



Successful Treatment of a VOC and Petroleum Hydrocarbon Source Zone Combining Ozone, Air Sparge and SVE

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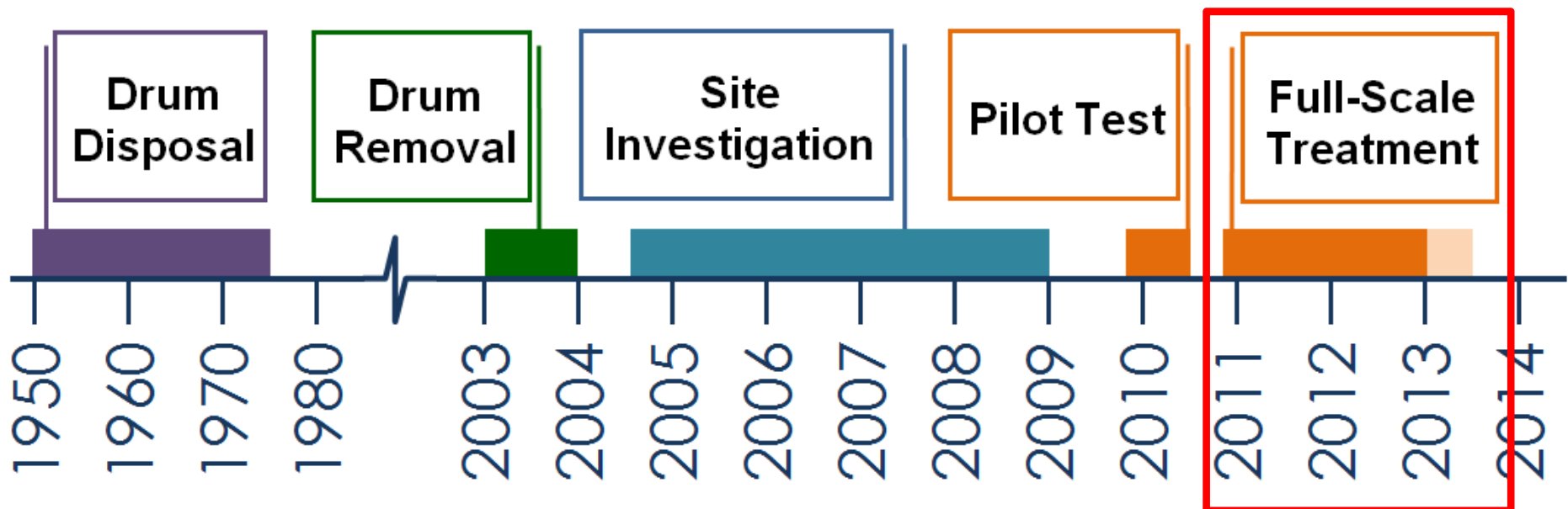
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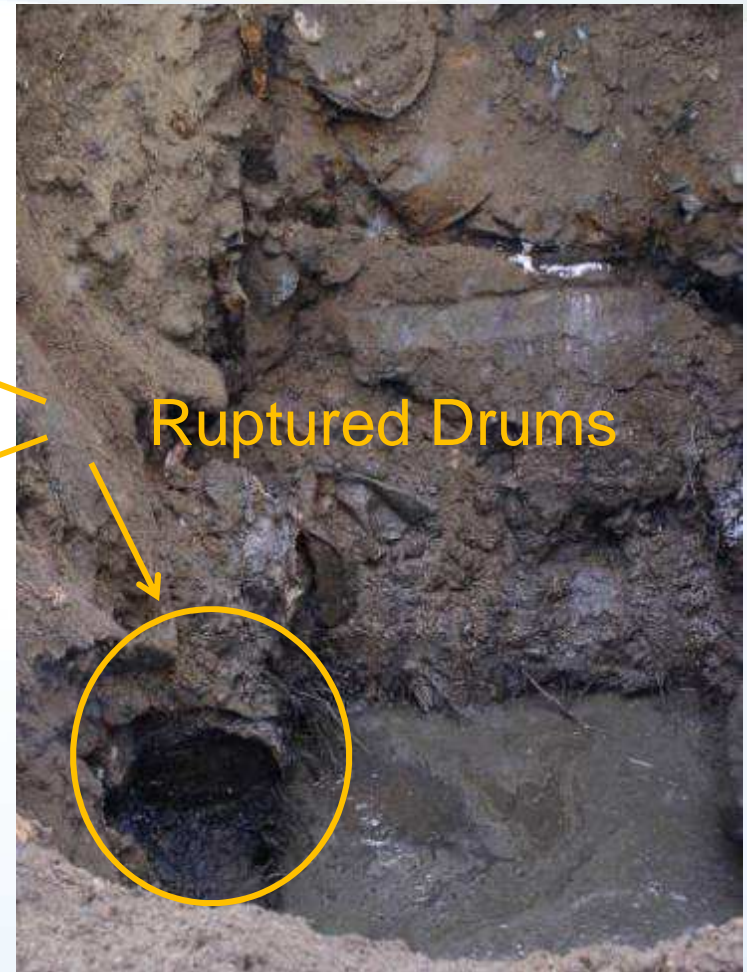
- Site Background
- Performance Monitoring
 - Methods
 - Results
 - Long-term trends
- Optimization
- Conclusions



- Former sand and gravel borrow pit in New England
- Removed 1,300 drums & 3,000 tons soil (up to 30 ft bgs)
- 2 Years into Full-Scale Treatment



Drum & Soil Removal



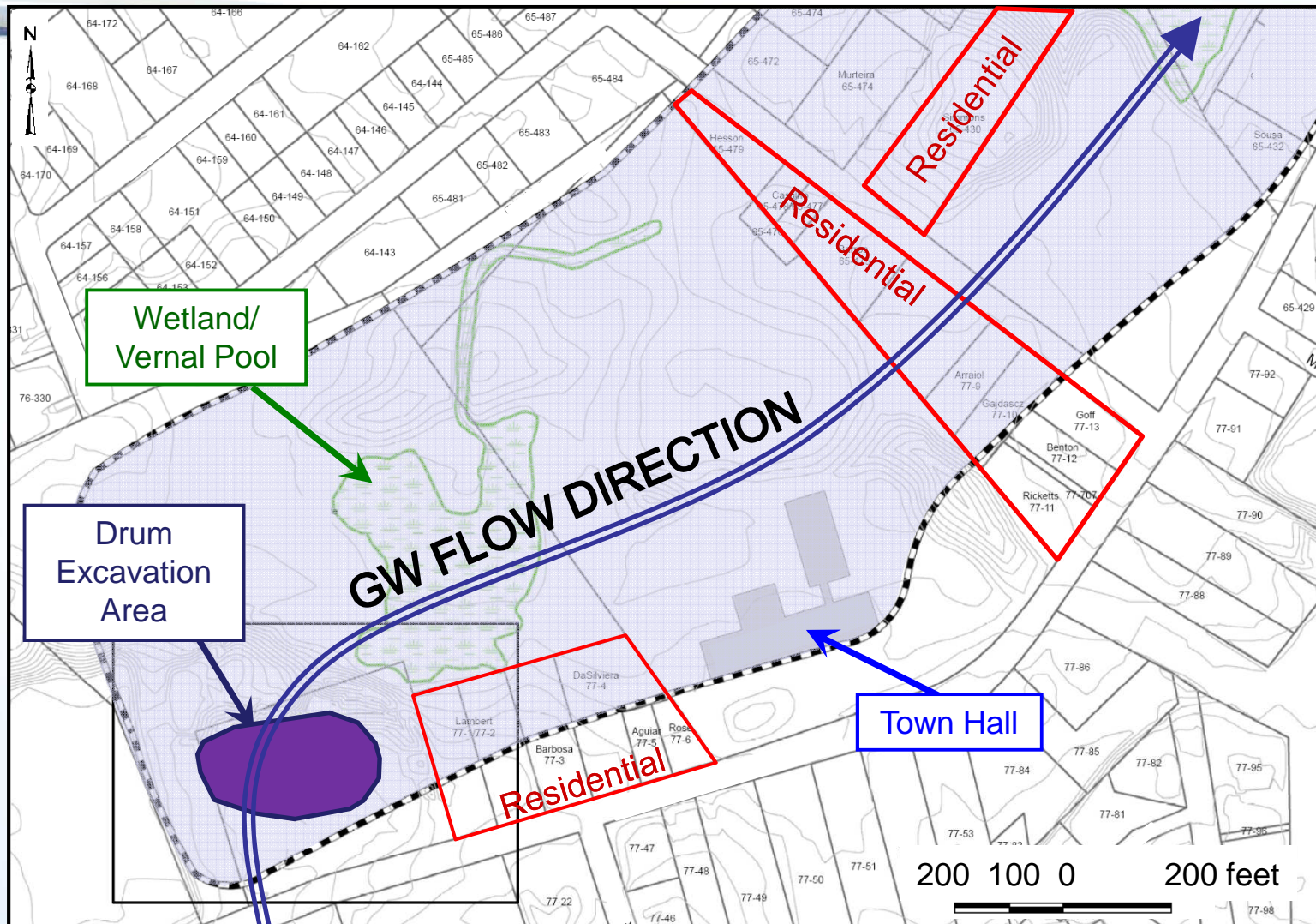
Chemical Properties of Site COCs

	Solubility mg/L	M O B I L I T Y	K_{oc} ml/g	Vapor Pressure mm Hg	V O L A T I L I T Y	Henry's Law Constant dimensionless
trichloroethene	1,100			125		60
cis-1,2-dichloroethene	800		50	210		0.2
1,1,1-trichloroethane	4,400		150	100		0.7
toluene	515		300	22		0.3
xylene	200		240	10		0.3
chlorobenzene	500		330	12		0.13
1,2,3-trichlorobenzene	18		7,400	0.2		0.12
1,2,4-trichlorobenzene	30		9,200	0.3		0.06

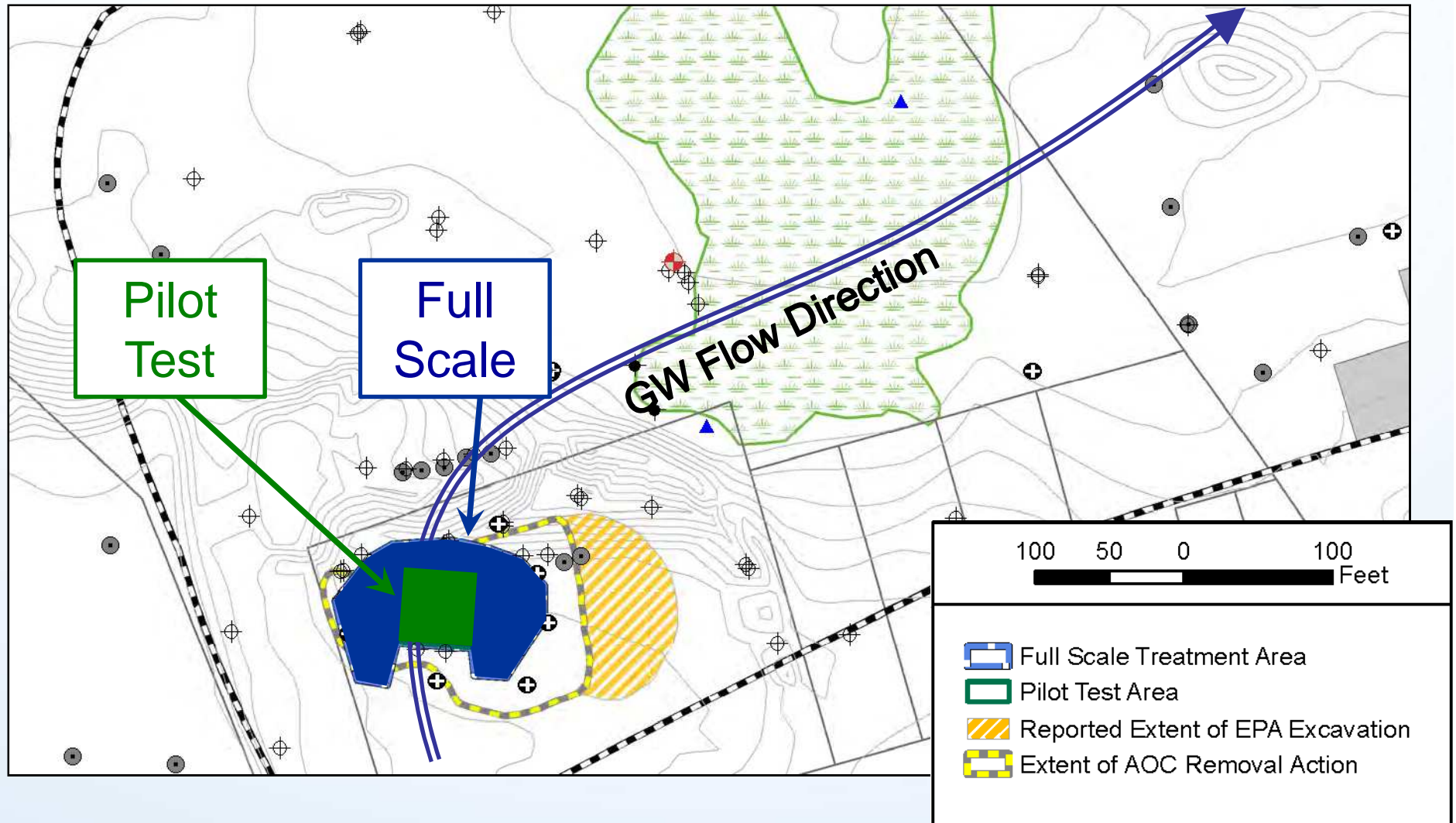
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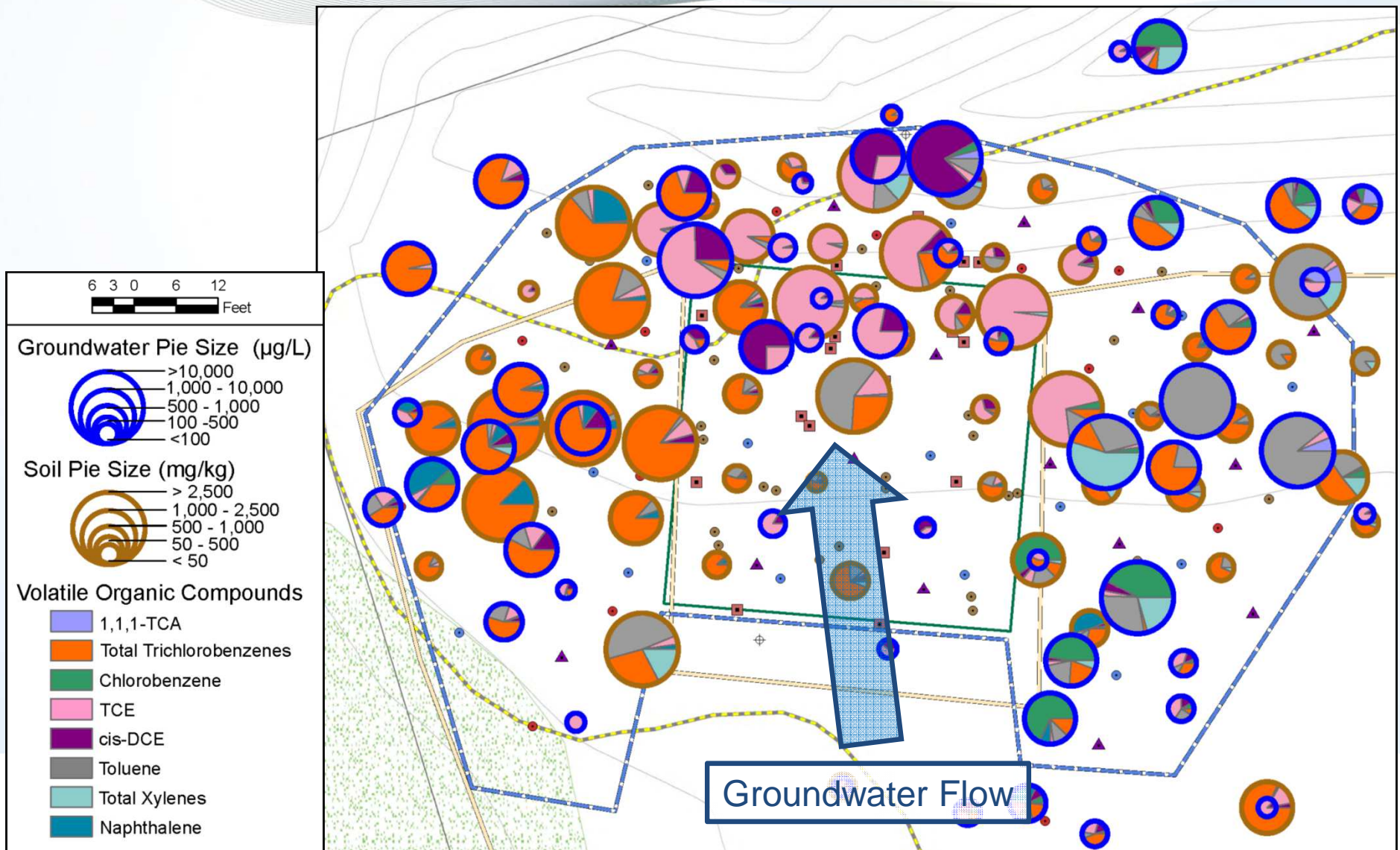
NAPL likely present.
7 VOCs in GW from
1 to ~20% of aq. solubility
prior to treatment



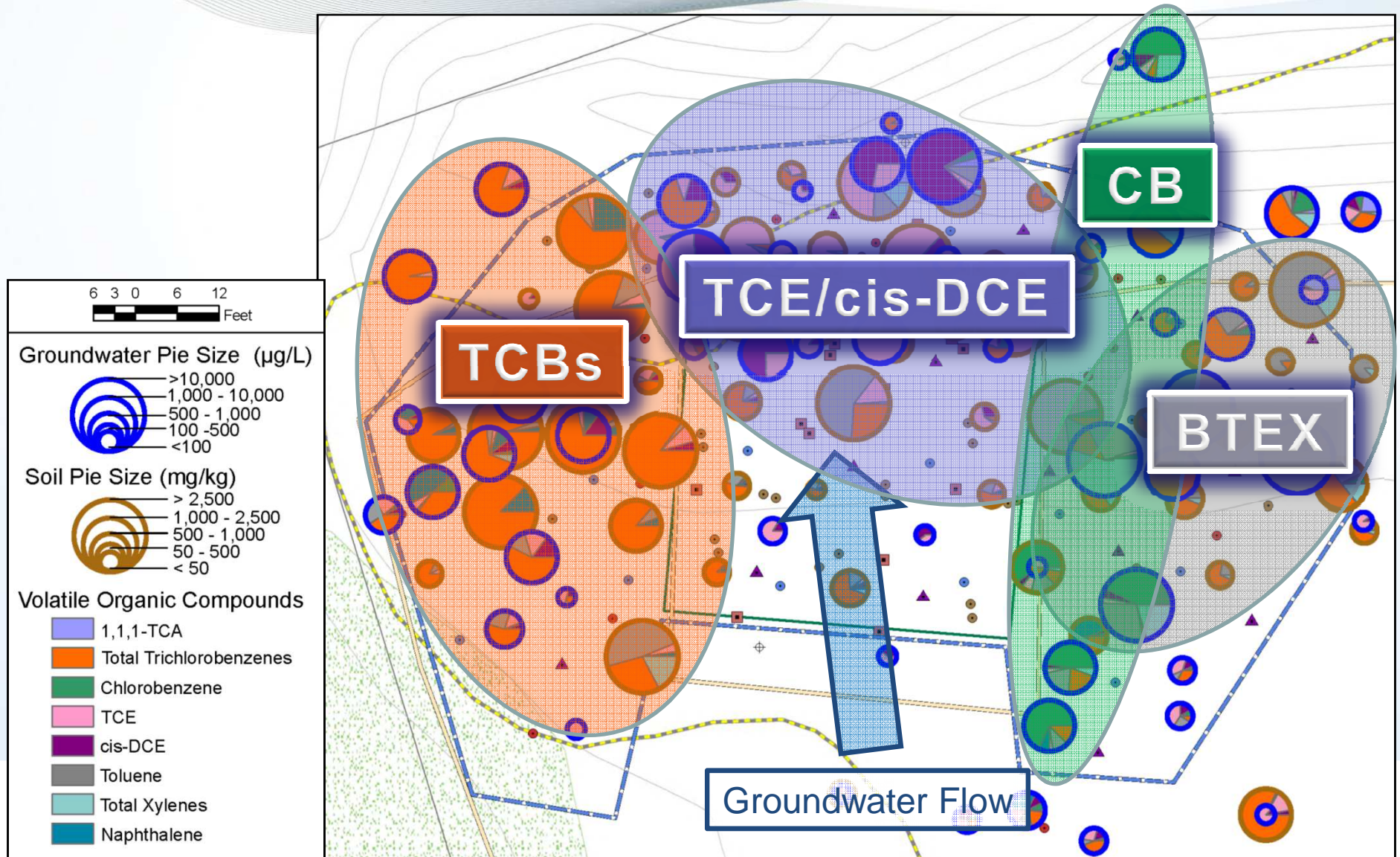
VOC plume is approximately ½ mile long

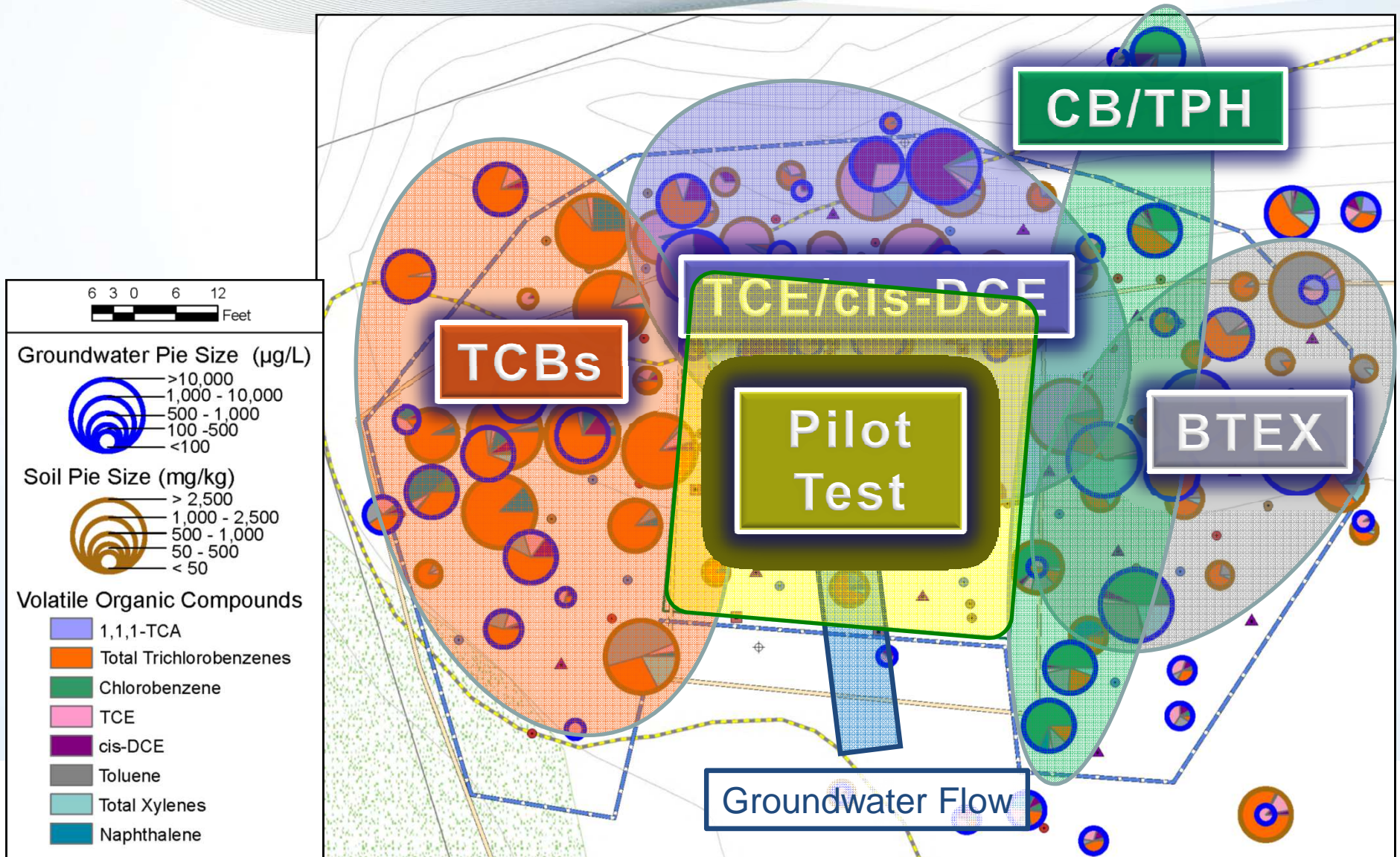


Source Characterization – Soil and GW

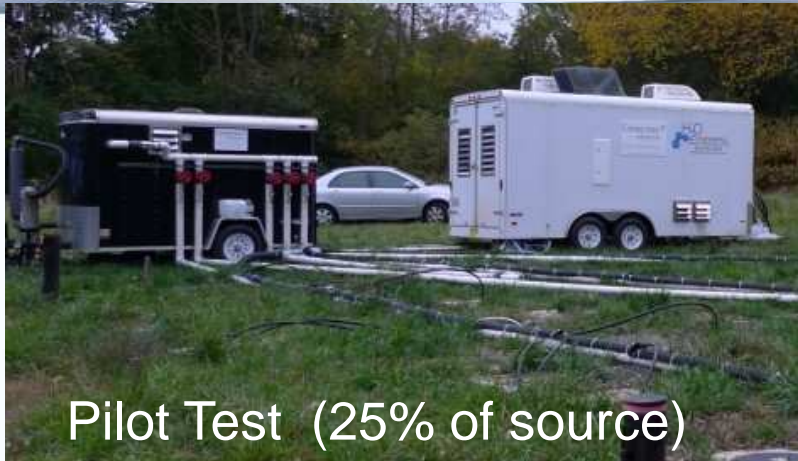


Source Characterization – Soil and GW





Pilot Test to Full-Scale Design

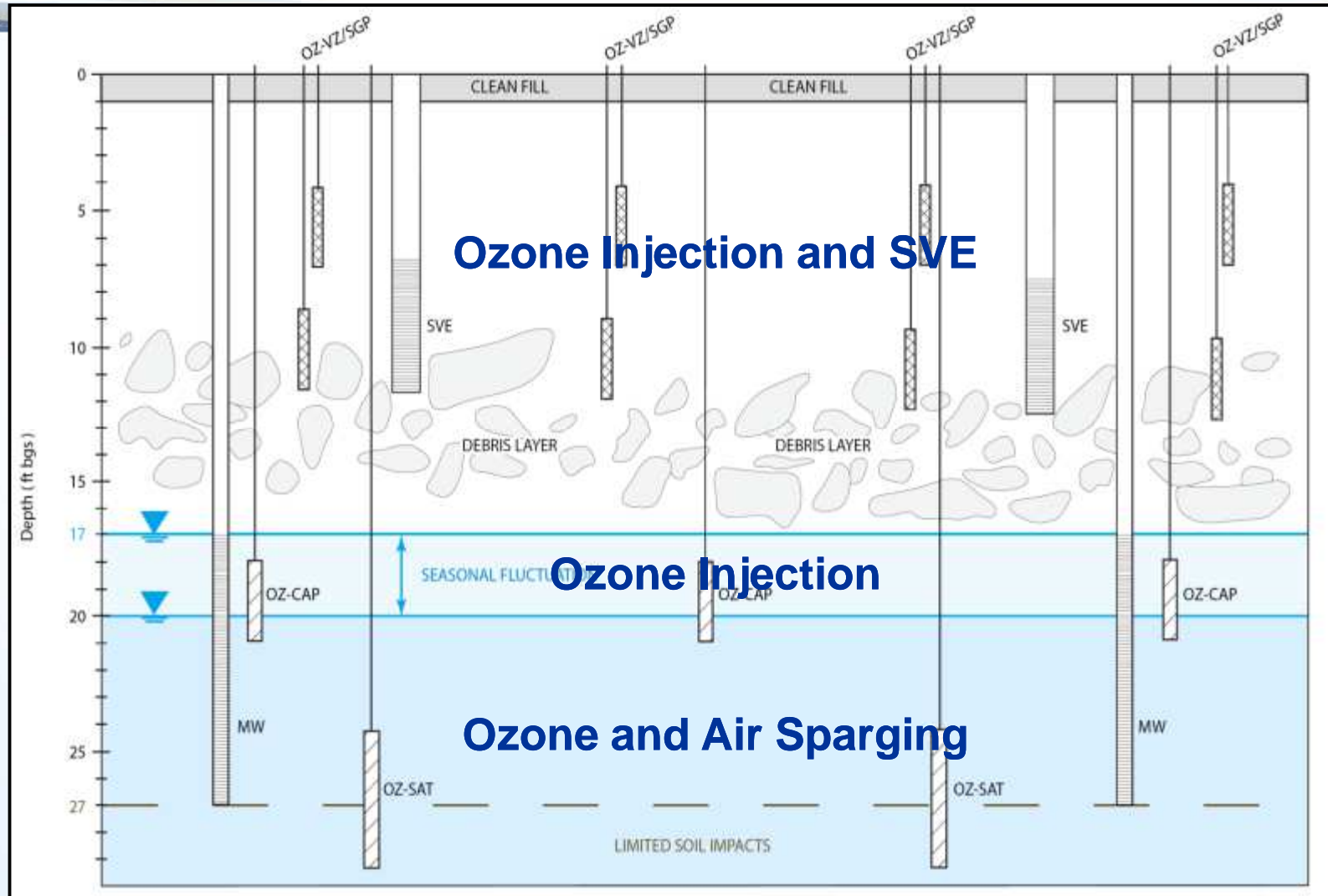


Pilot Test (25% of source)

	Pilot Test	Full-Scale
Treatment Area	2,500 ft ²	10,000 ft ²
Ozone	27 lb/day	100 lb/day
Air Sparge	25 scfm	55 scfm
SVE	300 scfm	600 scfm
Duration	7 months	2+ years



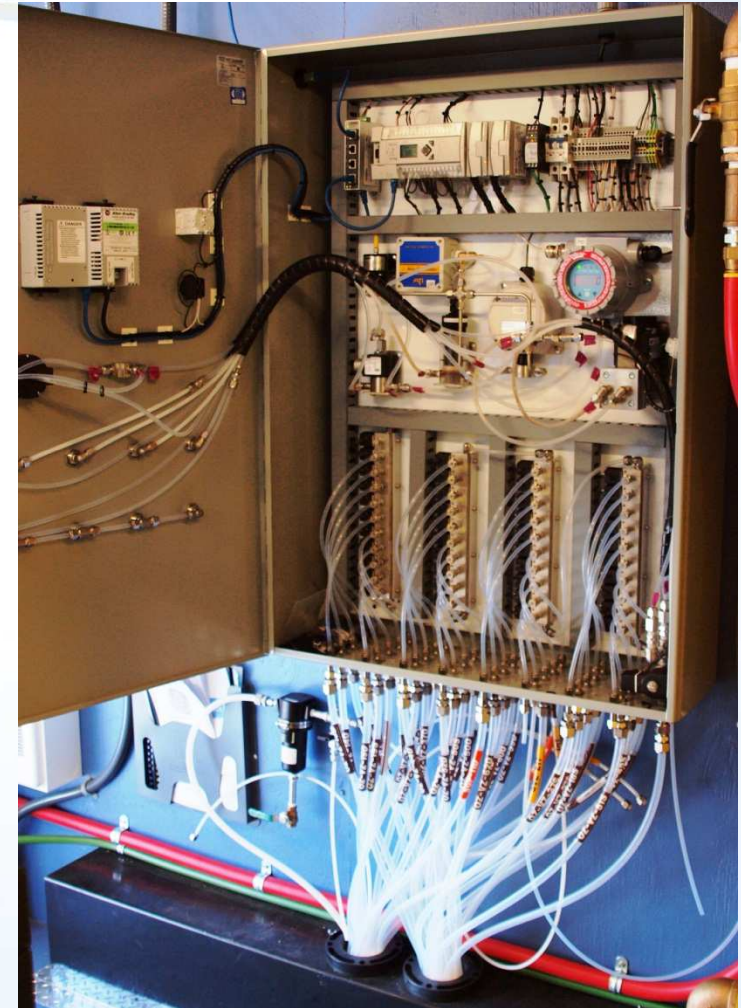
Full-Scale



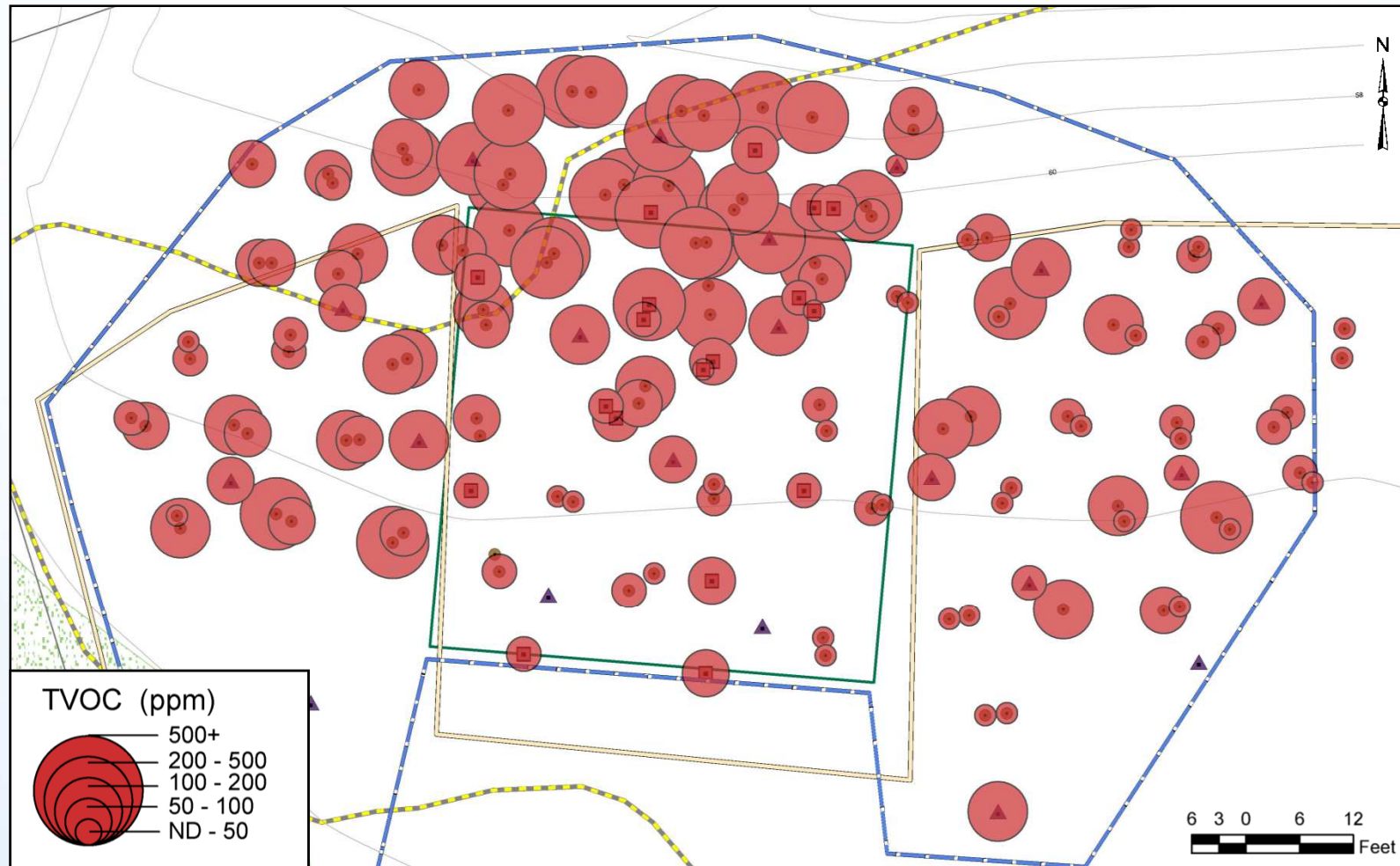
Catalyzed Hydrogen Peroxide (CHP) Injection

- Injection of catalyzed hydrogen peroxide (CHP) in portions of the existing treatment area
 - December 2012 – 8,000 gallons injected
 - February 2013 – 10,000 gallons injected
- Designed to supplement active ozone remedy
- Provides enhanced treatment in localized areas of residual contamination
- Intended to reduce overall duration of the existing remedy

- Soil Gas
 - Real time monitoring system: TVOC, O₃, O₂, CO₂
 - Waterloo Membrane Samplers (WMS™)
 - Handheld PID measurements
- Groundwater
 - Analytical laboratory data
 - ORP field data
- Shutdown Test

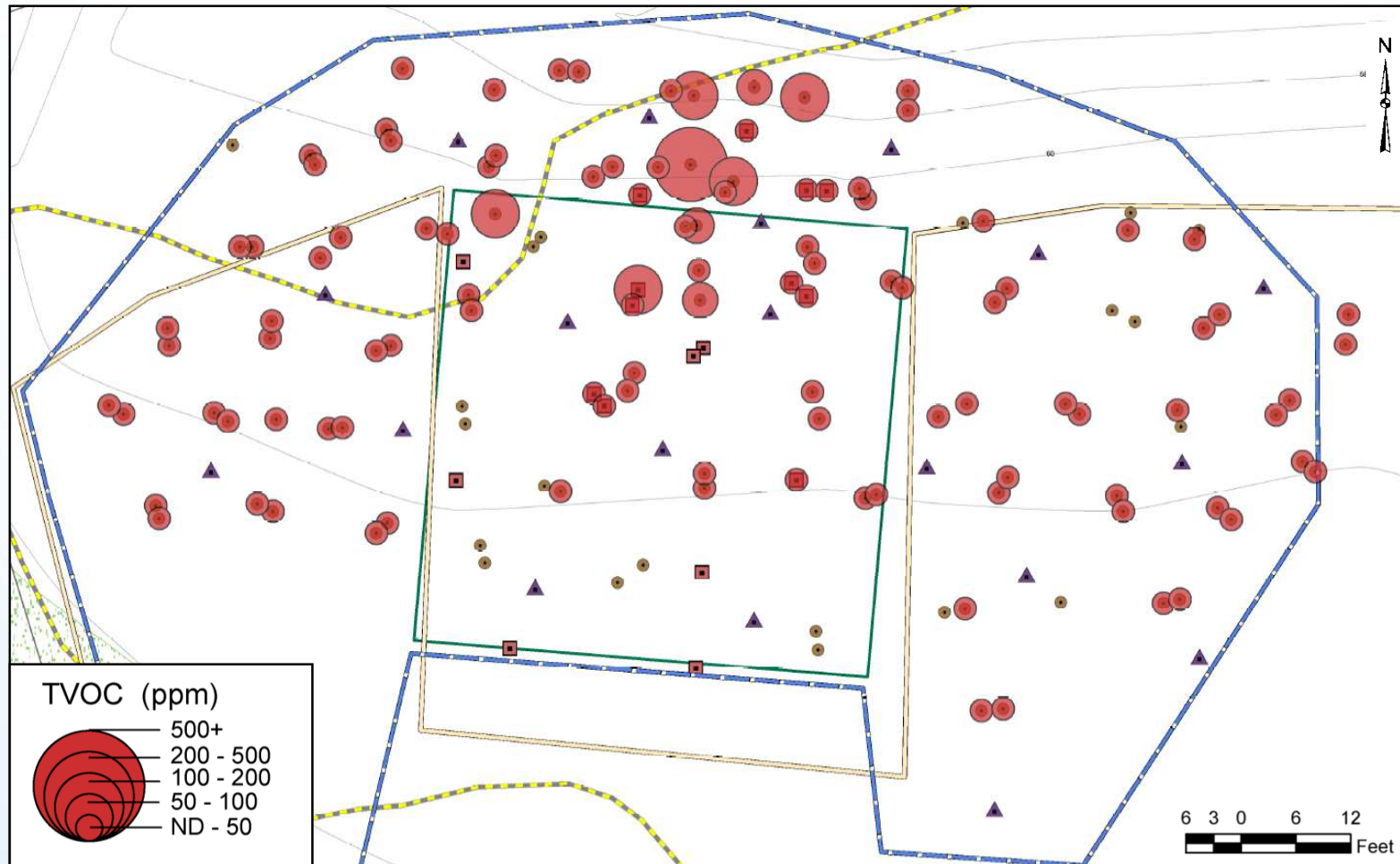


Soil Gas Results – Vadose Zone TVOCs



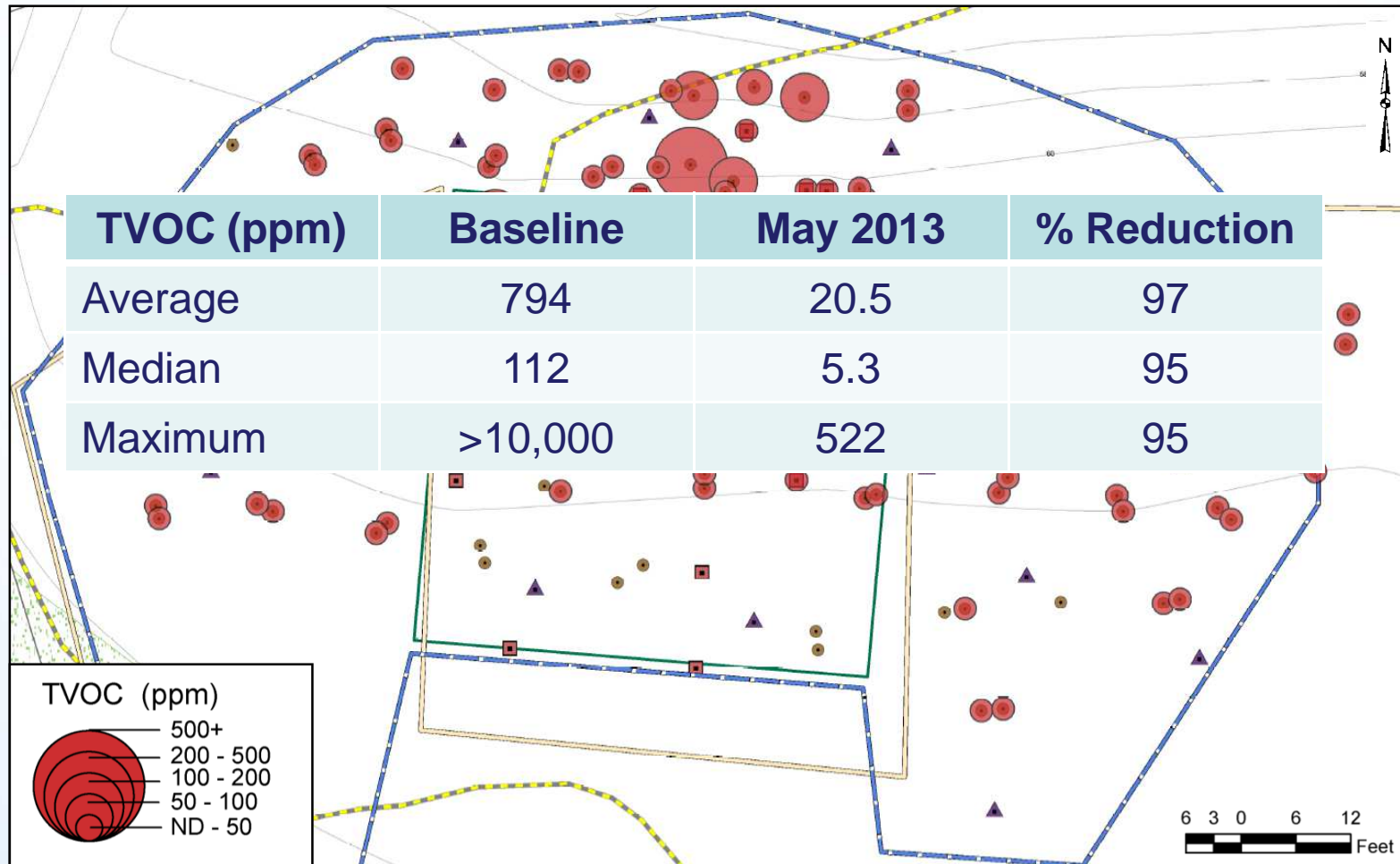
Baseline

Soil Gas Results – Vadose Zone TVOCs



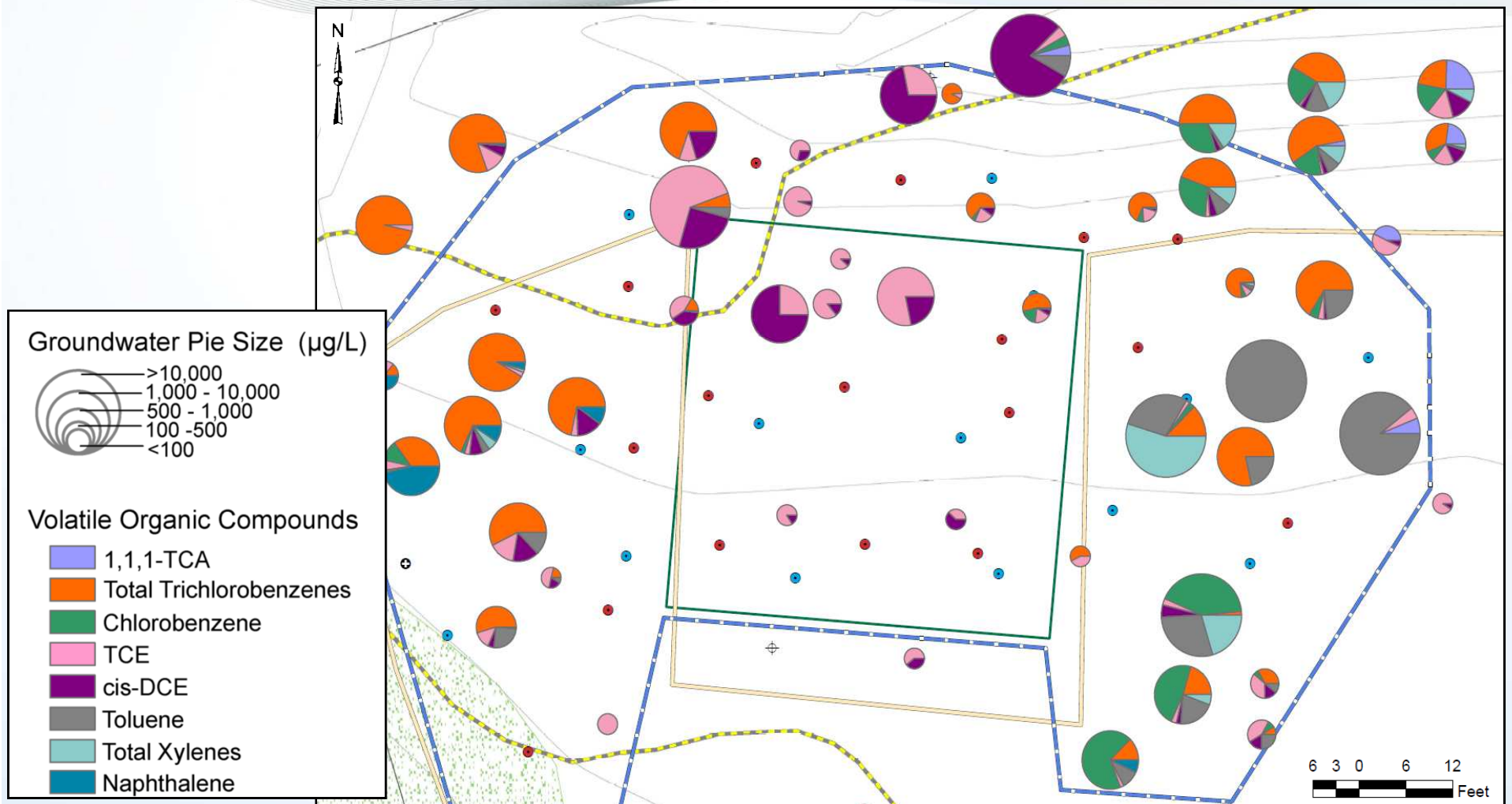
28 Months Operation

Soil Gas Results – Vadose Zone TVOCs



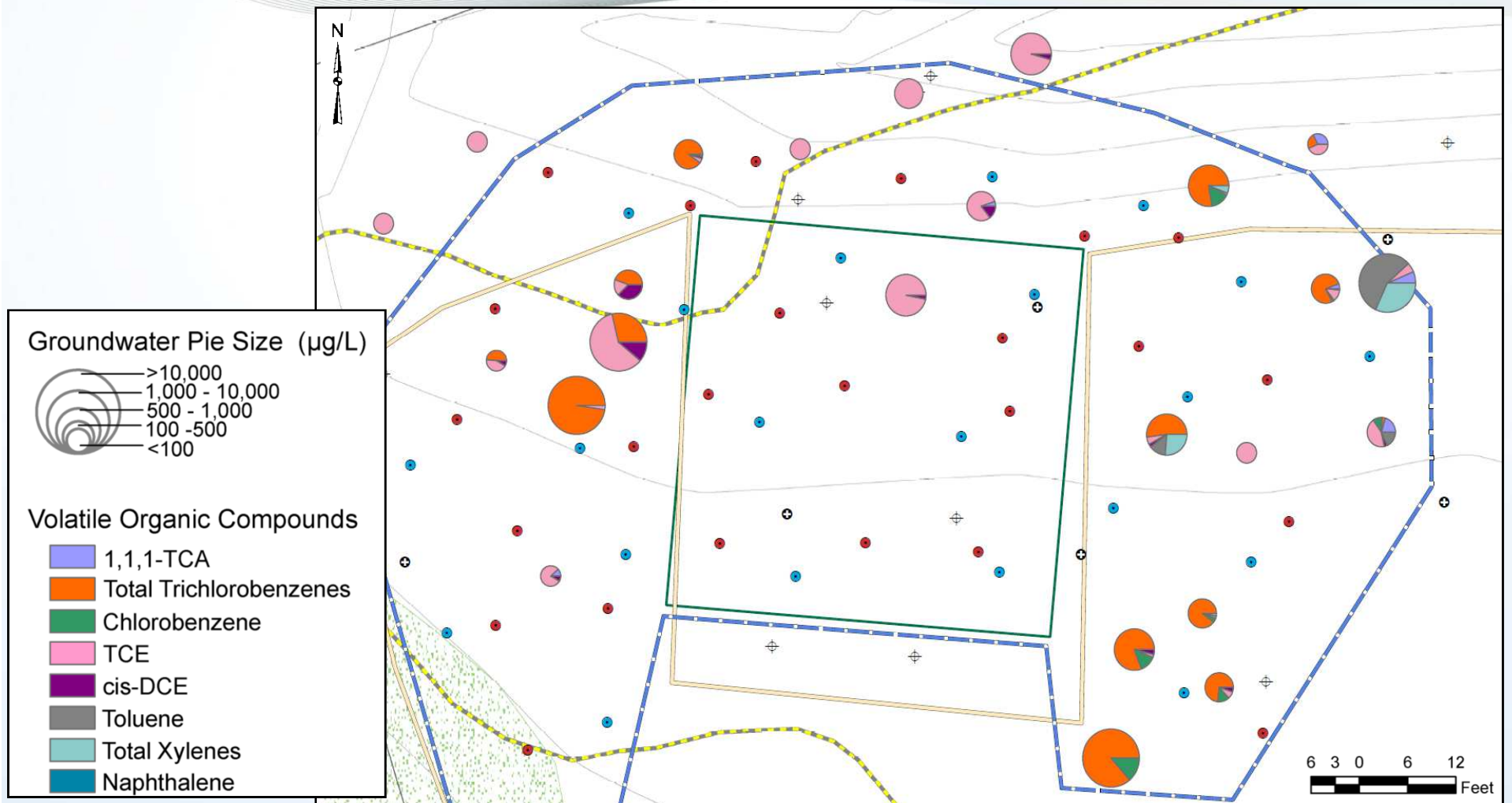
28 Months Operation

Groundwater Sampling Results – VOCs



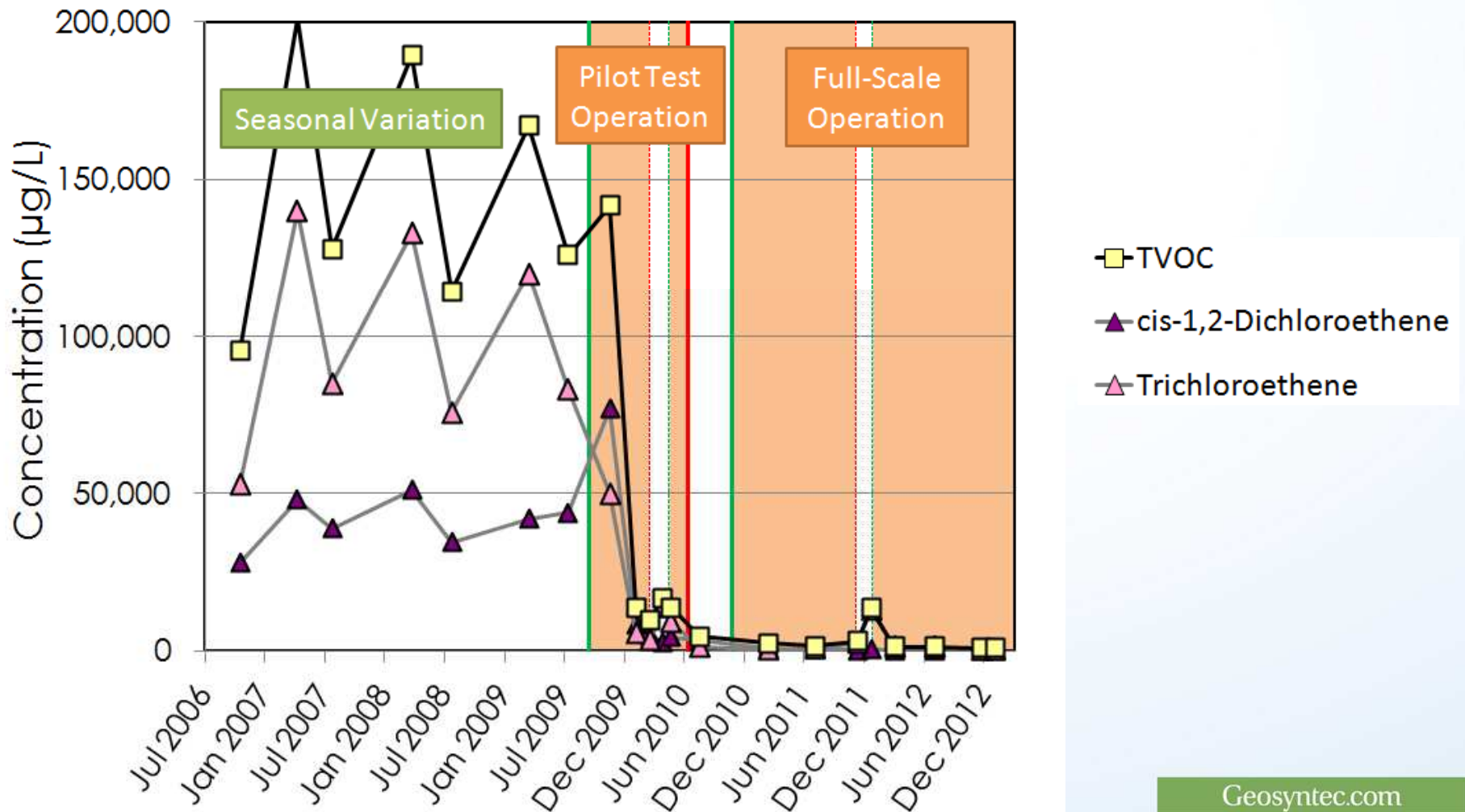
Baseline

Groundwater Sampling Results – VOCs

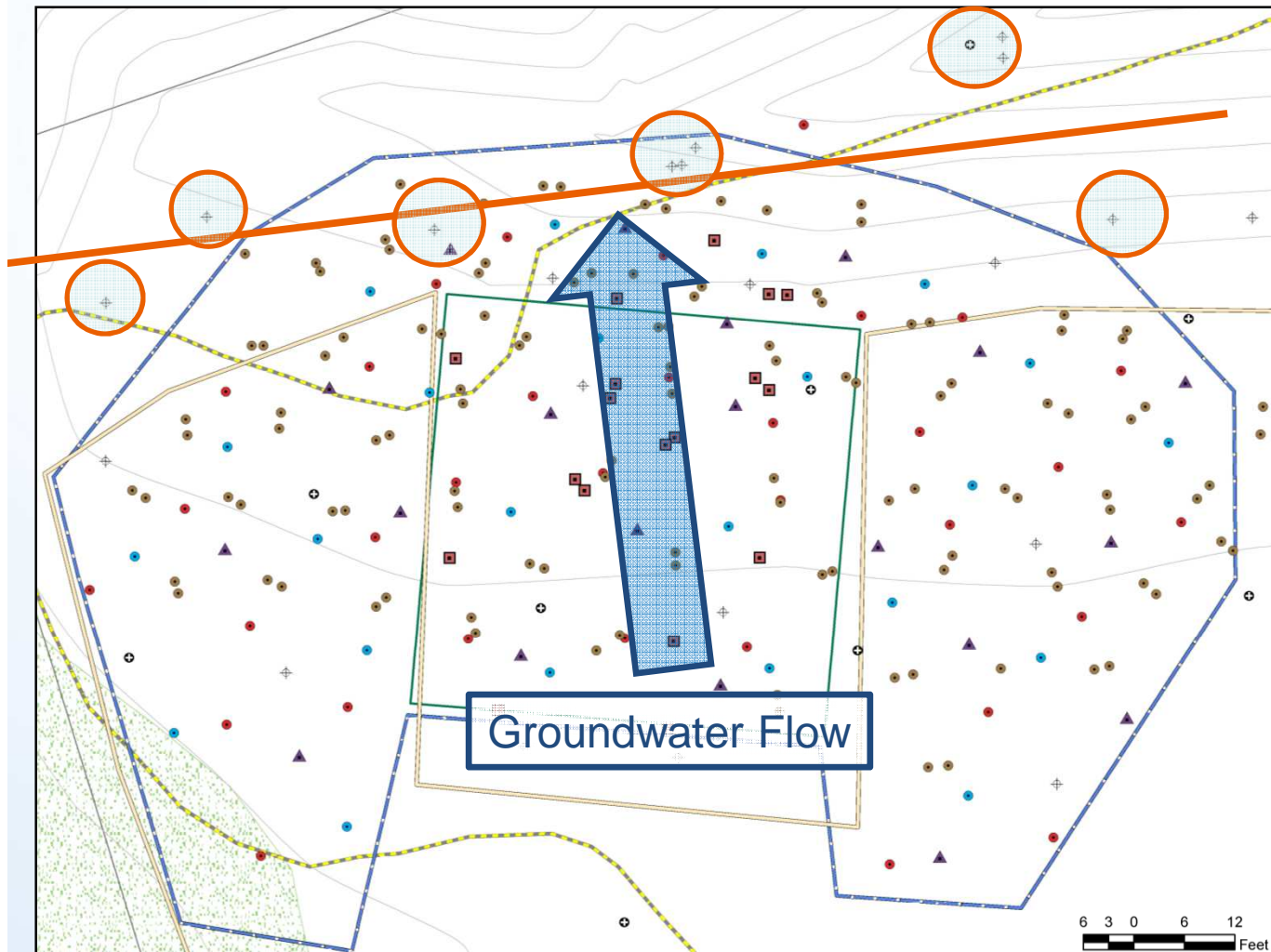


28 Months Operation

Long-term Trends in GW in TCE Plume Core: LR-18S



Mass Discharge of VOCs – Transect Method



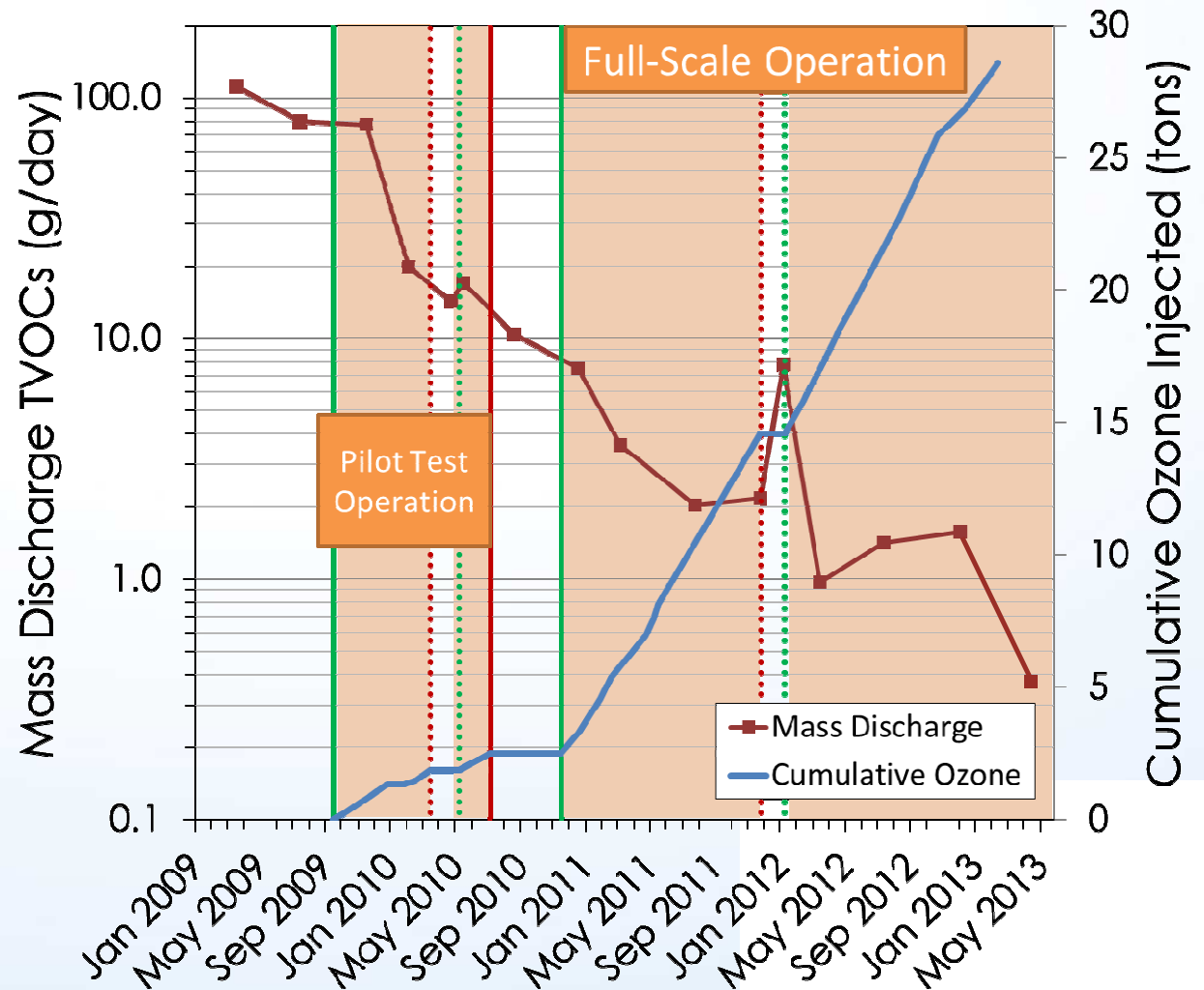
- 6 wells
- $K = 15$ ft/day
- $q = 0.045$ ft/day
- $B = 6$ to 11 ft

Einarson and Mackay, 2001

Mass Discharge of VOCs - Summary

- 28 months operation
- 30+ tons of ozone injected total (pilot and full-scale)

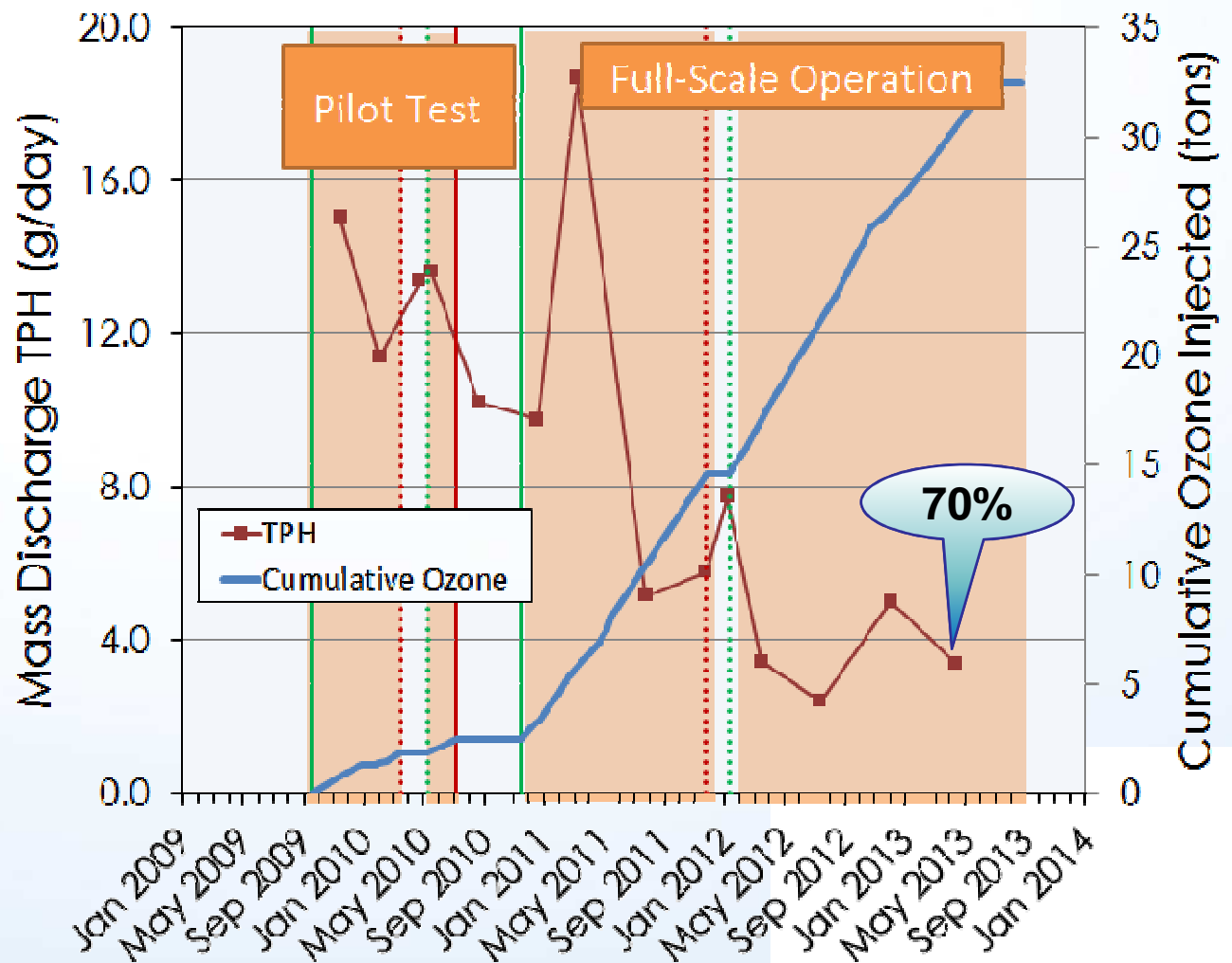
Treatment Area Mass Discharge of VOCs in Groundwater

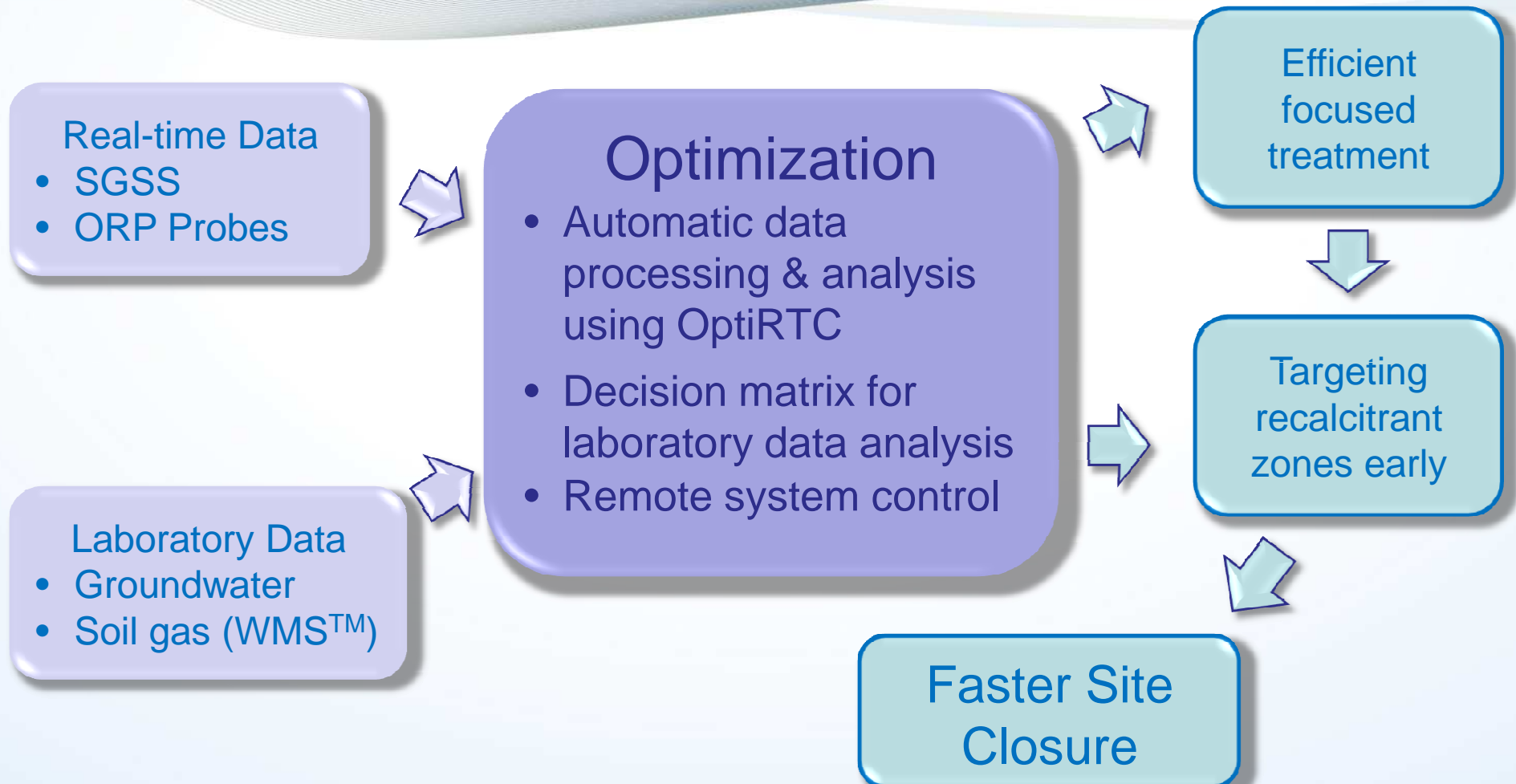


Mass Discharge of TPH- Summary

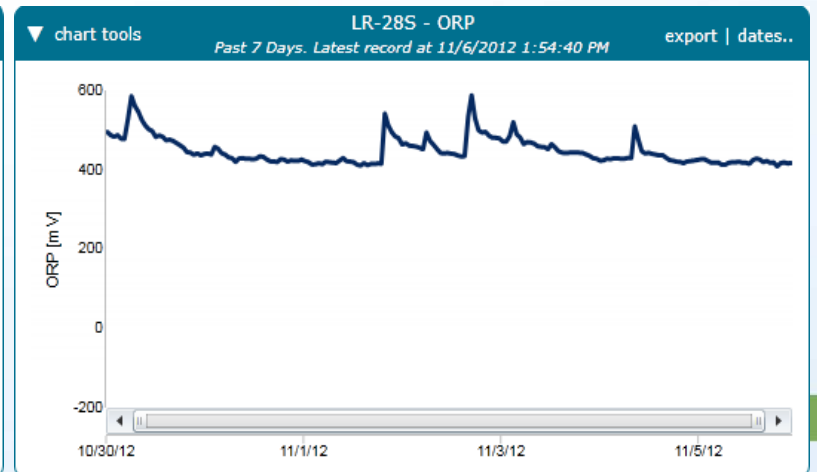
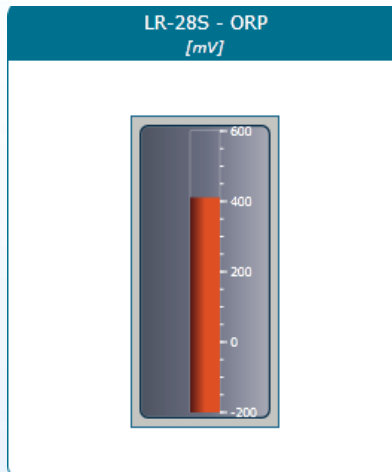
Treatment Area Mass Discharge of TPH in Groundwater

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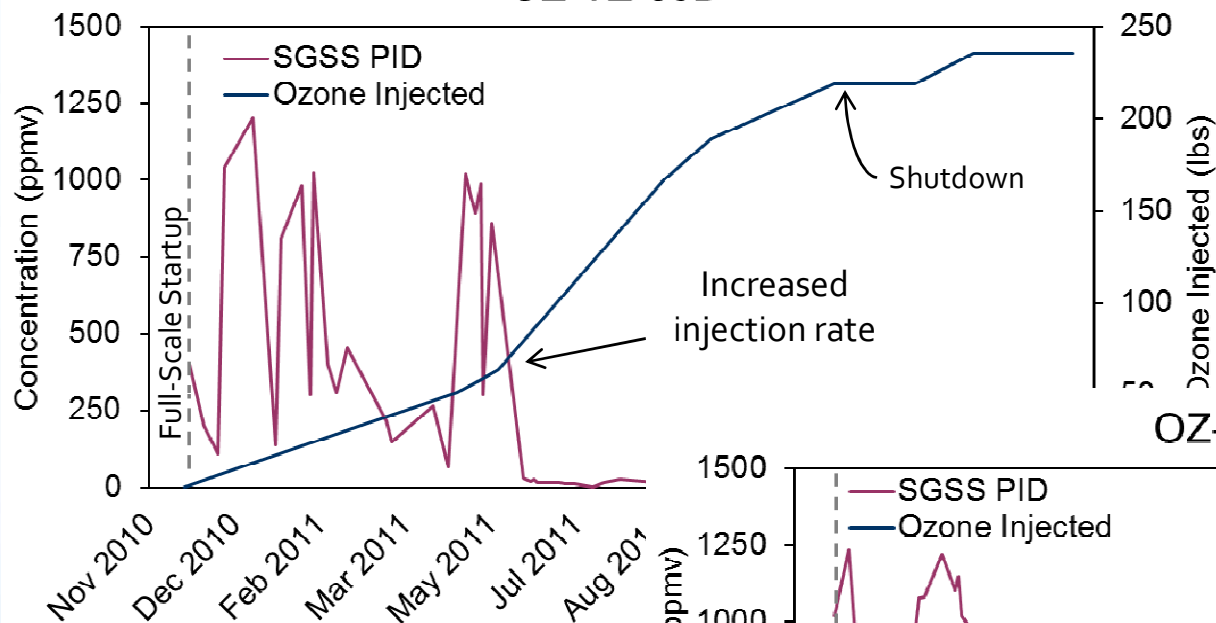




- Real-time monitoring of ORP
 - ORP probes in 6 sectors of the site
 - Monitors changes with injections
 - View data spatially and temporally



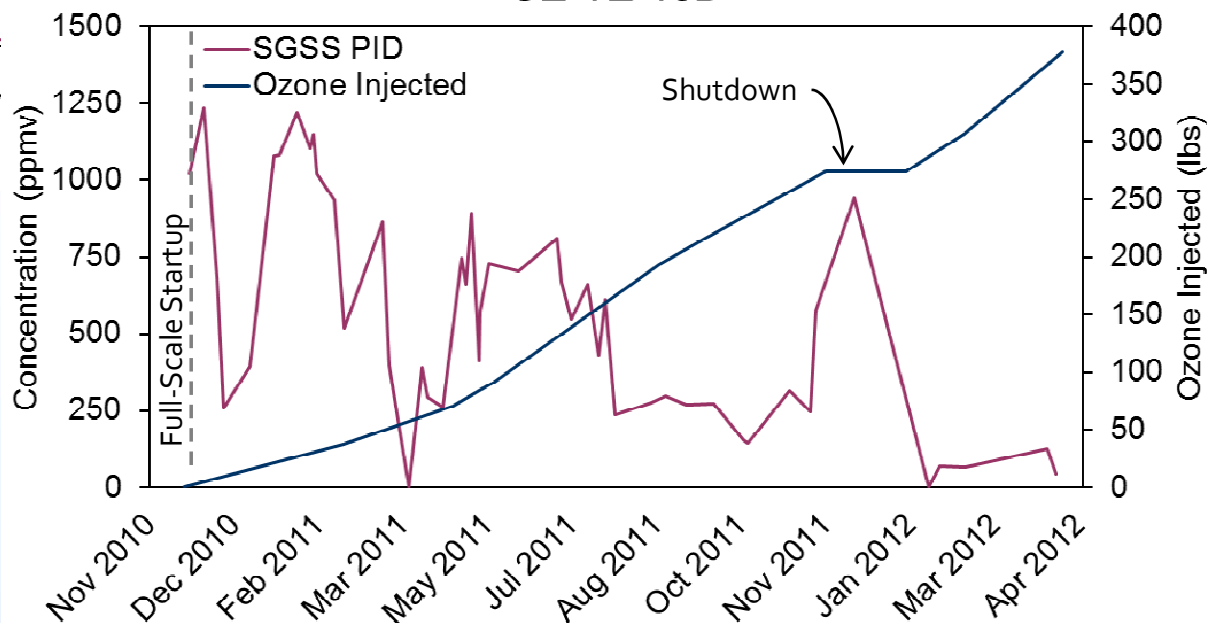
OZ-VZ-60D



- Increased injection rate in response to persistent contamination
- Low PID readings since July 2011
- Stopped injection, no rebound observed

- Rebound observed during shutdown test
- Targeted for continued injection

OZ-VZ-18D



- Decrease from 7 to 2 in number of VOCs present as NAPL
- 2 orders of magnitude reduction in groundwater VOC mass discharge
- Moderate rebound in groundwater VOCs after two 6+ week shutdown tests
- On target to meet goal of <1 mg/L TVOC in groundwater



Questions?

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