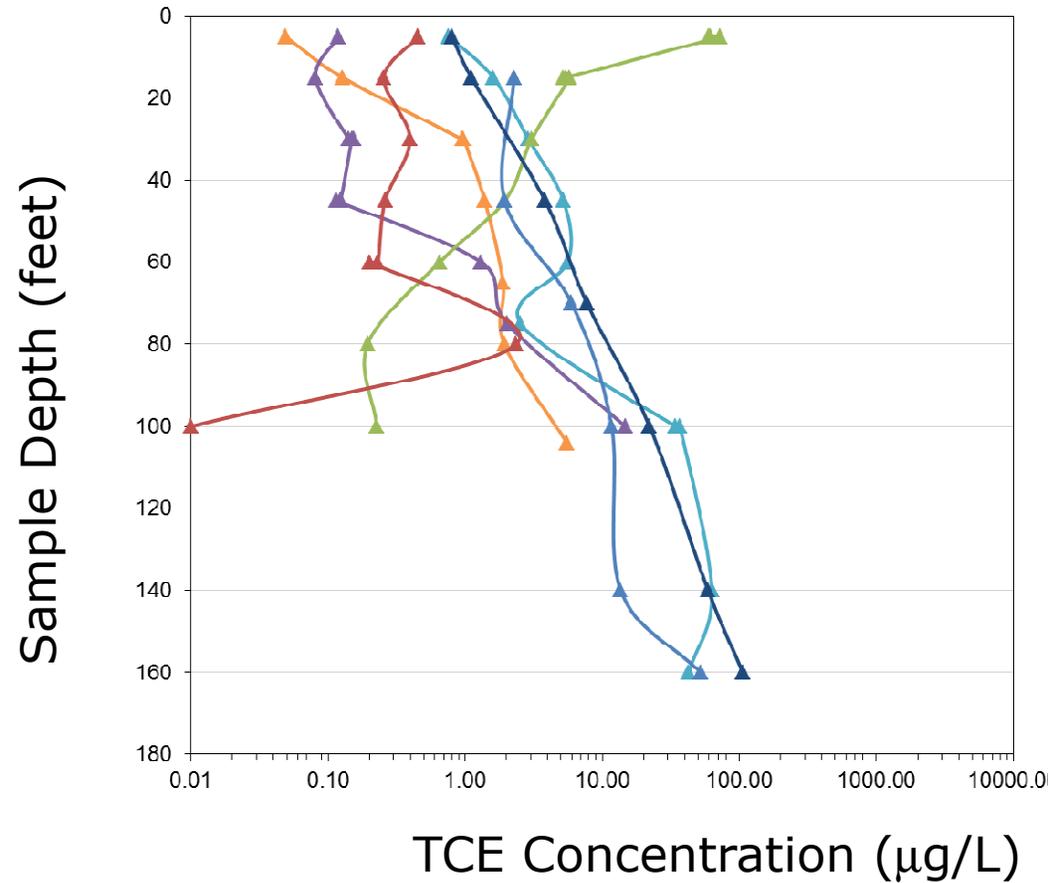
- PCE primary VOC in soil vapor
- Generally increasing concentrations to ~60 feet below ground surface
- Most mass in soil vapor
- Minor biodegradation

OIL VAPOR SAMPLING

TCE lower concentrations than PCE

TCE primary VOC in groundwater

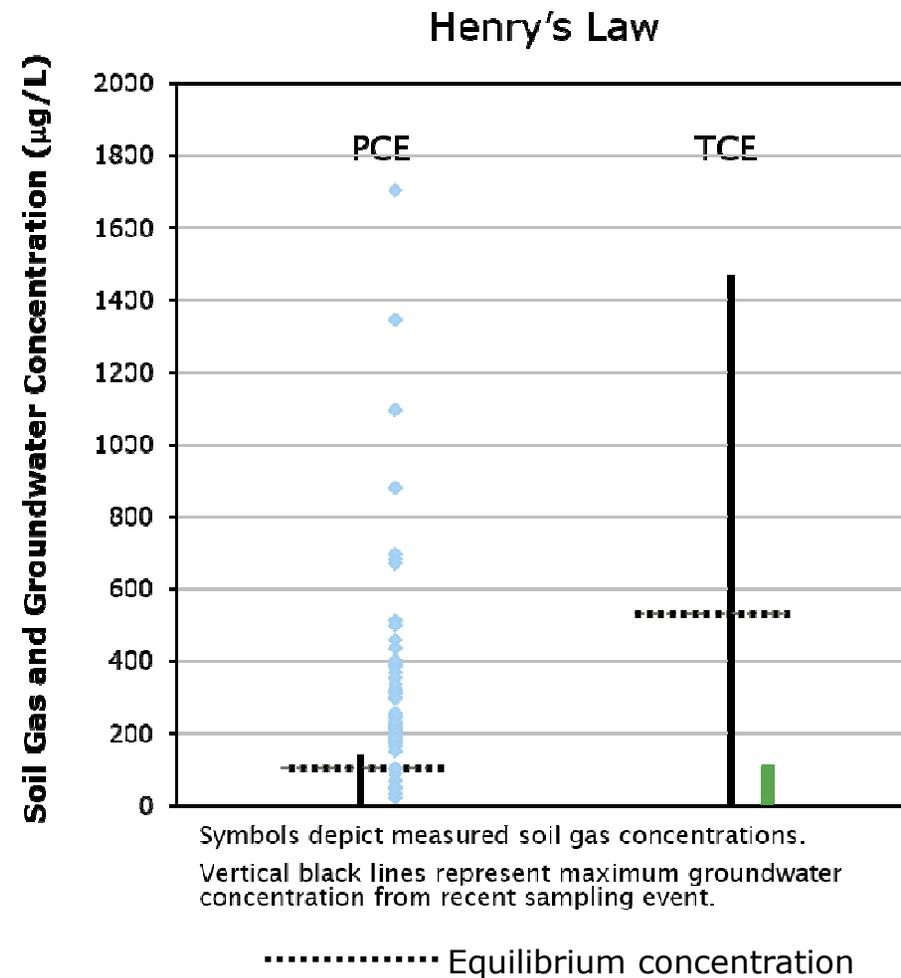
Increasing TCE concentrations with depth – off gassing from groundwater



OIL VAPOR FINDINGS

Soil vapor concentrations:

- PCE concentrations in vadose zone are sufficient to account for the observed concentrations in groundwater
- TCE concentrations in vadose zone too low to account for observed groundwater concentrations



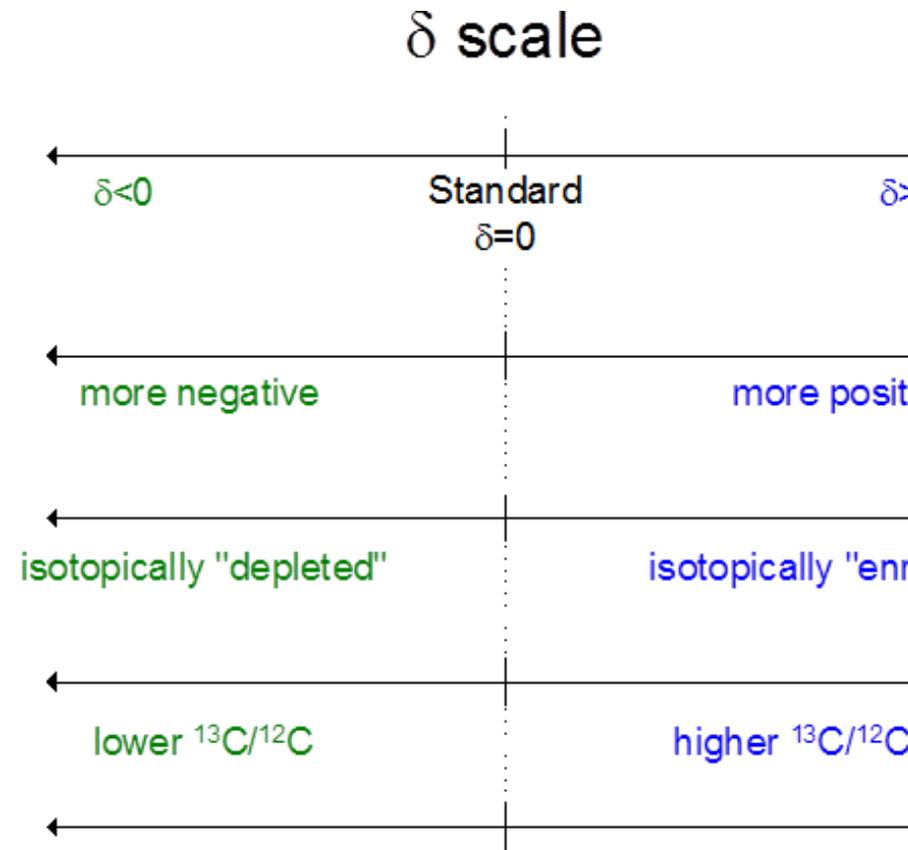
PRIMER ON CSIA

Values are an expression of the difference in isotope ratio (heavy:light) of a sample relative to that same ratio of a specific standard

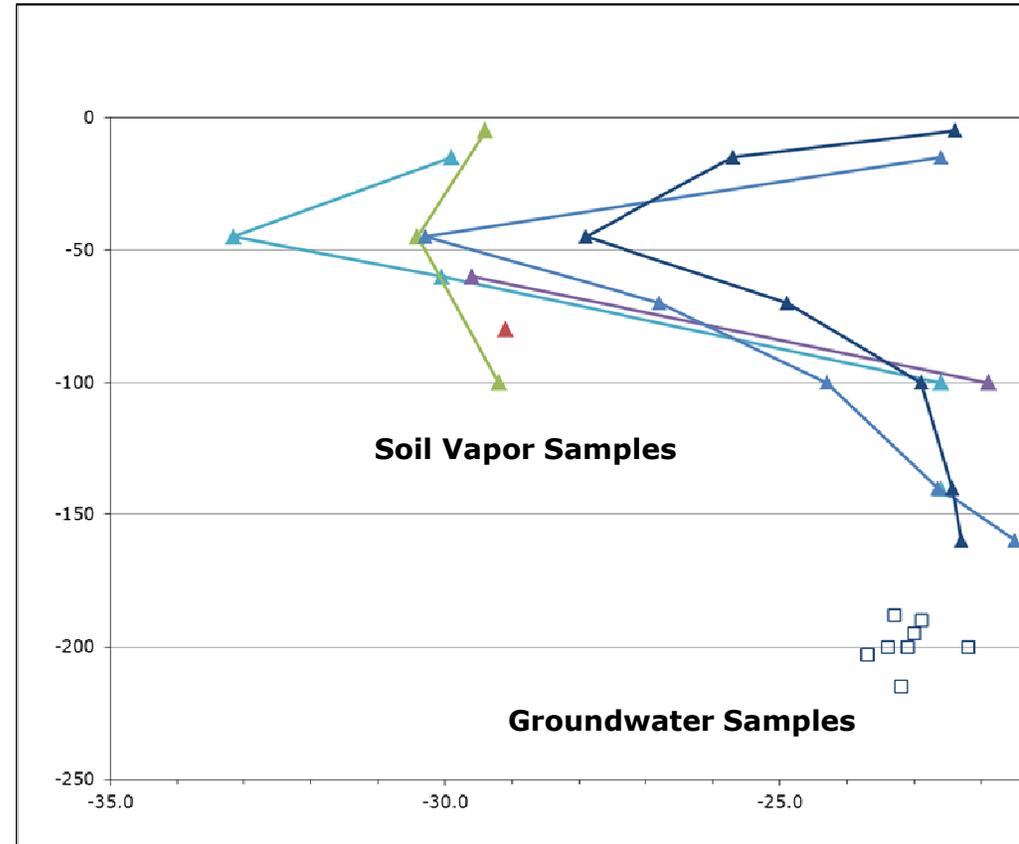
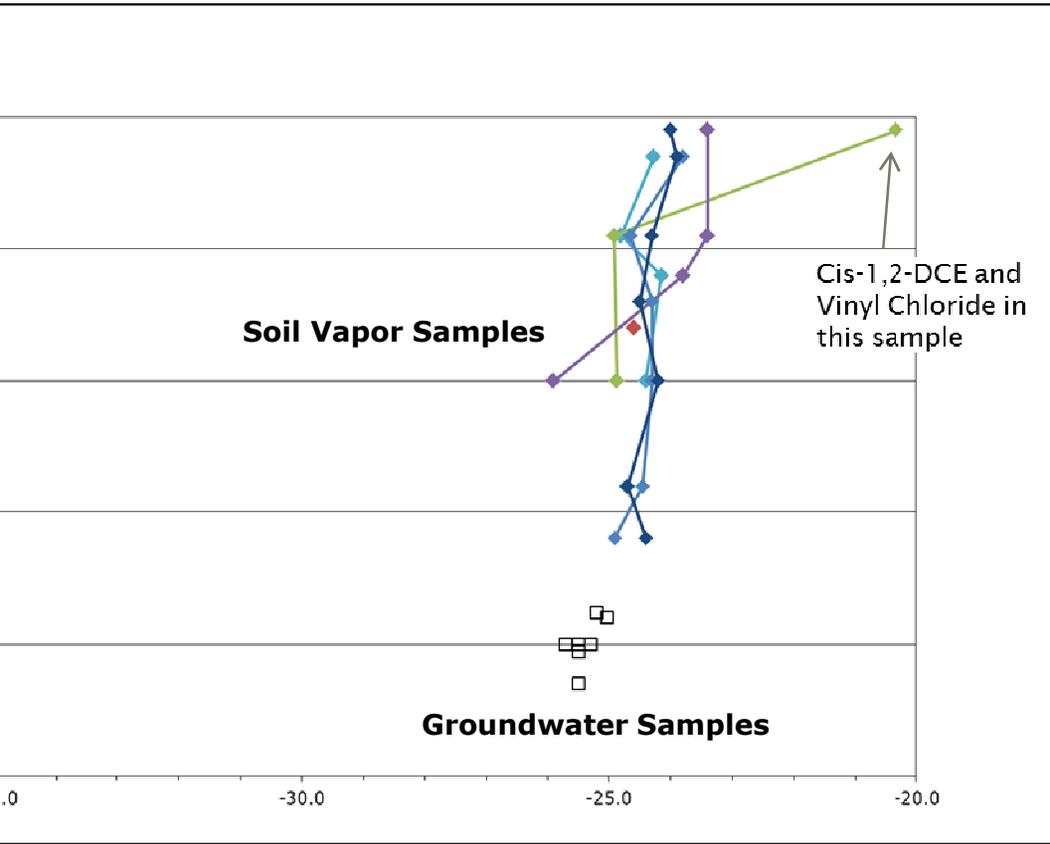
Unit is "per mil" (parts per thousand - ‰)

For two samples with $\delta^{13}\text{C}$ values of +25 ‰ (A) and -30 ‰ (B), one could say:

- Sample A is isotopically "enriched" than Sample B
- Both are isotopically "depleted" relative to the standard



OIL VAPOR AND GROUNDWATER CSIA RESULTS



$\delta^{13}C_{PCE}(\text{‰})$

$\delta^{13}C_{TCE}(\text{‰})$

- ENV-SV-1
- ENV-SV-2/8
- ENV-SV-3
- ENV-SV-4
- ENV-SV-5
- ENV-SV-6
- ENV-SV-7

INDINGS – MULTIPLE LINES OF EVIDENCE

CE

- Primary VOC in soil and soil vapor
- Lower concentrations in groundwater
- Mass in vadose zone could account for concentrations in groundwater
- Minor amounts of biodegradation
- Similar signature

- TCE

- Primary VOC in groundwater
- Lower concentrations in soil vapor (increases with depth - off-gassing from groundwater)
- Isolated occurrences in soil
- Insufficient mass in vadose zone to account for concentrations in groundwater
- Minor amounts of biodegradation
- Signature - multiple sources

EXT STEPS

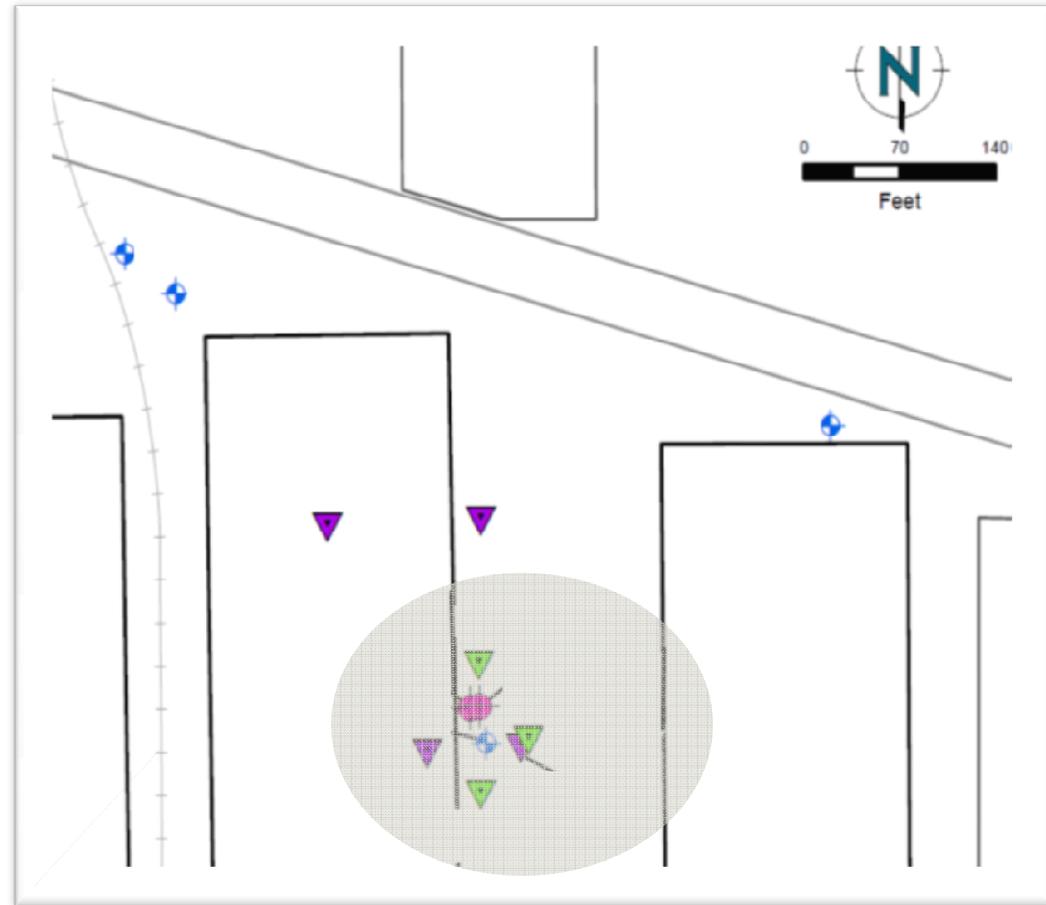
Vapor Extraction (SVE) Pilot
Study

Reductions of PCE concentrations
in vadose zone will result in
reduction of VOC sources to
groundwater

performed rebound testing

SVE system is an effective
remedial measure, will optimize

continue groundwater monitoring
program



**HANK YOU
ACKNOWLEDGEMENTS**

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