1,4-Dioxane Remediation by XSVE

Project Team

ESTCP Funded

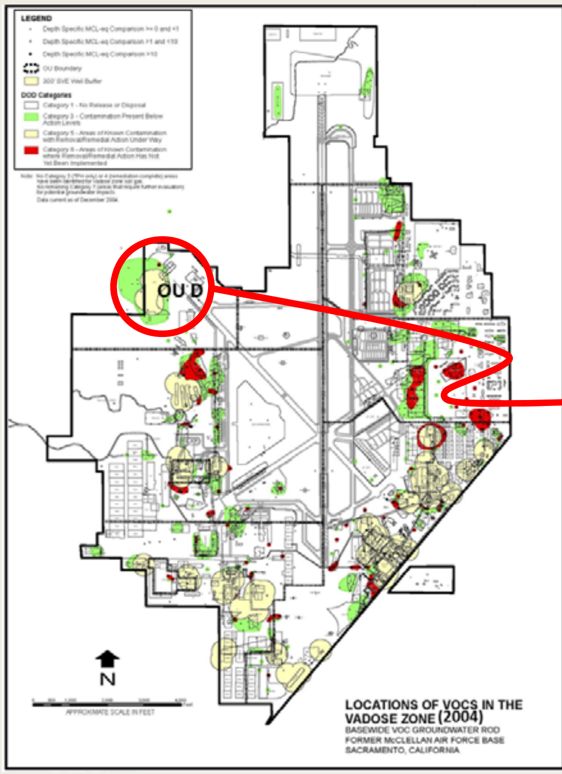
- IST
  - Rob Hinchee, PhD, PE – PI
  - Dave Burris, PhD, PG – Project Geochemist
- Colorado School of Mines
  - Paul Johnson, PhD – HypeVent Lead and Technical Advisor
- Arizona State University
  - Paul Dahlen, PhD – Technical Advisor and Lab Lead
- AECOM
  - Kimiye Touchi, PE & Paul Graff, PE – McClellan Remediation Team
- AFCEC
  - Ken Smarkel, PhD, PE – McClellan Program Manager
  - Hunter Anderson, PhD – Technical Advisor
- US Army Corps of Engineers
  - Dave Becker, PG – Technical Advisor

Technical Objectives

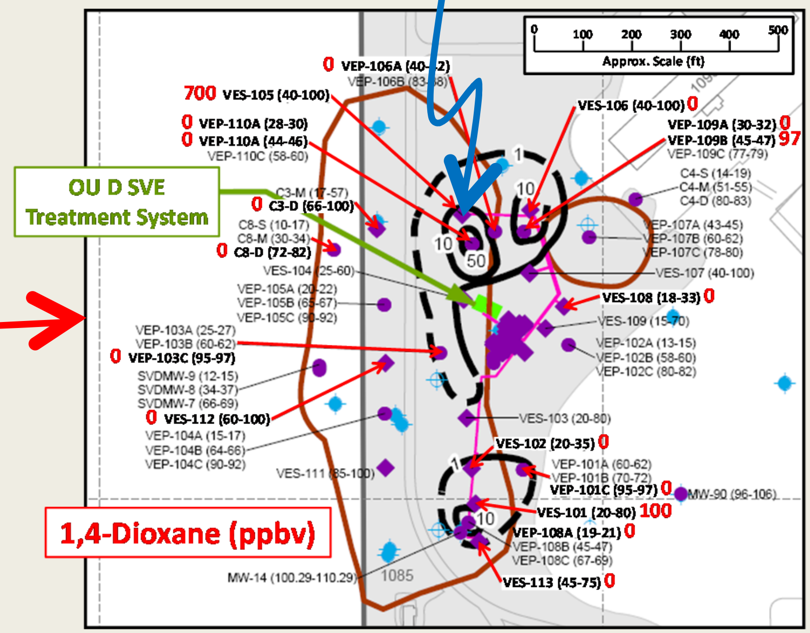
- Design, implement, and document successful remediation of 1,4-dioxane in the vadose zone.
  - *Adapt SVE to address 1,4-dioxane - enhanced or extreme SVE (XSVE).*
- Develop a tool to aid in XSVE system design and provide for effective technology transfer.
  - *Update the HypeVent SVE software package (original HypeVent helped promote the current widespread application of SVE).*
  - *Produce a succinct, common sense, effective guidance document incorporating HypeVent.*

Site Description

Former McClellan AFB, CA
OU D

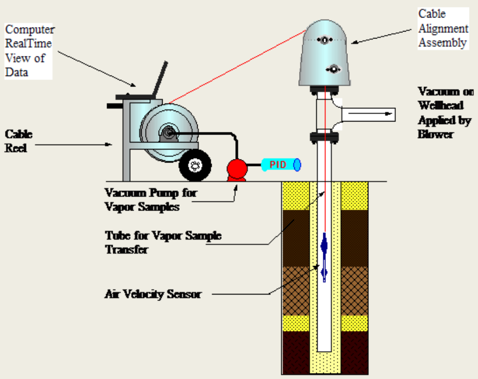


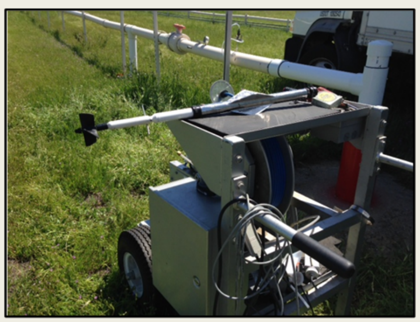
VES-105
1,4-dioxane: 1,000 ppb_v range

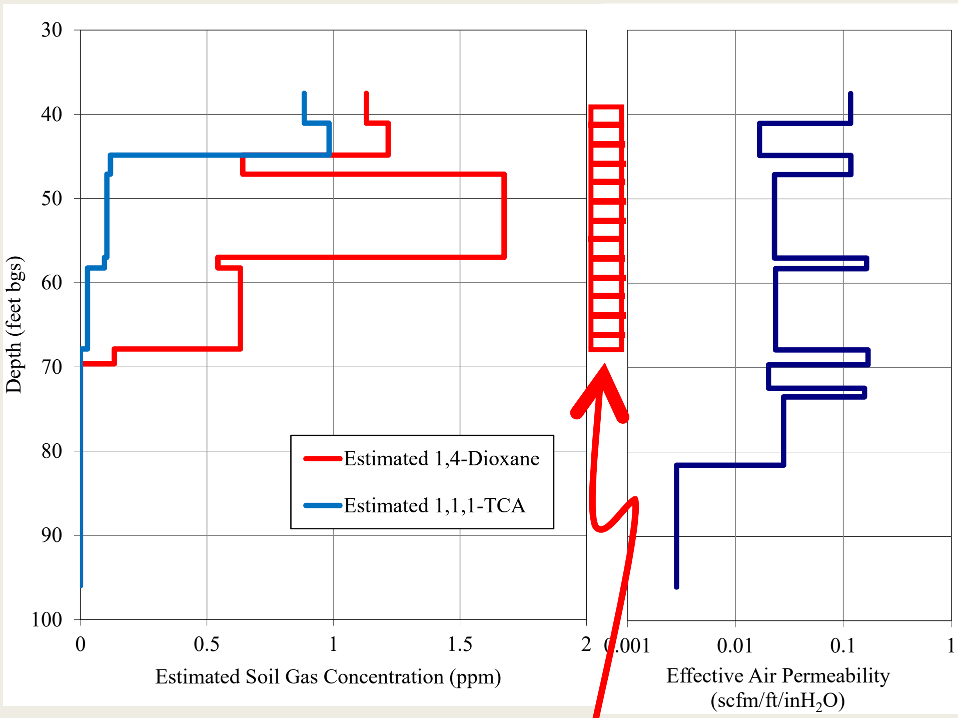


VES-105 PneuLog Results

Concentrations and Effective Permeability Obtained during SVE Operation



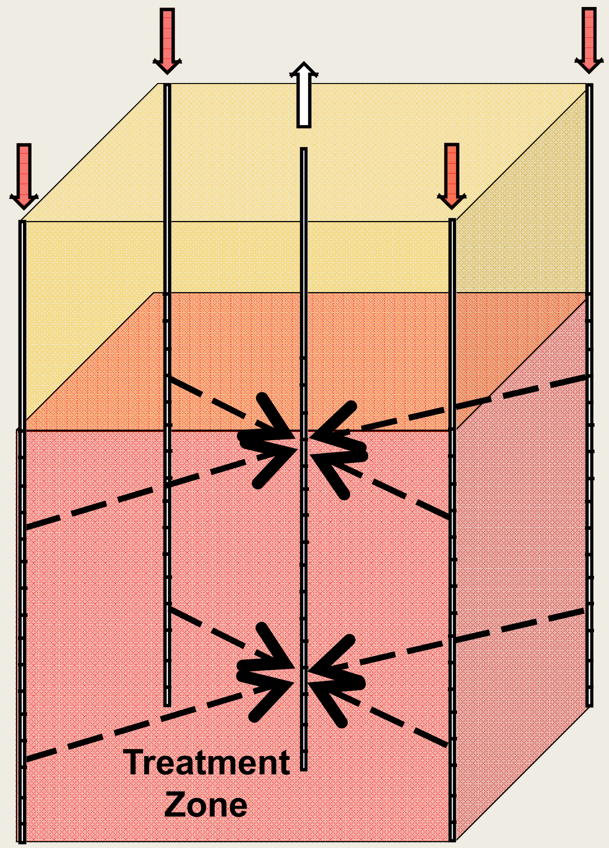




XSVE Screened Interval
38 to 68 ft bgs

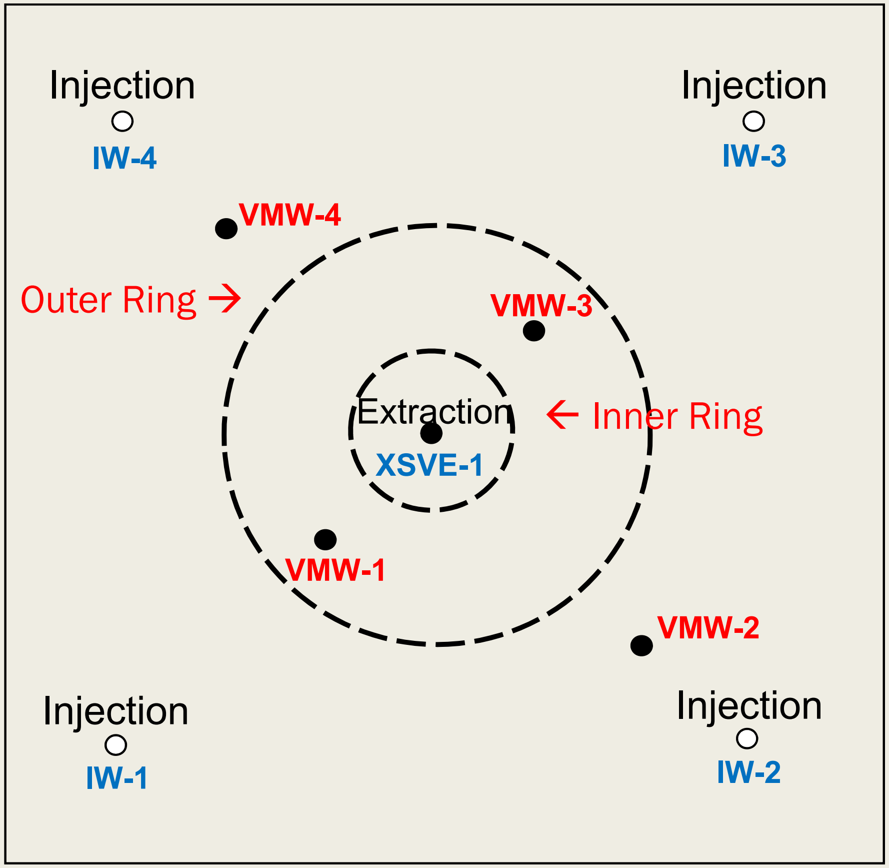
Test Design

- 4 injection wells - 20 ft corners
  - ~100 cfm; ~100 to 120 ºC
- 1 extraction well – center
  - ~100 cfm
- low carbon steel well casing
- concrete grout
- screened interval 38 – 68 ft
- existing vapor treatment system
- condensate collection

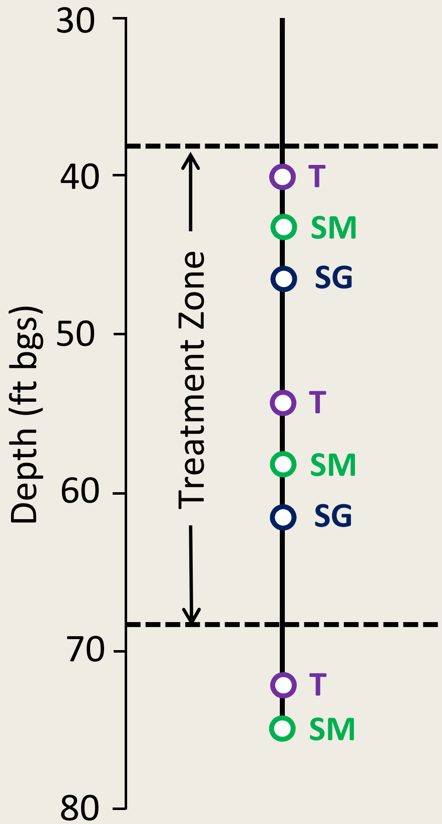


Well & Sensor Locations

VMW Locations – Multi-Level Sensors/Probes



- Temperature (T)
- Soil Moisture (SM)
- Soil Gas Probes (SG)

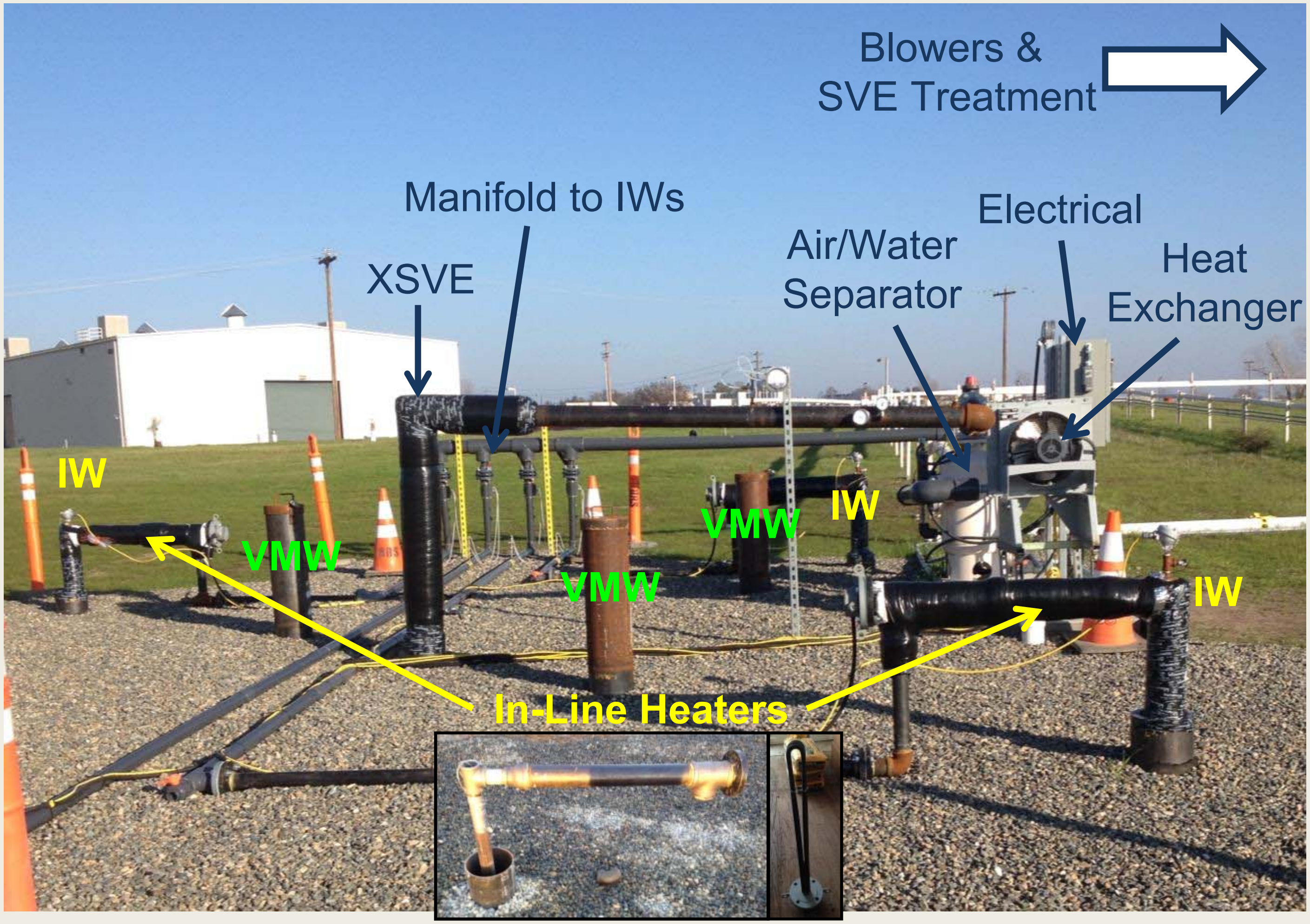


Well Installations

Stainless Steel Screen

Carbon Steel Casing

XSVE System

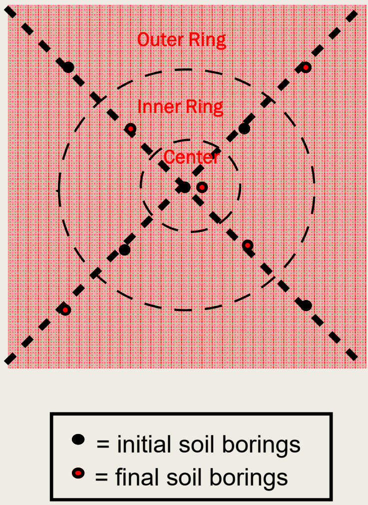


Blowers &
SVE Treatment
Manifold to IWs
XSVE
Air/Water
Separator
Electrical
Heat
Exchanger
IW
VMW
VMW
VMW
IW
IW
In-Line Heaters

Pre- and Post- Soil Borings

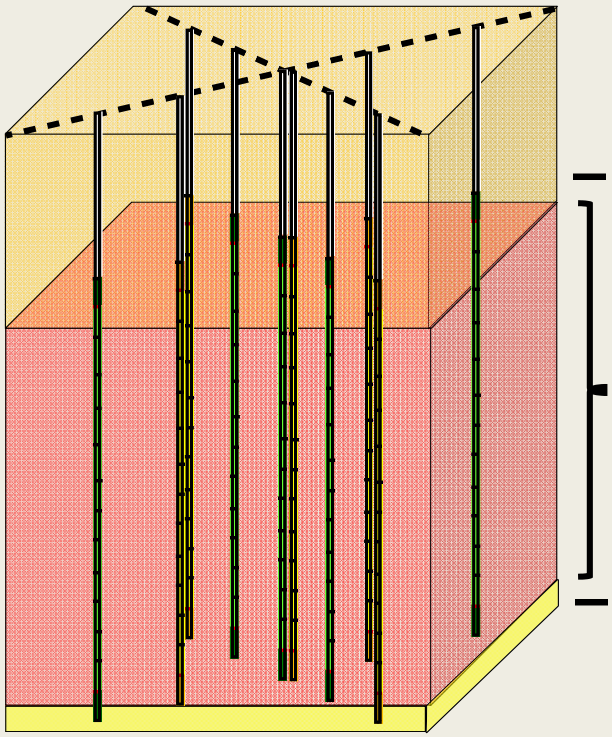
For 1,4-Dioxane & Soil Moisture

Plan View



5 initial soil borings
5 final soil borings

Cross-Section View

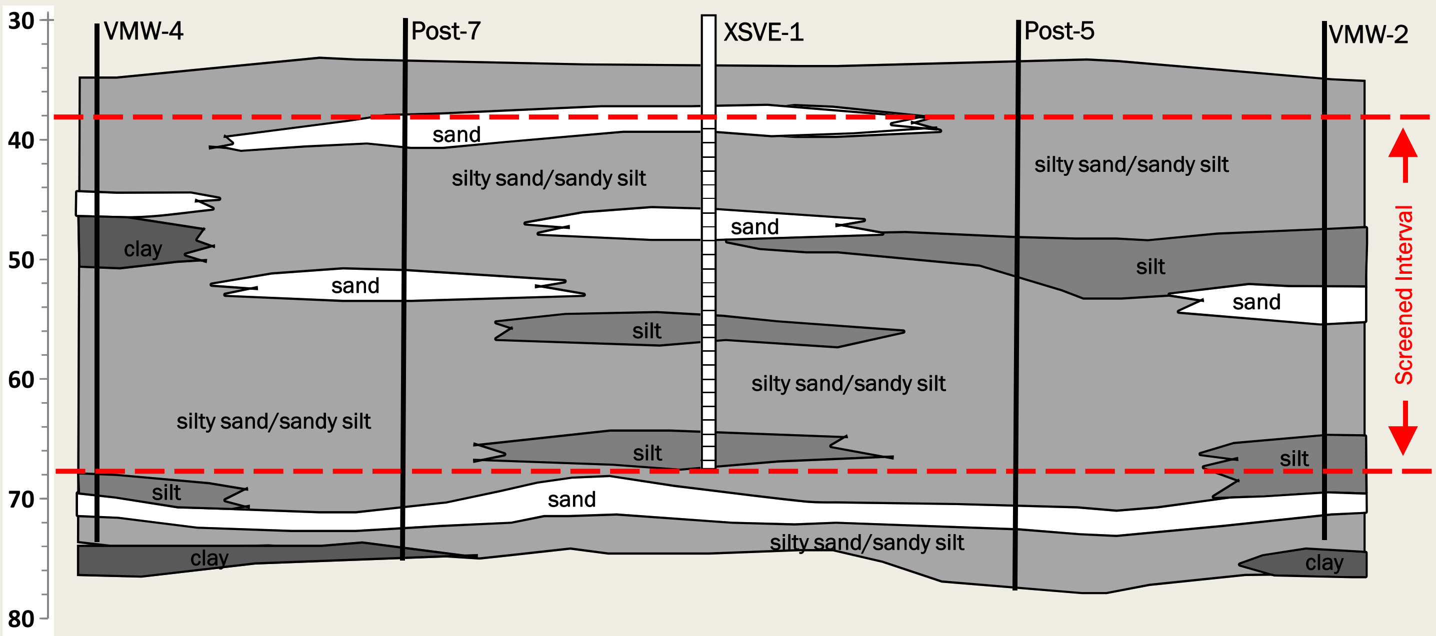


Each Soil Boring:

- 1 soil composite above
- 10 soil composites in treatment zone (screened interval)
- 2 soil composites below

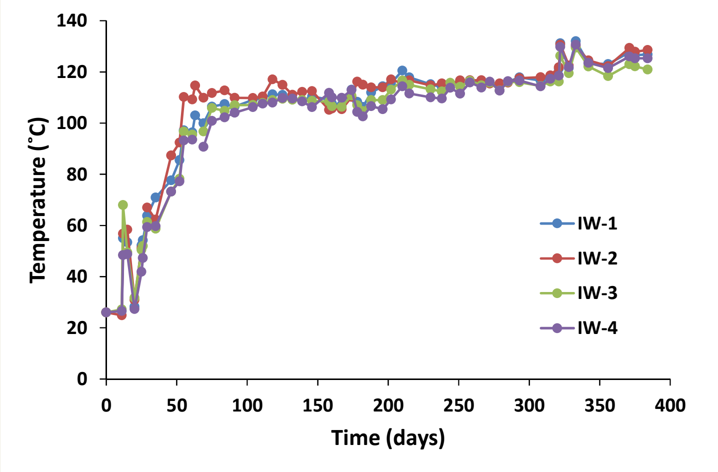
ITRC Incremental Sampling Method: Center; Inner Ring; Outer Ring

Cross-Section

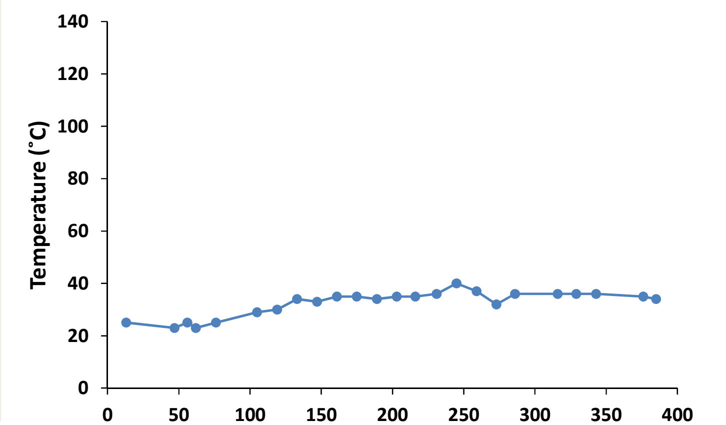


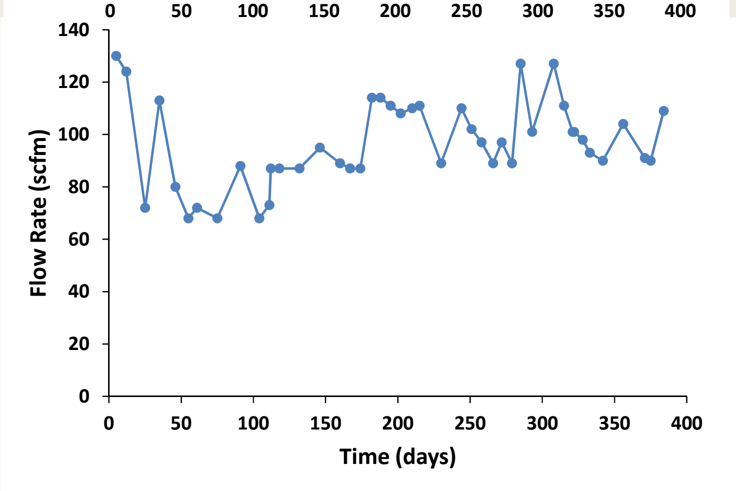
Operation (Injection & Extraction Wells)

Injection



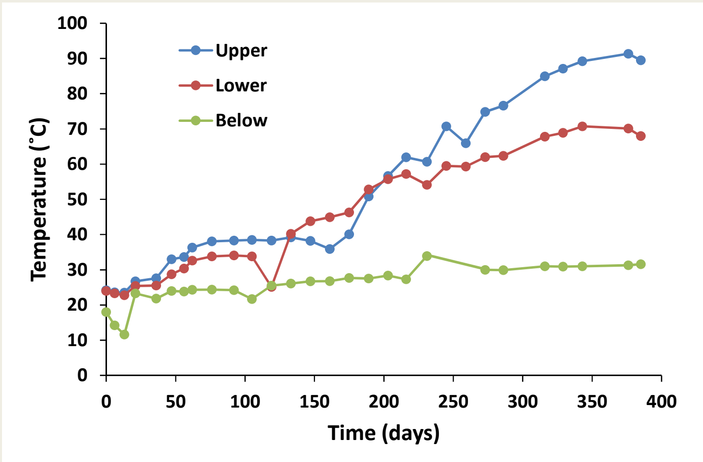
Extraction

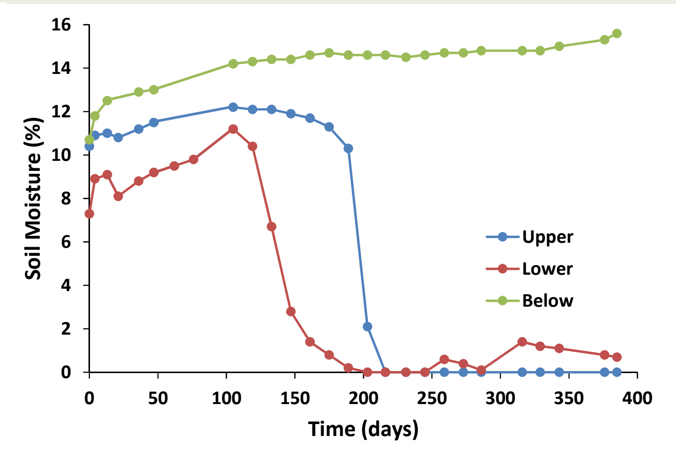




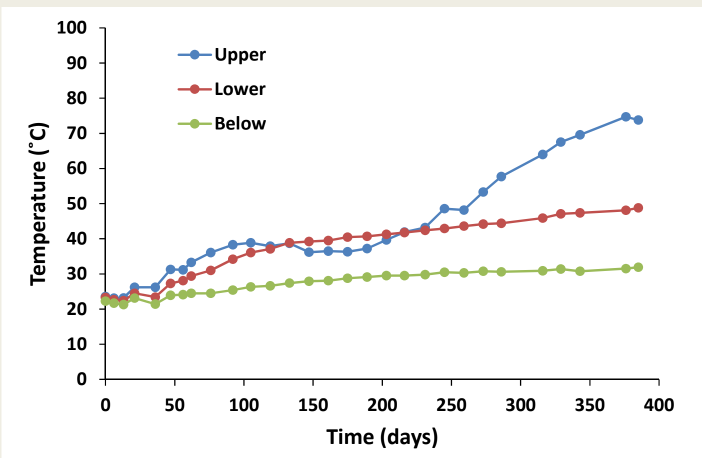
Outer Ring

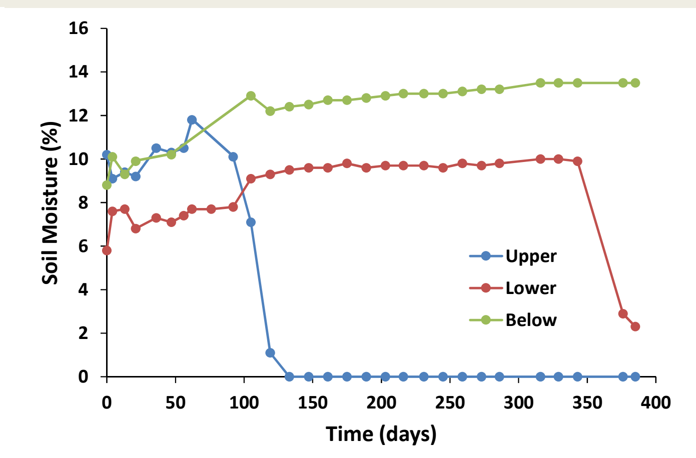
VMW-2





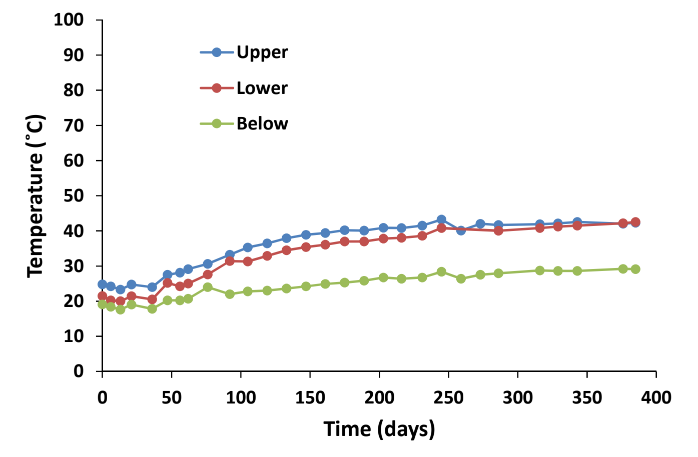
VMW-4

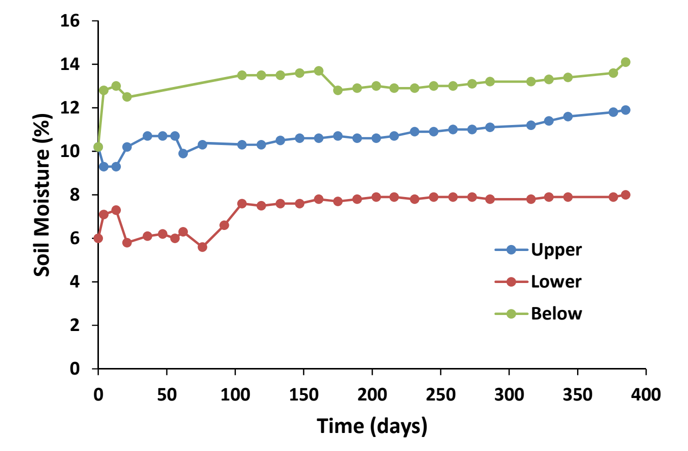




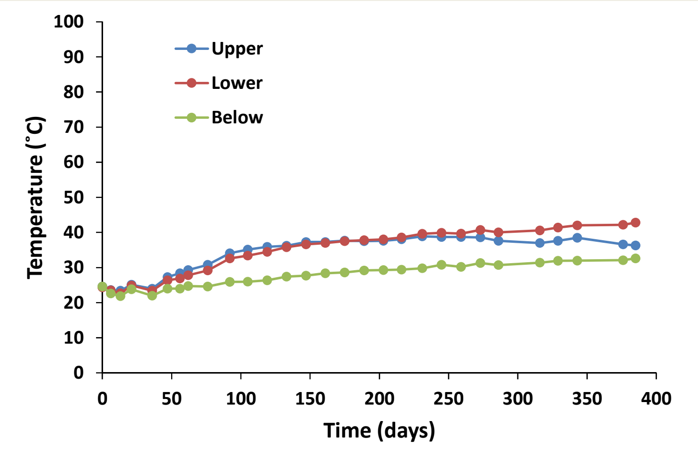
Inner Ring

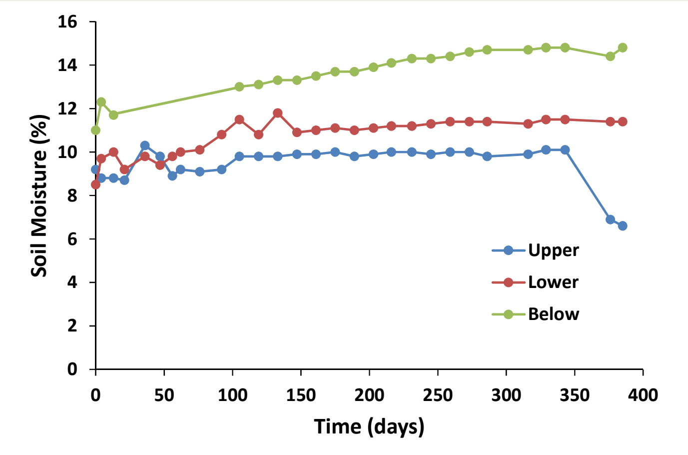
VMW-1



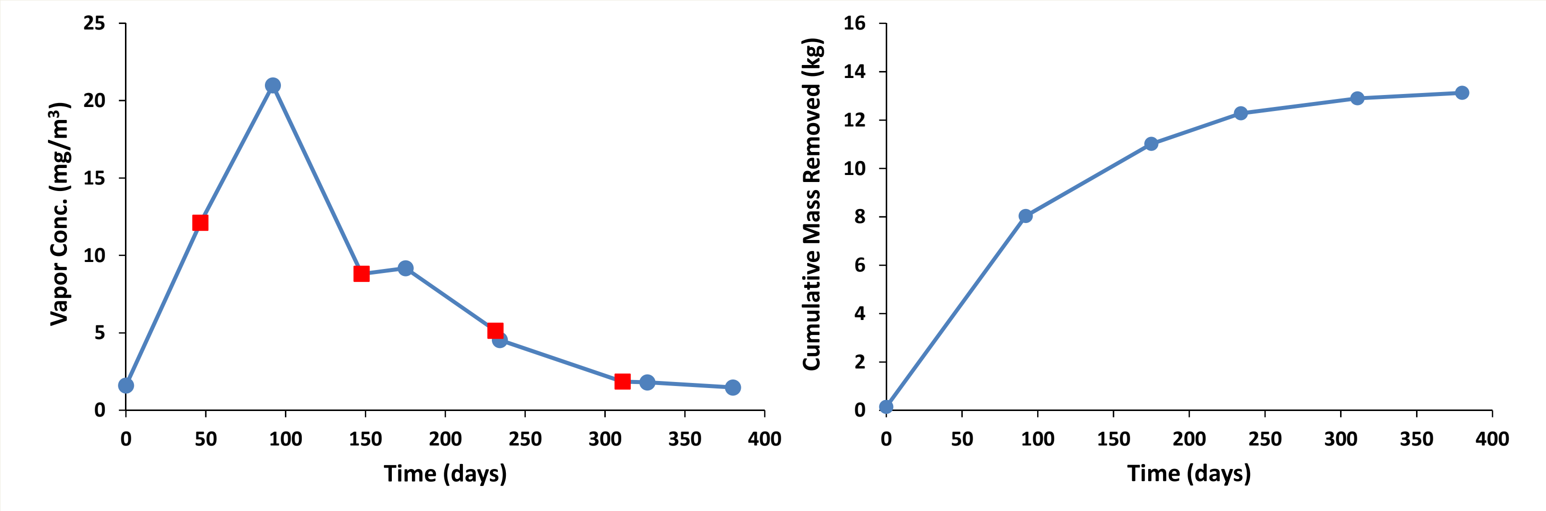


VMW-3



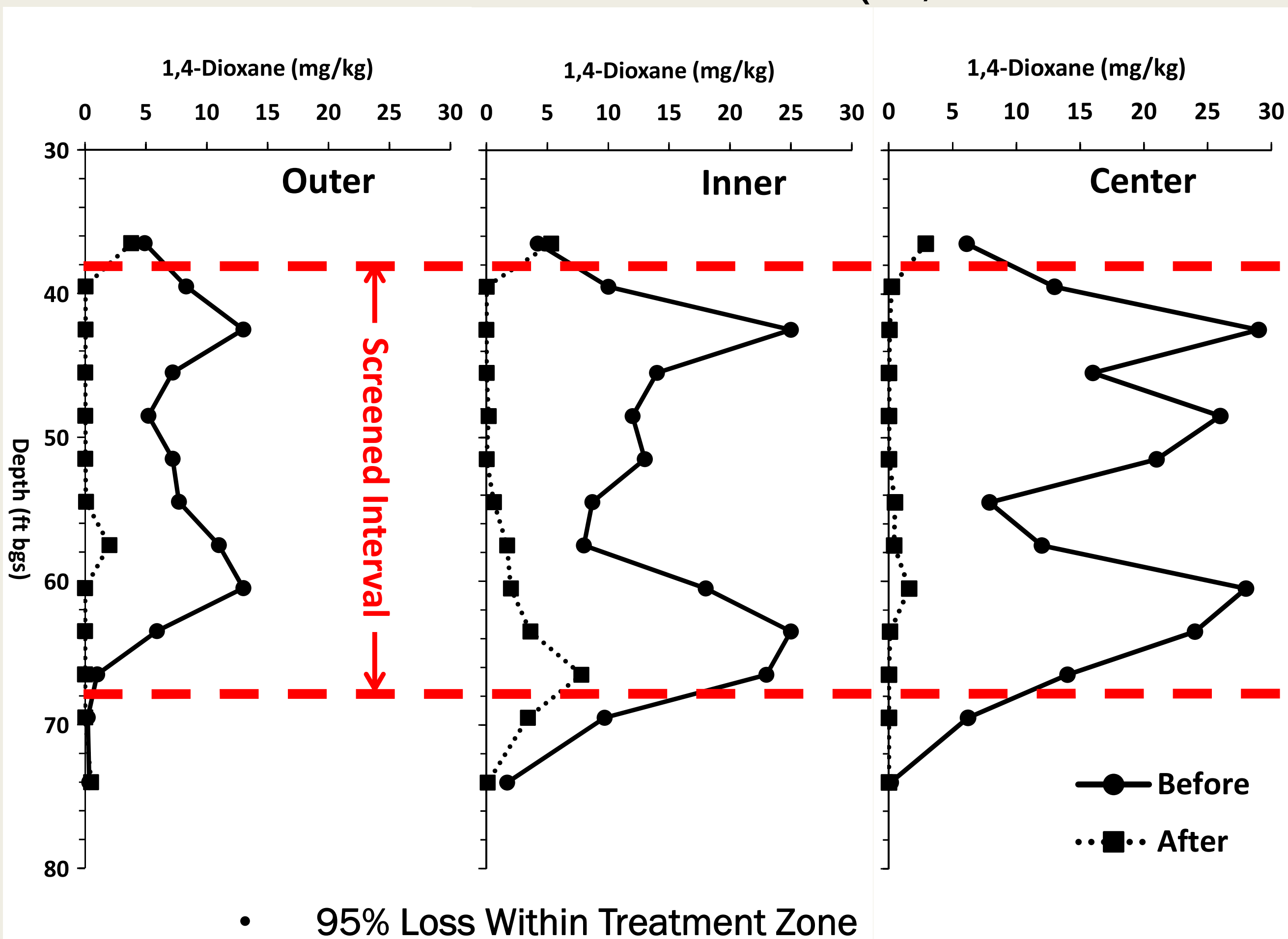


Operation (1,4-Dioxane Mass Removal)



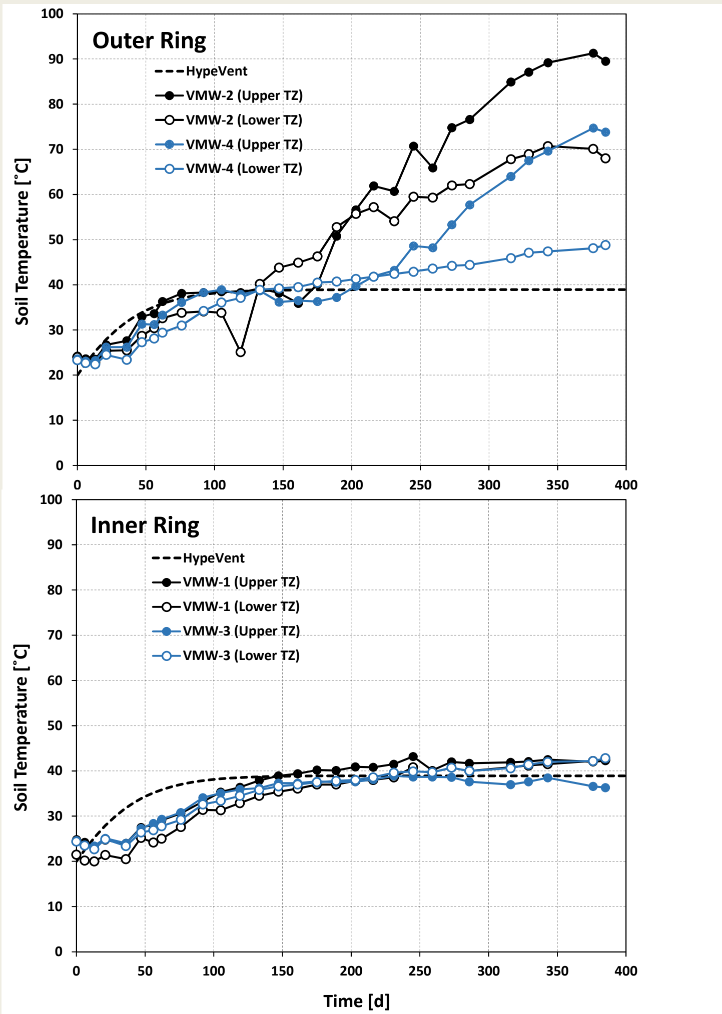
- Mass removal estimates (~13 kg 1,4-dioxane at shutdown) consistent with before and after soil concentrations
- Initial removal rate consistent with SVE well next to demonstration.

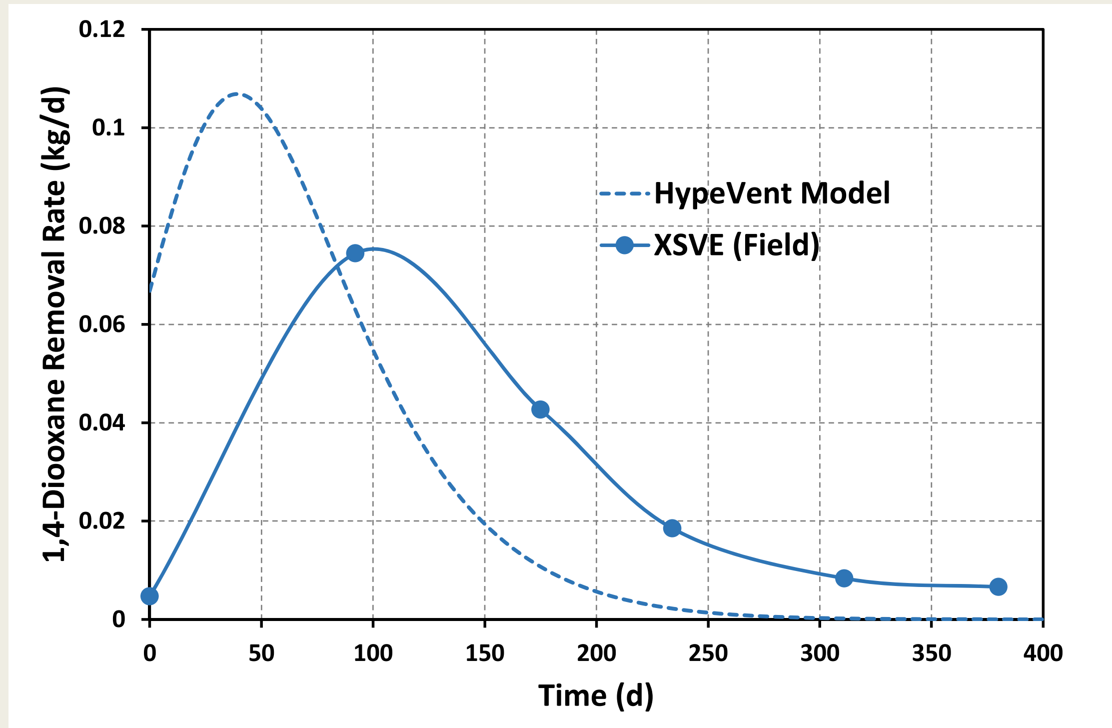
Performance Assessment (1,4-Dioxane Removal)



- 95% Loss Within Treatment Zone
- Decrease Below Treatment Zone

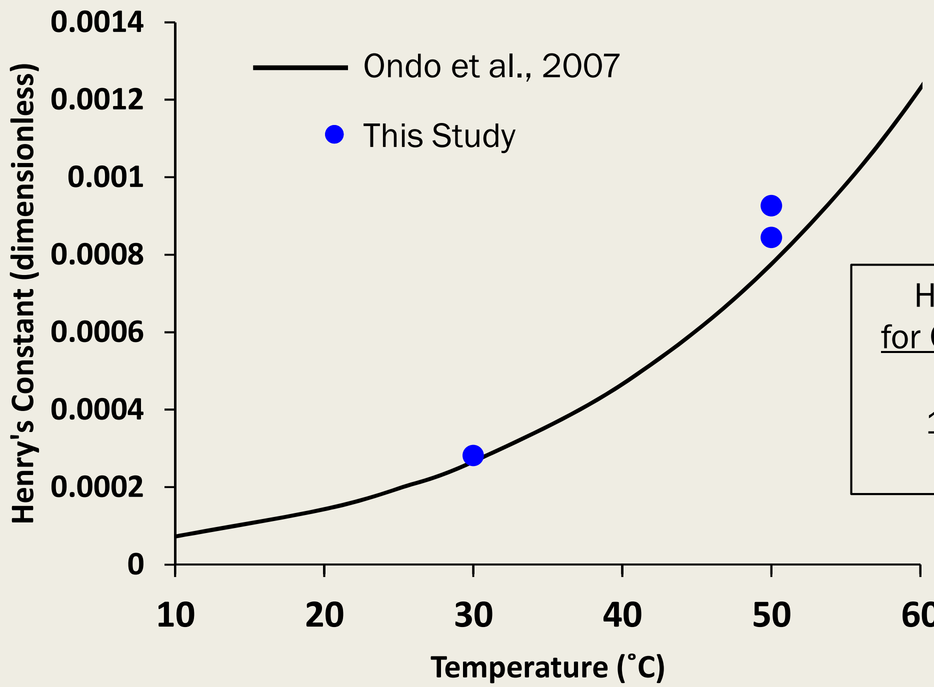
HypeVent Model (Paul Johnson, CSM)





Agrees with Field Results

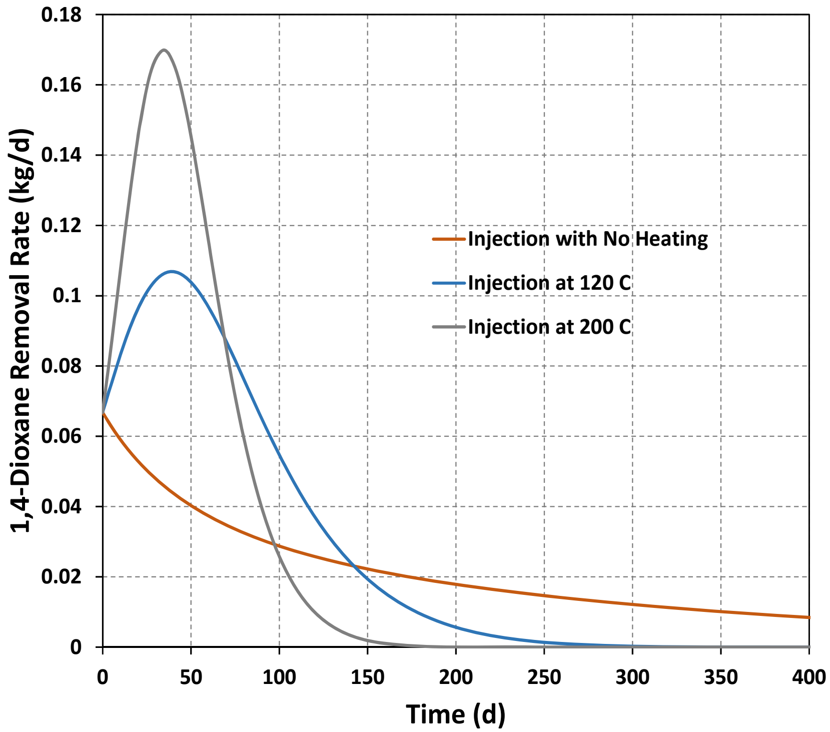
1,4-Dioxane Henry's Constant

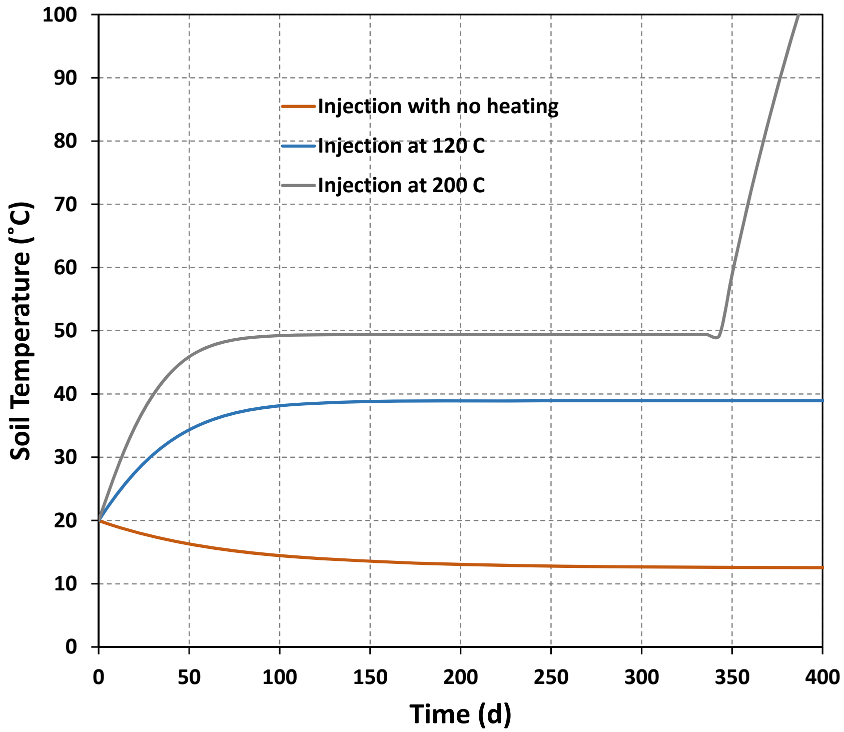


Henry's Constants
<u>for Comparison (25˚C):</u>
TCE – 0.40
1,1,1-TCA – 0.70
1,1-DCE – 1.1

- Henry's Constant increases ~17-fold from 10 to 60˚C.
- SVE removal efficiency for 1,4-dioxane should increase at elevated temperatures.

HypeVent Model (Sensitivity Analysis)





Heating Improved 1,4-Dioxane Removal Efficiency

Summary and Conclusions

- SVE can remediate 1,4-dioxane
  - *~95% mass removal in this study*
- However high flow rates are required
  - *~20,000 Void volumes in this study compared to*
  - *200 to 5,000 Void volumes for conventional SVE*
- Heating helps
  - *Estimated cost of heating ~$25/yd in this study*
    - 100 to 120 C injection
  - *More heat would accelerate the process, but could increase costs*