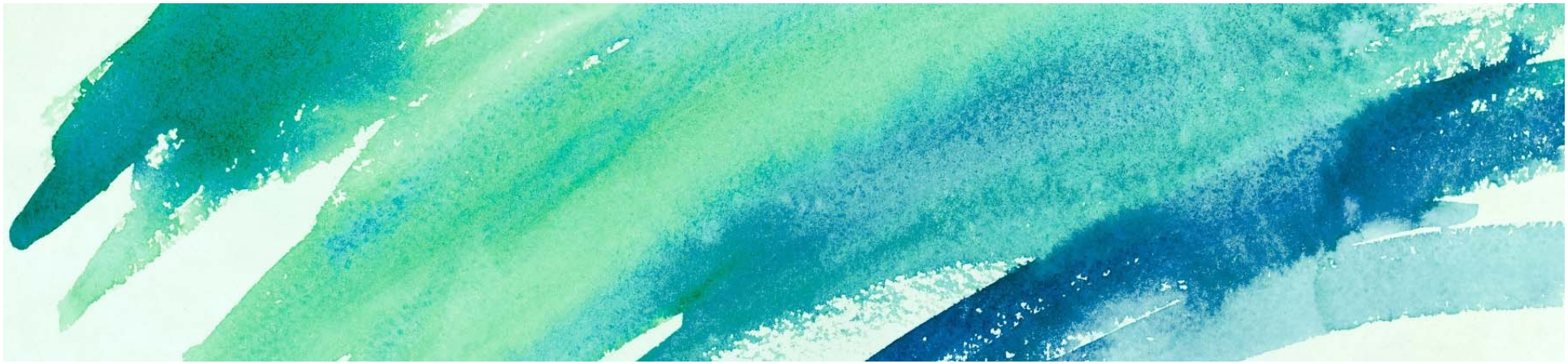
Treatment of Mixed Chlorinated Solvents and 1,4-Dioxane Groundwater

Testing of Two Biodegradation Strategies

Sophia Dore, Ph.D. | GHD

April 2018

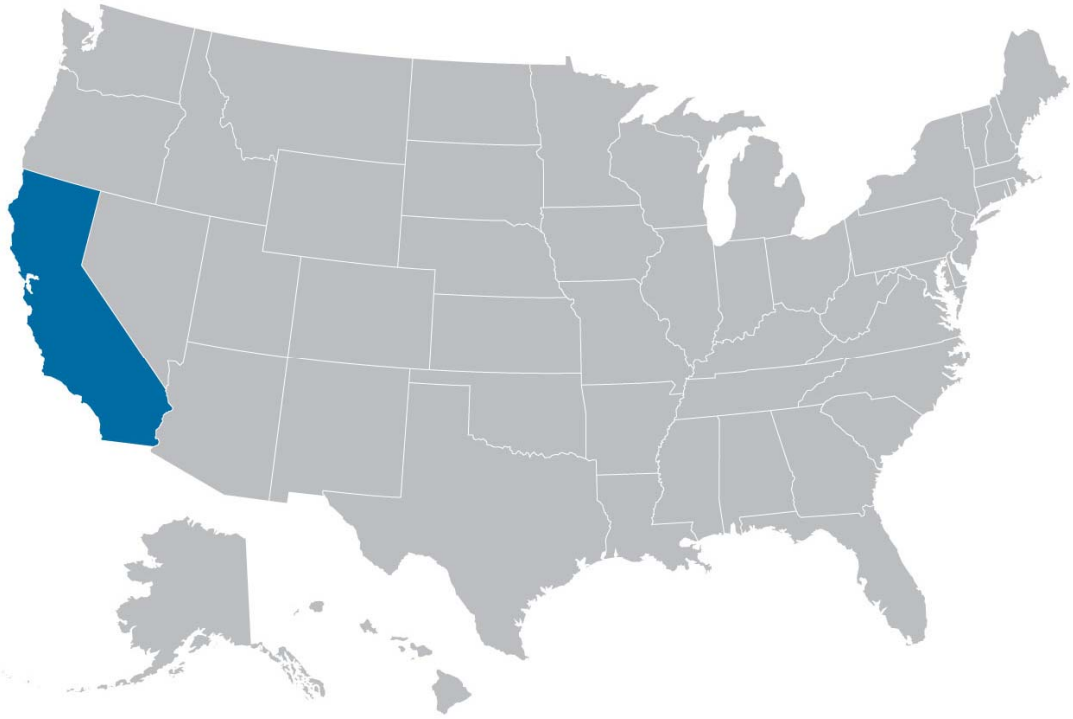


Agenda

- Background
- Treatability Study Approach
- Treatability Study Objectives
- Initial Characterization
- Treatability Set up
- Treatability Study Results
- Results/Lessons Learned

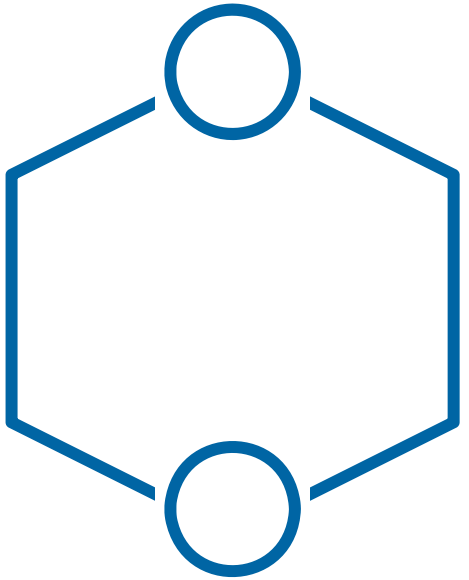
Background

- **Site location:** Southern California
- A former residential and commercial manufacturer of lighting fixtures
- 4.7 acres in size
- A single-story, 105,000 ft^2 concrete building and associated parking lot on site
- CVOCs and 1,4-dioxane are present in soil and groundwater
- CVOC of concern:
  - PCE
  - TCE
  - 1,1,1-TCA
  - 1,1-DCA



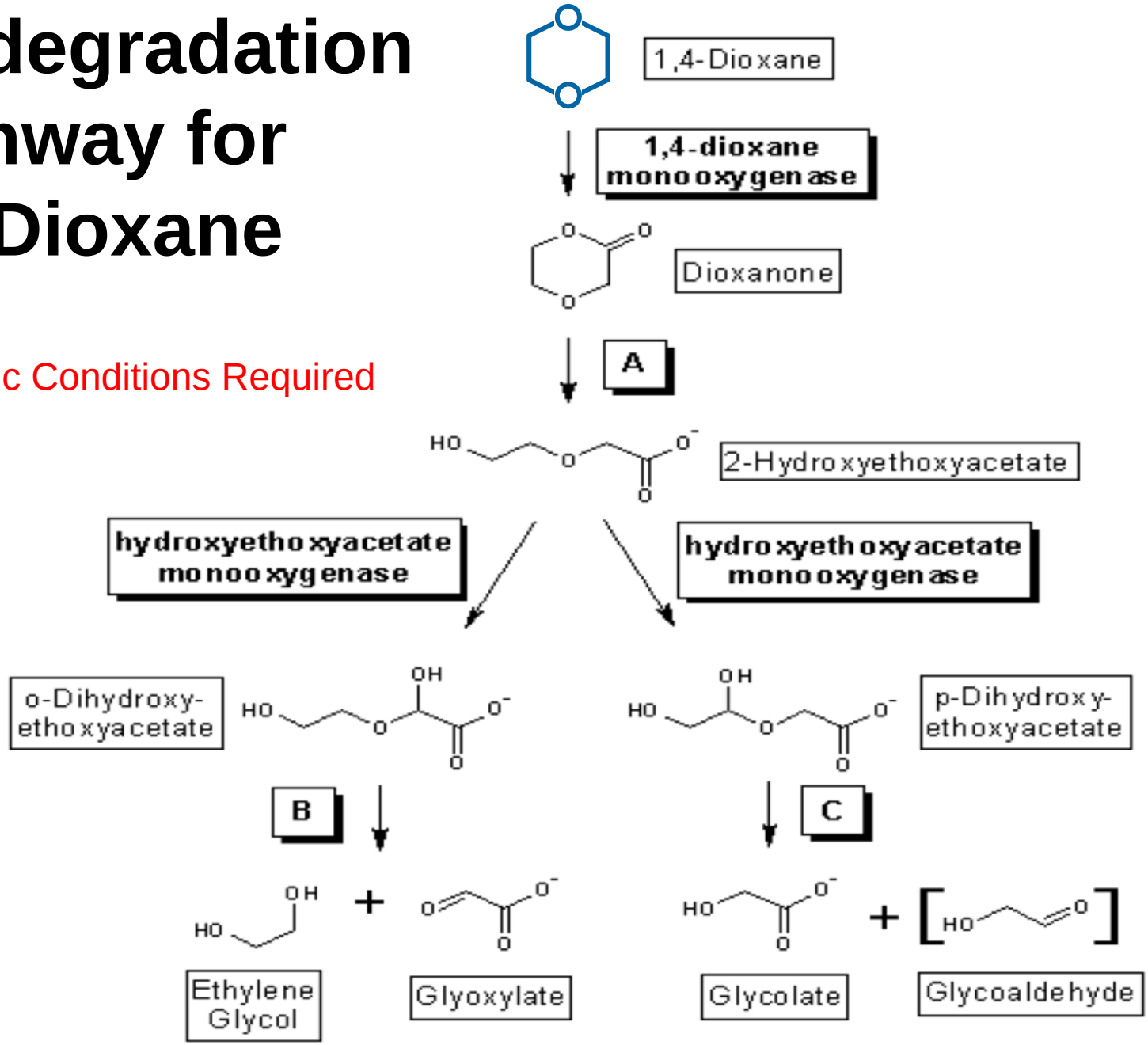
Background

- Irritating to respiratory tract
- Classified as “reasonably expected” to be a human carcinogen
- Considered an “emerging contaminant” because MCLs were either established recently or are in the process of being established depending on region
- Used as a stabilizer for chlorinated solvents
- Often found comingled with chlorinated solvents in the groundwater
- Very soluble in water
- Leading edge of plume often further downgradient than chlorinated solvents



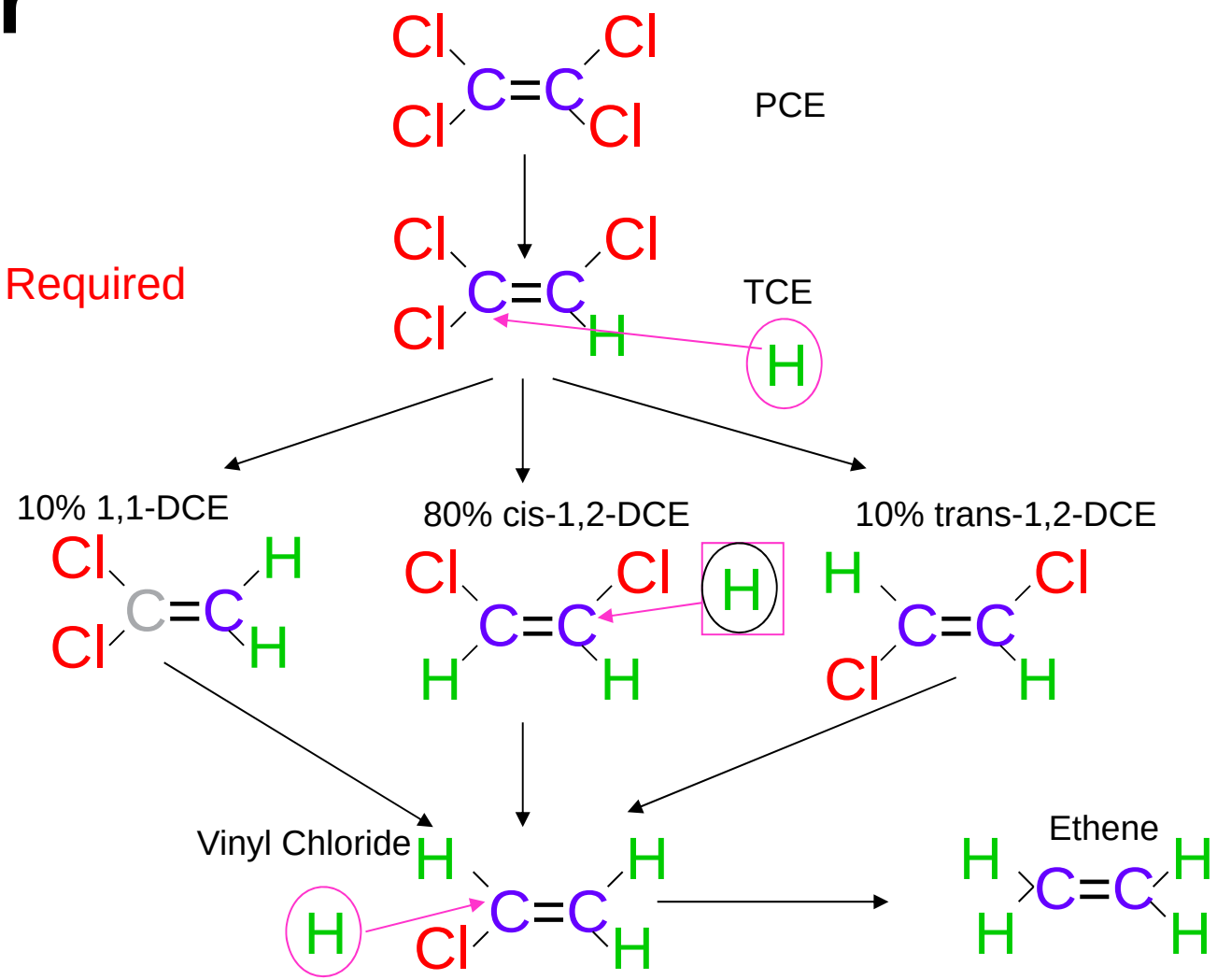
Biodegradation Pathway for 1,4-Dioxane

*Aerobic Conditions Required

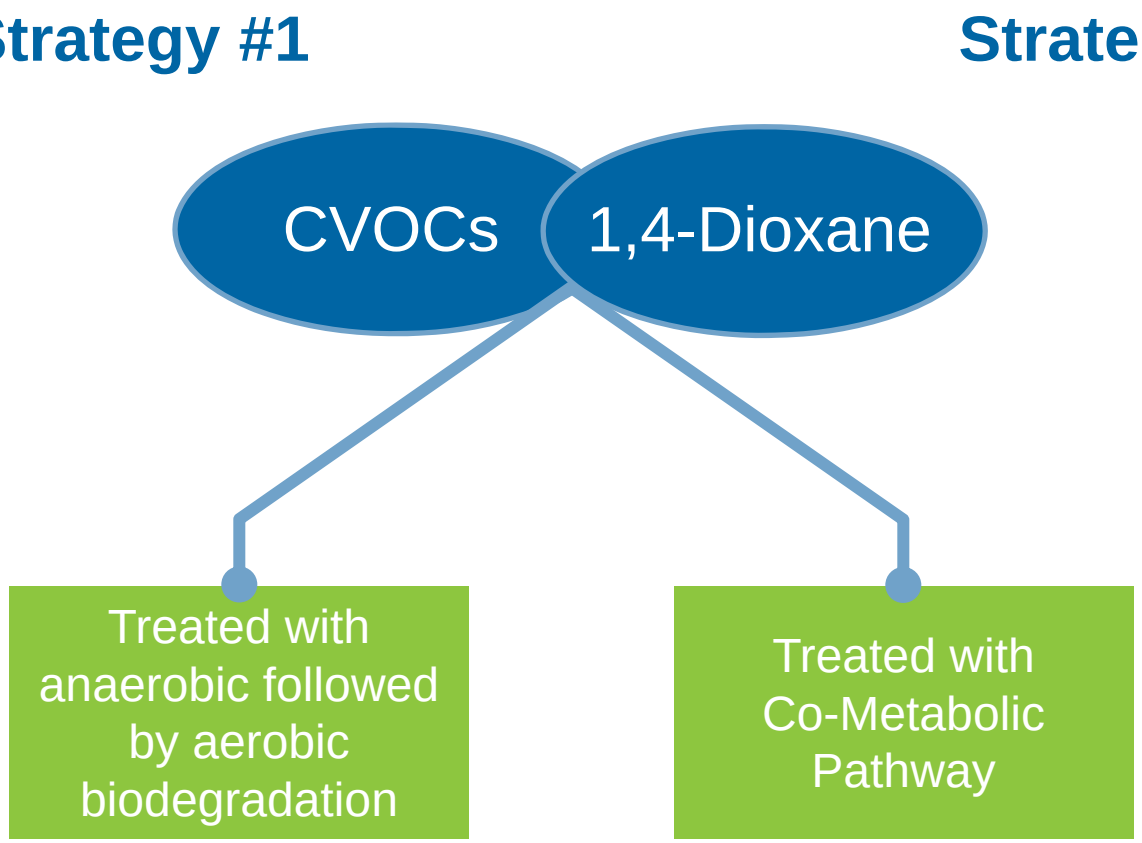


Biodegradation Pathway for CVOC

*Anaerobic Conditions Required



Strategies to Treat a Plume Containing CVOCs and 1,4-Dioxane



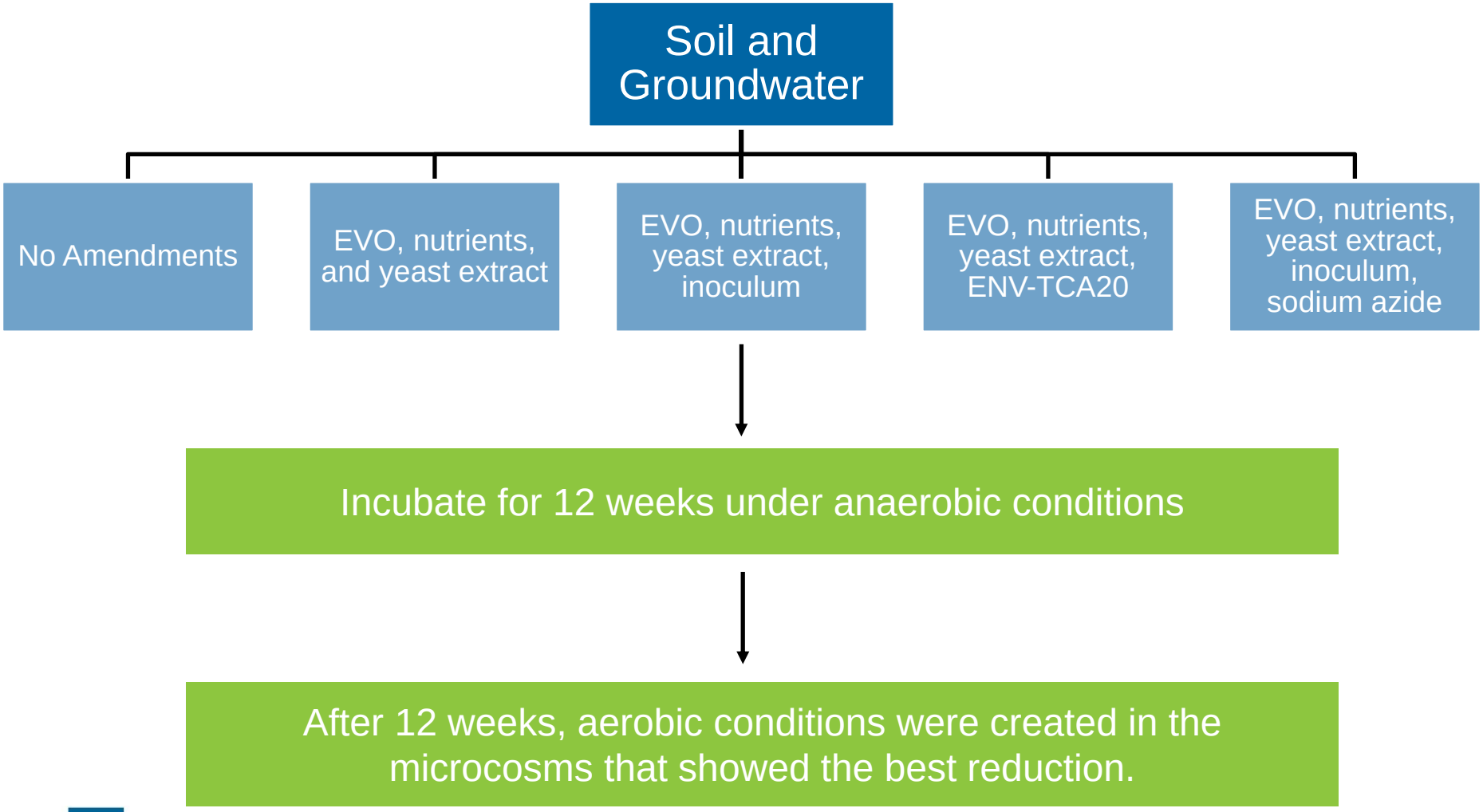
Treatability Study Approach

- Assess the potential of enhanced biodegradation for treatment of CVOC by anaerobic biodegradation
- Assess the potential of enhanced biodegradation for treatment of 1,4-dioxane by aerobic biodegradation
- Assess the potential of enhanced biodegradation for treatment of CVOC and 1,4-dioxane by co-metabolic biodegradation under aerobic conditions

Groundwater Sample

Parameter	Groundwater
1,4-dioxane	4,920 µg/L
PCE	650 µg/L
1,1-DCA	174 µg/L
1,1-DCE	20.6 µg/L
Cis-1,2-DCE	7.39 µg/L
1,1,1-TCA	45.1 µg/L
TCE	39.3 µg/L

Strategy #1
Anaerobic/Aerobic Biodegradation Microcosm Tests



Anaerobic/Aerobic Biodegradation Tests

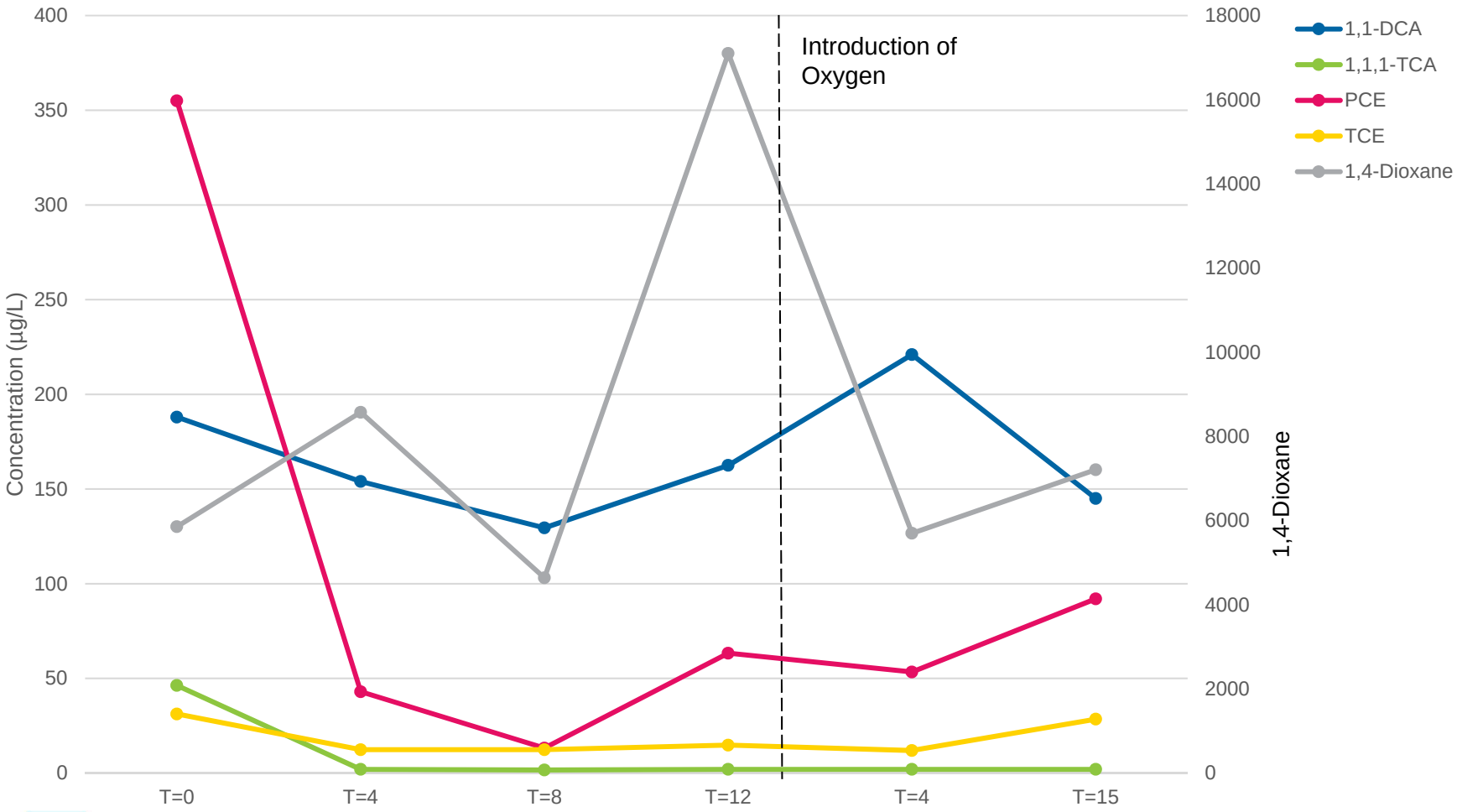
Anaerobic tests were set up in the anaerobic hood

Anaerobic/Aerobic Biodegradation Tests

After sufficient degradation of CVOC was observed, oxygen was added to turn the microcosms aerobic

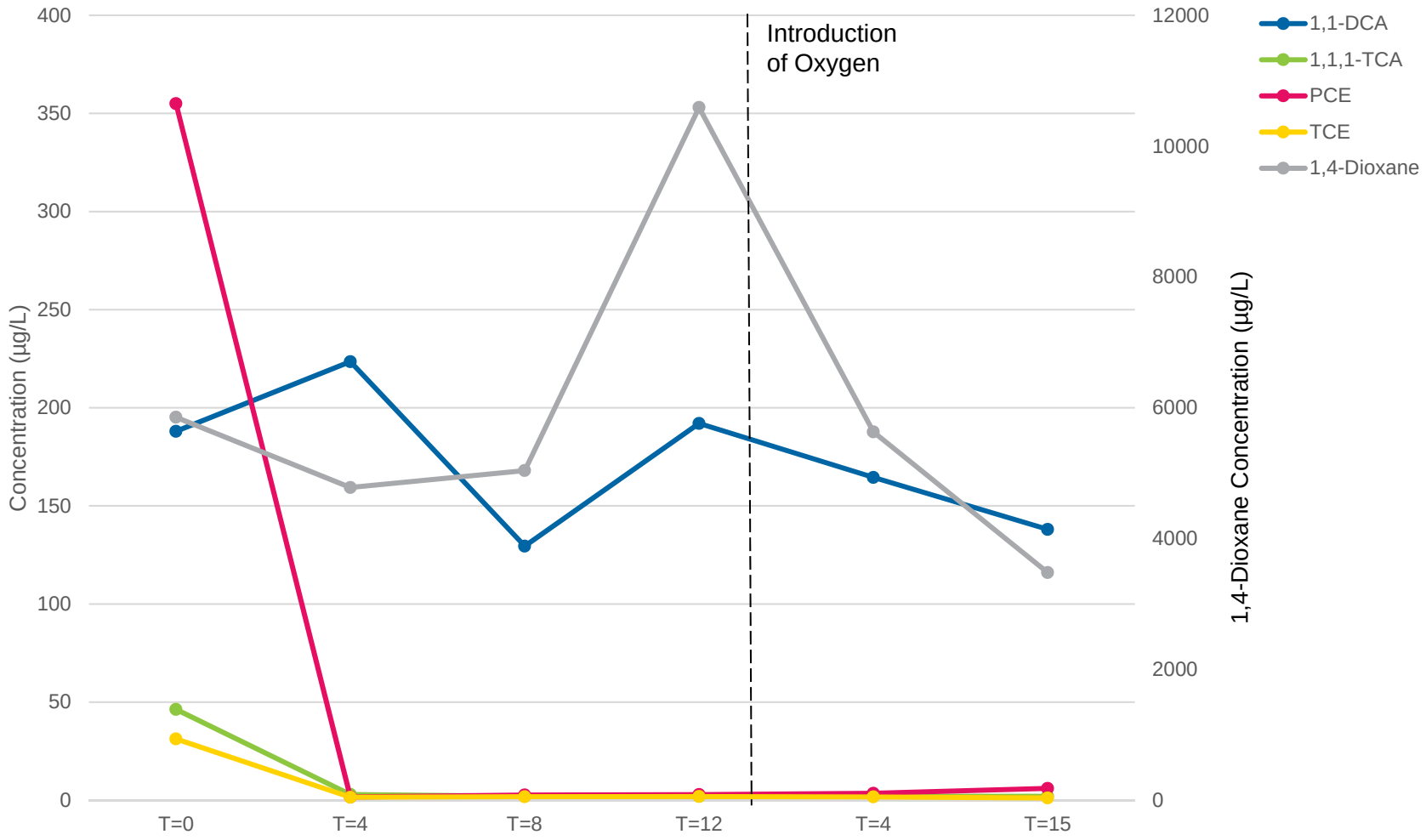
Anaerobic/Aerobic Biodegradation Tests

Microcosms with EVO, Nutrients, and Yeast Extract Concentration Over Time



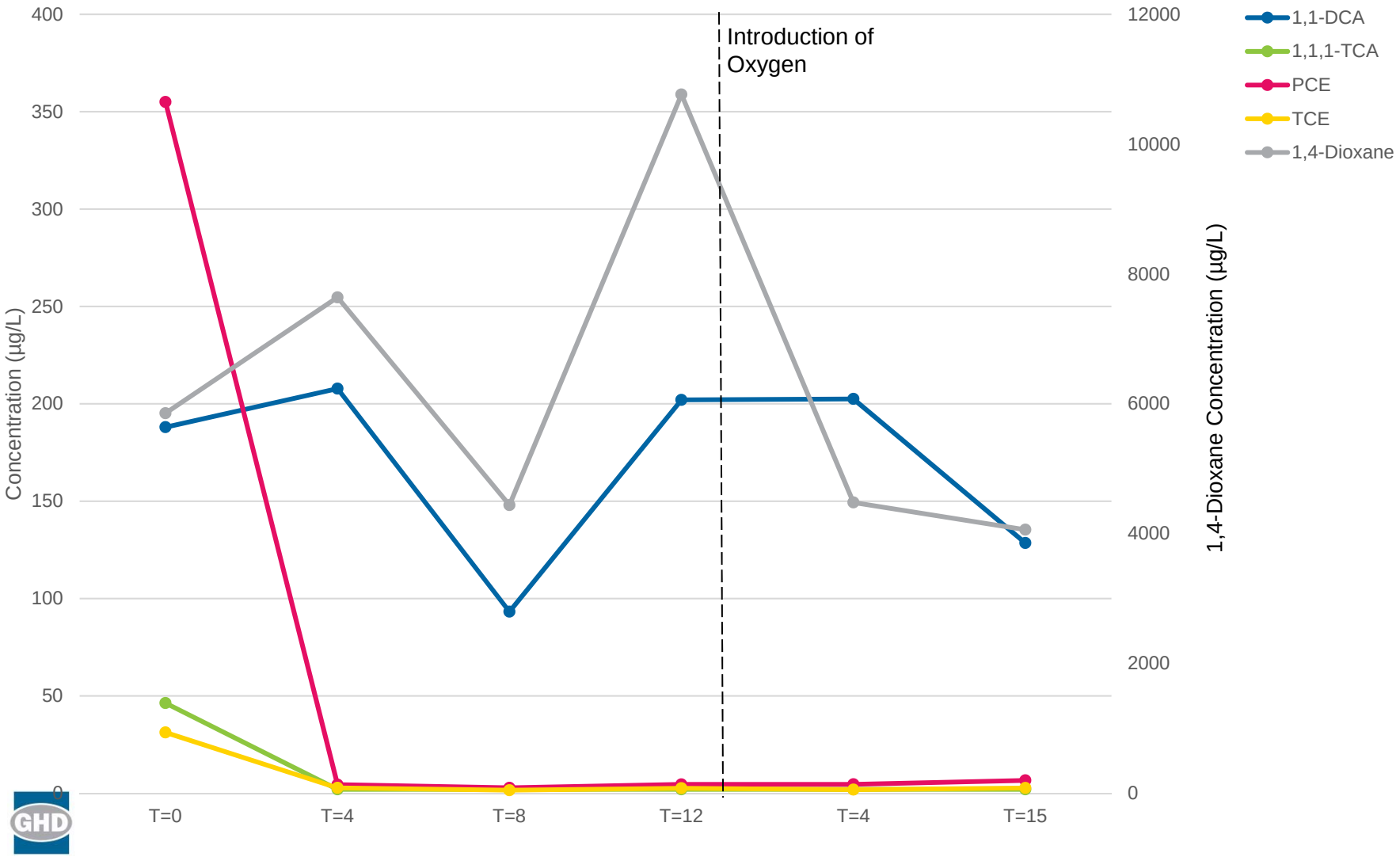
Anaerobic/Aerobic Biodegradation Tests

Microcosms with EVO, Nutrients, Yeast Extract, and Inoculum 1 Concentration Over Time



Anaerobic/Aerobic Biodegradation Tests

Microcosms with EVO, Nutrients, Yeast Extract, and Inoculum 2 Concentration Over Time

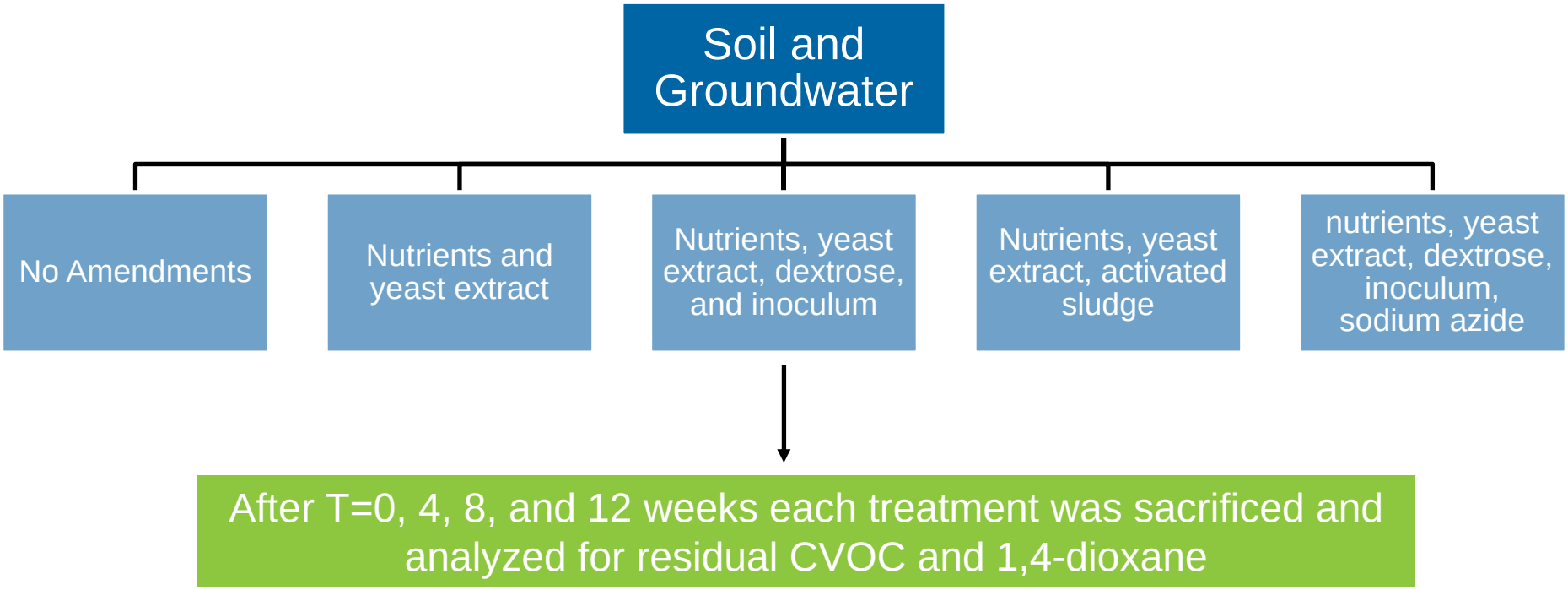


Anaerobic/Aerobic Biodegradation Tests

- After 12 weeks under anaerobic conditions, greater than 95% treatment of PCE, TCE, and 1,1,1-TCA occurred with a microbial inoculum
- Increases in cis-1,2-DCE and vinyl chloride and ethane in the headspace were also observed
- An increase of 1,4-dioxane was observed at 12 weeks as a result of the dissolution of 1,4-dioxane from the soil into the groundwater
- No treatment of 1,4-dioxane was observed under anaerobic conditions
- After 15 weeks under aerobic conditions, 41% treatment of 1,4-dioxane was observed in microcosms with SDC-9 and 31% treatment with ENV-TCA20
- Reductions were observed in cis-1,2-DCE and vinyl chloride
- No treatment of 1,4-dioxane was observed in uninoculated microcosms

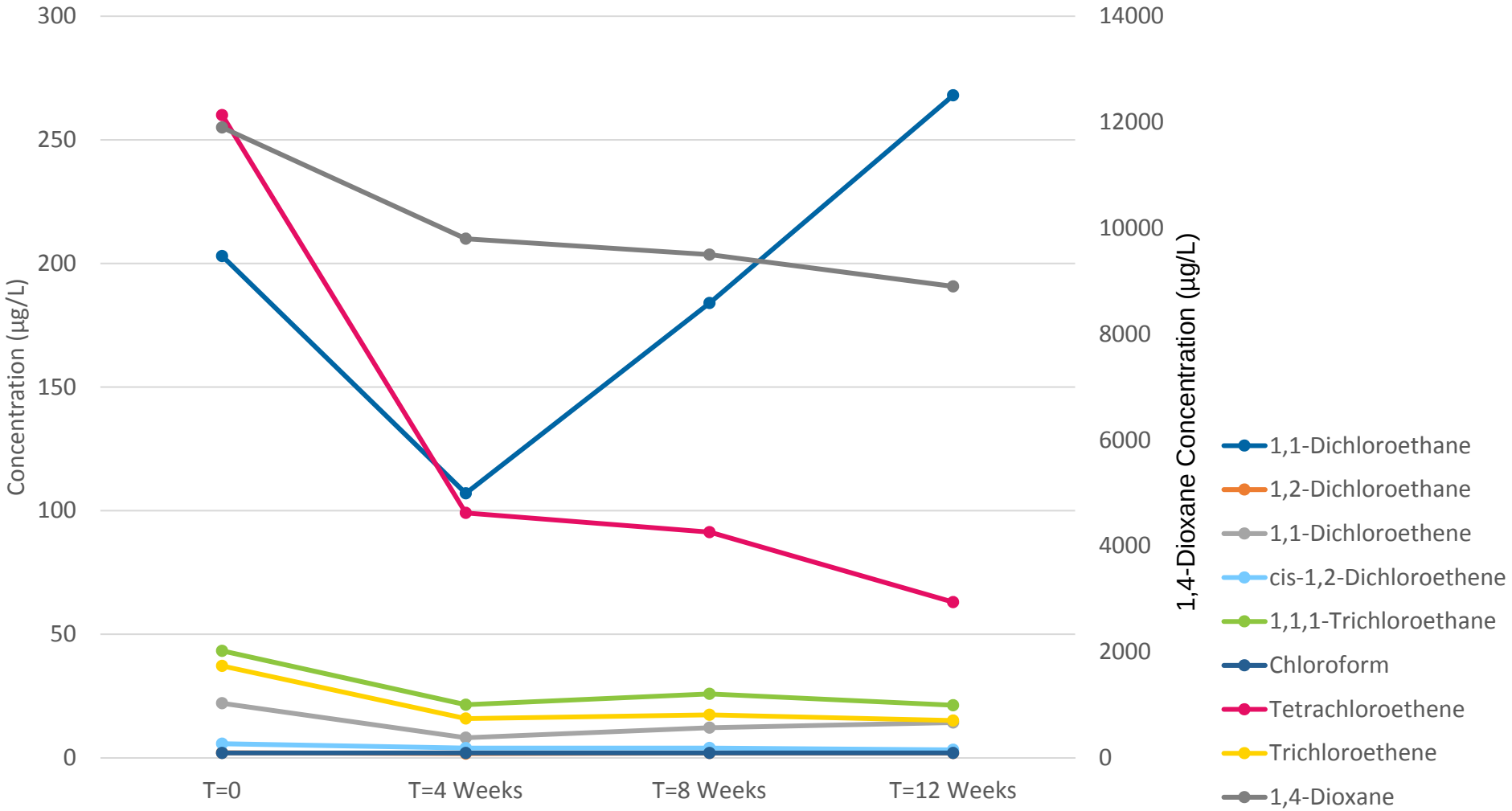
Strategy #2

Aerobic Co-Metabolic Biodegradation Microcosm Tests



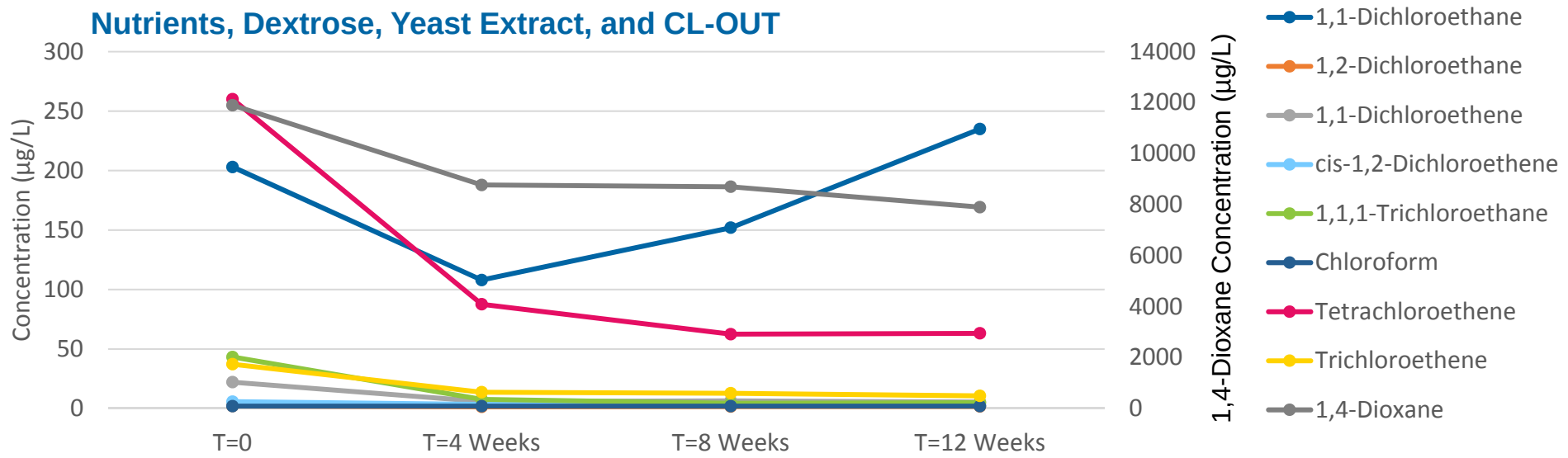
Strategy #2 Results

Nutrients and Yeast Extract

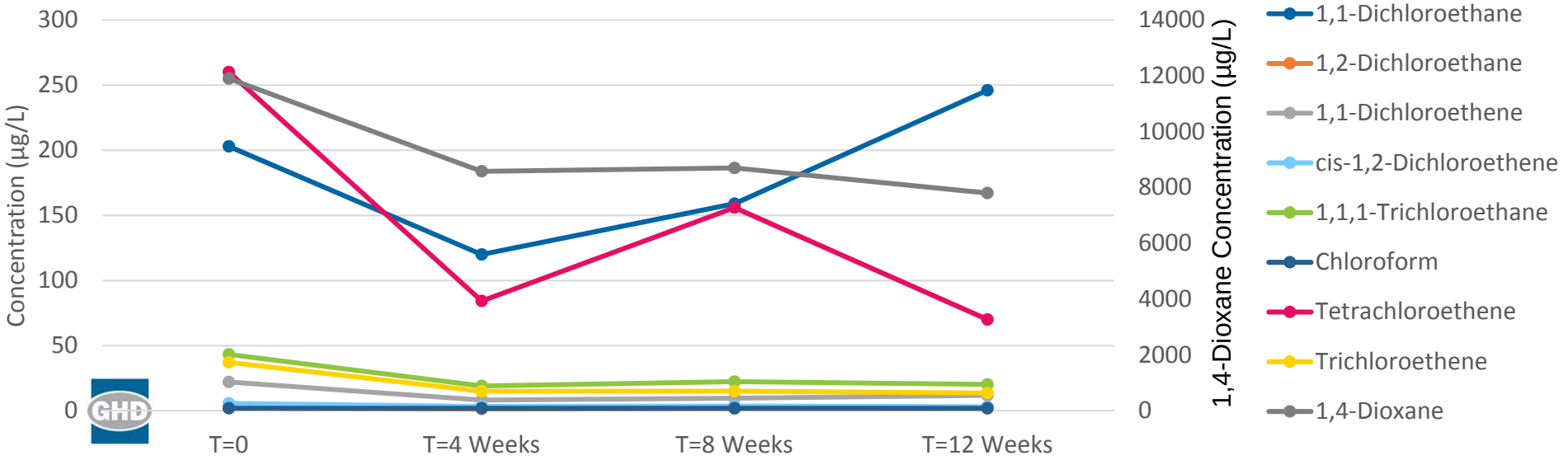


Strategy #2 Results

Nutrients, Dextrose, Yeast Extract, and CL-OUT



Nutrients, Yeast Extract, and Activated Sludge



Strategy #2 Results

- Microcosms that received nutrients, dextrose, yeast extract, and CL-OUT showed 23 percent treatment of 1,4-dioxane after 4 weeks and no additional reductions were observed over time
- Microcosms that received nutrients, yeast extract, and activated sludge showed 26 percent treatment of 1,4-dioxane after 4 weeks and no additional reductions were observed over time
- The addition of the CL-OUT inoculum resulted in up to 80 percent treatment of the CVOC and up to 24 percent treatment of 1,4-dioxane
- The use of activated sludge as the inoculum resulted in less treatment of CVOC but similar treatment of 1,4-dioxane
- Some treatment of CVOC but no significant treatment of 1,4-dioxane was observed when a microbial inoculum was not added

Results/Lessons Learned

- The results of this study showed that CVOC can be removed under anaerobic conditions.
- Some treatment occurred without the addition of a microbial inoculum; however, the data showed that the addition of a microbial inoculum was required in order for complete reductive dechlorination to occur.
- CVOC were also removed under aerobic, co-metabolic conditions; greater treatment was observed under anaerobic conditions.
- Up to 26 percent treatment of 1,4-dioxane was observed under aerobic co-metabolic conditions while up to 41 percent treatment of 1,4-dioxane was observed under sequential anaerobic/aerobic conditions.
- Since greater treatment of both 1,4-dioxane and CVOC were observed with the sequential anaerobic-aerobic treatment, this treatment was recommended for a field study

www.ghd.com