In Situ Chemical Oxidation of Dioxane Using Slow-Release Chemical Oxidant Candles

GRA Emerging Contaminants Symposium

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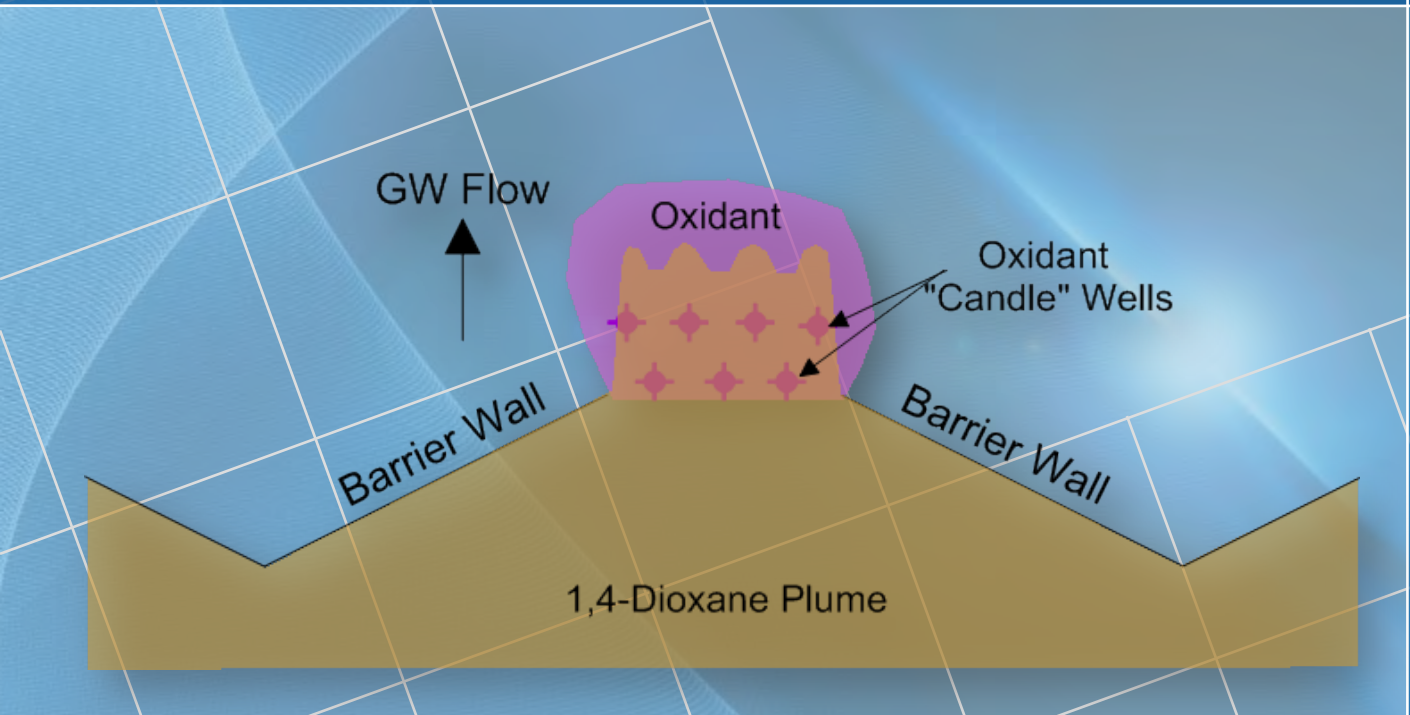
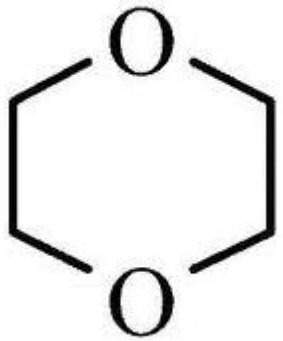


CDM Smith

Problem Statement

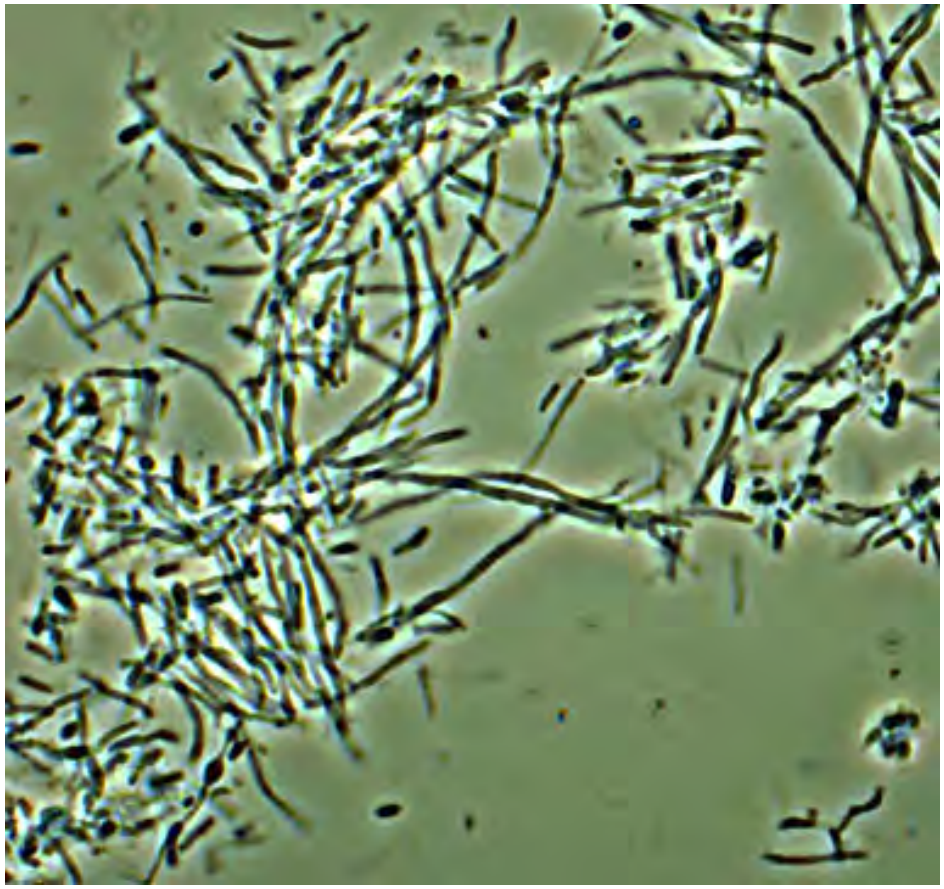
- Dioxane is a challenging contaminant:
  - More widespread than previously thought
  - Large and dilute plumes
  - Increased cancer slope factor published in 2010



- Current approaches don't work well or are expensive:
  - Pump and treat / advanced oxidation processes
  - Biodegradation (Evans, Parales, & Parales 2007)

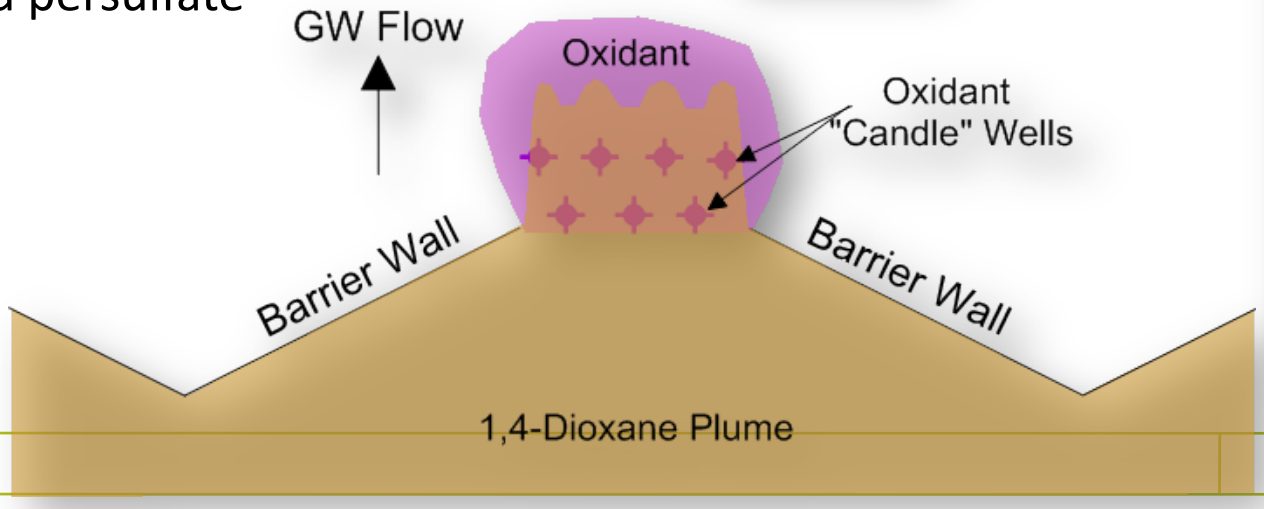
CB1190

- *Pseudonocardia dioxanivorans* – an antinomycte
- First isolate capable of growth on dioxane (Parales et al., 1994)
- > 50% dioxane converted to CO_2
- Specific activity 0.33 µg/mg/min
- Doubling time 30 hours
- Also grows on tetrahydrofuran



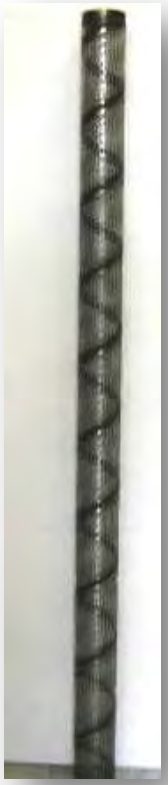
Possible Solution

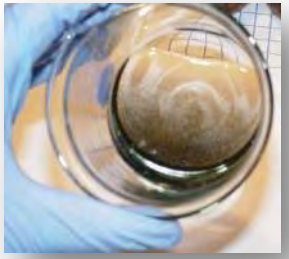
- Slow release oxidants are a solution
- Possible configurations
  - Permeable reactive barrier (PRB)
  - Funnel and gate (F&G)
  - Grid
- Oxidants
  - Permanganate
  - Unactivated persulfate
  - Activated persulfate



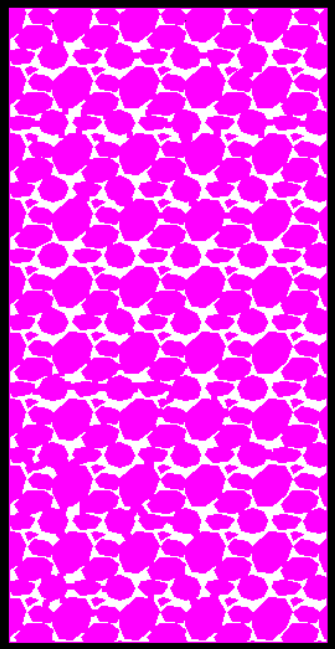
Technology Description

- Solid product formed as candle, chipped for barrier applications, or further processed for hydrofracturing into low permeability media/fractured bedrock
  - 1.35- or 2.5-inch diameter
  - 18 inches long





Permanganate Candle Release from Wax



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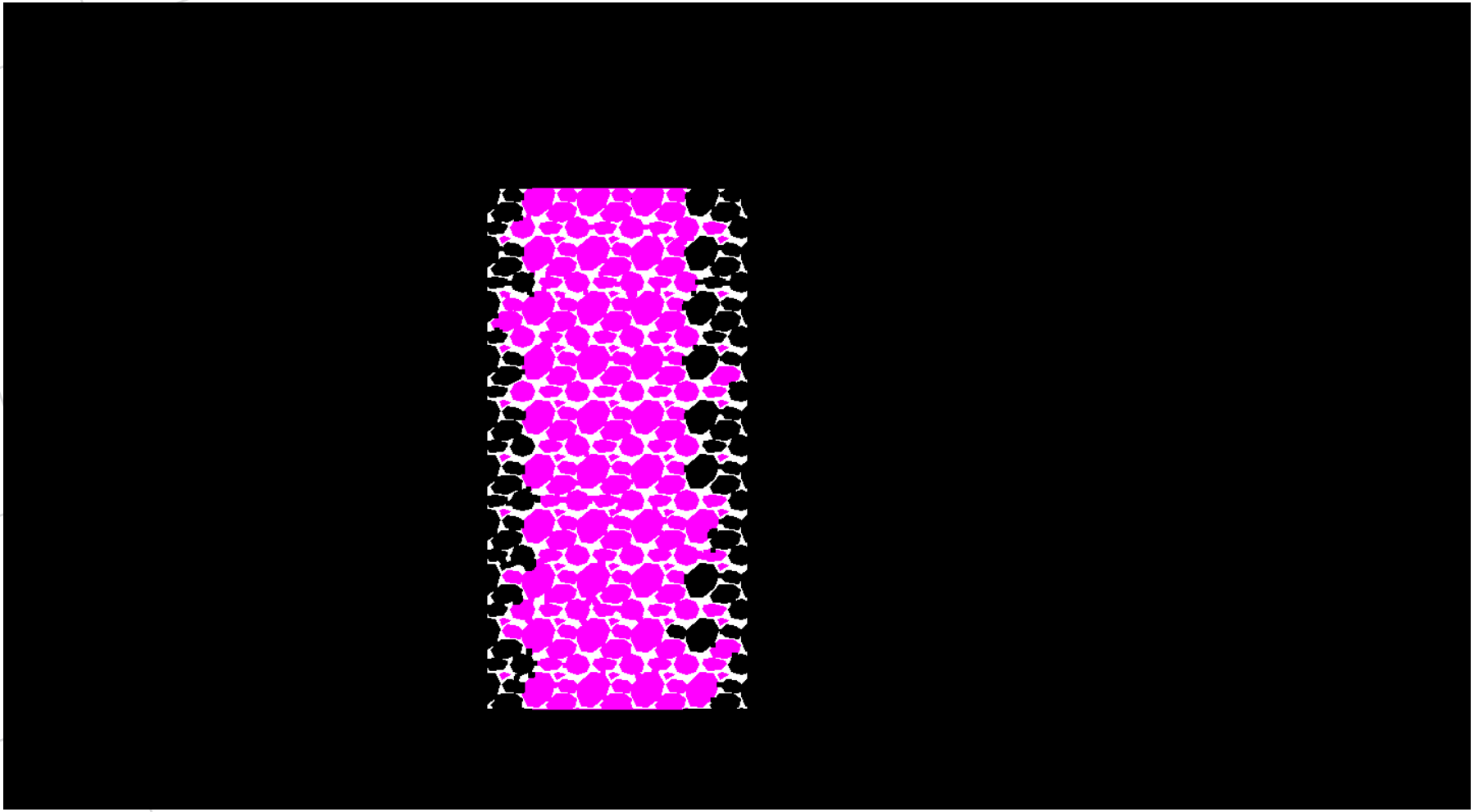

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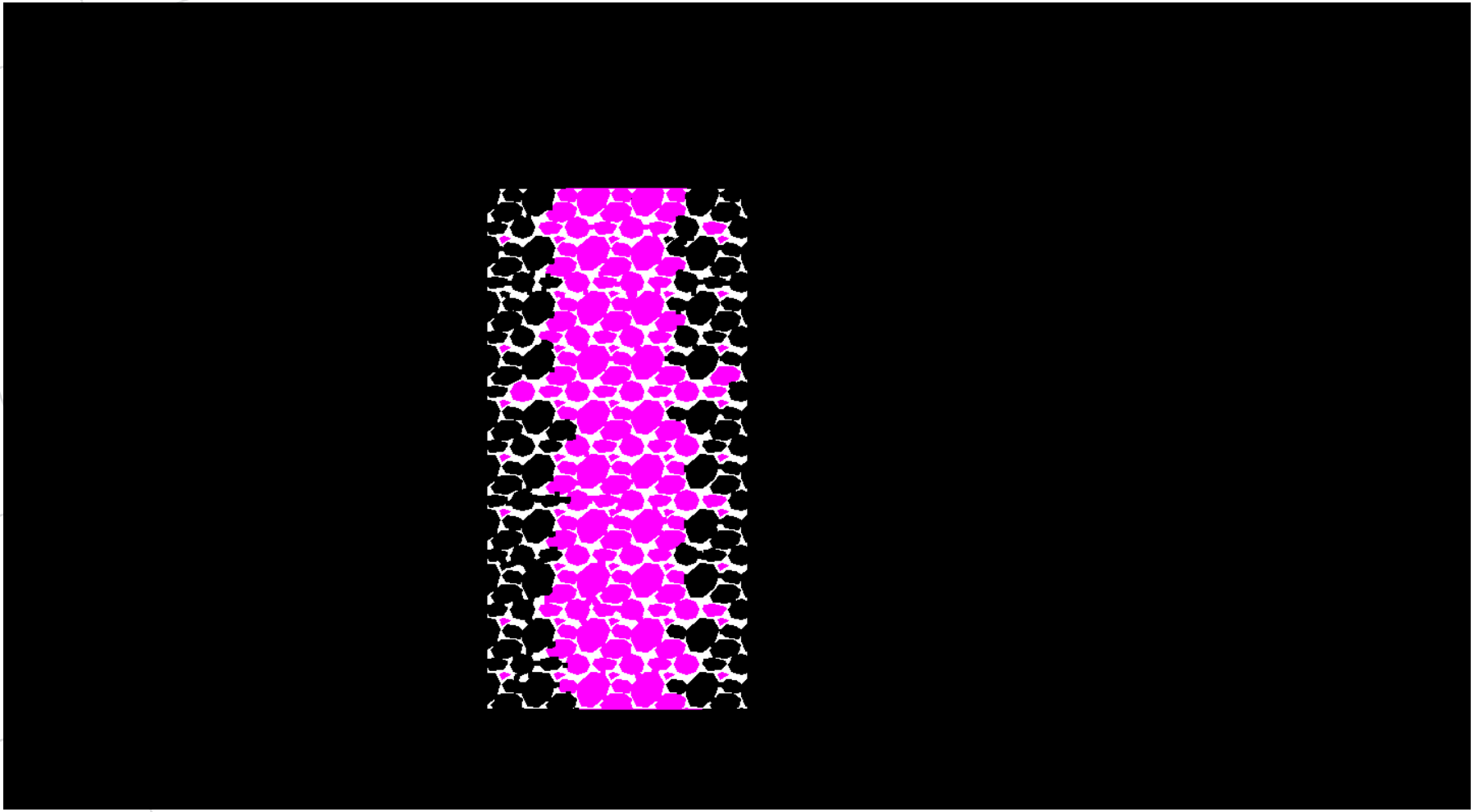

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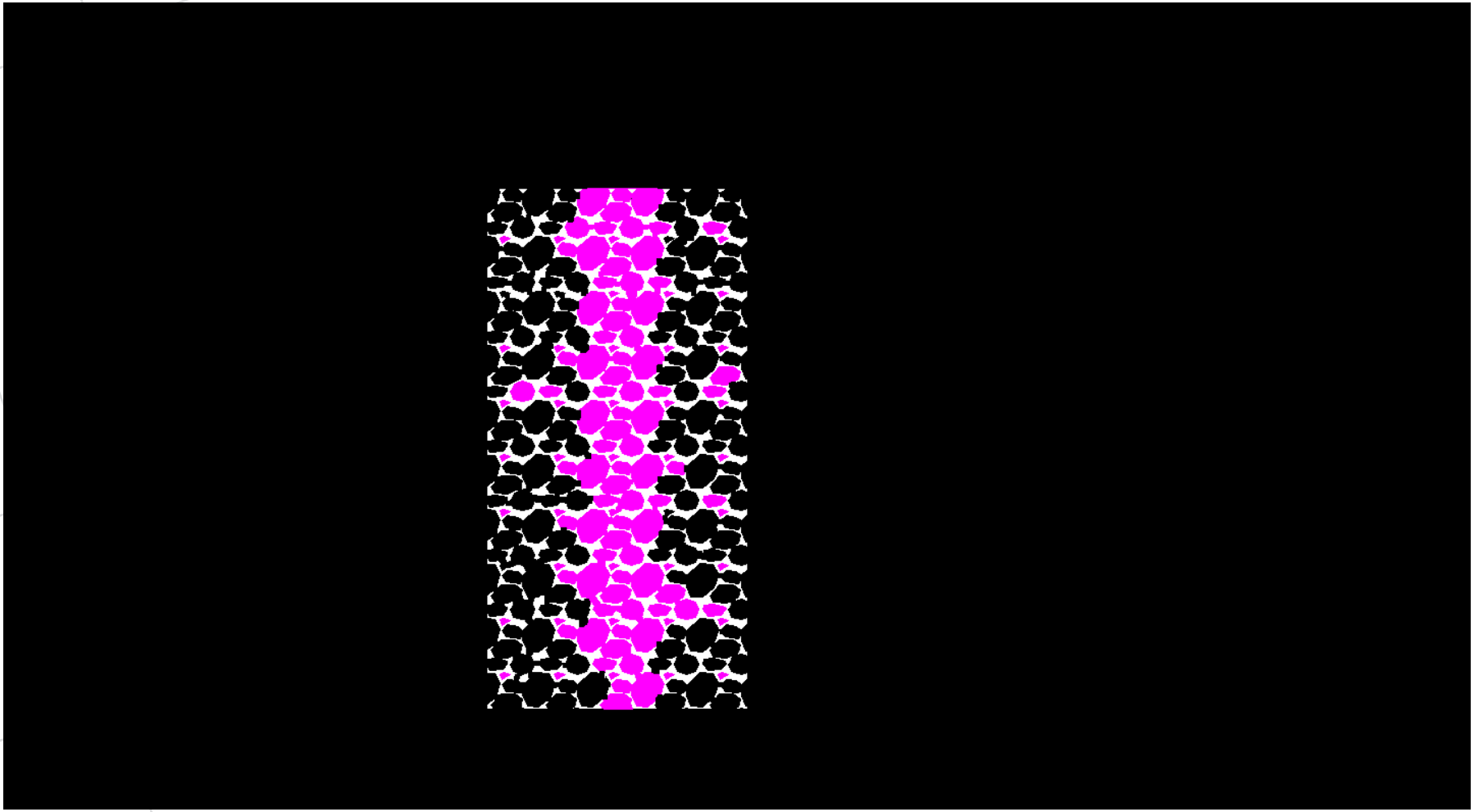

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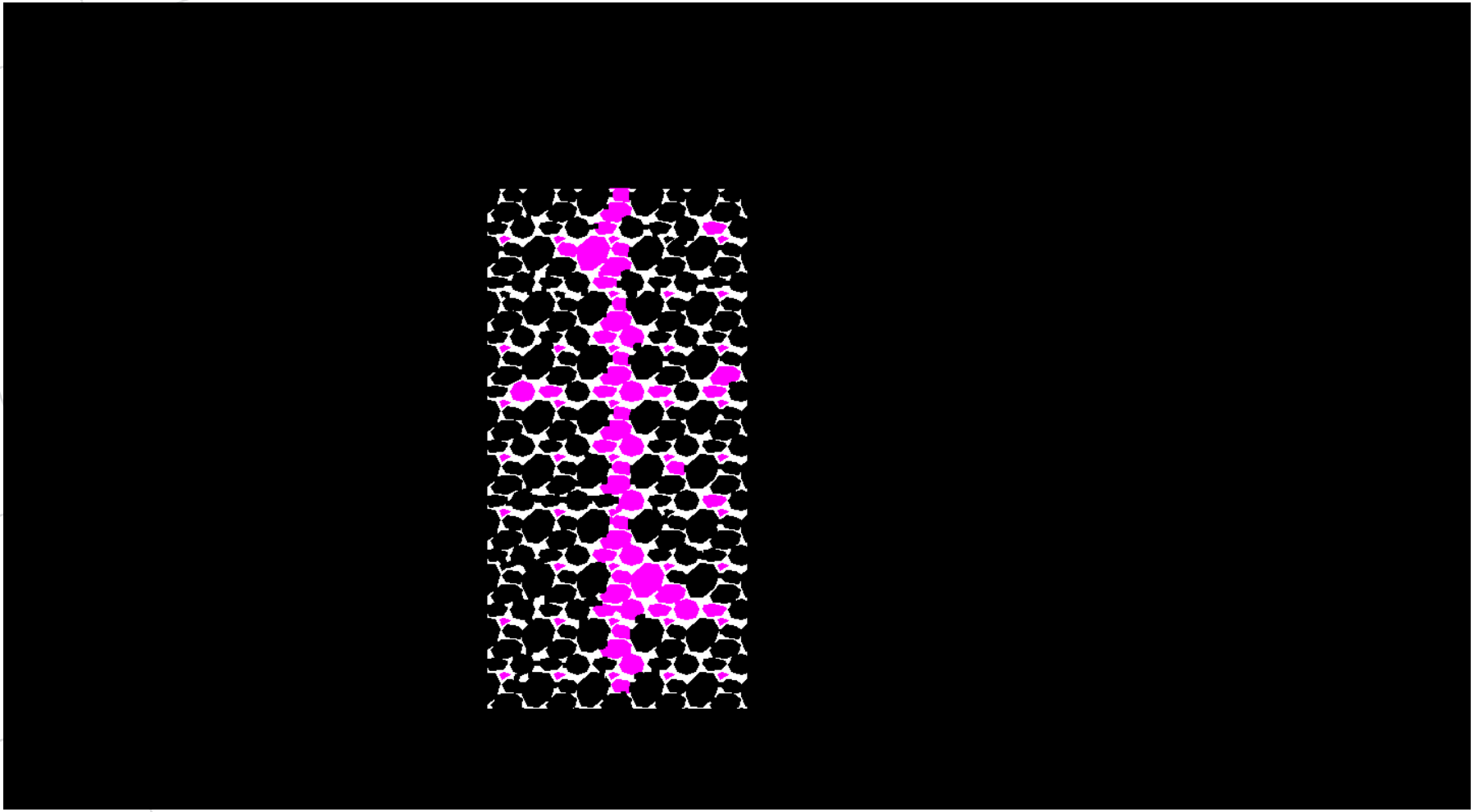

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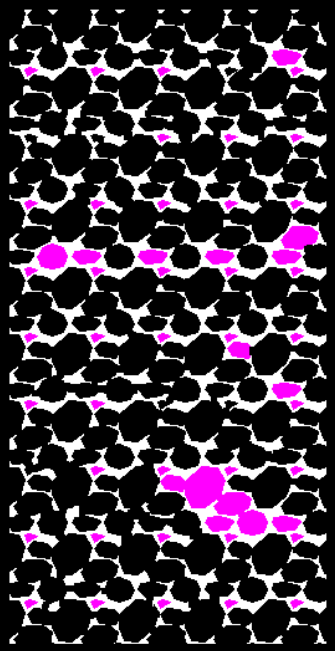
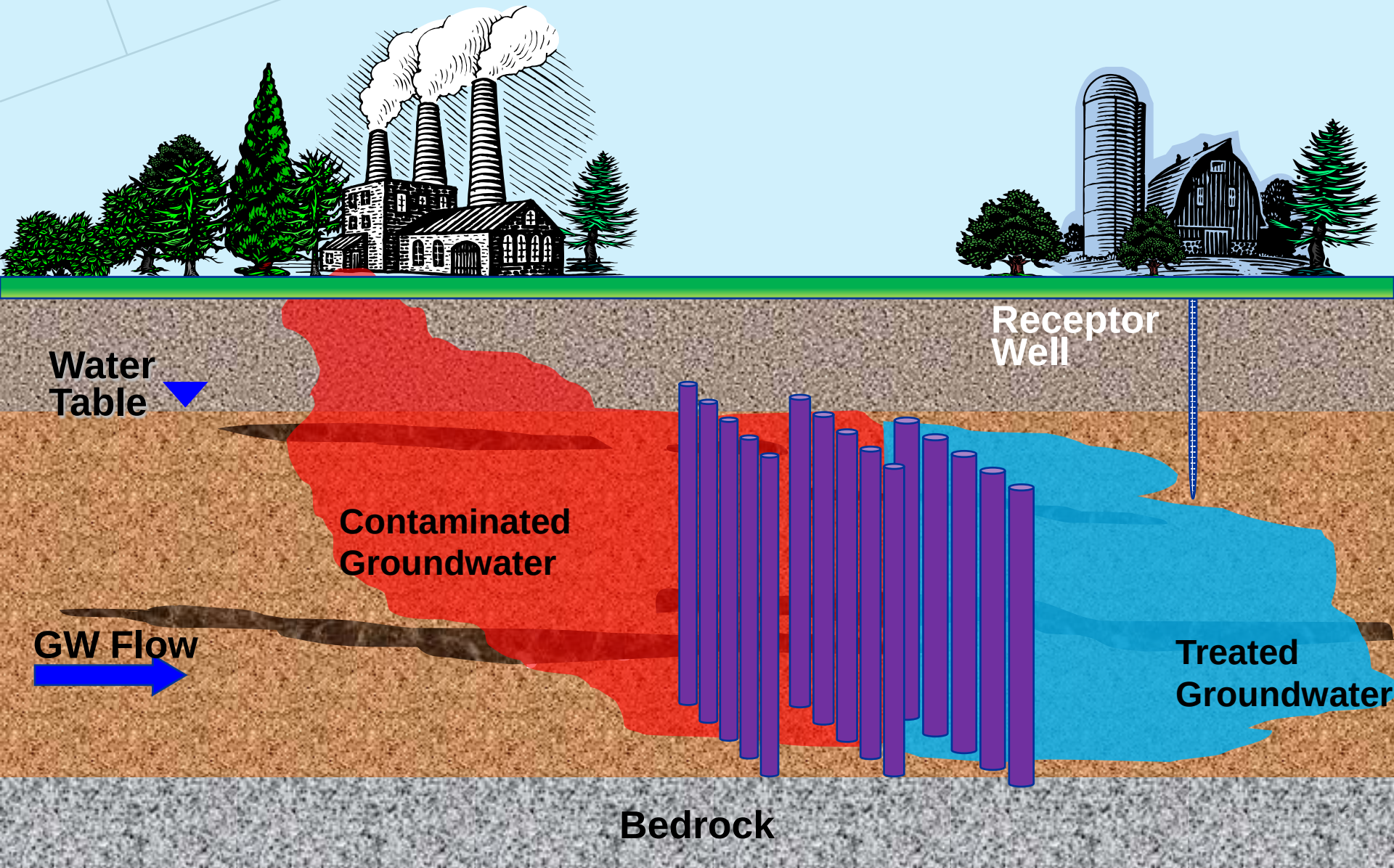
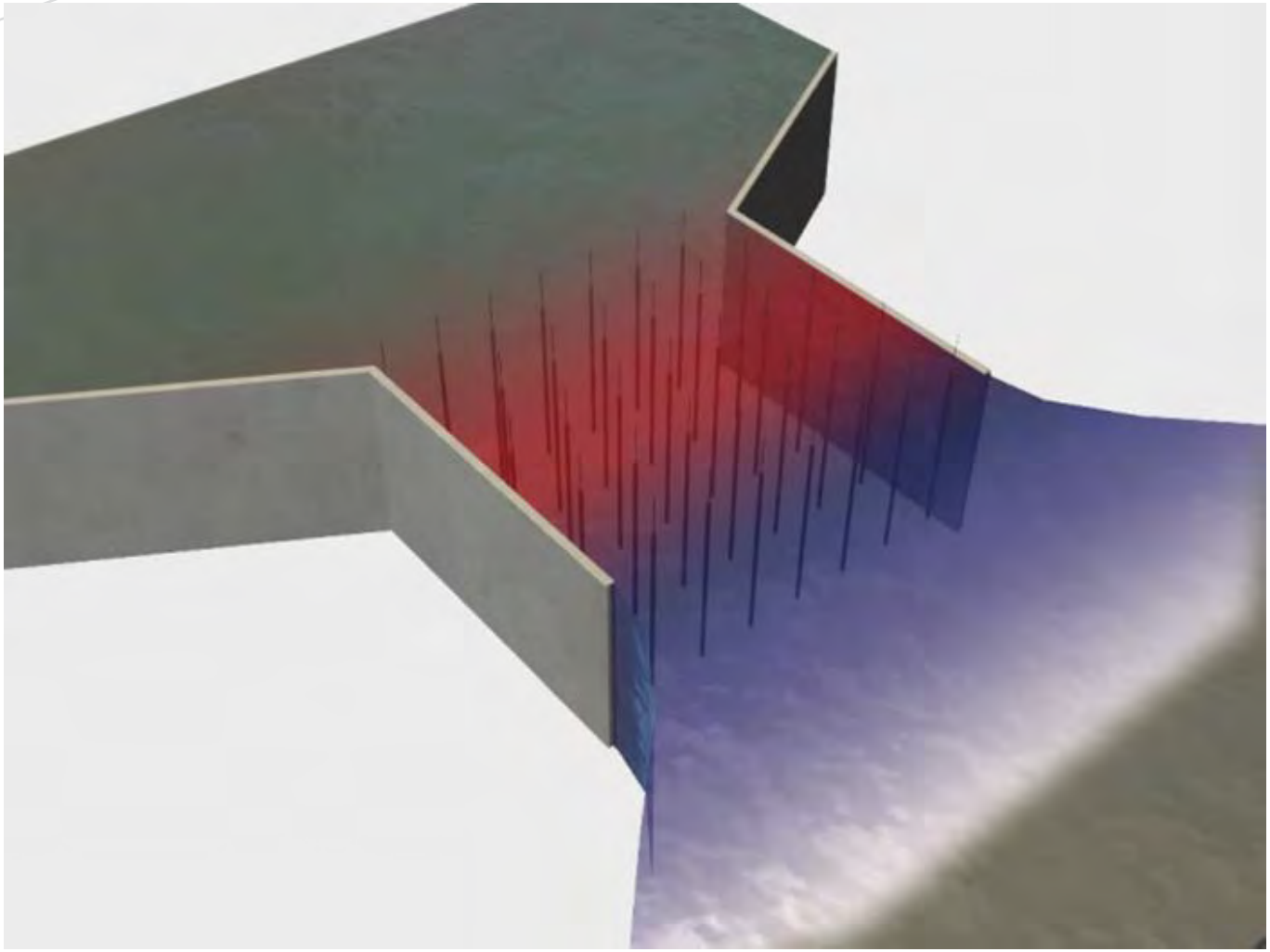


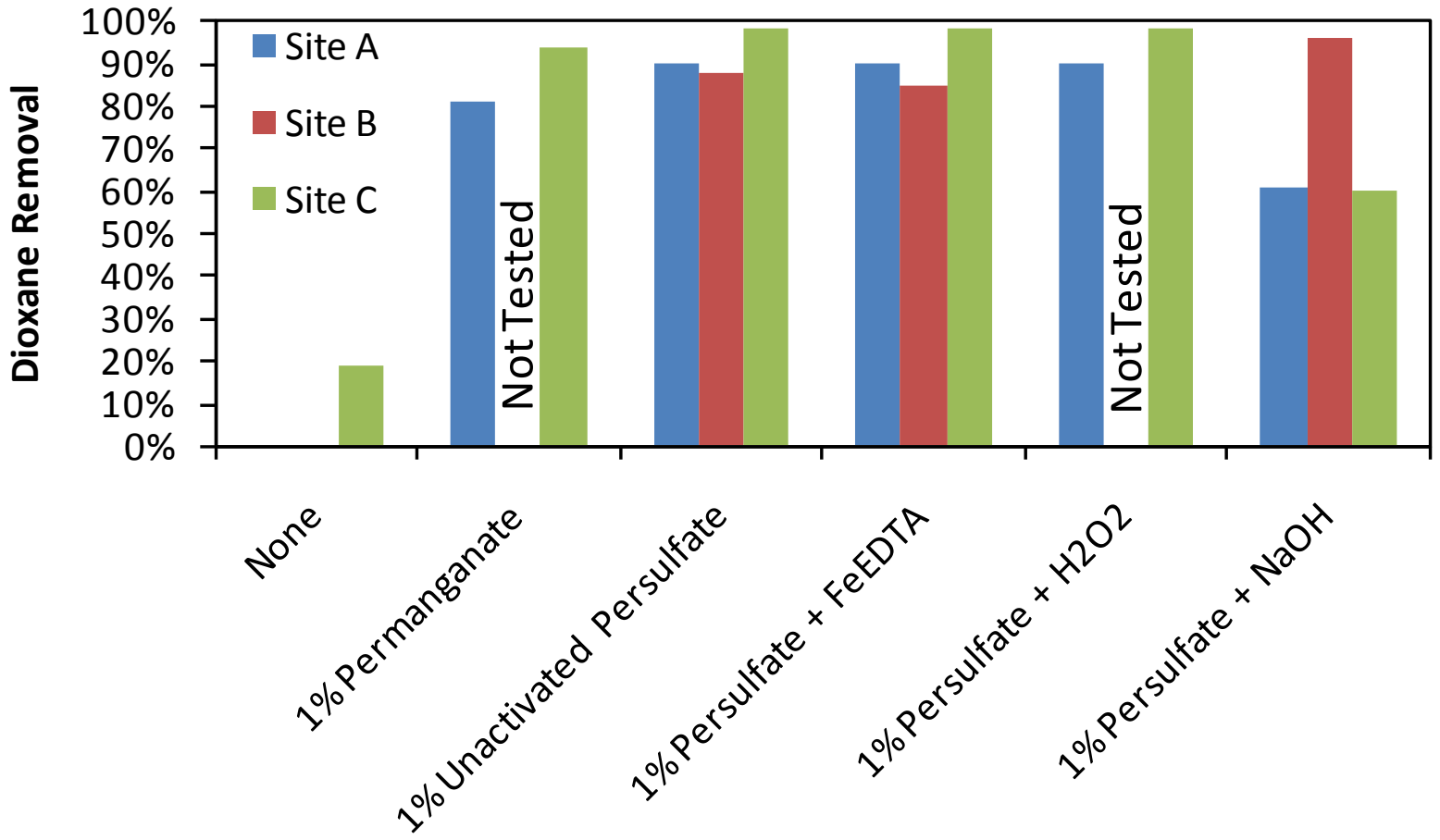
Passive Treatment with *In Situ* Reactive Zones / Barriers



Technology / Methodology Description

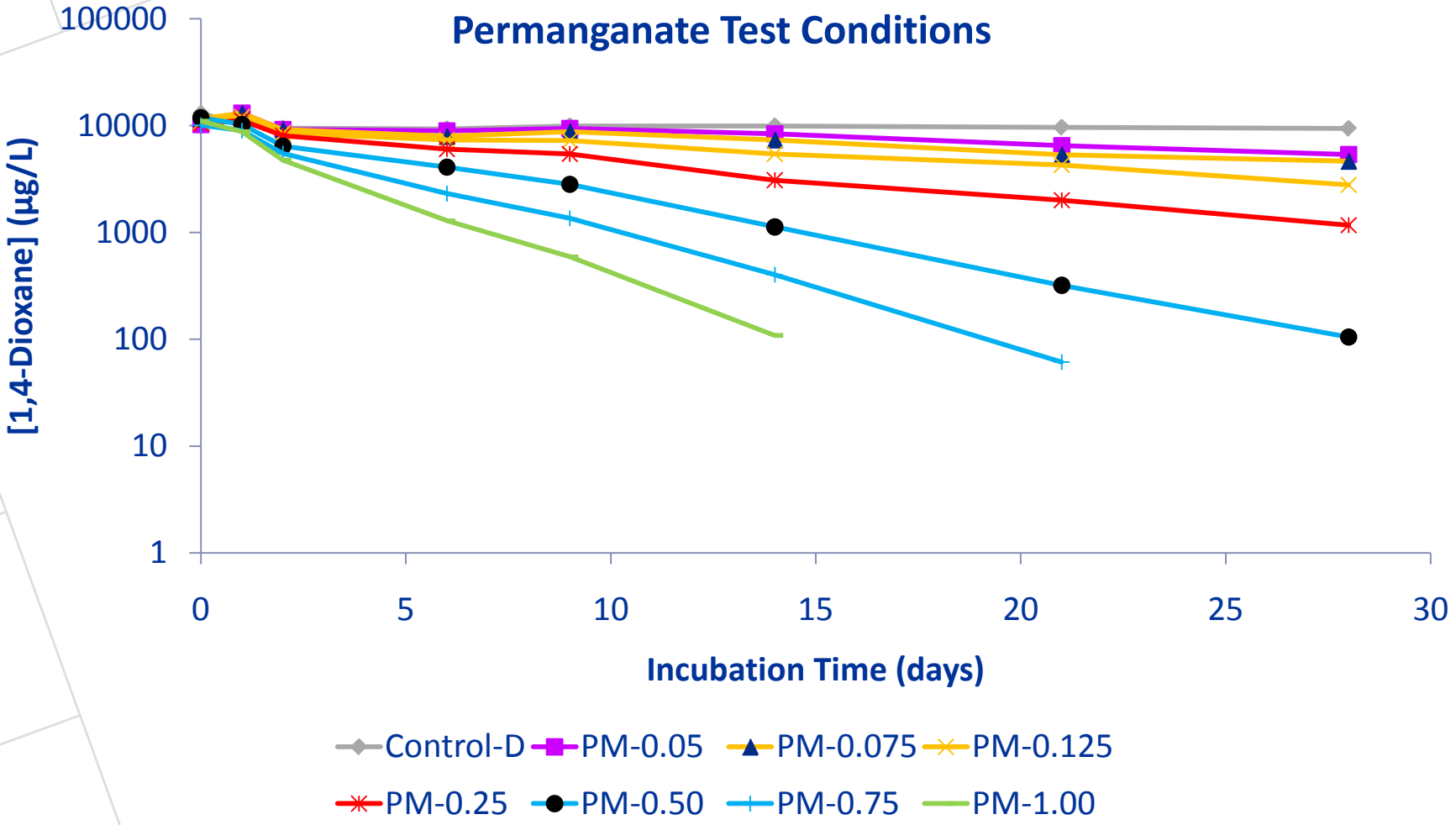


Dioxane Destruction with Permanganate and Unactivated Persulfate

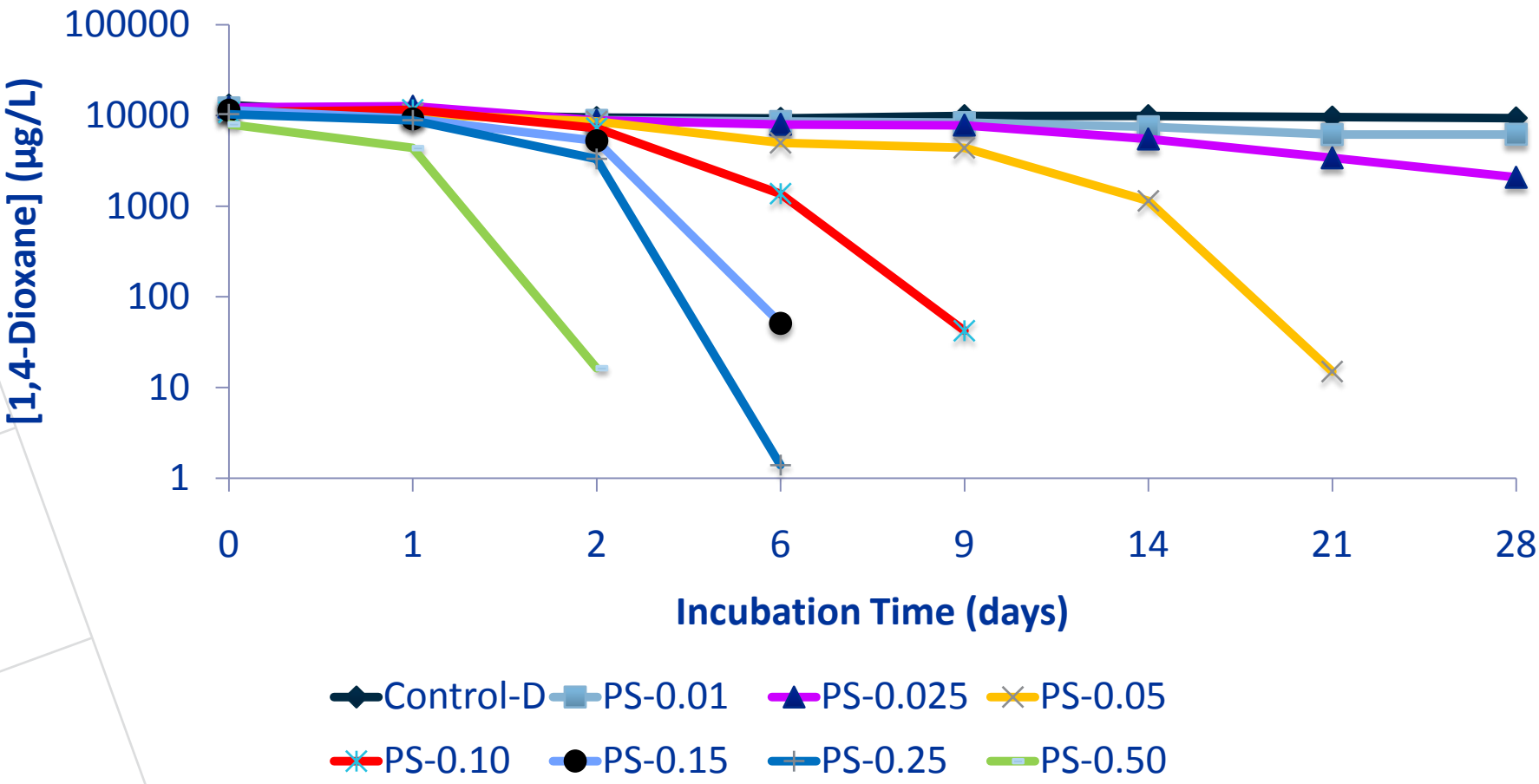


Both permanganate and unactivated persulfate oxidize dioxane at various sites

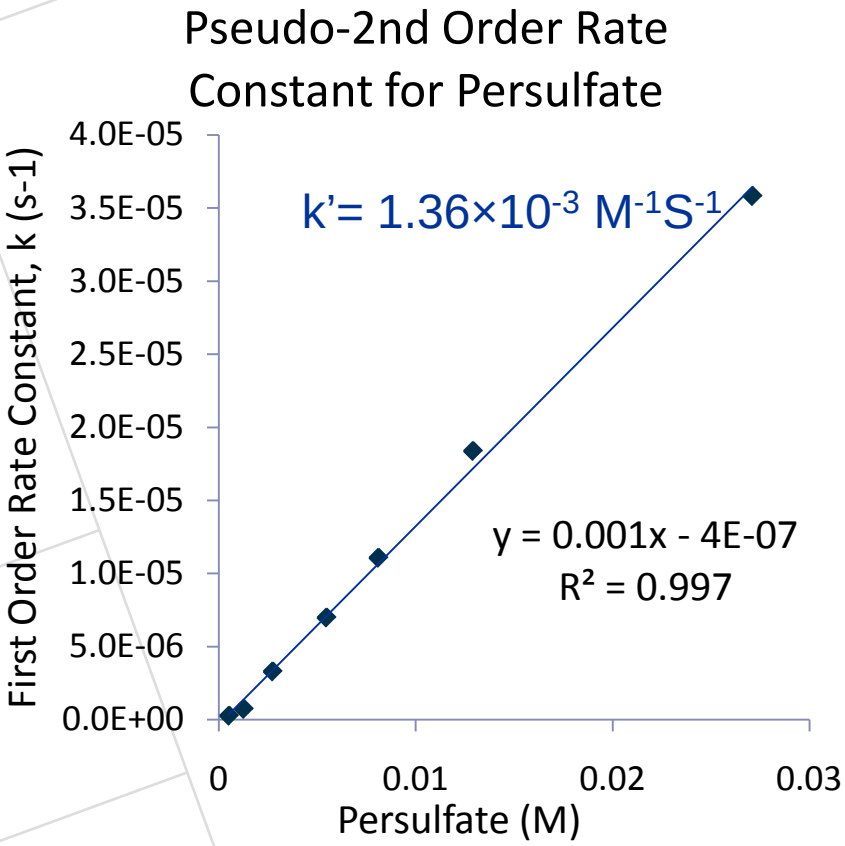
Dioxane Oxidation with Permanganate

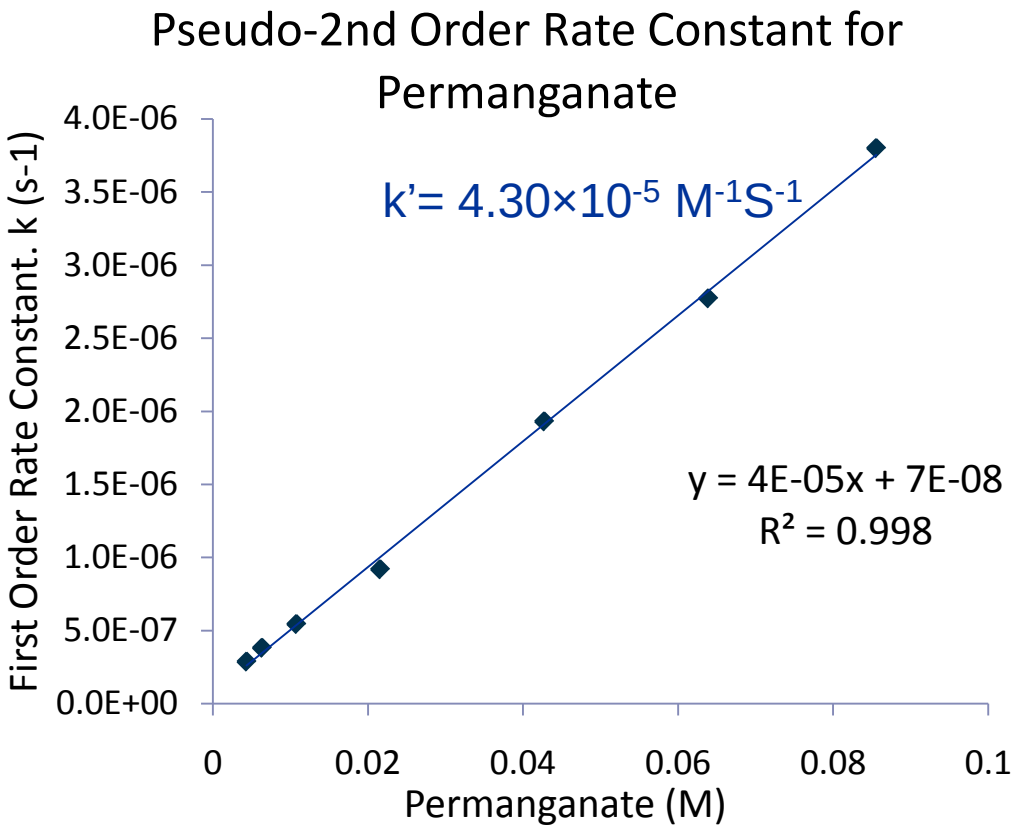


Dioxane Oxidation with *Unactivated* Persulfate

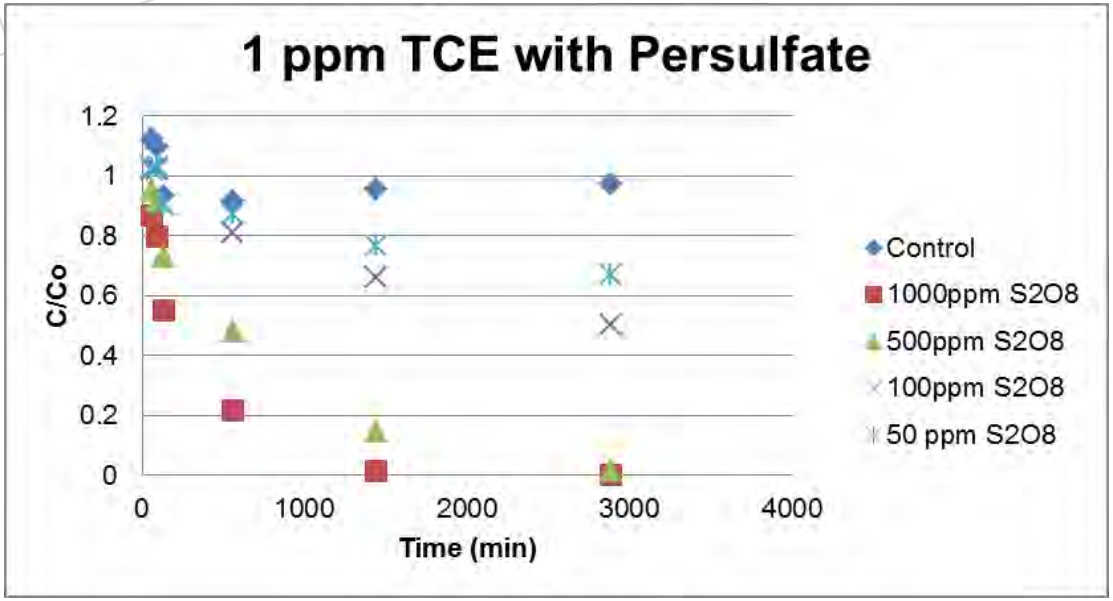


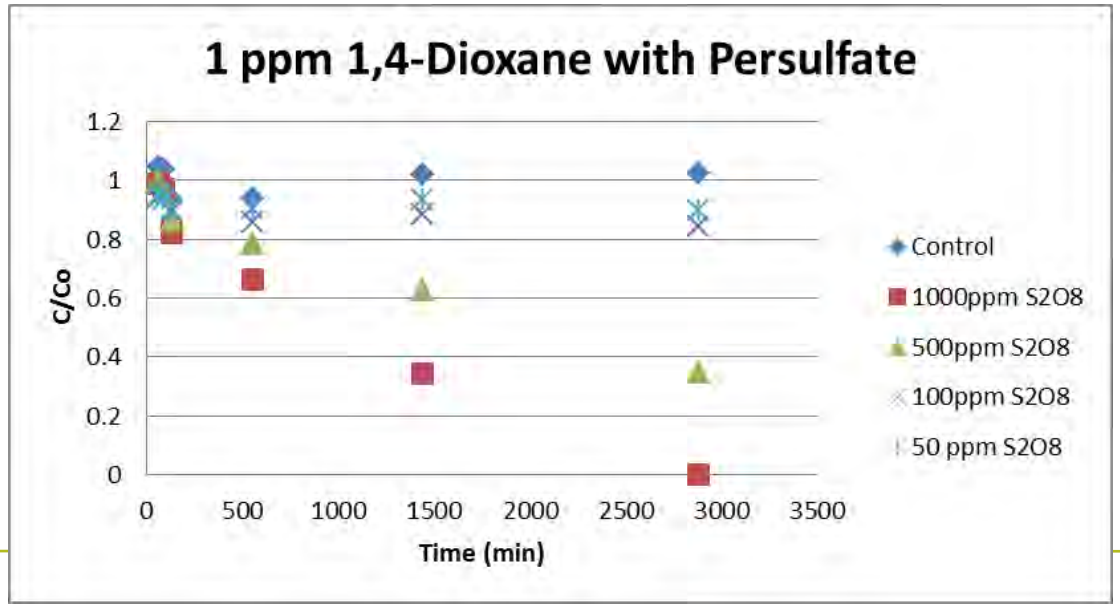
Laboratory Oxidant Kinetics Results





Comparison of TCE and Dioxane Oxidation



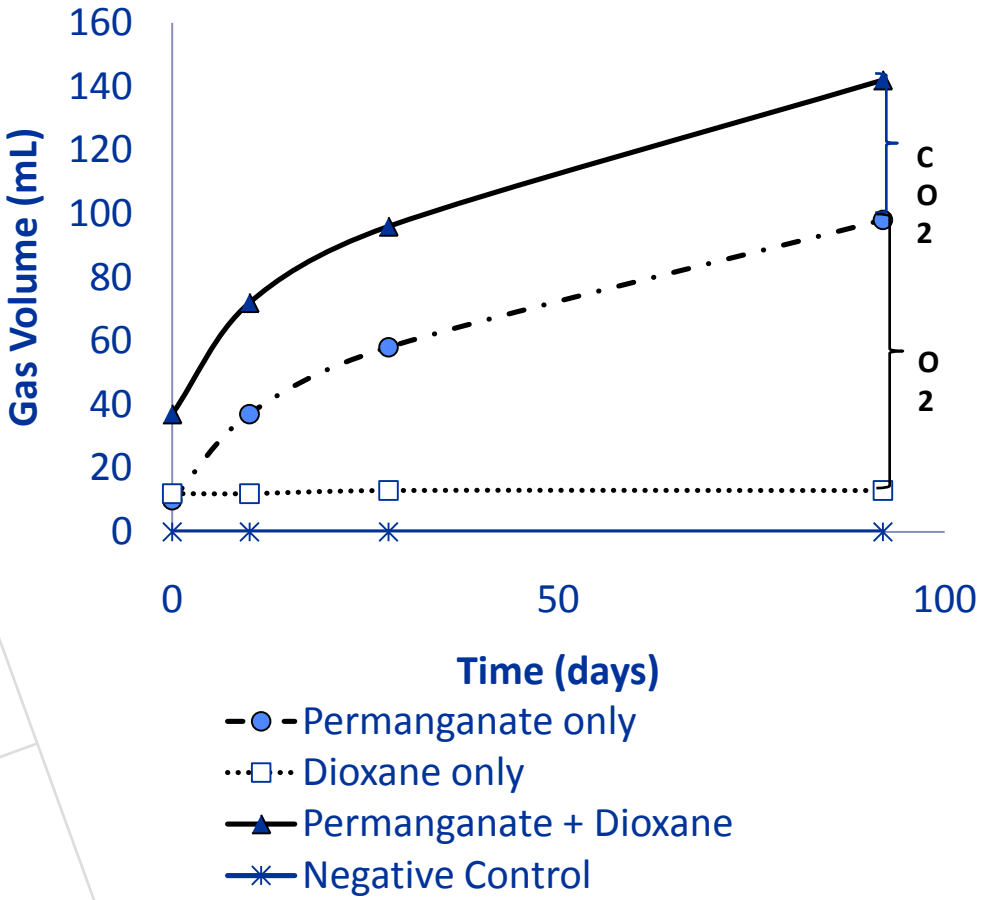


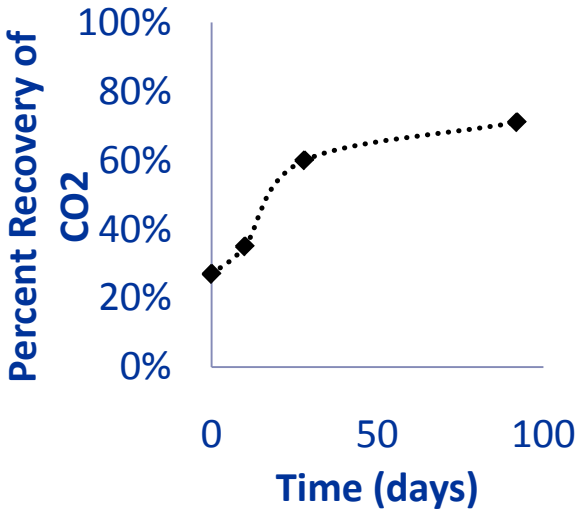
Kinetic Experiment Summary (Nanopure water, no soil)

Oxidant	Contaminant	Calculated Second Order Rate Constant ($M^{-1}s^{-1}$)
Persulfate	Dioxane	1.26 E-03
Persulfate	Dioxane and TCE	1.90E-03
Permanganate	Dioxane	3.25E-05

- Oxidation of dioxane with persulfate is about 30X faster than with permanganate.
- Potential enhancement of dioxane oxidation by TCE?
- In progress – Testing with site groundwater and soil

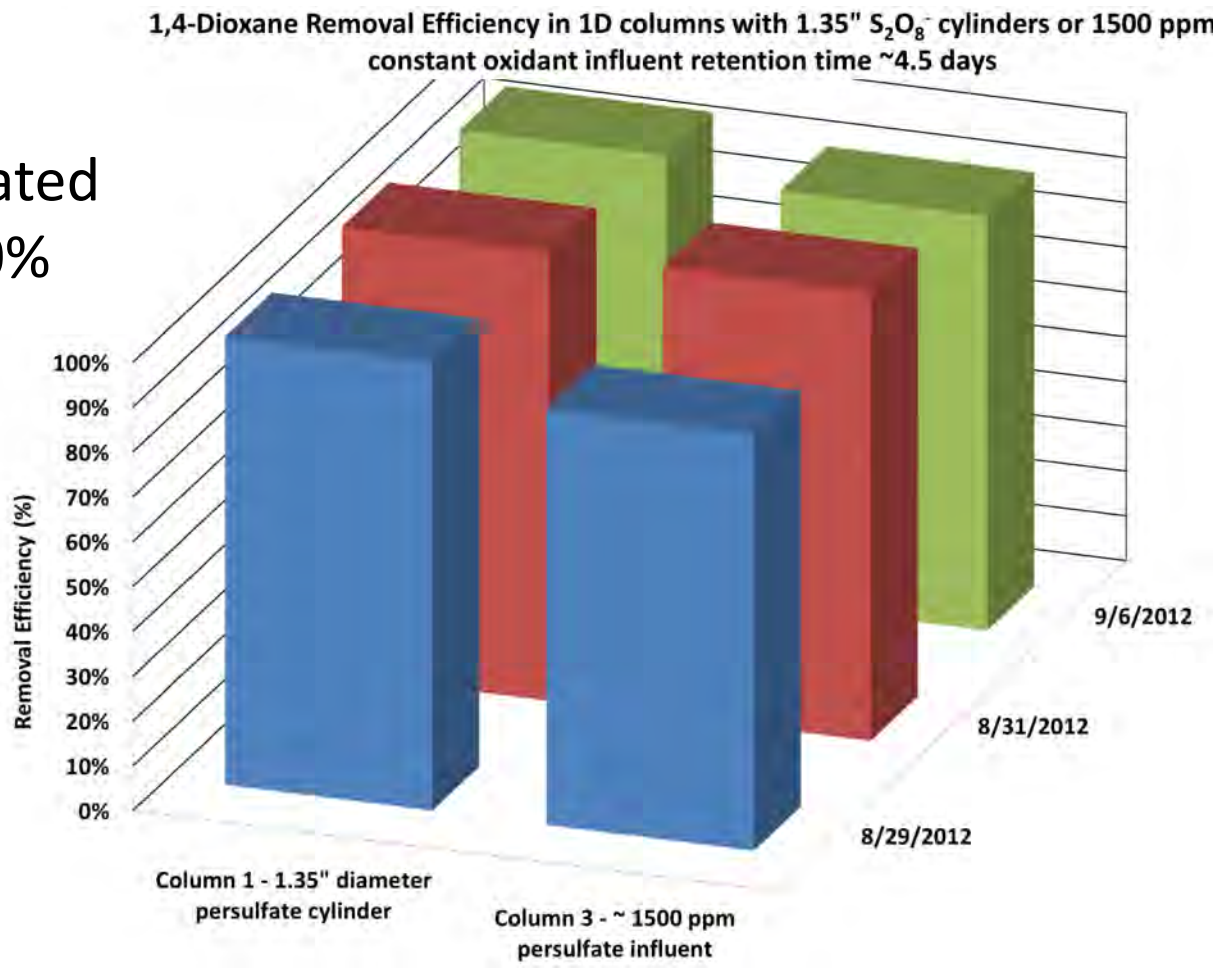
Dioxane Mineralization with Permanganate



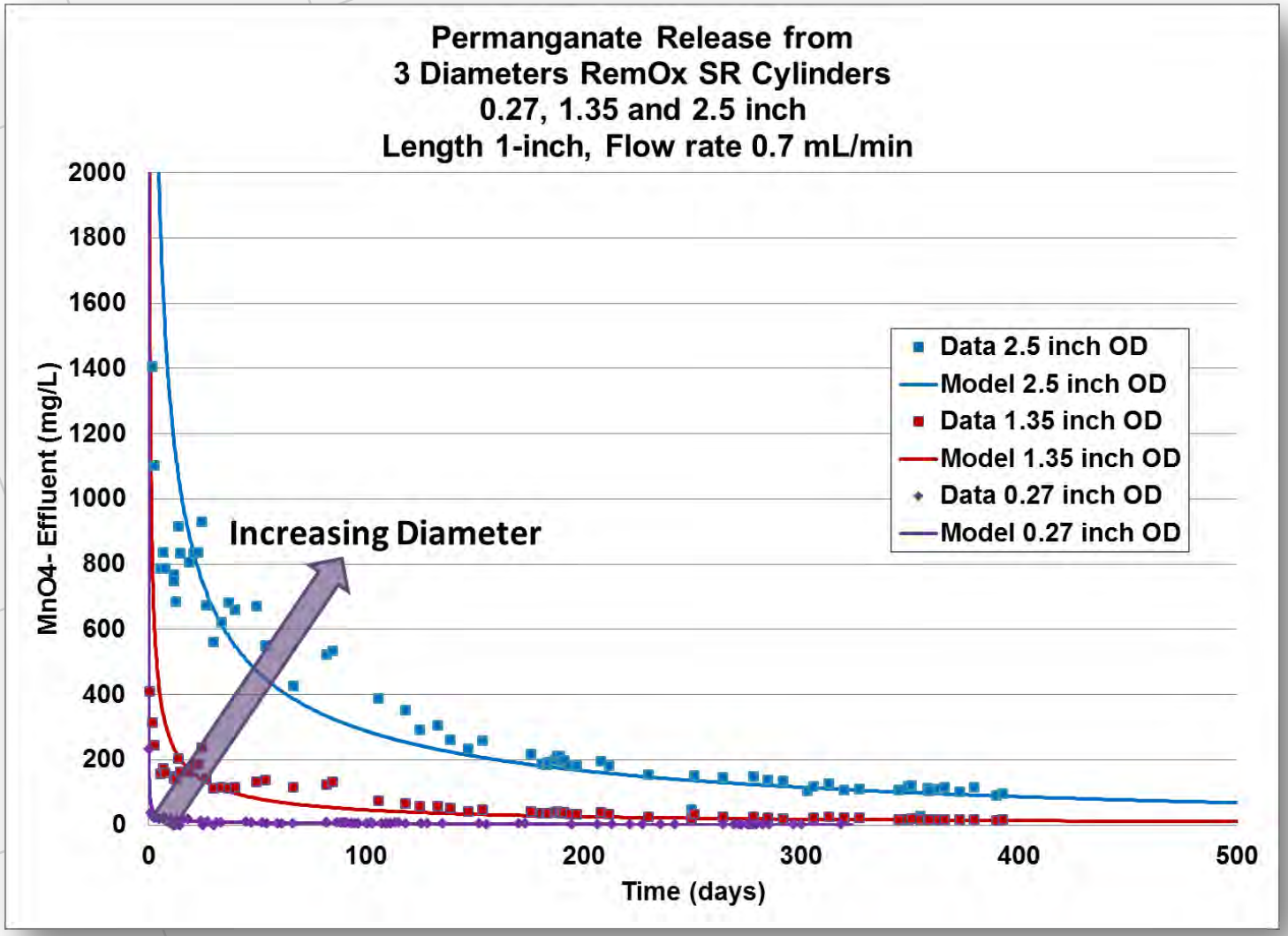


Column Results for Dioxane Removal

- Persulfate SR cylinder 97%-100%
- 1,500 ppm unactivated persulfate 93%-100%



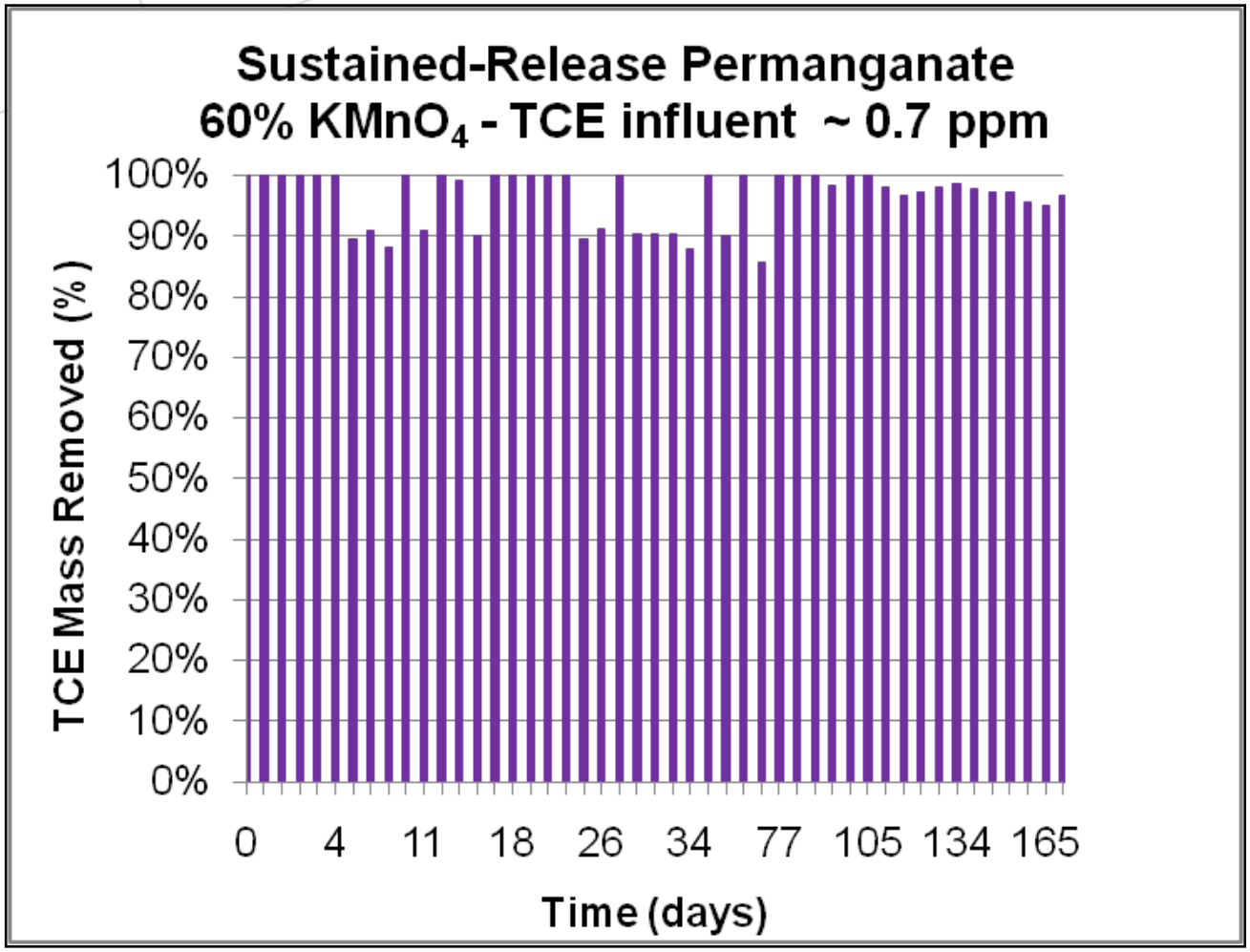
Oxidant Release Kinetics and Modeling



Permanganate Mini-Cylinder (80% w/w) running for ~6 months

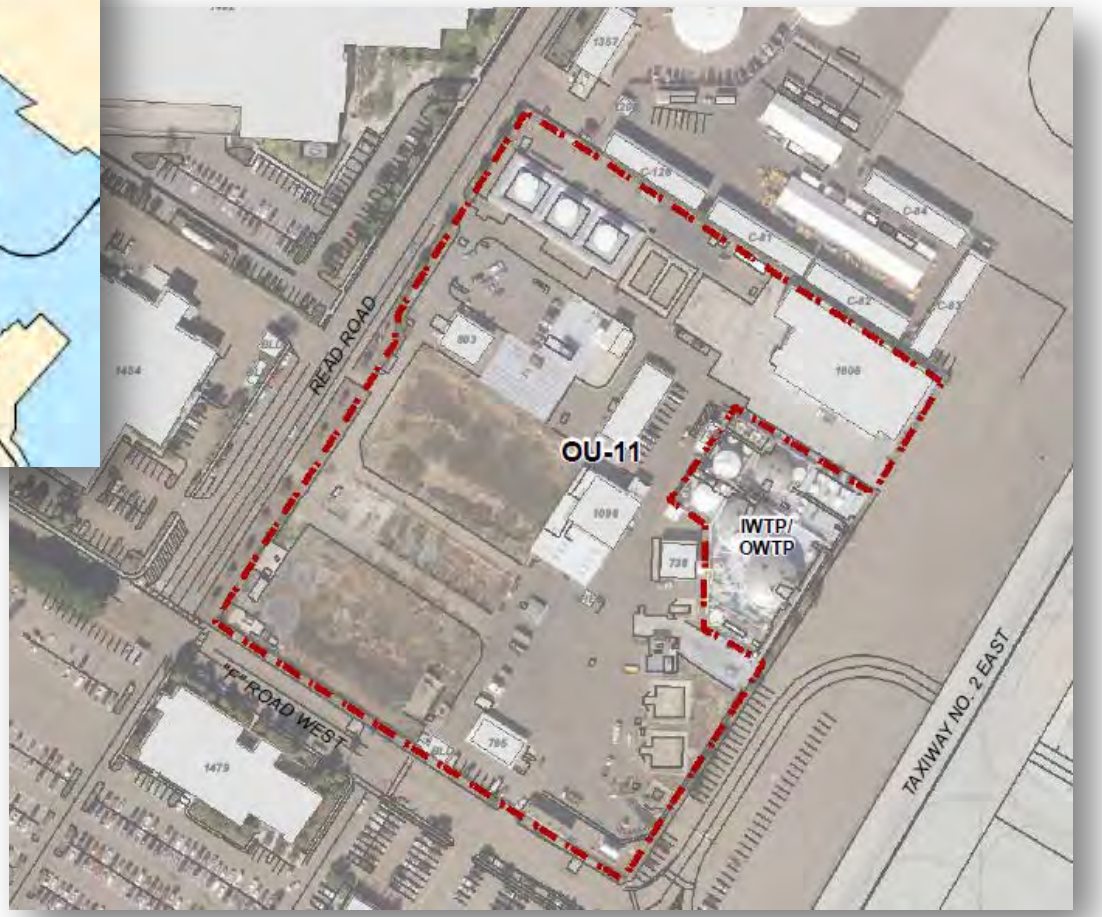
Measured permanganate concentrations match model!

Results – TCE Removal in 1D Columns

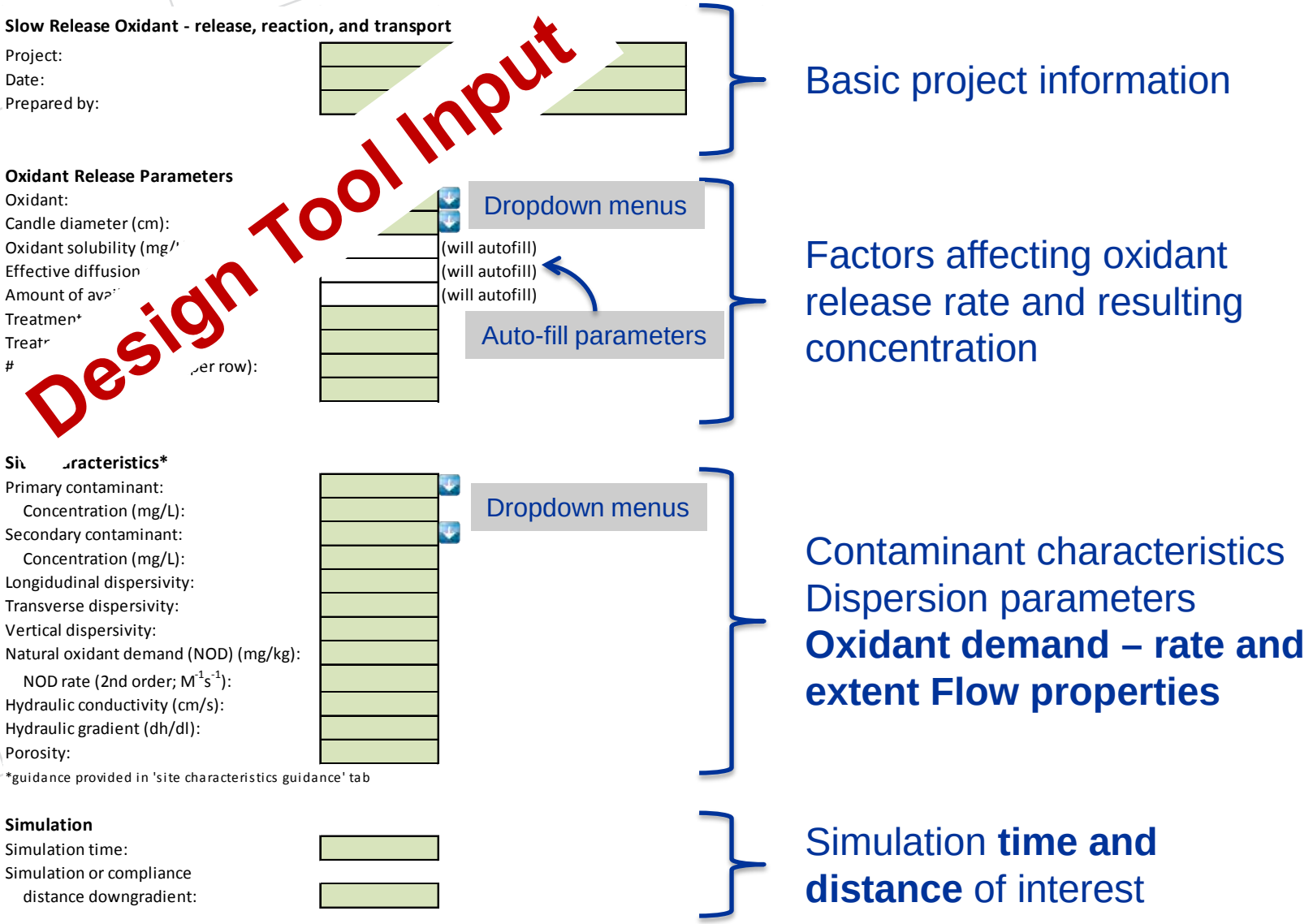


TCE mass removal 86%-100% over 170 days or > 470 PVs

ESTCP Demonstration: Naval Air Station North Island

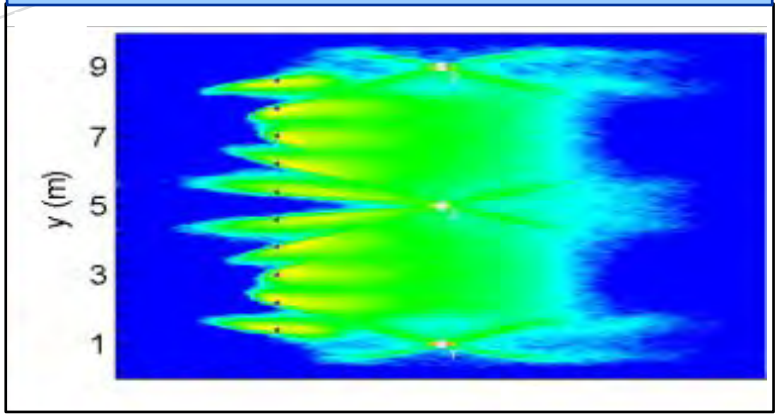


Engineering Design Tool

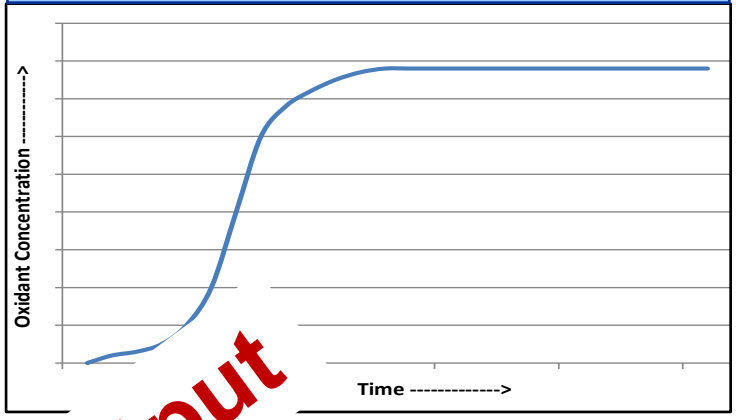


Engineering Design Tool

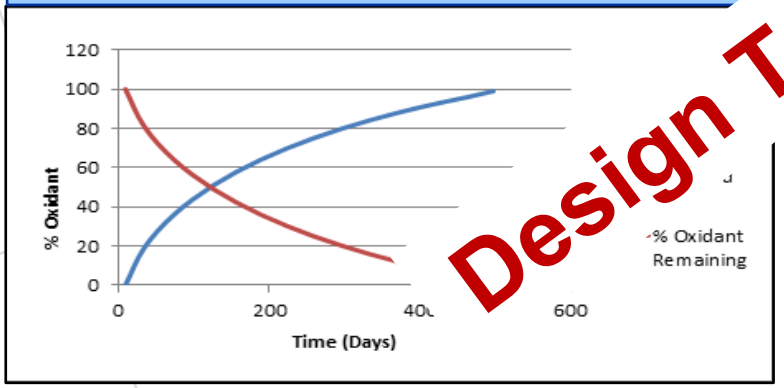
Oxidant concentrations vs. distance at a given time



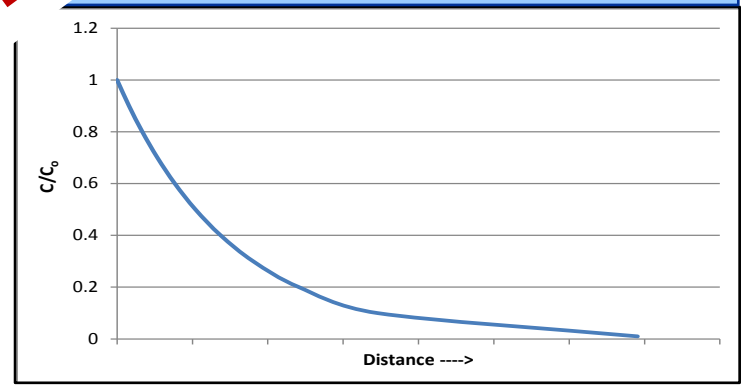
Oxidant concentrations at a given point over time



Oxidant release from candles



Contaminant concentrations vs. distance at a given time



Conclusions

- Dioxane and other contaminants often create large dilute plumes
- Unactivated persulfate and permanganate have potential for treatment
- Slow-release chemical oxidant candles can be used for plume treatment
- Various configurations include permeable reactive barriers, funnel and gate, and grid
- An ESTCP field demonstration will yield practical cost and performance data

Thank You!

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