



In Partnership with:



Self-Sustaining Treatment for Active Remediation (STAR): Scientific Principles and Field Applications of the Technology

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Overview

- Brief summary of STAR process
- Experiments conducted to date:
 - Proof-of-concept experiments
 - Column experiments
 - *Ex situ* field experiment
- Case Study: First *in situ* pilot test
- STAR implementation



What is STAR?

- **STAR: Self-sustaining Treatment for Active Remediation**
- **Patent-pending technology based on principles of smoldering combustion**
- **Addresses recalcitrant contaminants**
- **Reduced costs versus other technologies**
- **Extensive laboratory research and pilot testing**

What is STAR?

- **Combustion**

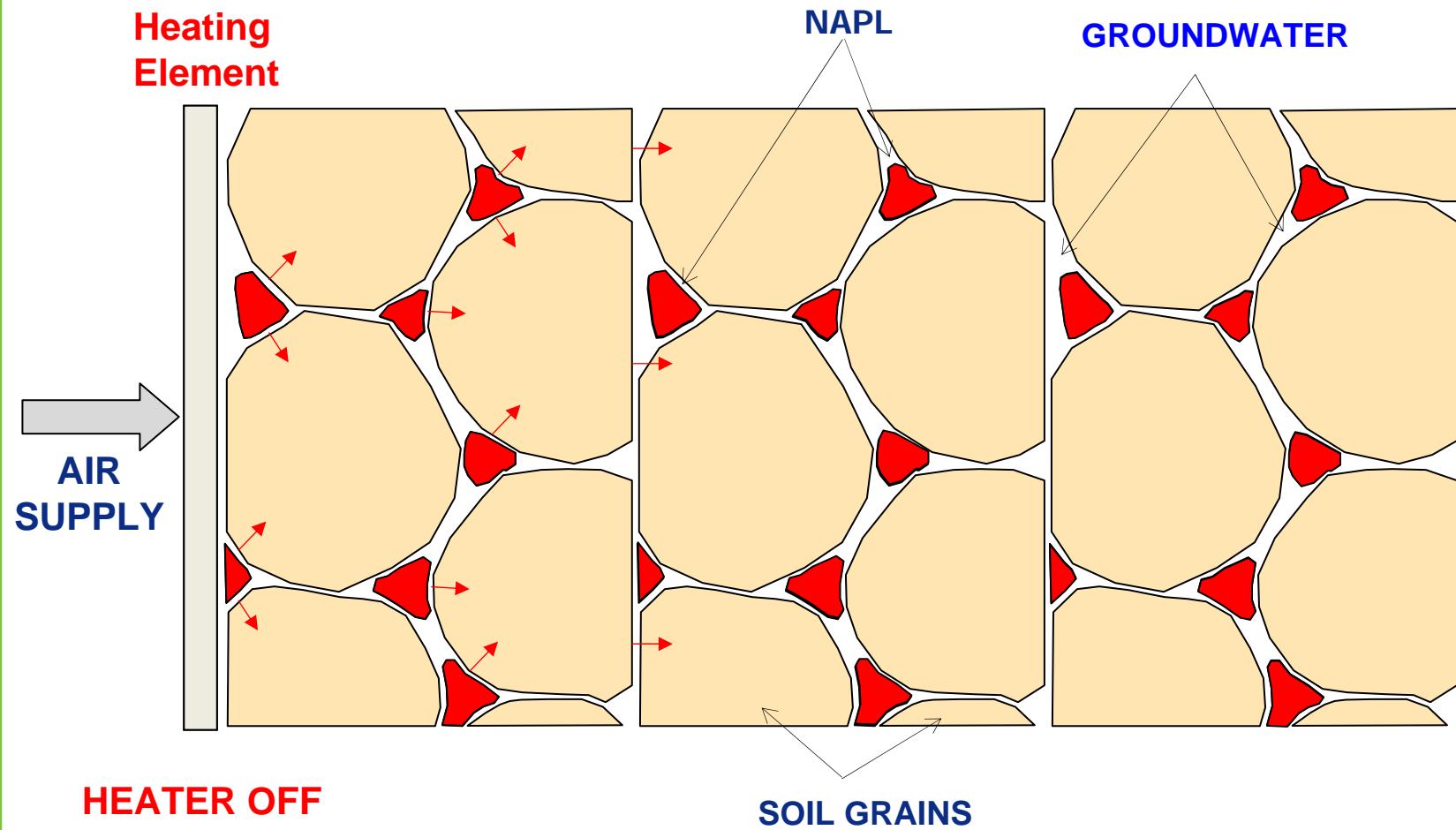
- Exothermic reaction converting carbon compounds $\rightarrow \text{CO}_2 + \text{H}_2\text{O}$

- **Smoldering**

- Flameless
- Occurs in porous materials
- Temperatures typically between 400 – 800 °C
- Propagation typically 5 ft/day
- Oxygen-limited, thus controllable

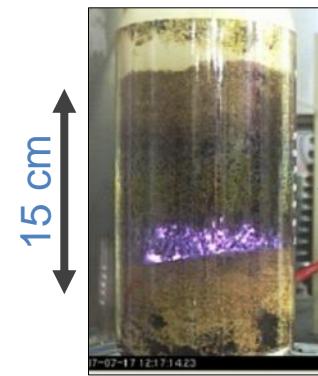
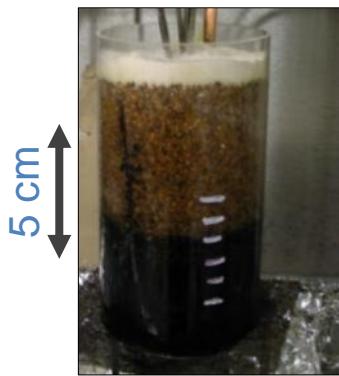


NAPL Smoldering

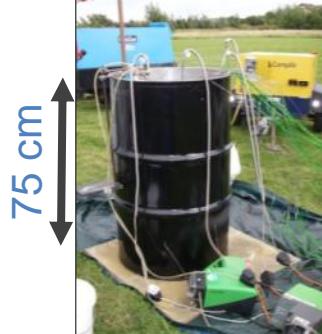


STAR Experimental Scales

TREATABILITY STUDIES



Proof of
Concept
Experiments



Column
Studies

PILOT TESTING

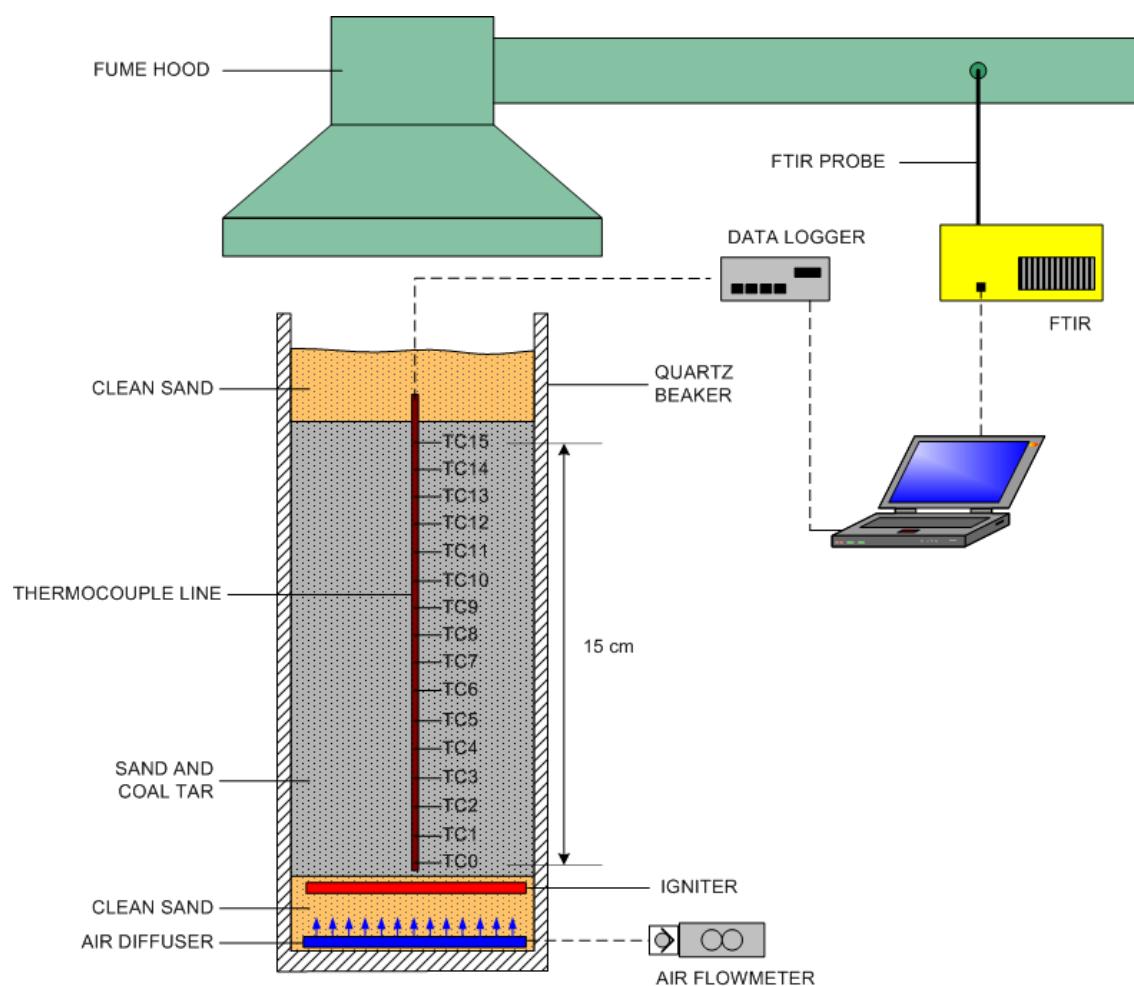


Ex Situ
STAR



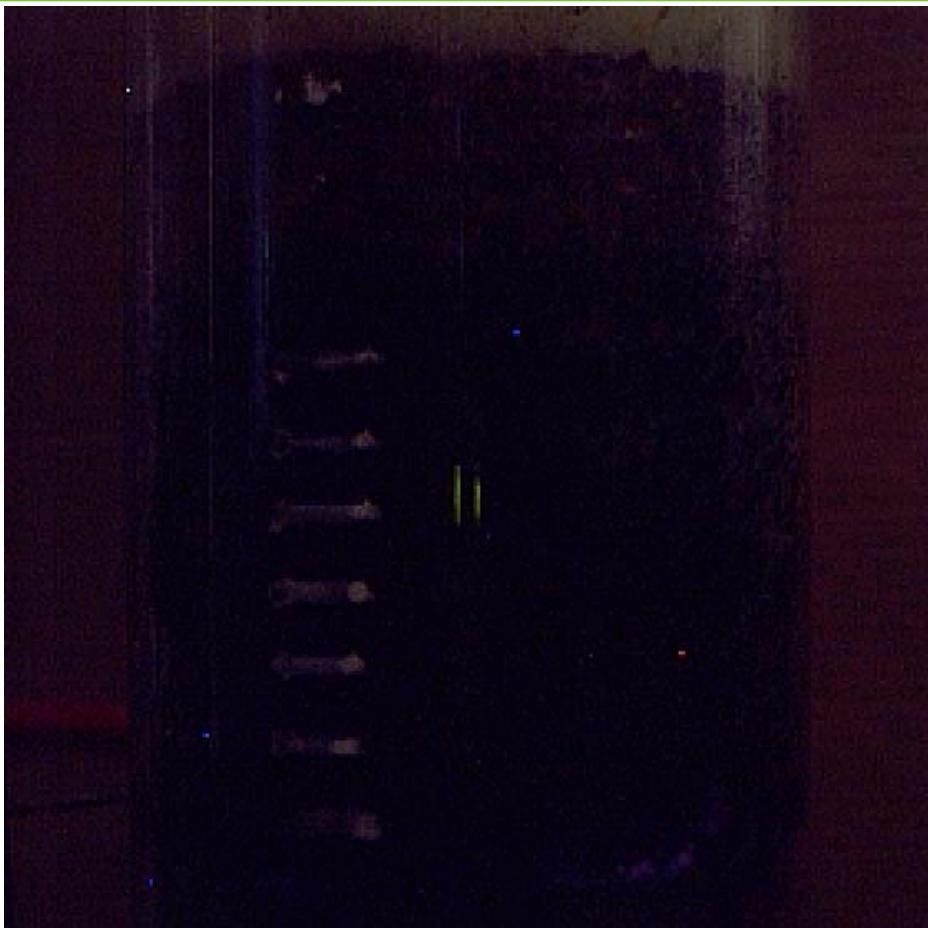
In Situ
STAR

Column Experiments



Column Experiments

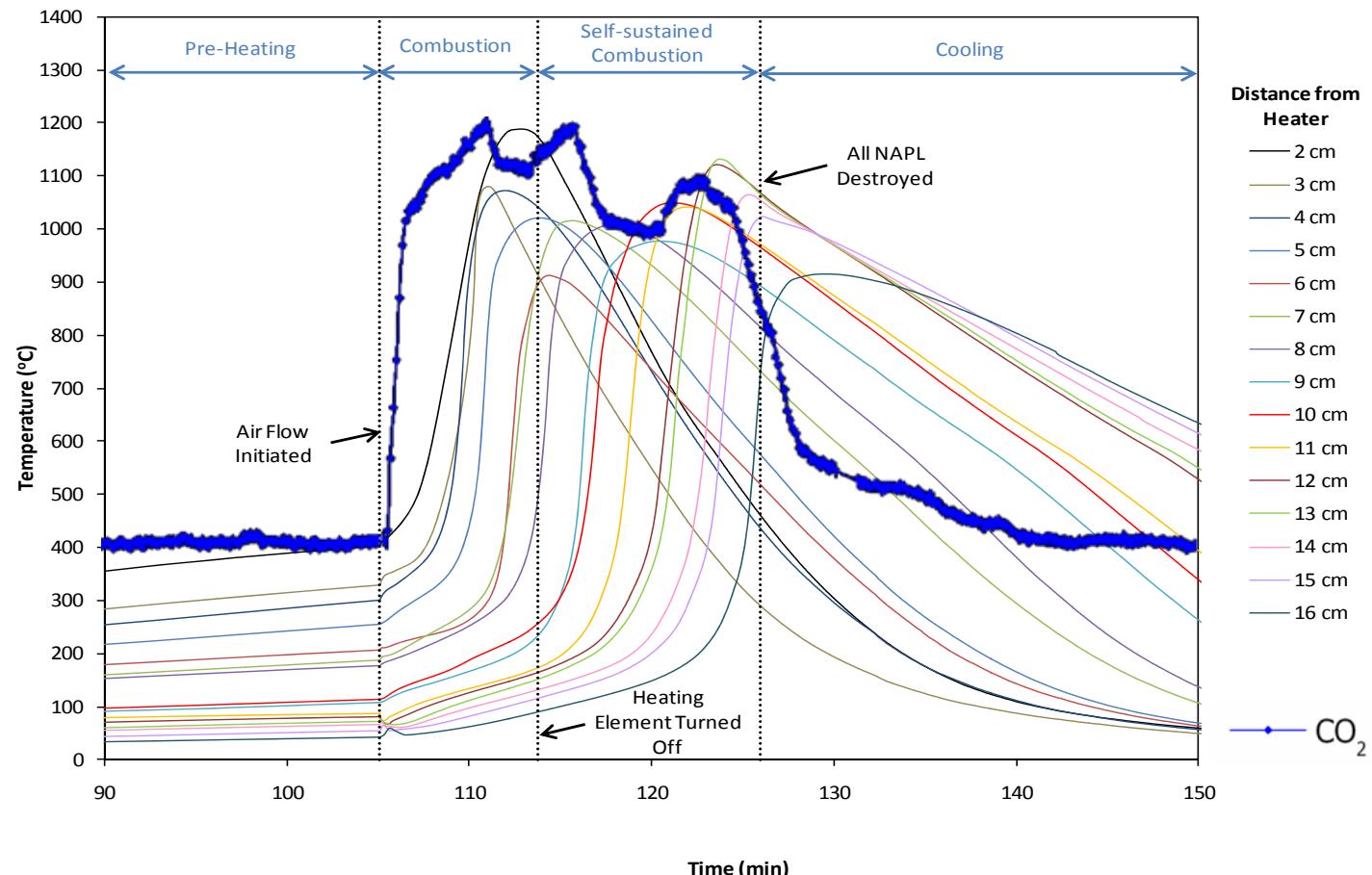
Video



*Video accelerated
50 times*

Column Experiments

Base Case TC Profiles



Column Experiments

Base Case Results



Distance from Ignition Element (cm)	TPH (mg/kg)	PAH (mg/kg)
Initial Concentration	38,000	9,500
0-1	<0.1	<0.1
1-2	<0.1	<0.1
2-3	<0.1	<0.1
3-4	<0.1	<0.1
4-5	0.3	0.3
5-6	<0.1	<0.1
6-7	<0.1	<0.1
7-8	<0.1	<0.1
8-9	<0.1	<0.1
9-10	<0.1	<0.1
10-11	<0.1	<0.1
11-12	<0.1	<0.1
12-13	1.2	1.2
13-14	<0.1	<0.1
14-15	<0.1	<0.1
15-16	<0.1	<0.1



Column Experiments

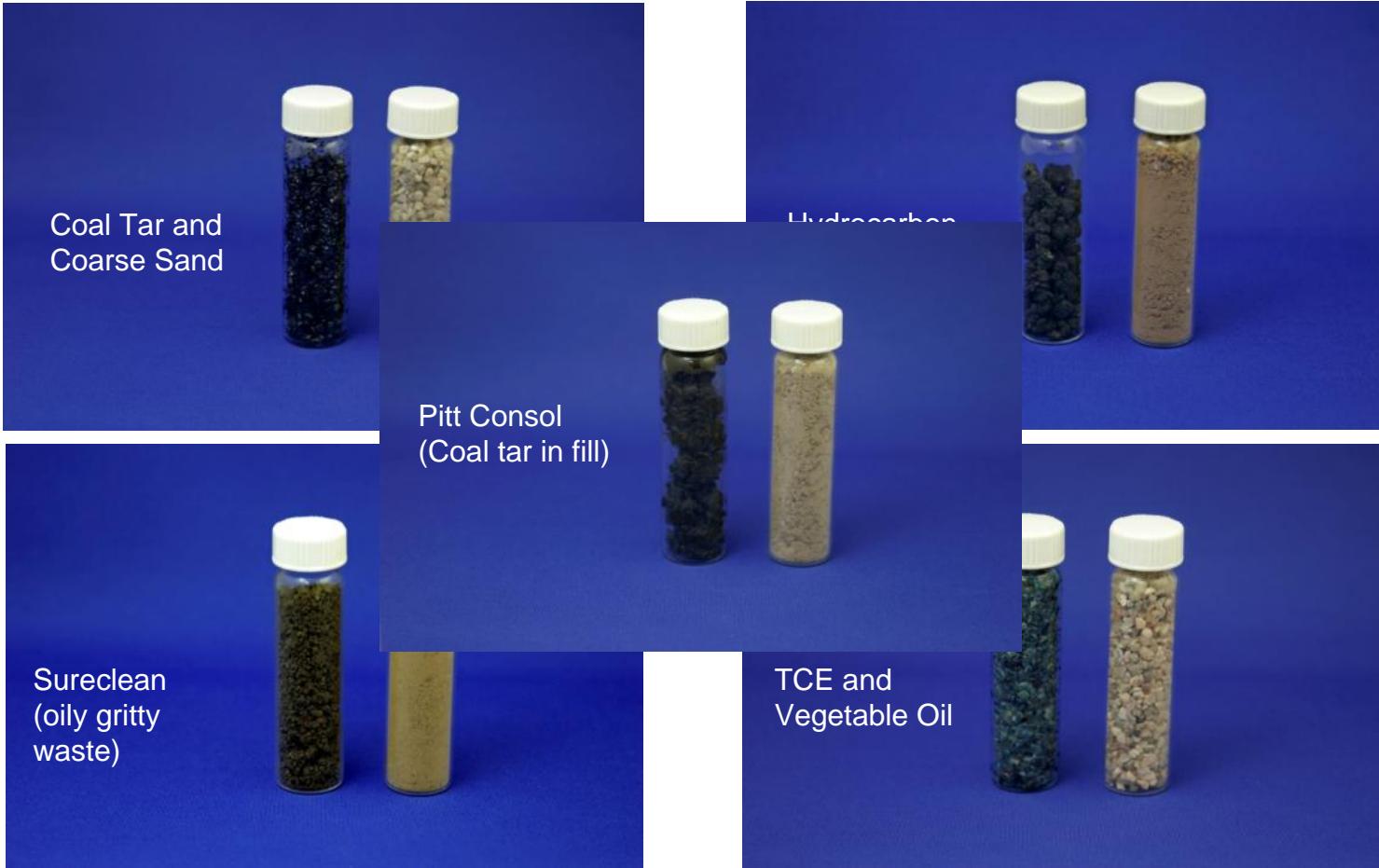
Scenarios Examined

- Various porous media types (silty sand to gravel)
- Variable air flow rates
- Variable NAPL / water saturations
- Variable NAPL types (coal tar, creosote, hydrocarbons, chlorinated solvents and oils)

Results showed process to be self-sustaining and to result in > 99% reduction in contaminant concentrations

Column Experiments

Additional Results



Ex Situ Field Experiments

Setup



- Air delivered at base of bin through air diffusers
- Air flow rate = 100 cfm (at 100 psi)

Ex Situ Field Experiments

Excavation



Before

**Conc (TPH) = 31,000 mg/kg
± 14,000 mg/kg**



After

**Conc (TPH) = 10 mg/kg
± 4 mg/kg**



Case Study: *In Situ* STAR Pilot Test at a Former Industrial Facility in New Jersey

In Situ Pilot Test

Overview

- Former Cresol Manufacturing Facility in Newark, New Jersey
- 37 acre site – currently shipping container storage yard
- Current proposed remedy is excavation and disposal of >300,000 CY of soil
- STAR Evaluation:
 - Treatability study
 - Phase I (POC) pilot study (October 2009)
 - Phase II pilot study (on-going)



In Situ Pilot Test

Phase I Objectives



- Pilot test in former lagoon area
- Test designed to evaluate STAR:
 - At a large scale
 - Under saturated conditions (i.e., below ground surface and below the water table)

In Situ Pilot Test

Pre-Pilot Characterization



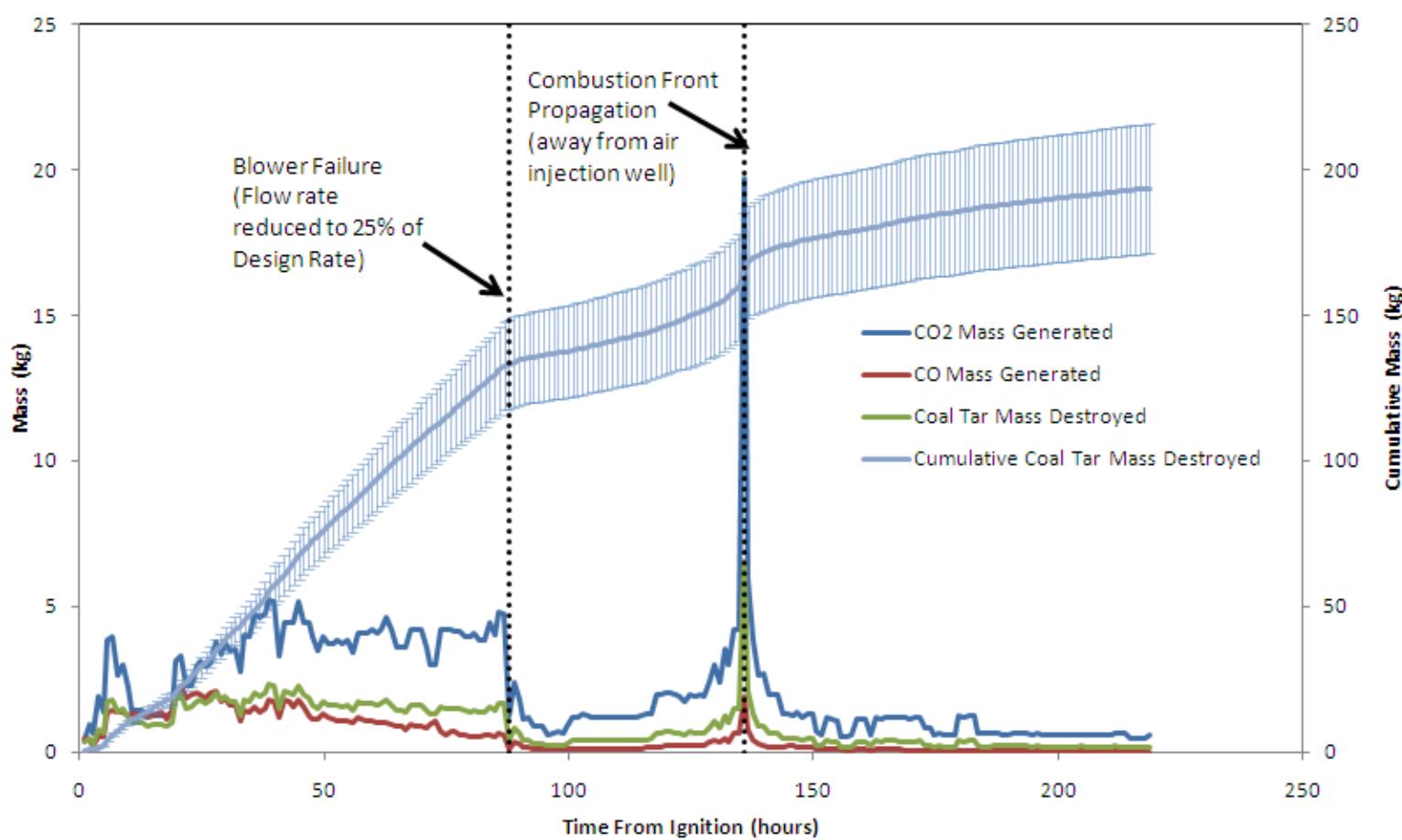
In Situ Pilot Test

Phase I Instrumentation



In Situ Pilot Test

Results: Mass Destroyed





In Situ Pilot Test

Phase I Summary

- Successfully achieved self-sustaining smoldering combustion below ground surface and below the water table for 9 days
- Approximately 200 kg coal tar destroyed
- Phase II testing approved

In Situ Pilot Test

Phase II Objectives



- More aggressive combustion
- Multiple ignition points
- Remediate PTA (destroy 26 tons of coal tar)

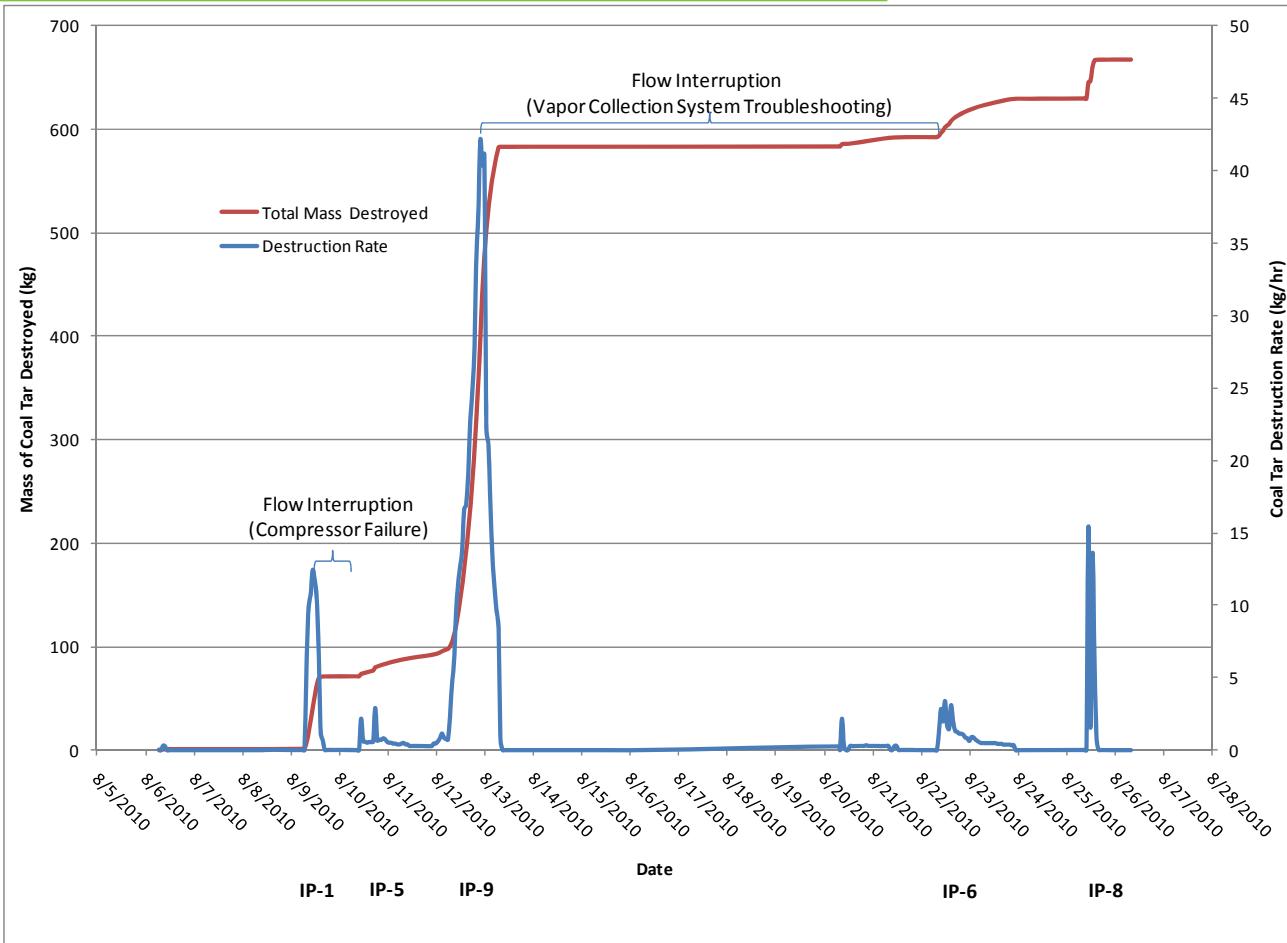
In Situ Pilot Test

Phase II Instrumentation



In Situ Pilot Test

PII: Mass Destroyed to Date





In Situ Pilot Test

Phase II Summary

- Successful ignitions at multiple locations
- Destruction rate as high as 30 kg/hr at a single well
- Total mass destroyed to date = 622 kg
 - 3 times the mass destroyed in Phase I
 - 500 kg destroyed in a single 24-hr period

STAR Implementation

- **STAR Evaluation:**
 - Treatability study to evaluate suitability of contaminants and soils (\$12k - \$18k)
 - Single well pilot study in the field
- **STAR Availability:**
 - STAR available exclusively through SiREM
 - SiREM offers Site licenses to consultants and Site owners
 - SiREM offers technical support to implement STAR



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Questions?

Visit us at: www.siremlab.com/STAR

Ex Situ Field Experiments

Emissions

Detected Vapors	Total Mass in Effluent Air(kg)*
Water vapor (H ₂ O)	65
Carbon dioxide (CO ₂)	146
Carbon monoxide (CO)	63
Nitrogen monoxide (NO)	0.2
Methane (CH ₄)	0.4
Benzene	0.2
Toluene	0.2
Naphthalene	2.8
Xylenes	0.4

*As measured by FTIR