Aerobic Cometabolic Bioremediation to Address a Large, Dilute, Solvent Plume

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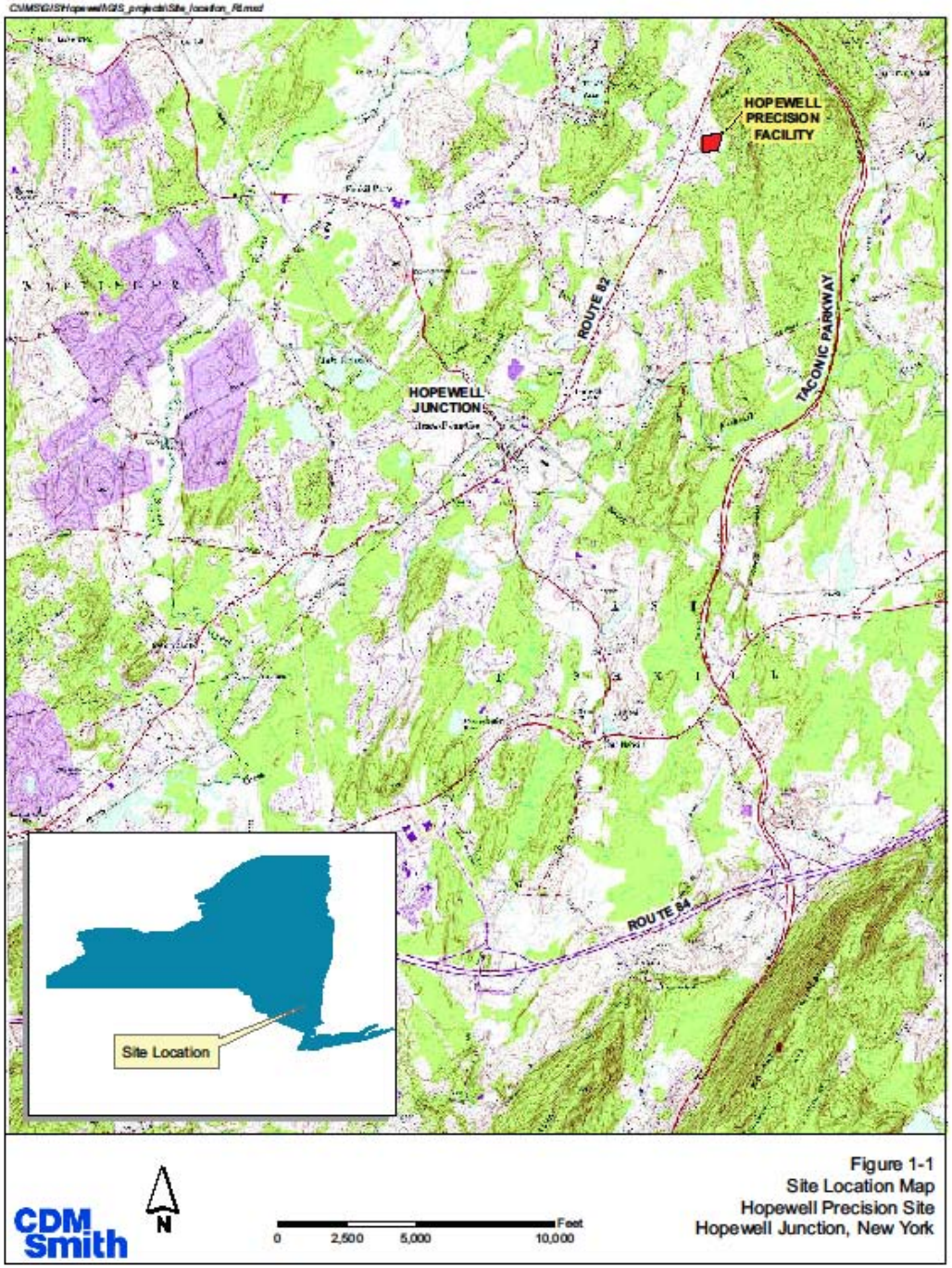
Federal Remediation Technologies Roundtable
June 2012

Presentation

- Introduction
- Hopewell Precision site description
- Overview of Aerobic Cometabolic Bioremediation (ACB)
- Activities to Date
- Conclusions and Next Steps

Hopewell Site Location Map



Hopewell Site Location Map

Hopewell Precision Site

- 7000' dilute, shallow aerobic TCE plume
  - No source(s) (found)

- TCE contaminant levels generally <100 ppb (#'s appear to be declining)
  - But Note: Possible plume core(s) w higher #'s

- MCL exceedances and Vapor Intrusion impacts
  - Mitigation as required for residences

Driving Aerobic Plumes Anaerobic

- A Fool's Errand?
  - *2010 U Mass Amherst Soils Conf*: Presenter started off describing Sisyphean effort to 'push the boulder uphill', and then proceeded to provide gory details of a failed effort
- On the Other Hand…
  - *6/6/12 SiRem BioAugmentation Webinar*: Presenter described adding donor to create an 'anaerobic bubble' to sustain Bio-aug w/ DHC
  - 6/18/12 Follow-up disc w/ Presenter – "We do it all the time."
- Any (Other) Experiences/Expectations?

When Not to Try to Drive an Aerobic Plume Anaerobic

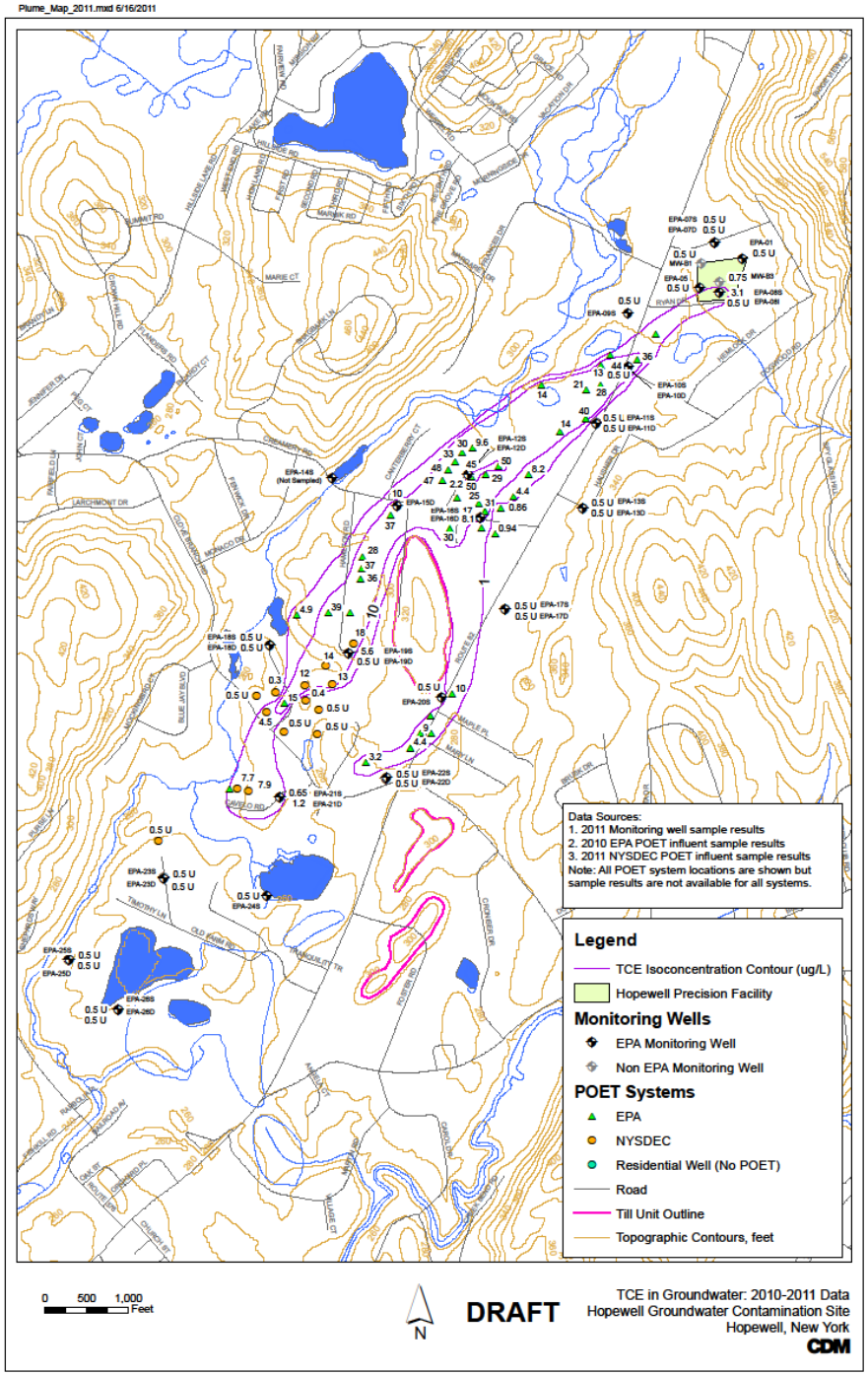
- High(er) DO levels/ORP
- High(er) GW flow regimes (continuing to bring DO into treatment zone)
- Low(er) solvent concentrations (100 ppb (?))
-
- Large(r) plumes – But not necessarily fun for Aerobic either

Hopewell Precision Site

- Listed on NPL in **April 2005**

- **OU 1 and OU 2 RODs Specify**:
  - Possible use of Aerobic Cometabolic Bioremediation to restore resource **(9-28-09 OU 1 ROD)**
  - Alternative Water Supply **(9-30-08 OU 2 ROD)**

TCE Isoconcentration Contour Plume Map (as of April 2011)



TCE Isoconcentration Contour Plume Map (as of July 2007)

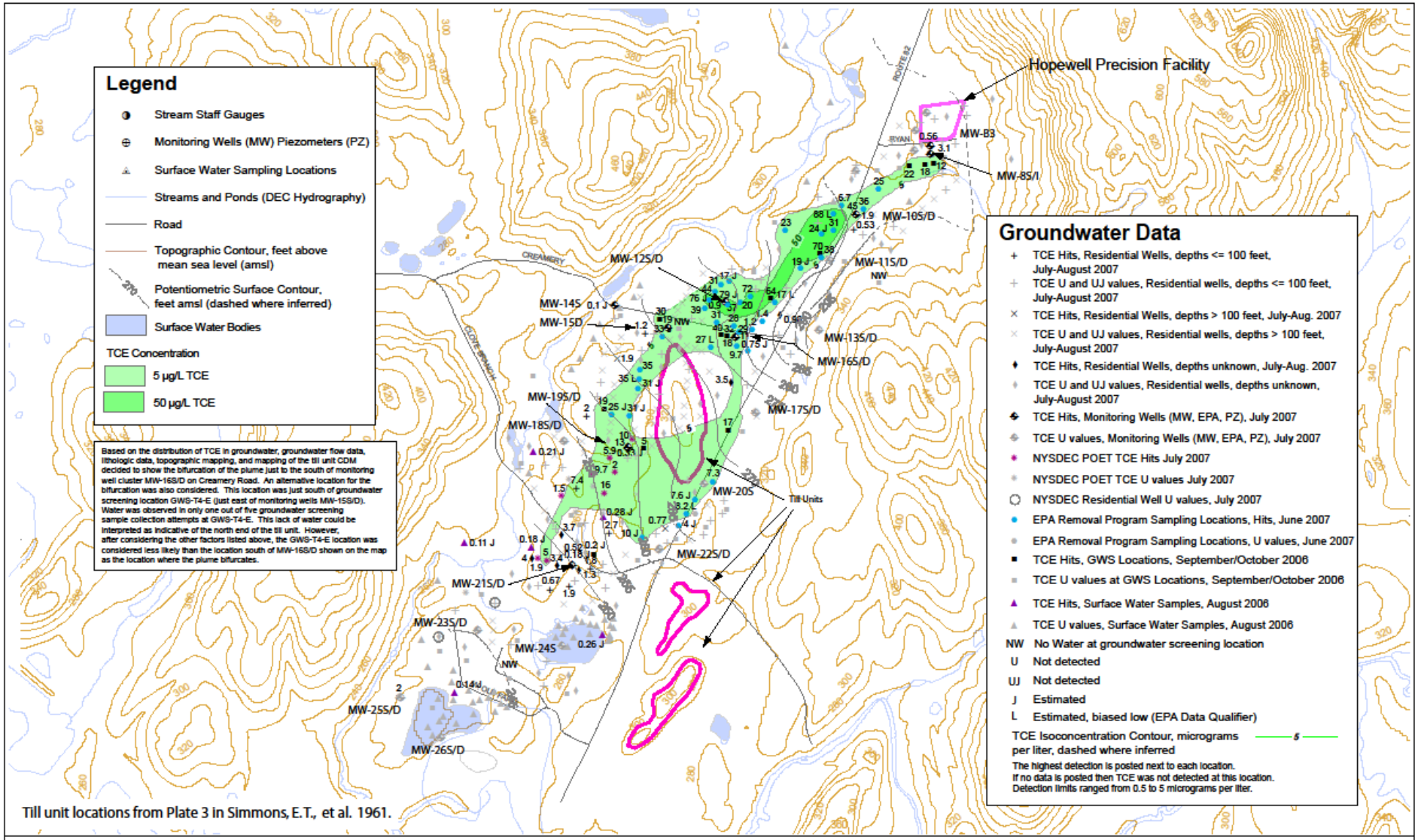


Figure 1-18
TCE Isoconcentration Contours, Round 2 Data, and
Shallow Monitoring Well Potentiometric Surface, July 13, 2007
Hopewell Precision Site
Hopewell Junction, New York

How Accurate is the Depiction?

(*Data from a variety of sources***)

- **NEWS FLASH**: 'Plumes are Not (Necessarily) Blobs'

- **Plume Cores**: '90% of mass may be in as little as 10% of the cross-section' (*Parker et al)*
  - But, can you find them?

** *The norm (?)*

Hopewell Precision NPL site

- Complex site hydrogeology and innovative technology require a team approach
  - Lorenzo Thantu, RPM EPA R 2
  - CDM Smith – R 2 contractor
    - Dr Kent Sorenson
    - Ryan Wymore
    - Joan Knapp
  - Dr John Wilson, EPA/ORD Ada, Ok
  - Dr. Brian Looney, DOE/SRNL
  - Jim Cummings, TIFSD, EPA Hq

Aerobic Co-metabolic Bioremediation (ACB)

- Dr. John Wilson and wife of EPA's Ada lab were among first to discover
- Carefully orchestrated addition of substrate and oxygen
- Limited utilization since advent of Enhanced Reductive Dechlorination (ERD) due to slow rates

ACB

- In process of digesting substrate, micro-organisms exude enzyme which fortuitously degrades TCE
  - No metabolic benefit to bugs
  - TCE epoxide gives the bugs a ‘hot foot’ – thus may evolve away from capability – requiring repeated bio-augmentation
    - Not thought to be a problem at Hopewell due to lower starting concentrations (?)

Remedial Design

- ***Mantra*** – "Cheapest Possible Substrate, Cheapest Possible Delivery Mechanism(s)"

- ***Remedial Strategy***:
  - Identify and address hot/warm spot(s) to reduce mass and mass discharge
    - Refine CSM through use of vertically discrete sampling
  - Explore/exploit abiotic and biotic natural attenuation mechanisms to 'polish' the plume

Candidate Substrates

- Gases
  - Propane
  - Butane
  - Methane
- Liquid
  - Under development by SRNL

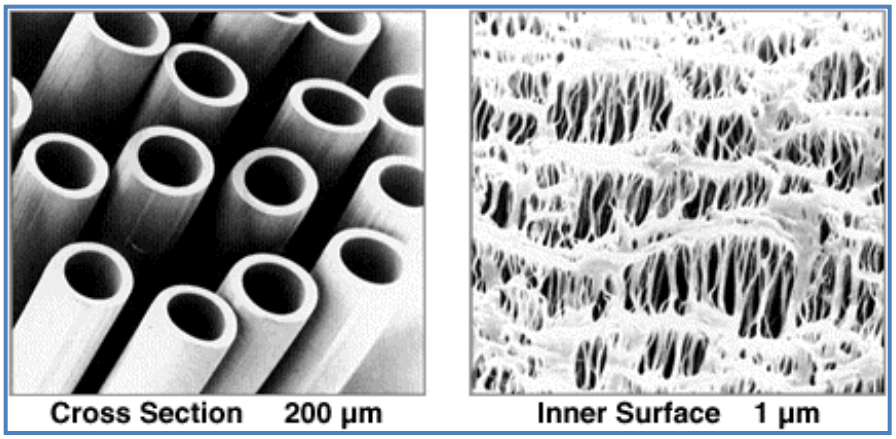
Candidate Delivery Mechanisms

- Waterloo Emitter
- Tersus ISOC
- Tersus Ex-Situ Infusion system

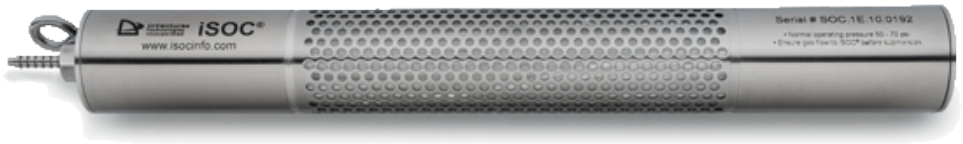
- Currently contemplating recirculating well configuration

Gas inFusion™ iSOC® Technology

700 Microporous Hollow Fibers



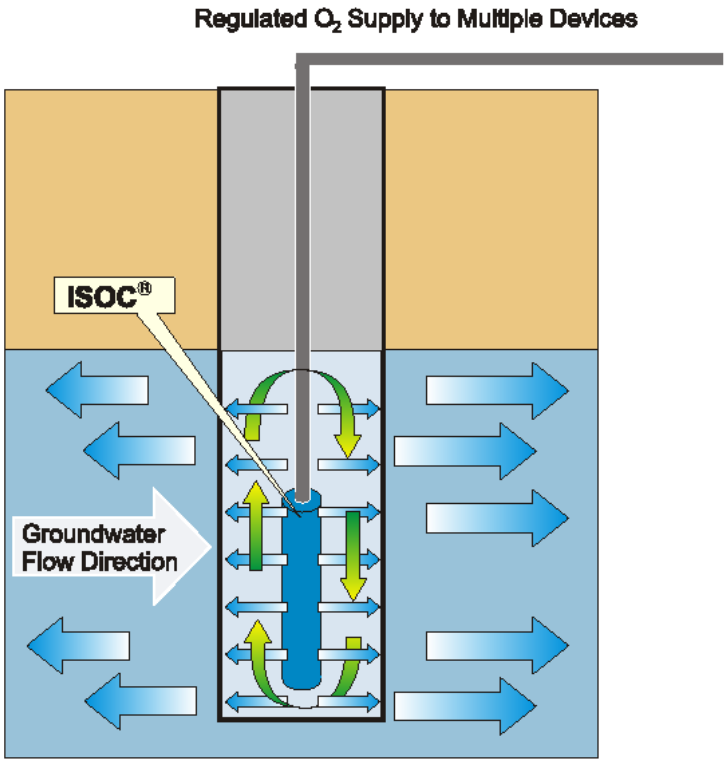
Mass Transfer Device



Diameter: 1.62 inches (4.1 cm) Height: 12.65 inches (32.1 cm)

- Large surface area for mass transfer (7000 sq. ft per cu ft)
- Mass transfer occurs when gas pressure is less than GW
- High DO supersaturates treatment well, no sparging
- High DO migrates to biomass
- Microbes degrade targeted compounds

iSOC® Gas inFusion Process



Direct aerobic treatment example:

- Uses industrial grade pure oxygen
- Supersaturates well DO (40+ PPM depending on groundwater depth)
- Convection current fills well with uniform DO
- DO disperses into groundwater stimulating bioremediation

iSOC® Dissolved Gas Concentrations

Gas Type	Water Column Depth in Feet (Dissolved Gas in ppm)				
	5’	10’	15’	20’	50’
Oxygen	42	55	62	69	111
Methane	22	30	33	37	59
Propane	66	88	99	110	175
Hydrogen	2	2	3	3	5
Ethane	57	75	85	95	150
Carbon Dioxide	1,660	1,875	2,090	2,300	3,590

Injection Well Concentrations

Technology	Dissolved Oxygen (ppm)
iSOC®	**40 - 60**
Peroxygens	3
Oxygen Emitters	10 - 13
Air Sparging	8 - 11

Ex-Situ Gas inFusion

Waterloo Emitter

‘Wild and Crazy…’ Ideas

- ‘Proletariat Pump and Treat’ – Put (some) private wells to use in remedial effort (??)

- Use both ERD and ACB
  - ERD for plume core(s)
  - ACB for lower contaminated zones

Natural Attenuaton - Abiotic

- Initial work by Dr. Wilson indicates promising presence of *magnetite*

- Exploring geophysical tools to allow more definitive determination of volumetric prevalence of magnetite

Natural Attenuation - Biotic

- Utilizing various quantitative Bio tools to determine presence and prevalence of appropriate organisms
  - e.g., Contracting with INEL to conduct Enzyme Activity Probe (EAP) analyses

Conclusions and Next Steps

- Additional characterization planned - vertical profiling tools
- ACB cost, performance and duration - TBD
- Hope that pilot will have a major impact on plume longevity
- Competing for funding in time of declining budgets