

A Multi-Year Evaluation of Natural Attenuation of Chlorinated Ethenes and Methanes using CSIA

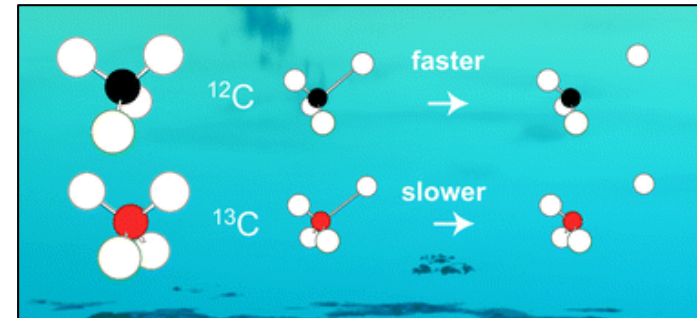
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Topics

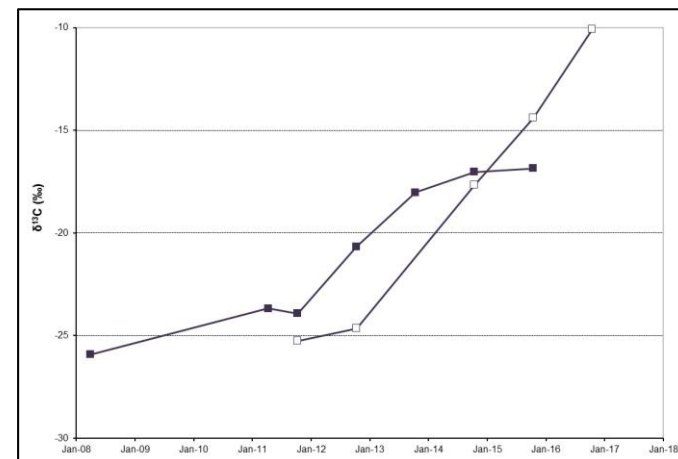
- CSIA in support of MNA – a brief primer
- Site and regulatory setting
- How we modified our monitoring program, and a word about costs
- Multi-year demonstration of destructive NA – some examples
- How site complexity confounds the data interpretation
- What CSIA taught us about our CSM

CSIA in Support of MNA - Briefly

- In a compound, heavy isotopes bond more strongly to adjacent atoms than lighter isotopes
- During reactions, lighter isotope molecules react more quickly
- As the reaction proceeds, a progressively higher heavy isotope fraction remains
- Fractionation trends in time or space can be used to help demonstrate contaminant breakdown under natural conditions (or to support active remedy success)

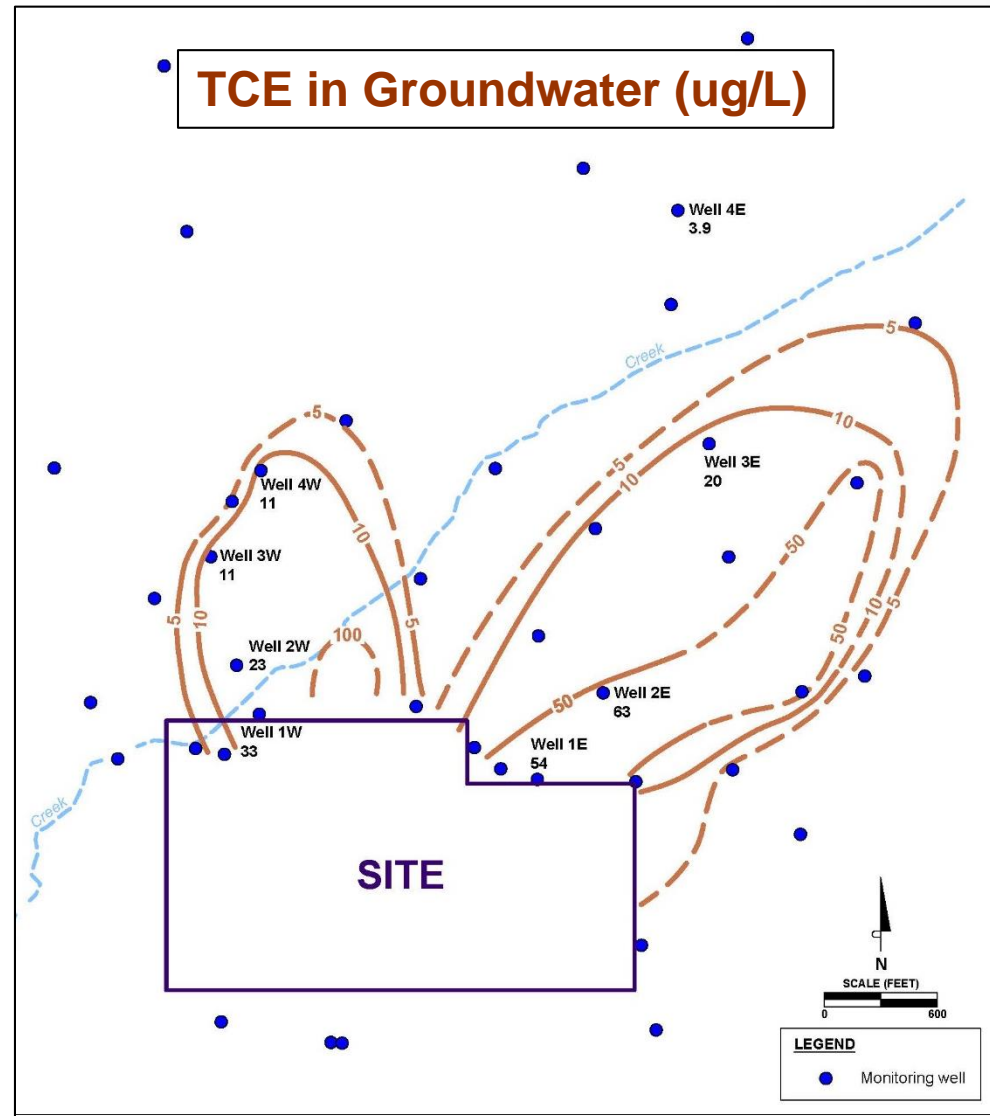


<http://pubs.rsc.org/en/content/articlelanding/2010/em/c0em00277a#ldivAbstract>



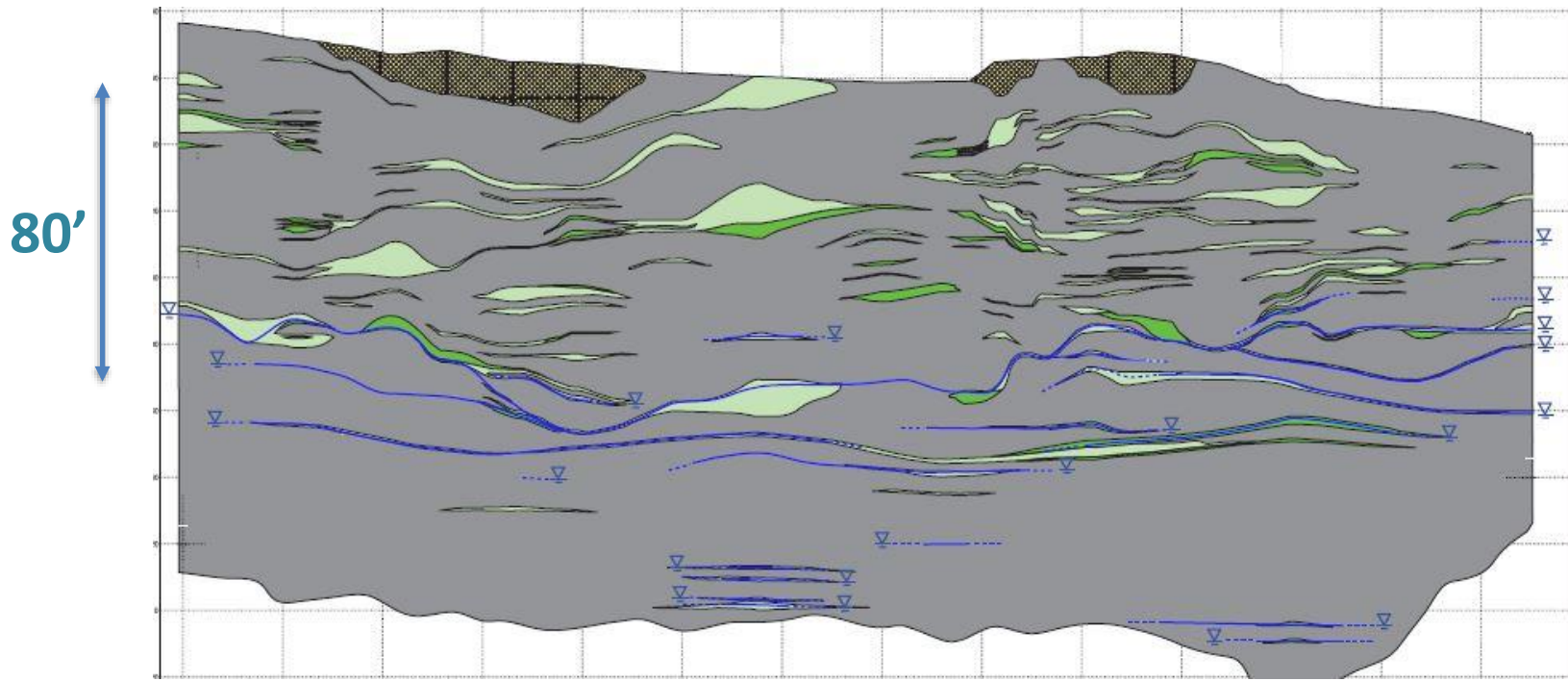
The Setting

- Former landfill site (1940s – 1990s)
- Heterogeneous, alluvial geology, deep groundwater
- Large, diffuse plumes
- PCE+daughters, CT+daughters, 1,2-DCP, others
- Likely multiple sources/releases
- Variable groundwater chemistry



More on Setting

- East-west cross-section through landfill northern boundary
- Thin, discontinuous interbedded sandy lenses within a matrix of low-permeability clays/silts
- 40+ monitoring wells installed by various parties under different CSM assumptions



Regulatory Setting (2008)

Existing RAP =
containment at landfill + active downgradient remediation

Preferred approach =
containment + downgradient MNA

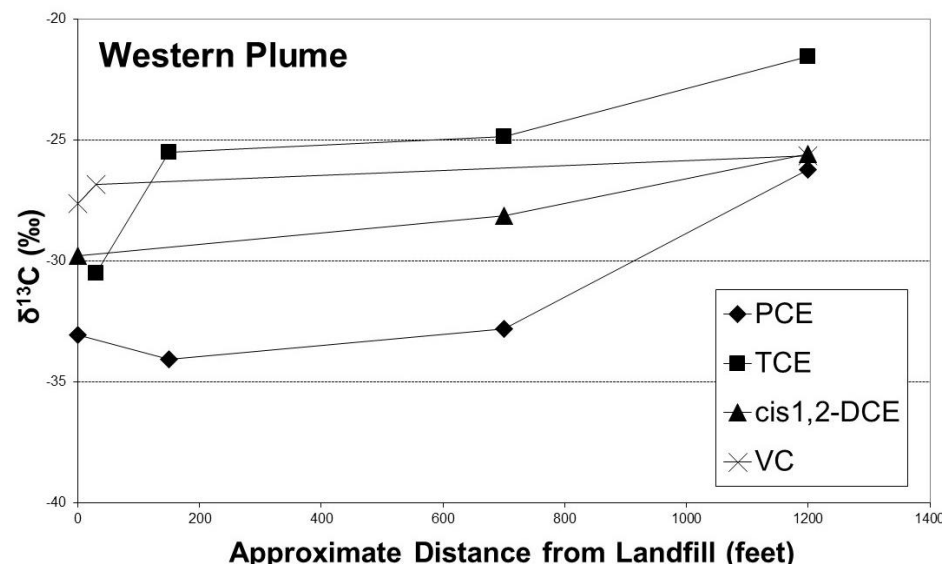
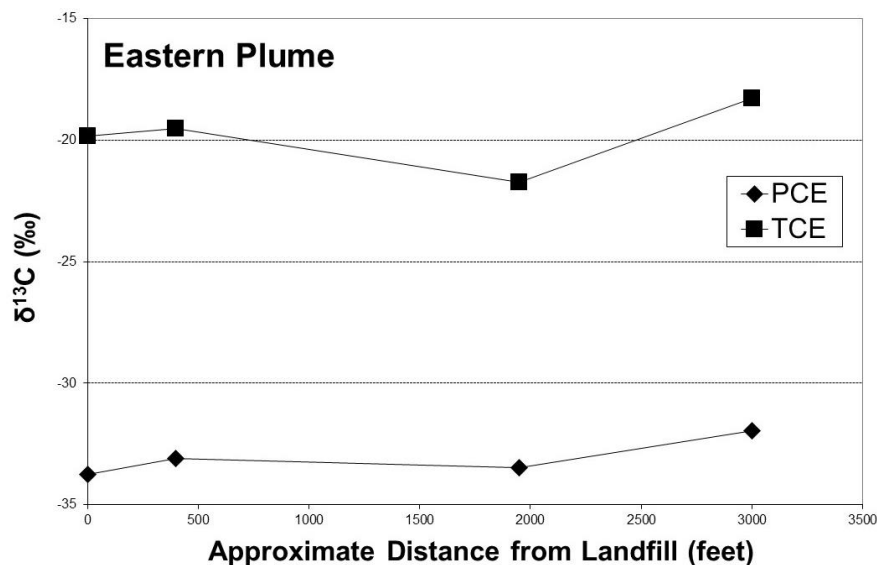
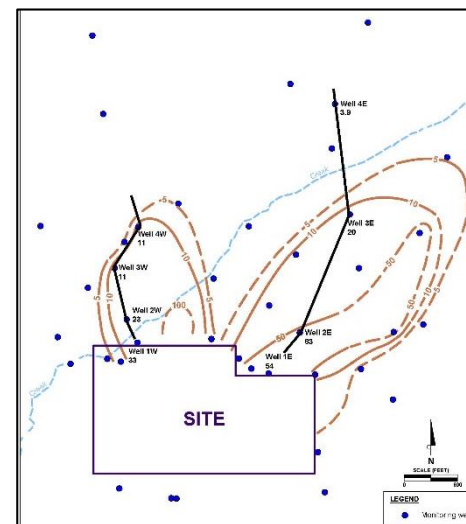
Rigorous MNA demonstration central to agency acceptance

We had already done:

- ✓ *Sampled for DHC – present*
- ✓ *Daughter products*
- ✓ *Concentration trends*
- ✓ *Geochemistry – sulfate, nitrate, iron, etc.*
- ✓ *EPA scorecard*
- ✓ *Biochlor*

Enter CSIA – What We Did First (2008)

- Carbon stable isotope snapshot down plume centerlines - ethenes
- Would expect fractionation with distance



Modifications to our Monitoring Program

Well	VOCs	HC gases	<u>MNA</u> DOC, Mn, Alkalinity, SO_4^{2-} , S^{2-} NO_3^- , NO_2^- Fe^{2+} , Fe^{3+}	<u>CSIA (carbon)</u> PCE, TCE, cis-1,2-DCE, VC, CT, TCM, 1,2-DCP
1E	✓	✓	✓	✓
2E	✓	✓	✓	✓
3E	✓	✓	✓	✓
4E	✓	✓	✓	✓
1W	✓	✓	✓	✓
2W	✓	✓	✓	✓
3W	✓	✓	✓	✓
4W	✓	✓	✓	✓
One other well	✓	✓	✓	✓
29 other wells	✓	<i>This space represents cost benefits using the plume centerline approach.</i>		

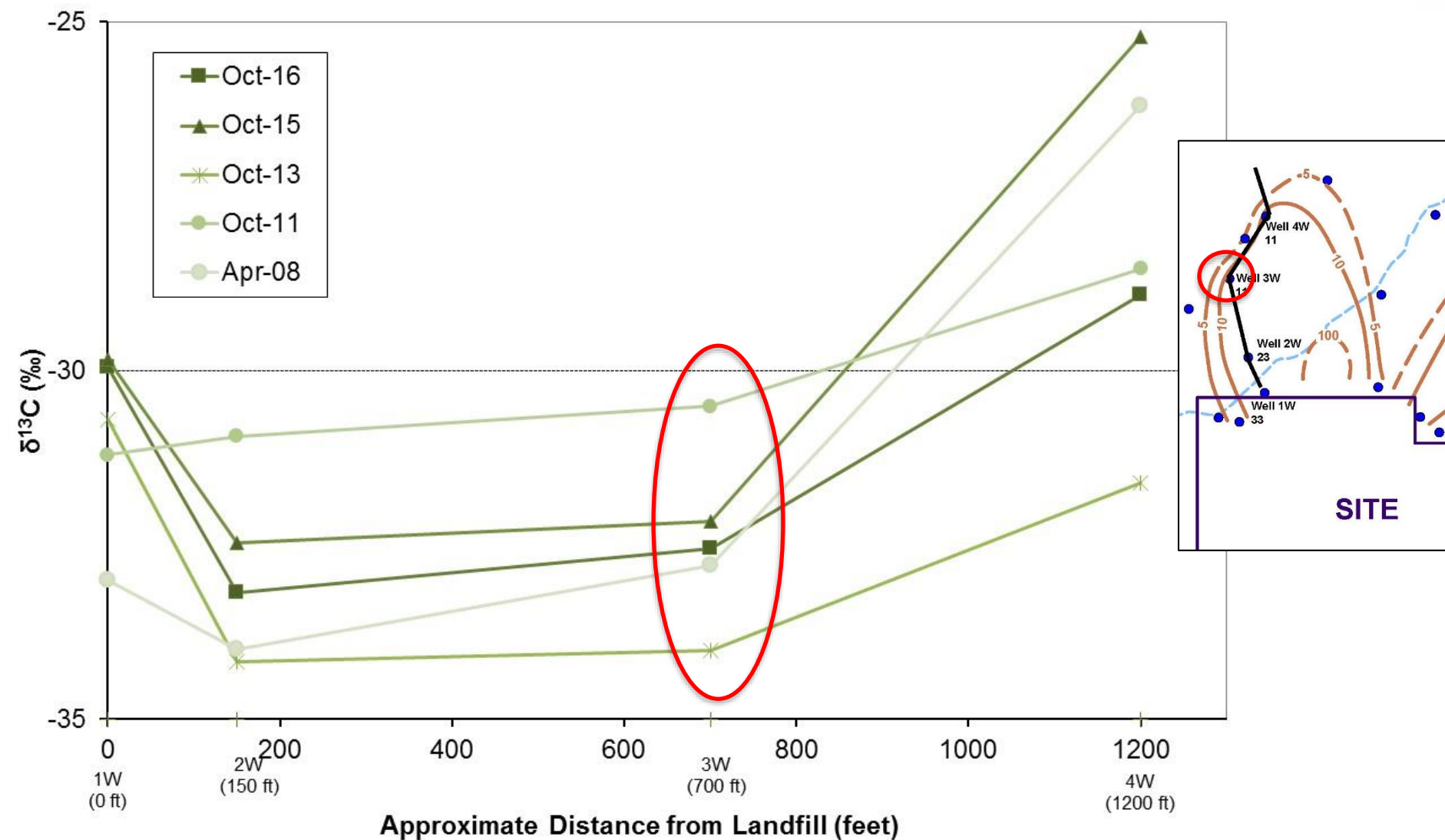
GREEN = important at our site

A Word about Cost

Former Program	MNA parameters at all wells. No CSIA.	\$27,000
Current Program	MNA parameters and CSIA at plume centerline wells.	\$20,500
Annual Cost Savings (Analytical)		\$6,500

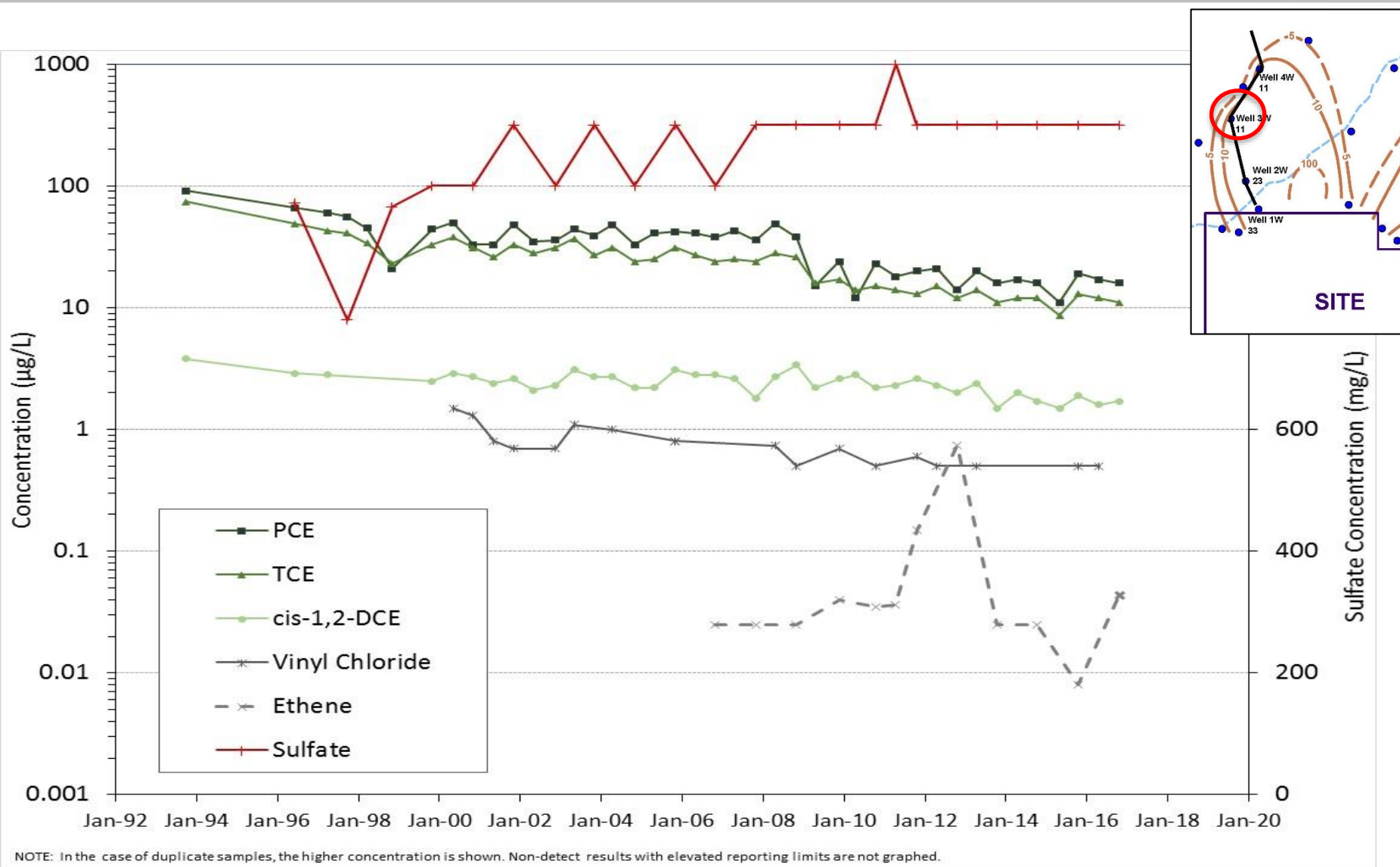
Fractionation with Distance

PCE – Western Plume



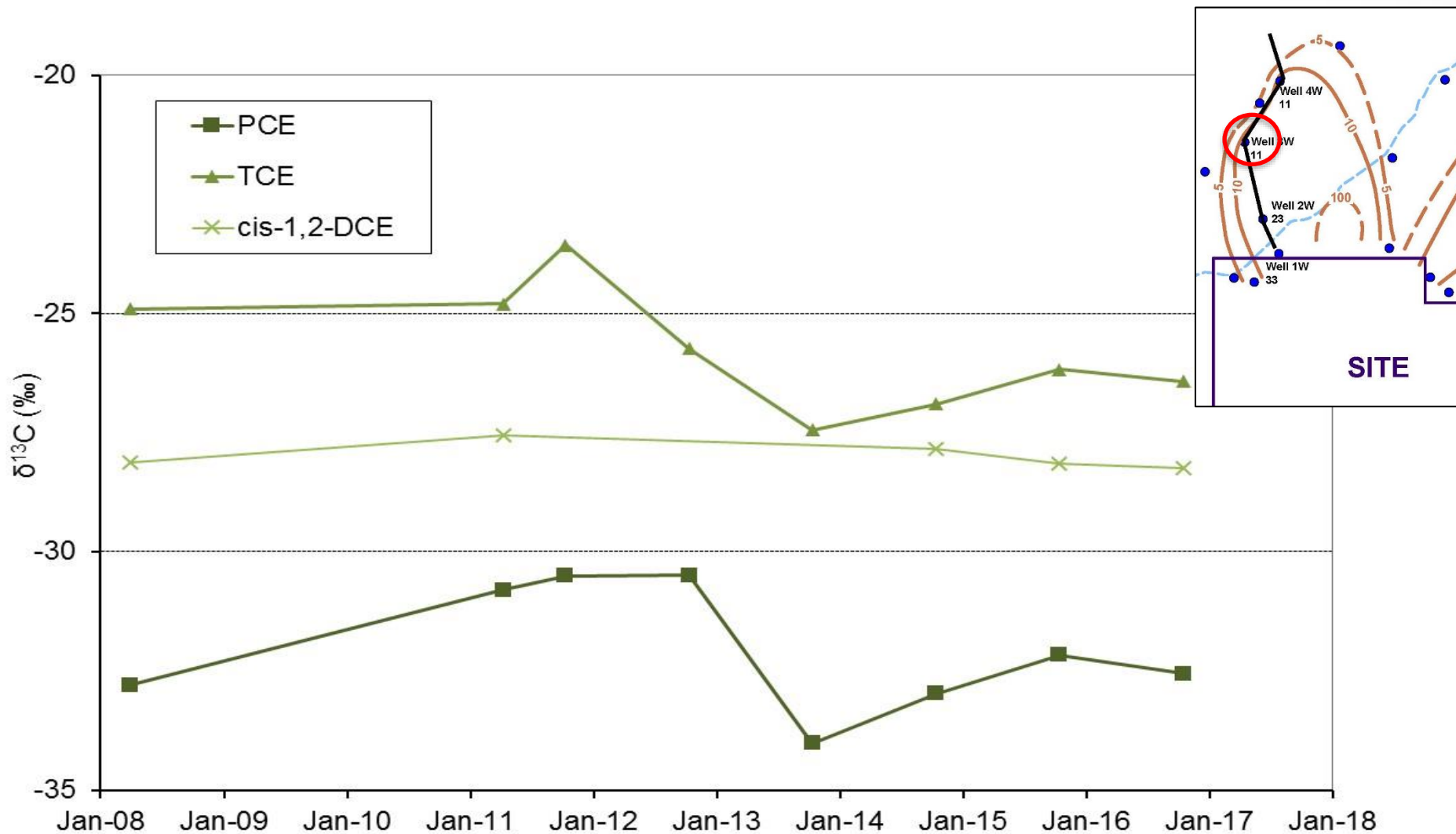
Concentration with Time

Well "3W" - Chlorinated Ethenes – Western Plume

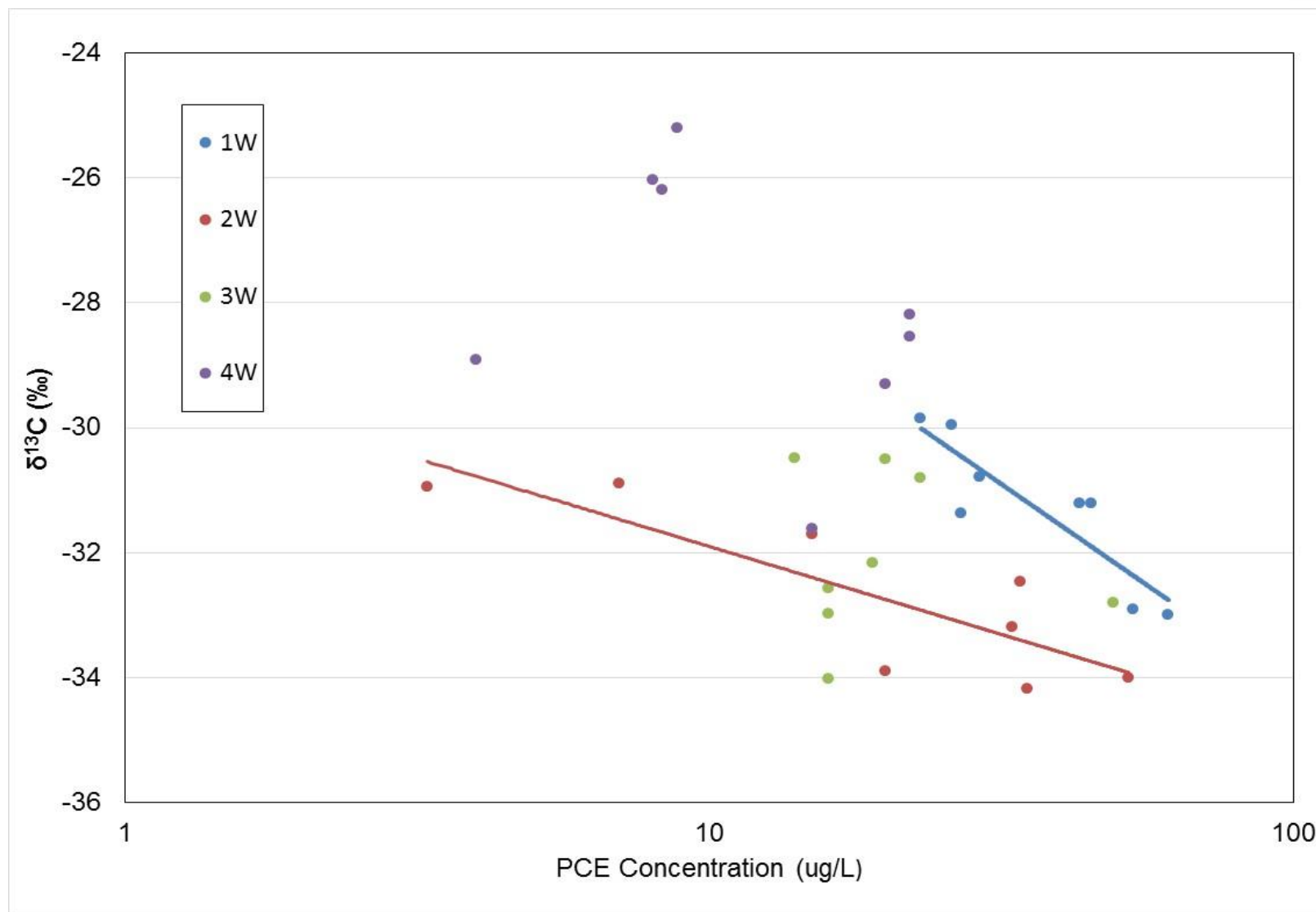


Fractionation with Time

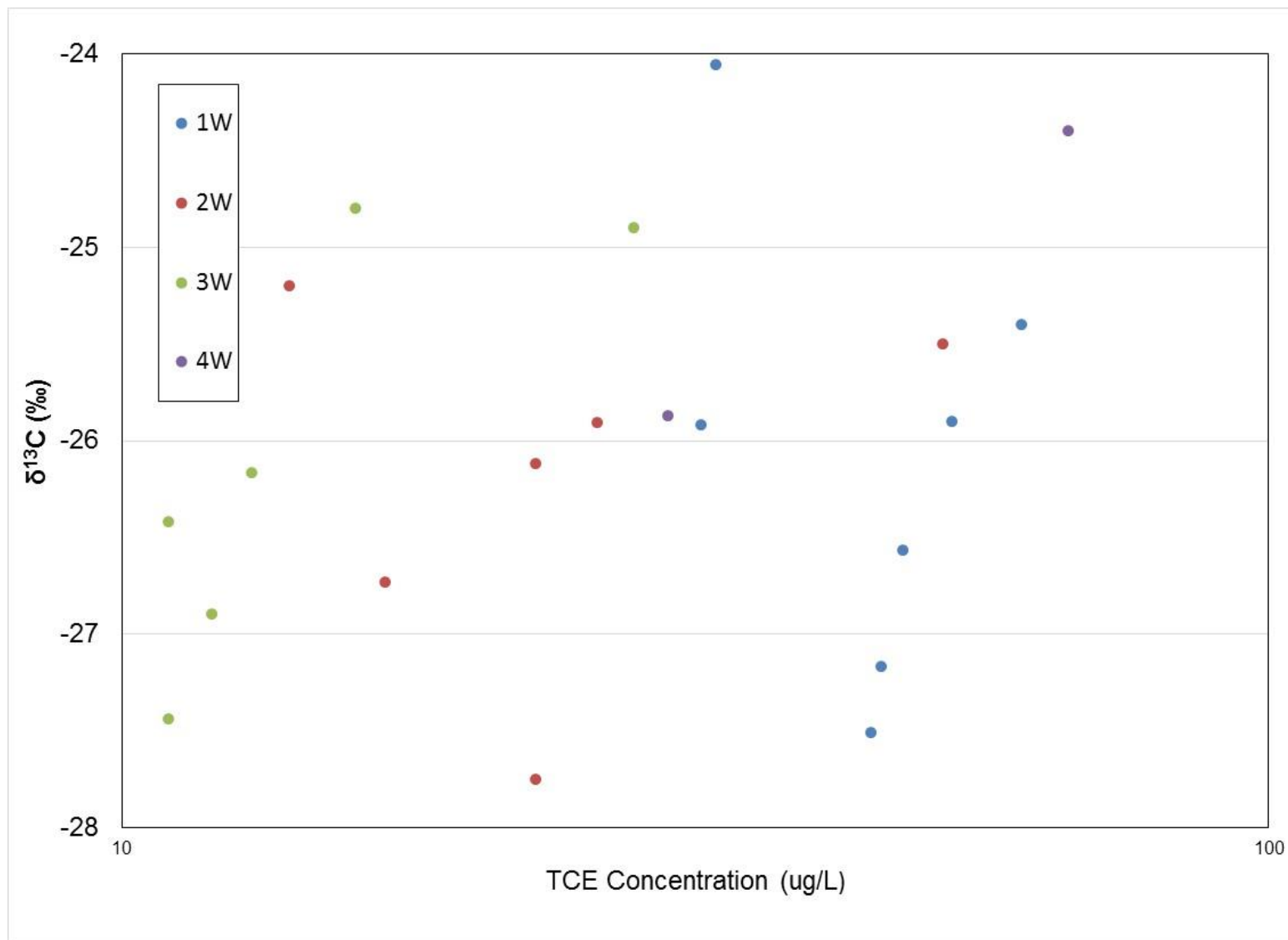
Well “3W” - Chlorinated Ethenes – Western Plume



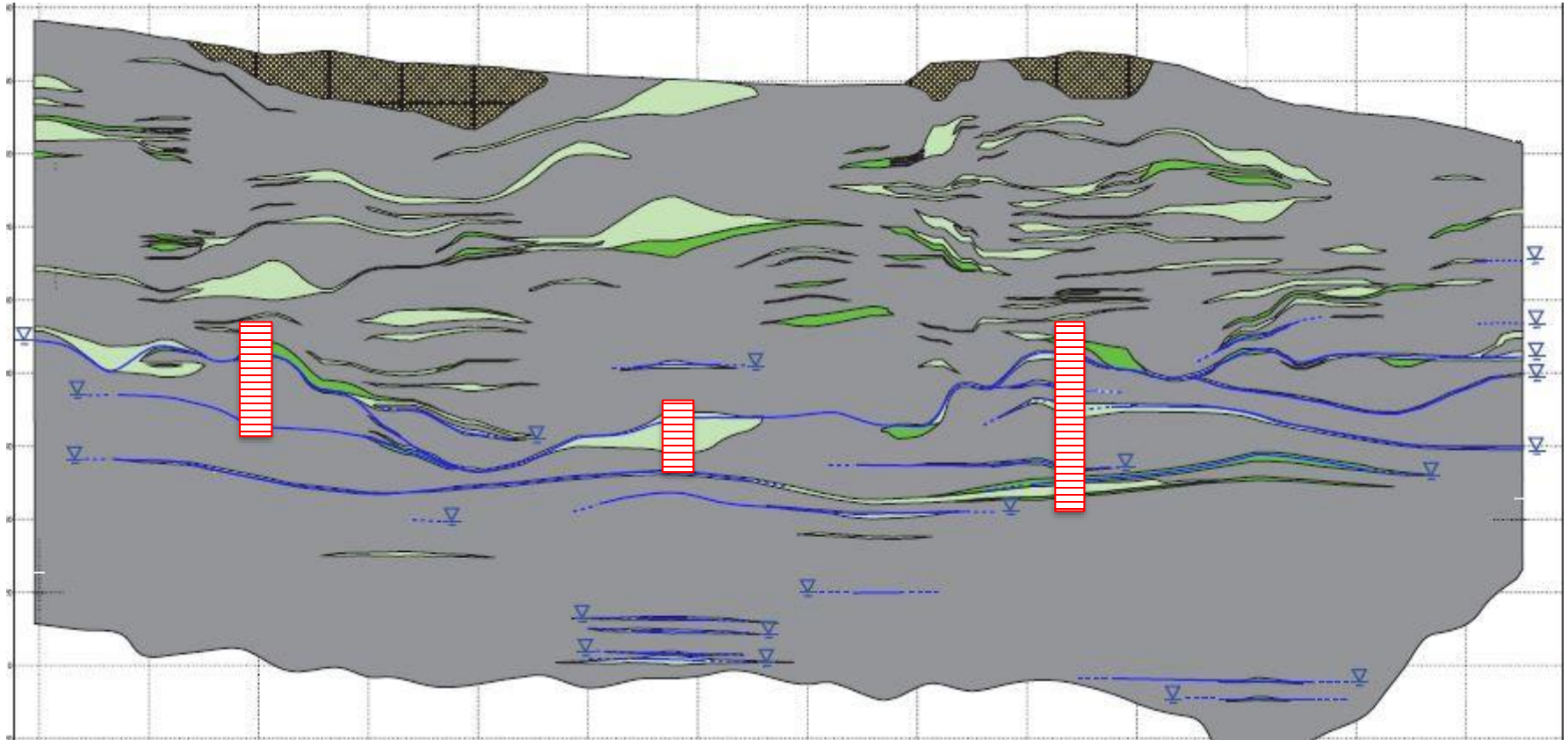
Rayleigh Test - PCE



Rayleigh Test - TCE

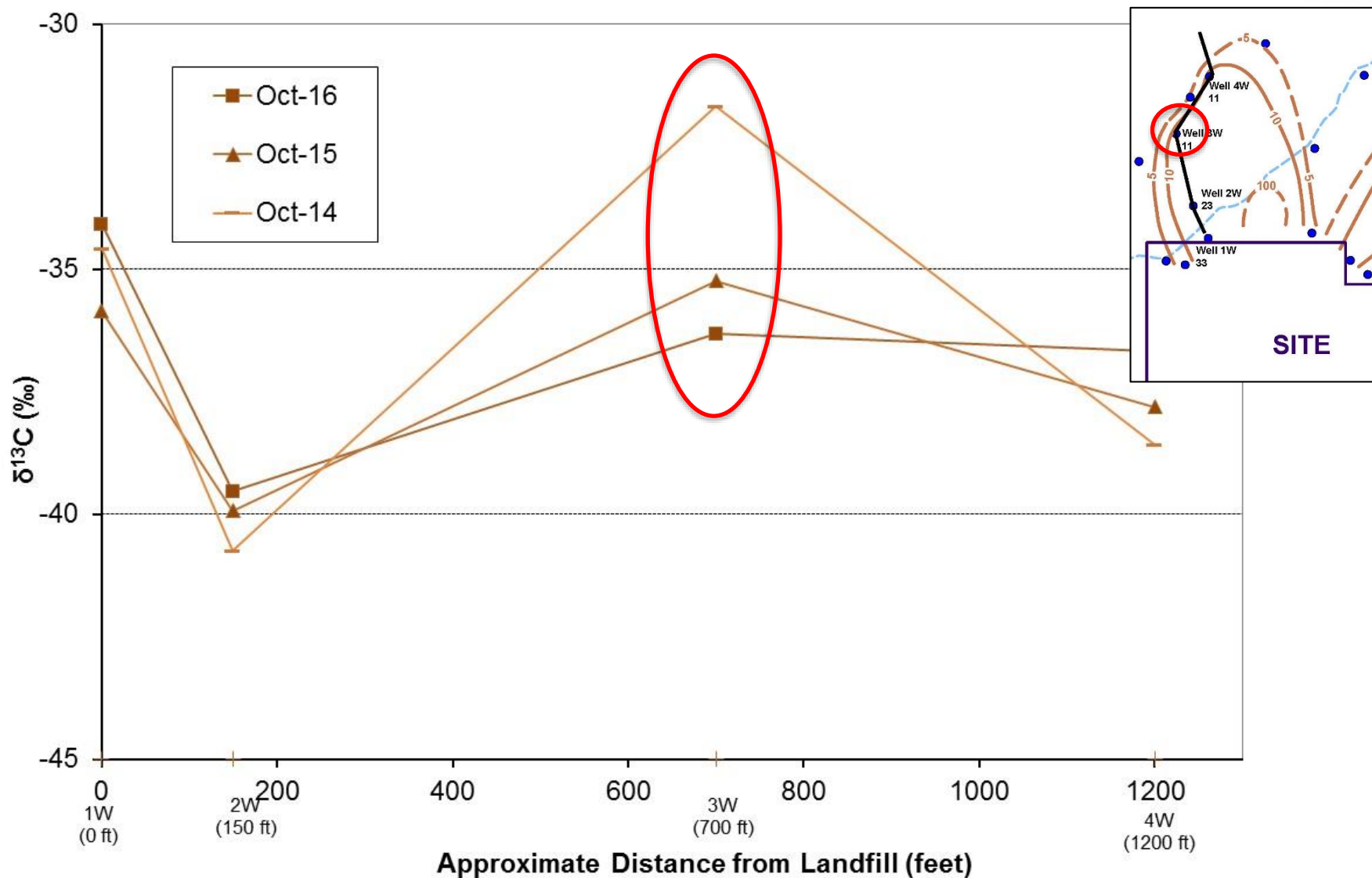


Well Screens – Another Issue?



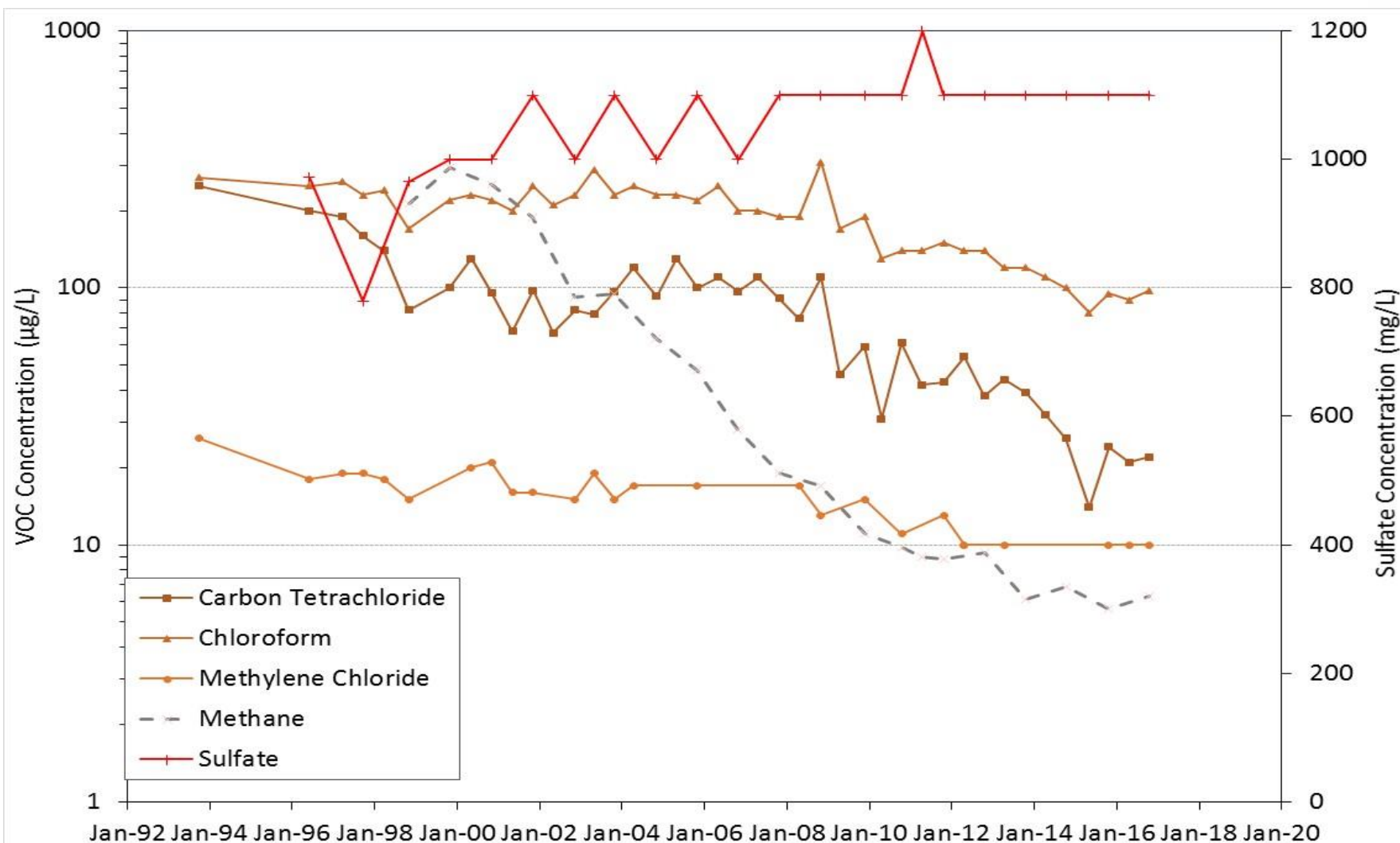
Fractionation with Distance

Carbon Tetrachloride – Western Plume



Concentration with Time

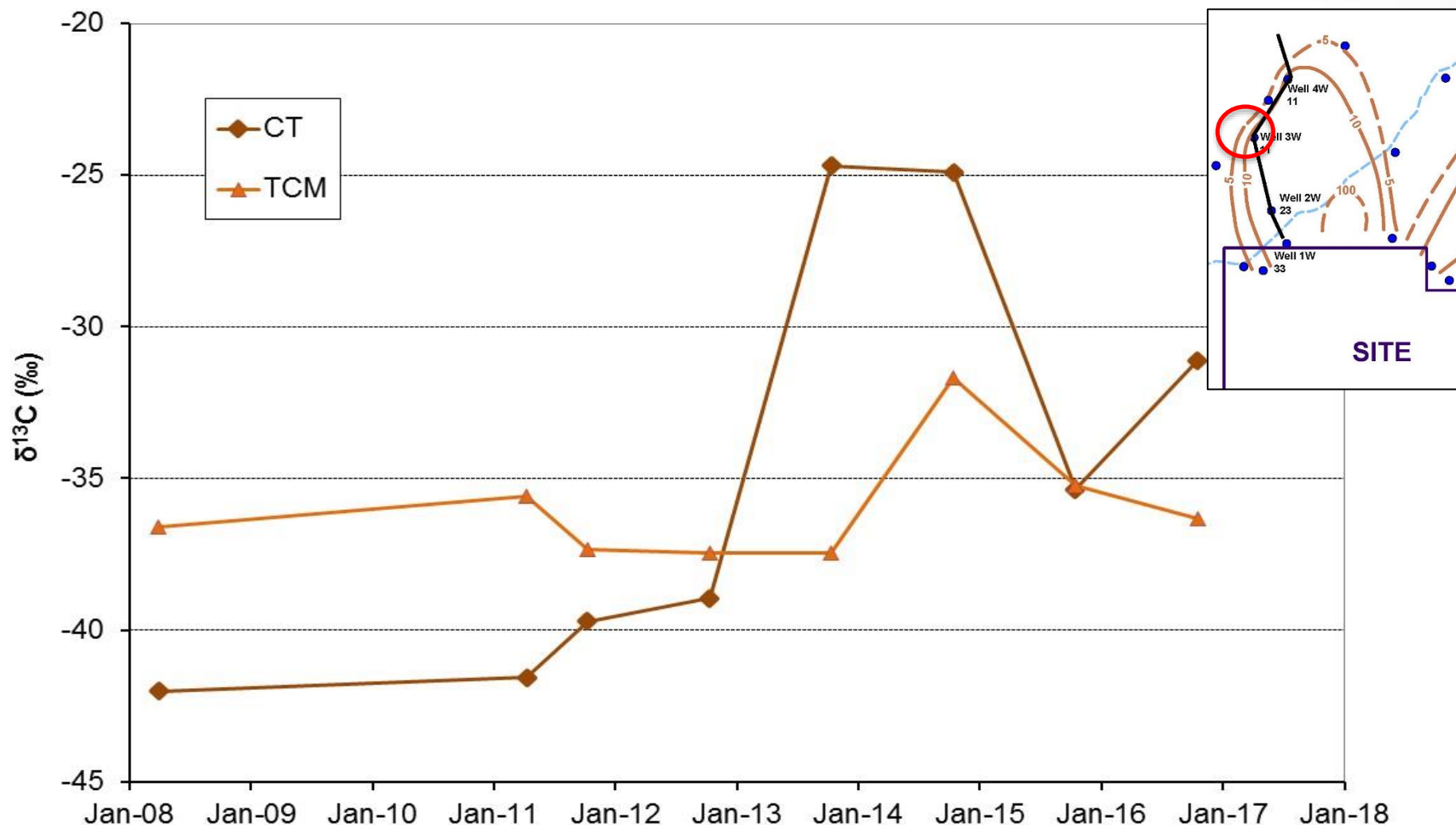
Well “3W” - Chlorinated Ethenes – Western Plume



NOTE: In the case of duplicate samples, the higher concentration is shown. Non-detect results with elevated reporting limits are not graphed.

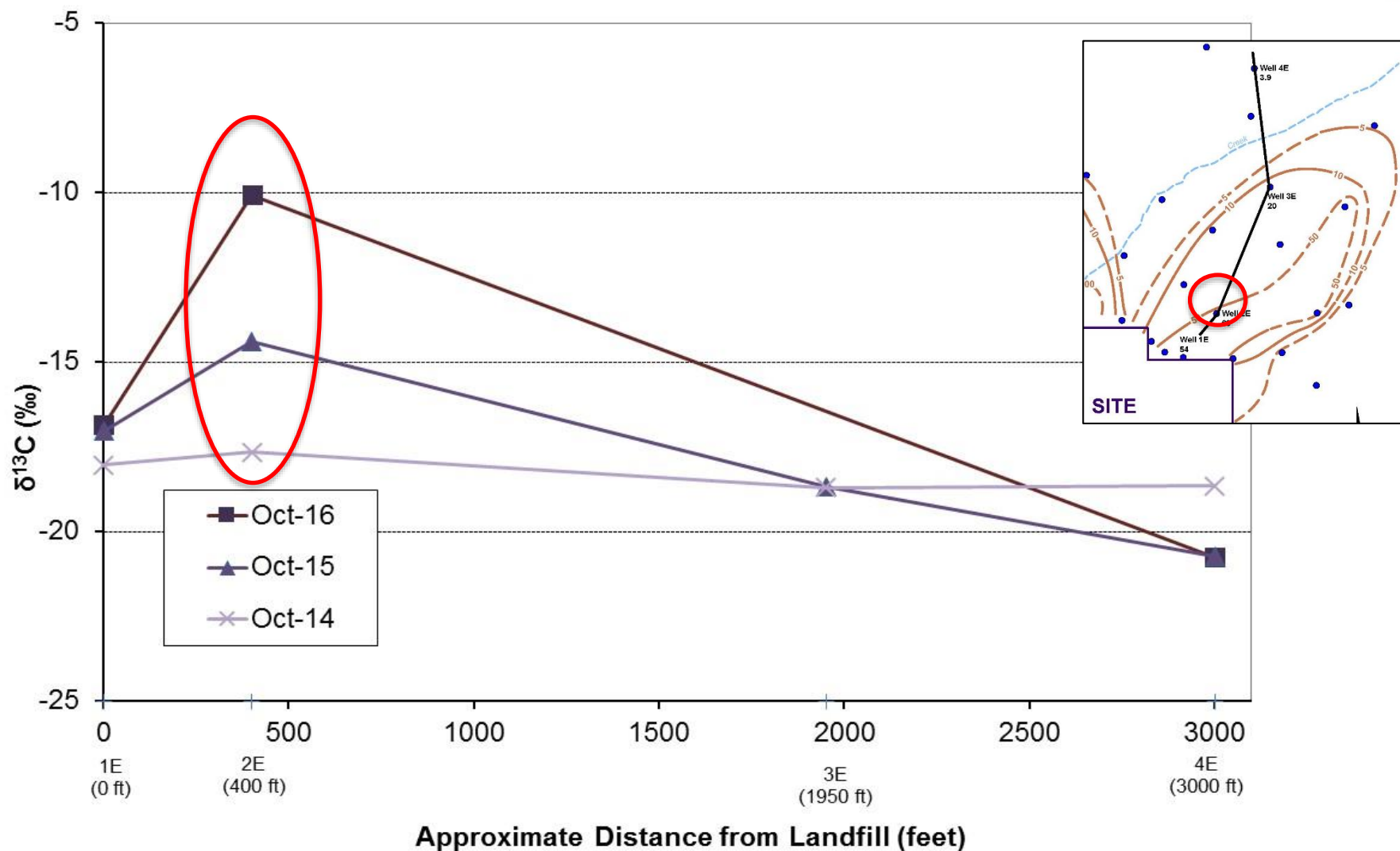
Fractionation with Time

Well “3W” - Chlorinated Methanes – Western Plume



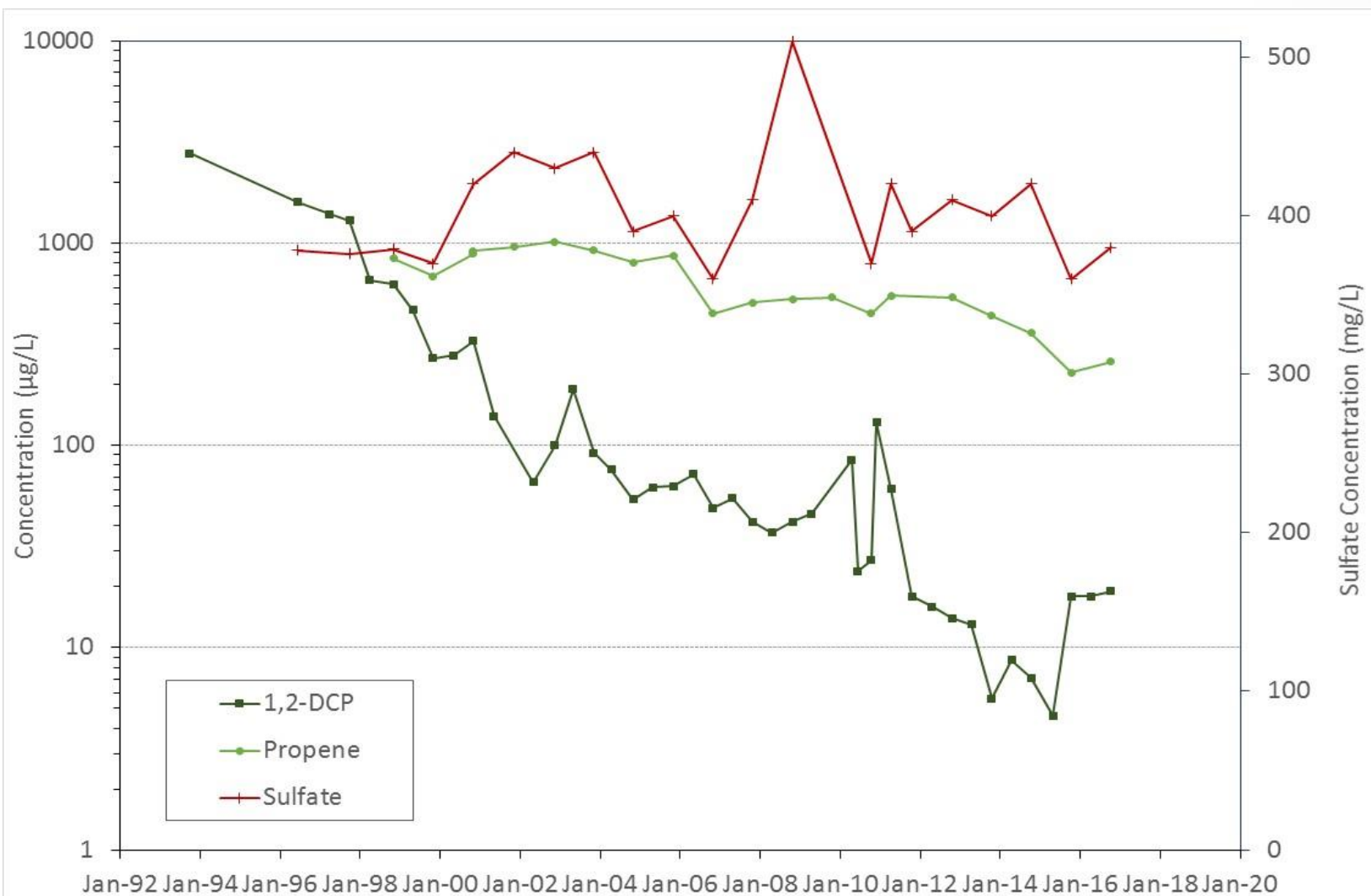
Fractionation with Distance

1,2-DCP – Eastern Plume



Concentration with Time

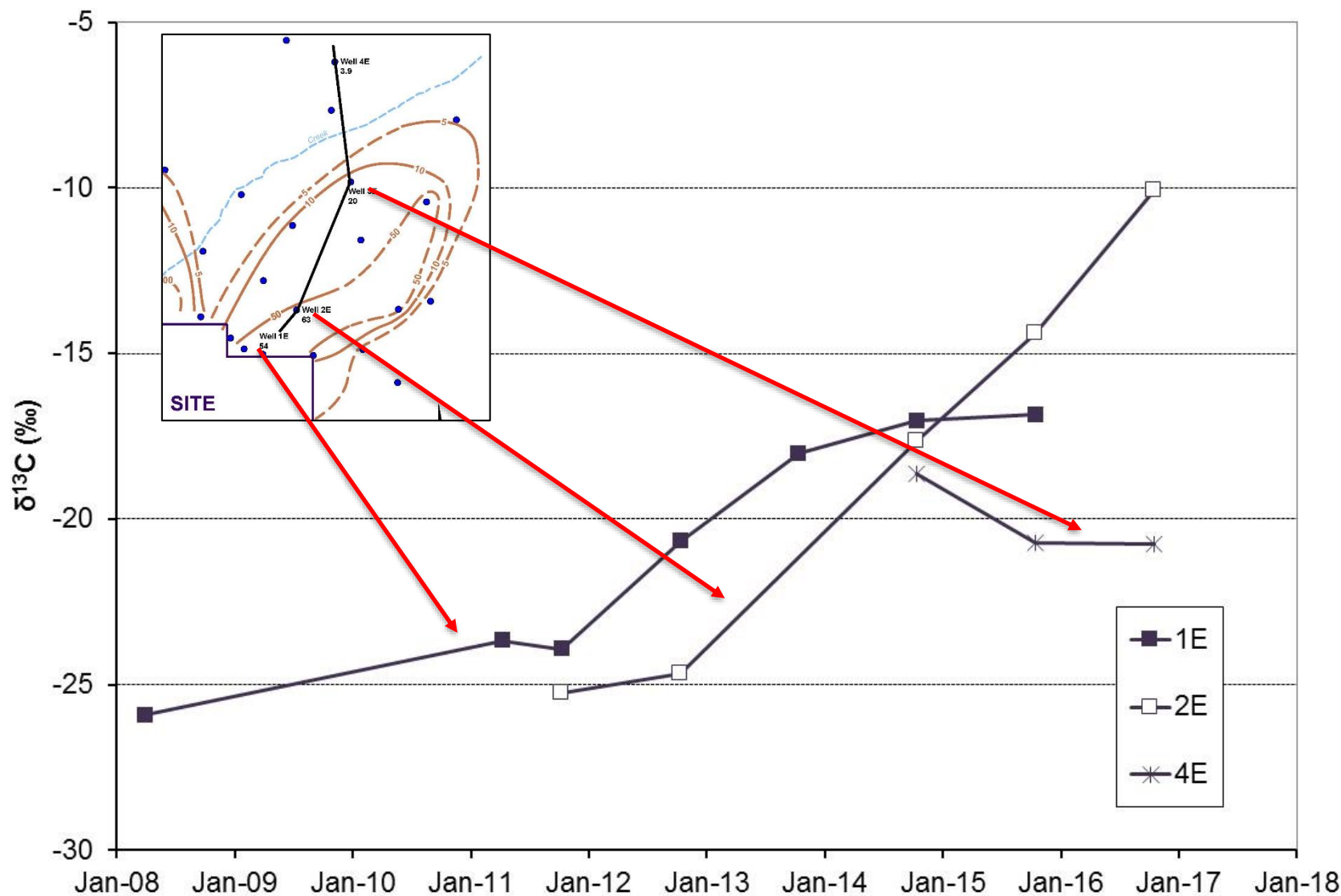
Well “2E” – 1,2-DCP – Eastern Plume



NOTE: In the case of duplicate samples, the higher concentration is shown. Non-detect results with elevated reporting limits are not graphed.

Fractionation with Time

Well "2E" – 1,2-DCP – Eastern Plume



Summary

How site complexity confounds the data interpretation and what CSIA taught us about our CSM

- Long landfill release history – multiple sources/releases
- Some daughter products may also be sources themselves
- Multiple thin sand lenses and wells screening various zones
- Likely seasonal surface dilution
- Varied geochemistry (e.g., sulfate competing as an electron acceptor in some locations)

Thank You. Questions?

