

# Estimating Time to Reach NSZD Endpoints Using Active Remediation Analogs

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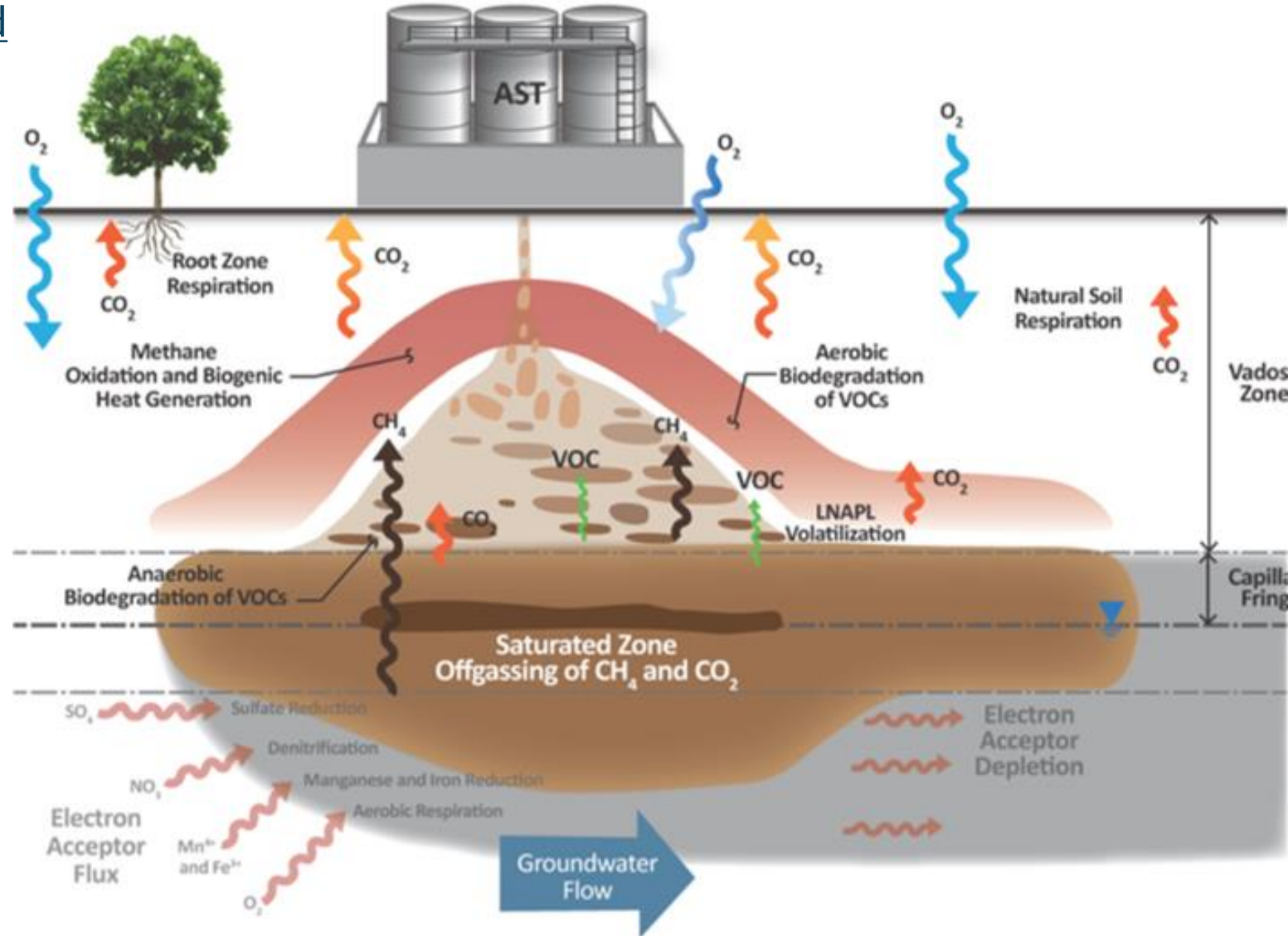
# How Long Will Cleanup by NSZD Take?

## Site-Specific NSZD Rates can be Estimated

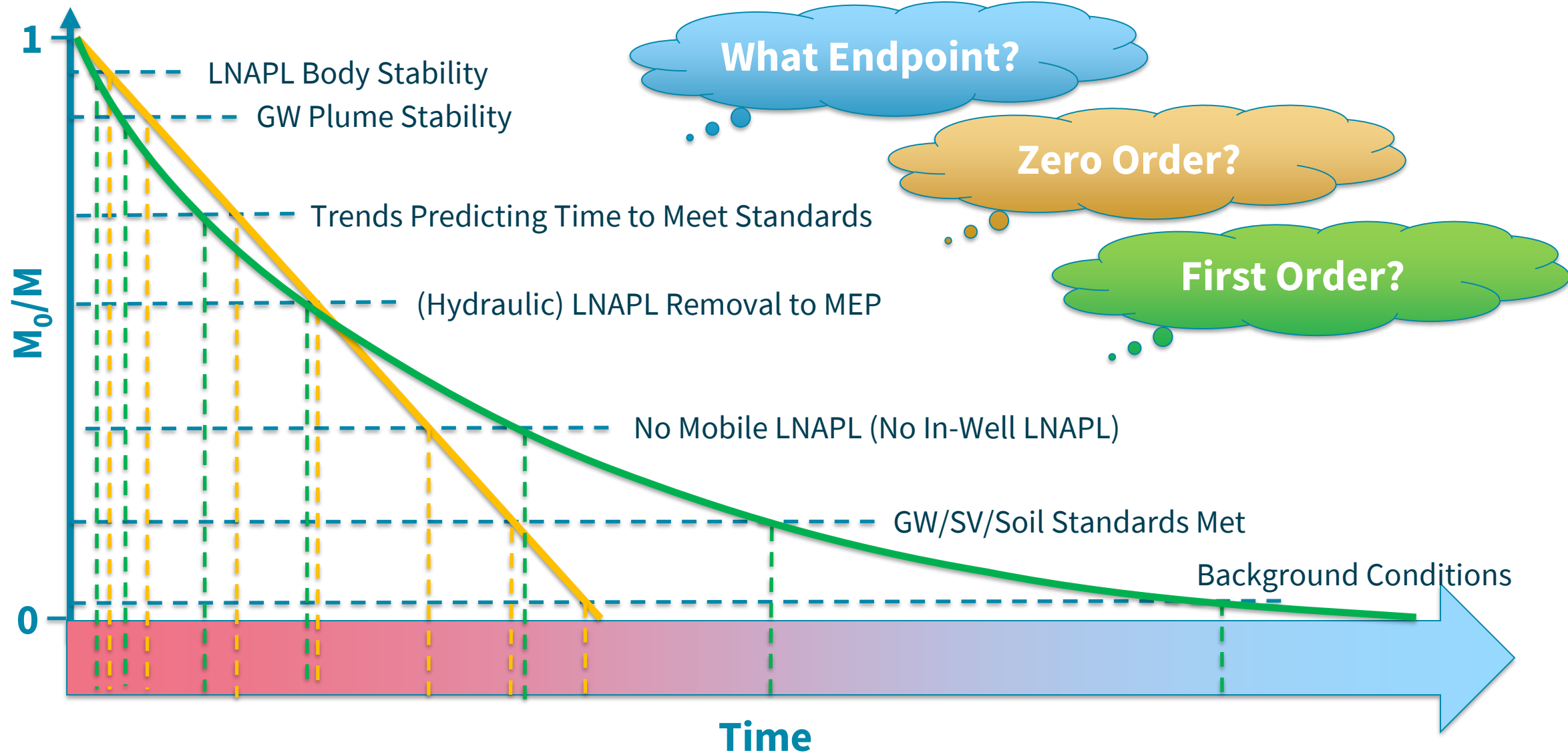
- Site-Specific Measurements
- Site-Specific Estimate (Nomogram; ITRC 2018)

## Sources of Uncertainty

- Measured site-wide NSZD rates
  - 1.3 OoM variation (Palaia 2016)
  - 2.4 OoM variation (Kulkarni et al. 2022)
- Site Mass
  - Poorly characterized
  - Generally underestimated

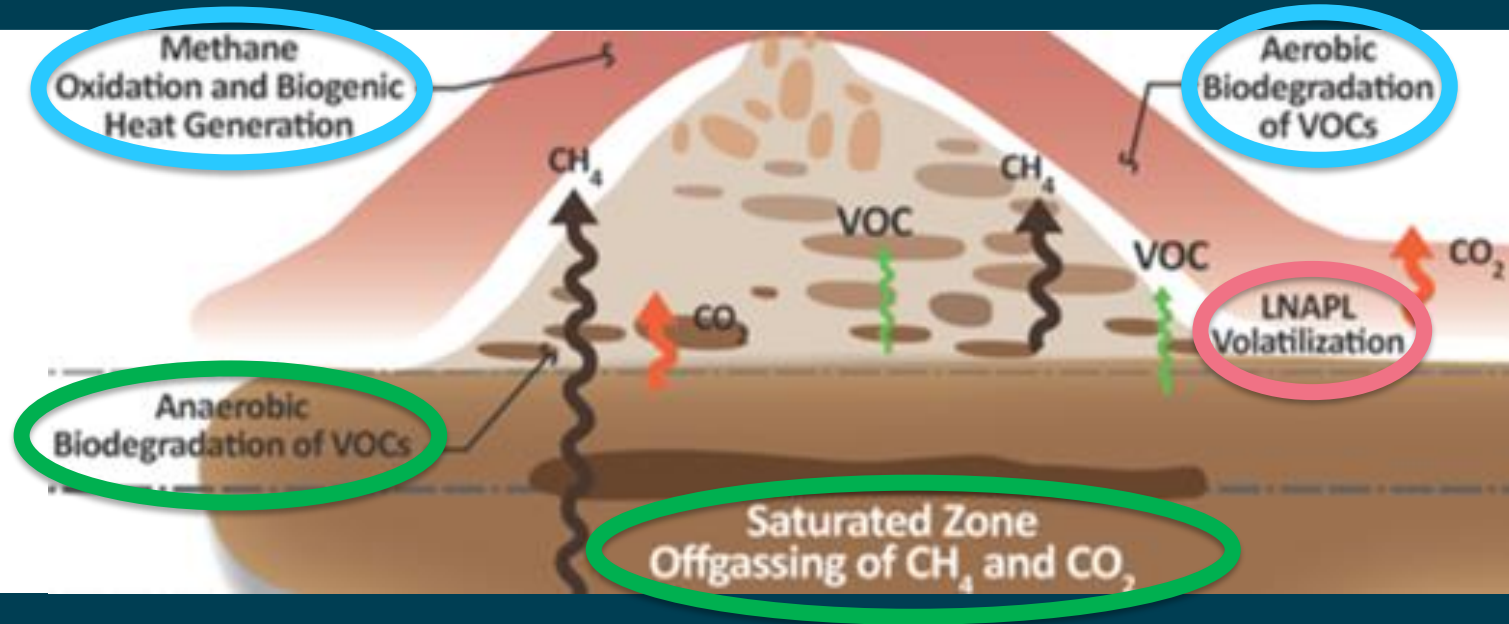


# How Long Will NSZD Take to Reach an Endpoint?

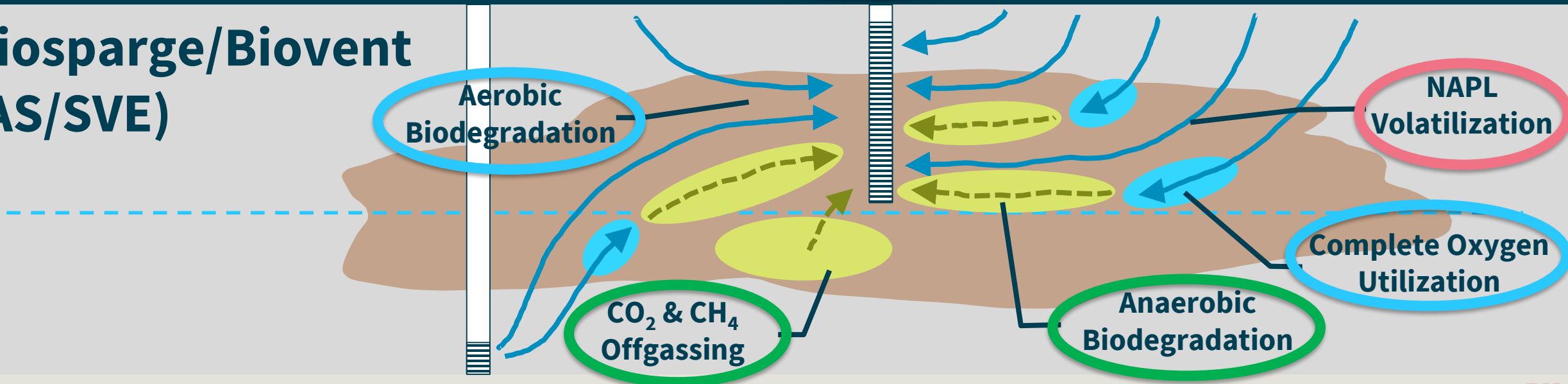


# NSZD Analog

## NSZD

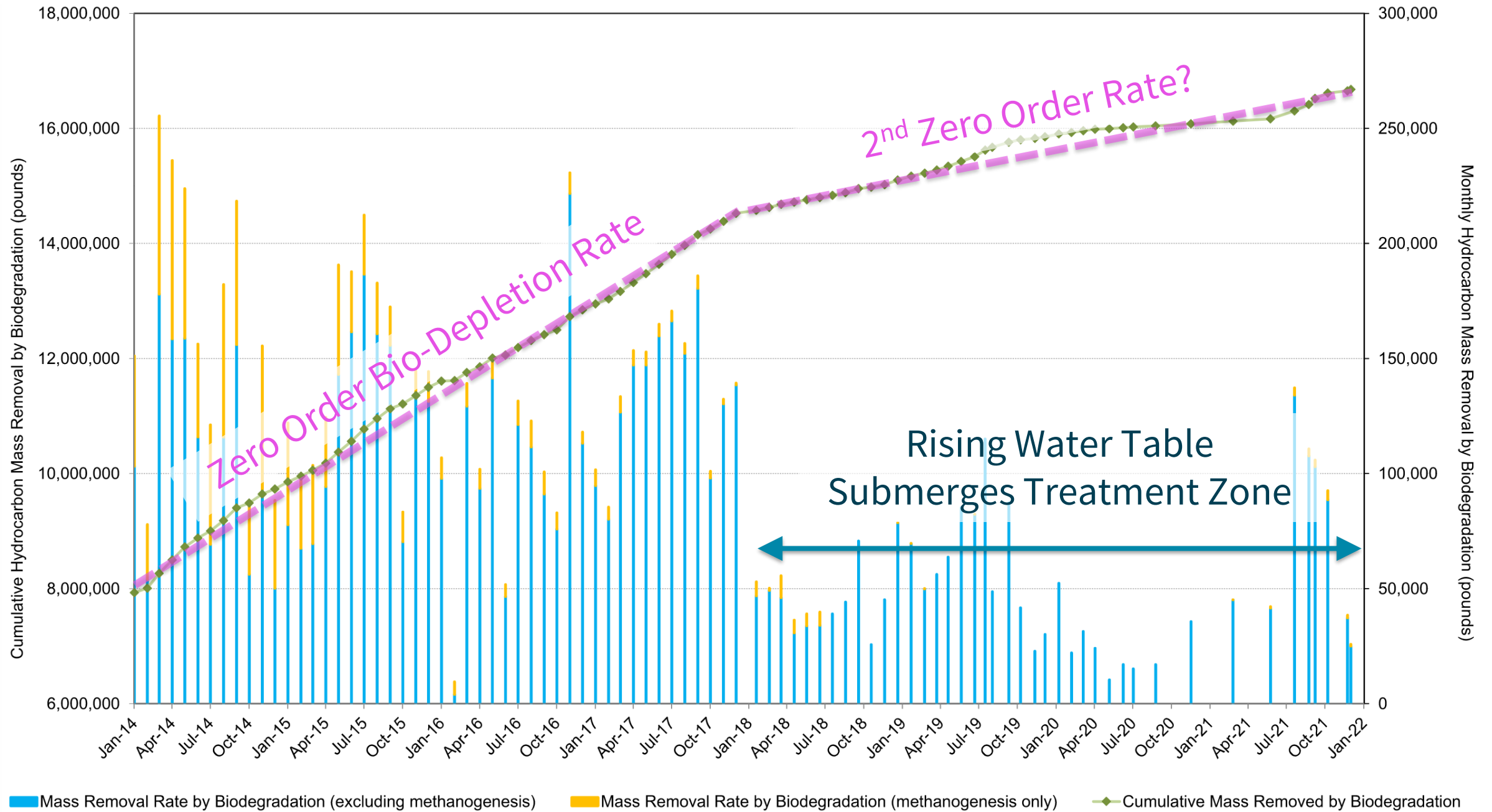


## Biosparge/Biovent (AS/SVE)

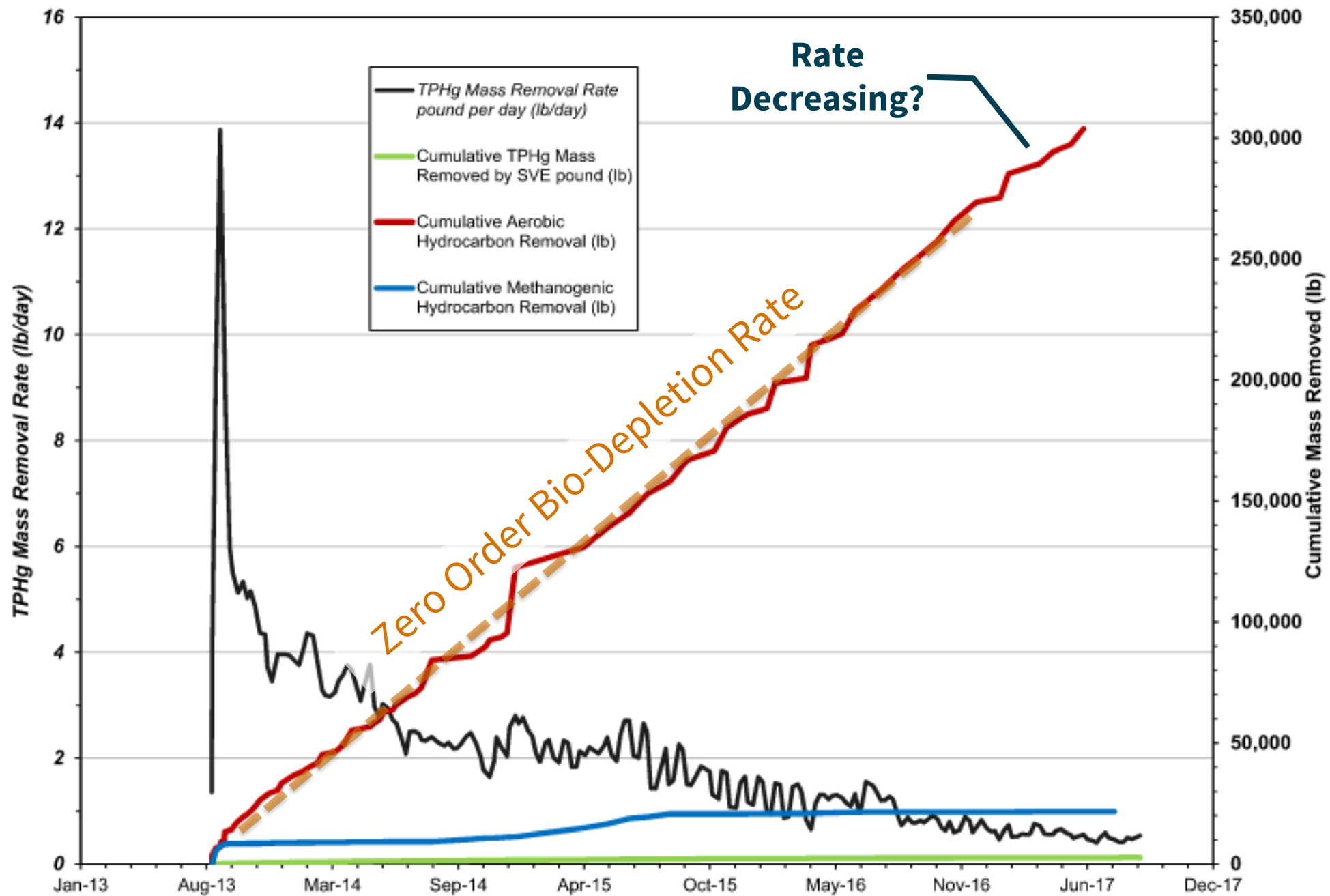


# Site 1

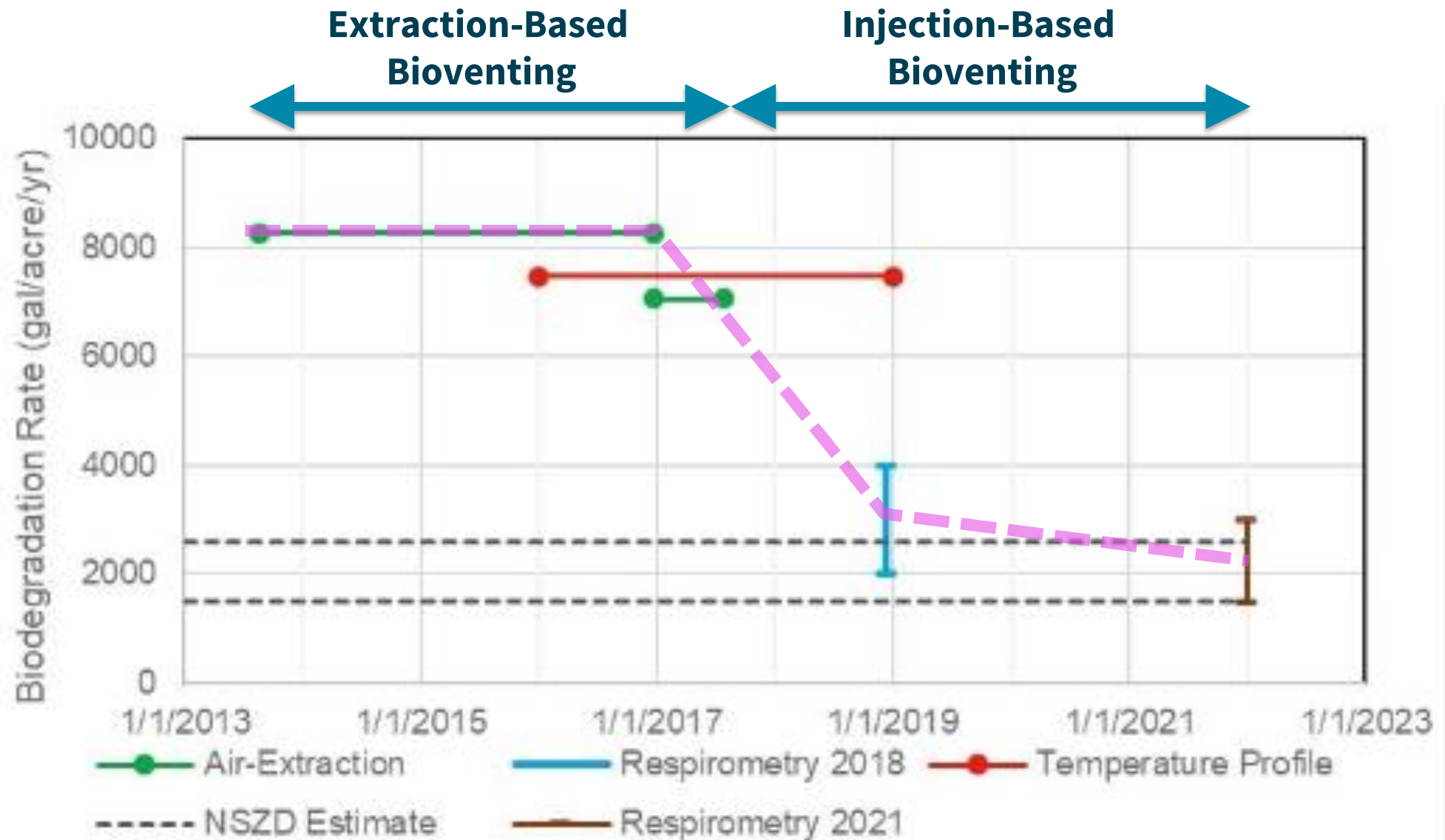
Area of LNAPL Zone	~45 acres
Thickness of LNAPL Zone	~150 ft
Depth to Water Table	120 ft to 190 ft
Type of LNAPL	Intermediate and Finished Products
Remedial Technology	Air Sparge / Soil Vapor Extraction
Volume Depleted	>140,000 gallons/acre (>40% biodegraded)
Endpoint(s)	Low Tn LNAPL LNAPL Occurrence in Fewer Wells COCs at or near MCLs (reduced up to 4 OoM)



Area of LNAPL Zone	1.3 acres
Thickness of LNAPL Zone	~40 ft
Depth to Water Table	50 ft
Type of LNAPL	Diesel
Remedial Technology	Extraction-Based then Injection-Based Bioventing
Volume Depleted	40,000 gallons/acre (>99% biodegraded)
Endpoint(s)	Low Tn LNAPL LNAPL Occurrence in Fewer Wells

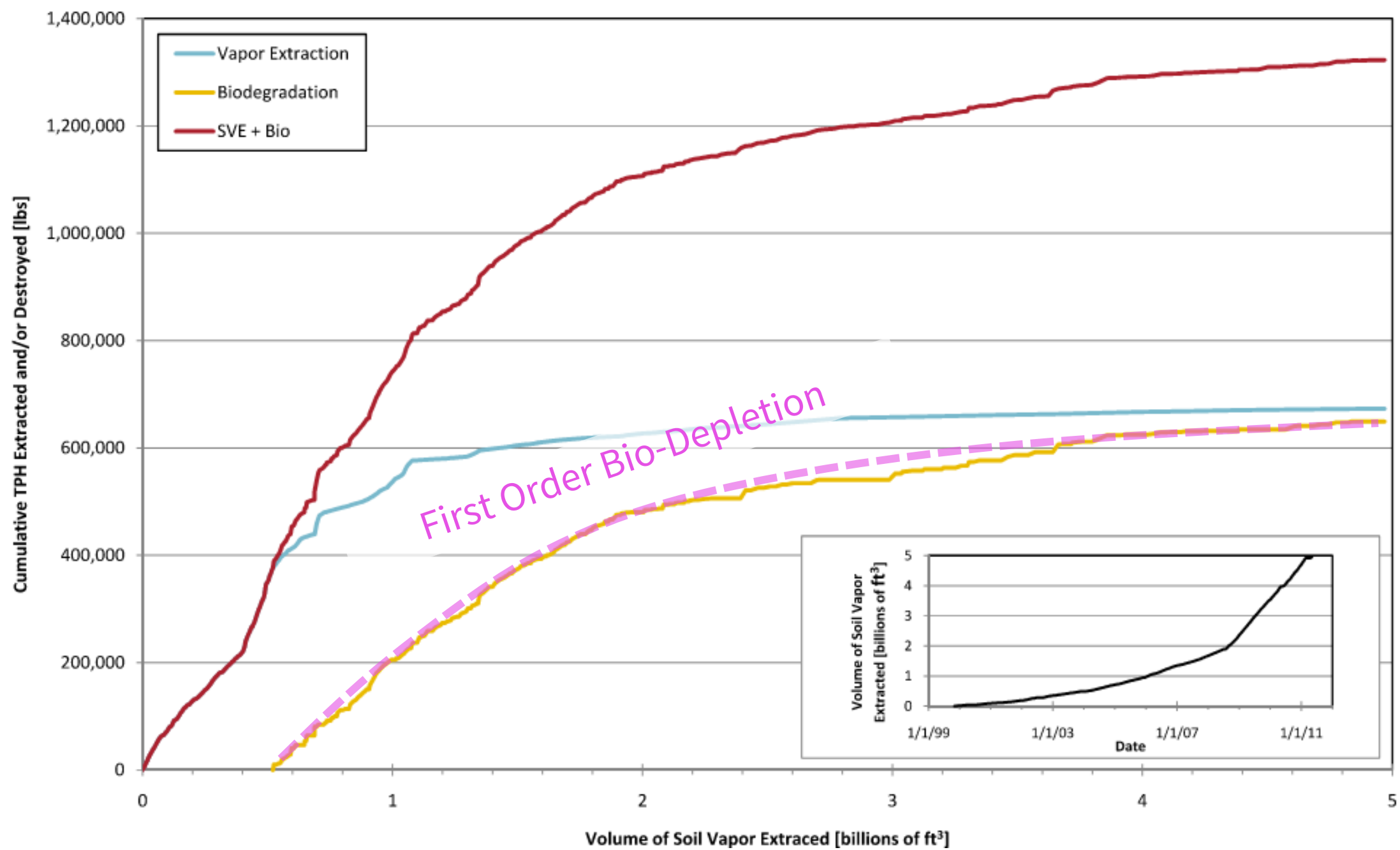




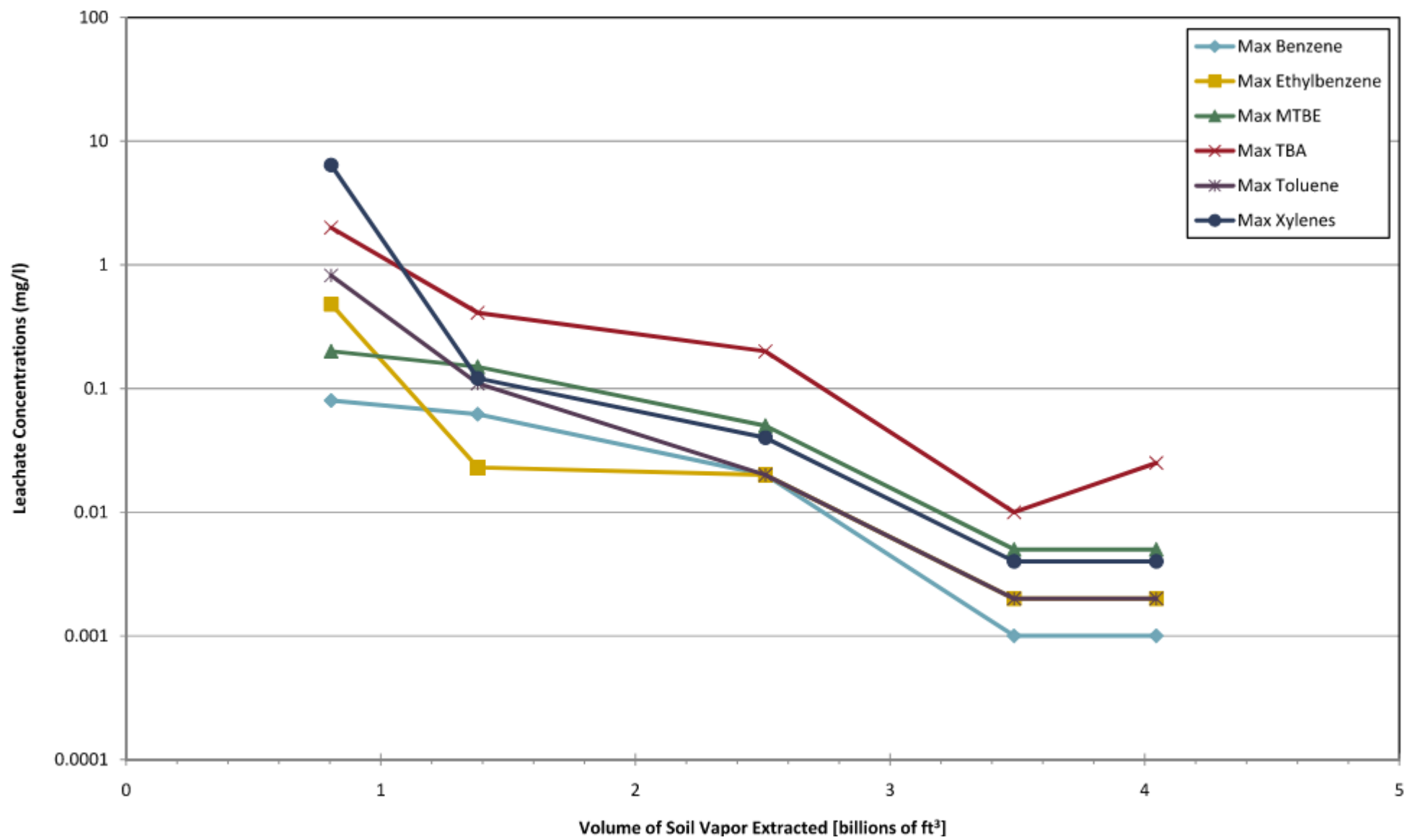


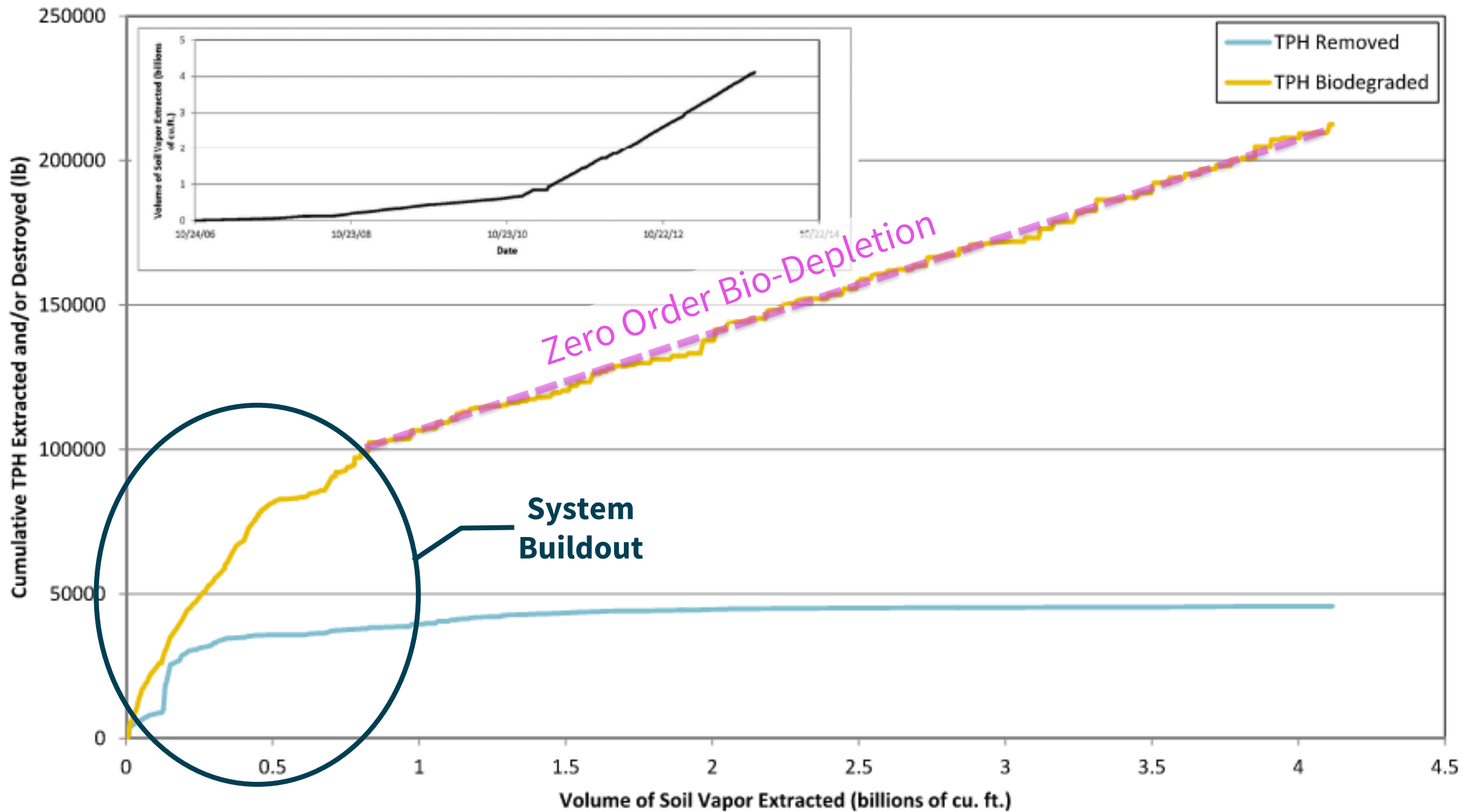
# Site 3

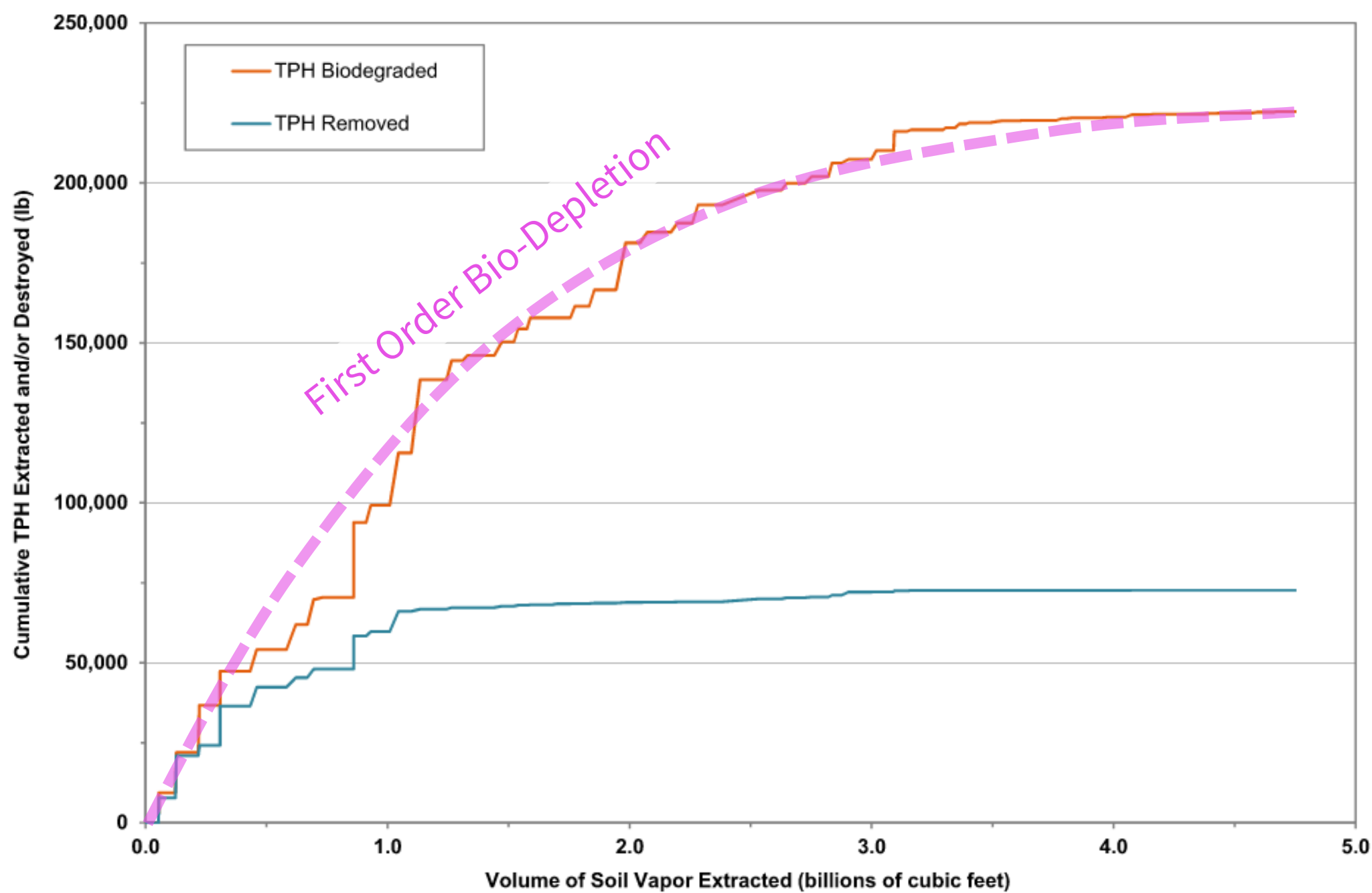
	Phase I	Phase II	Phase III
Area of LNAPL Zone (acres)	8 acres	2 acres	6.5 acres
Thickness of LNAPL Zone	5-10 ft	5-10 ft	5-10 ft
Depth to Water Table	~30 ft	~35 ft	~20-30 ft
Type of LNAPL	Gasoline	Gasoline	Gasoline & Diesel
Remedial Technology	SVE + Dewatering	SVE + Dewatering	SVE + Dewatering
Volume Depleted	~25,000 gallons/acre (>50% biodegraded)	~20,000 gallons/acre (~80% biodegraded)	~7,000 gallons/acre (~75% biodegraded)
Endpoint(s)	Groundwater & Leachate Meet MCLs	Groundwater & Leachate Meet MCLs	Groundwater & Leachate Meet MCLs







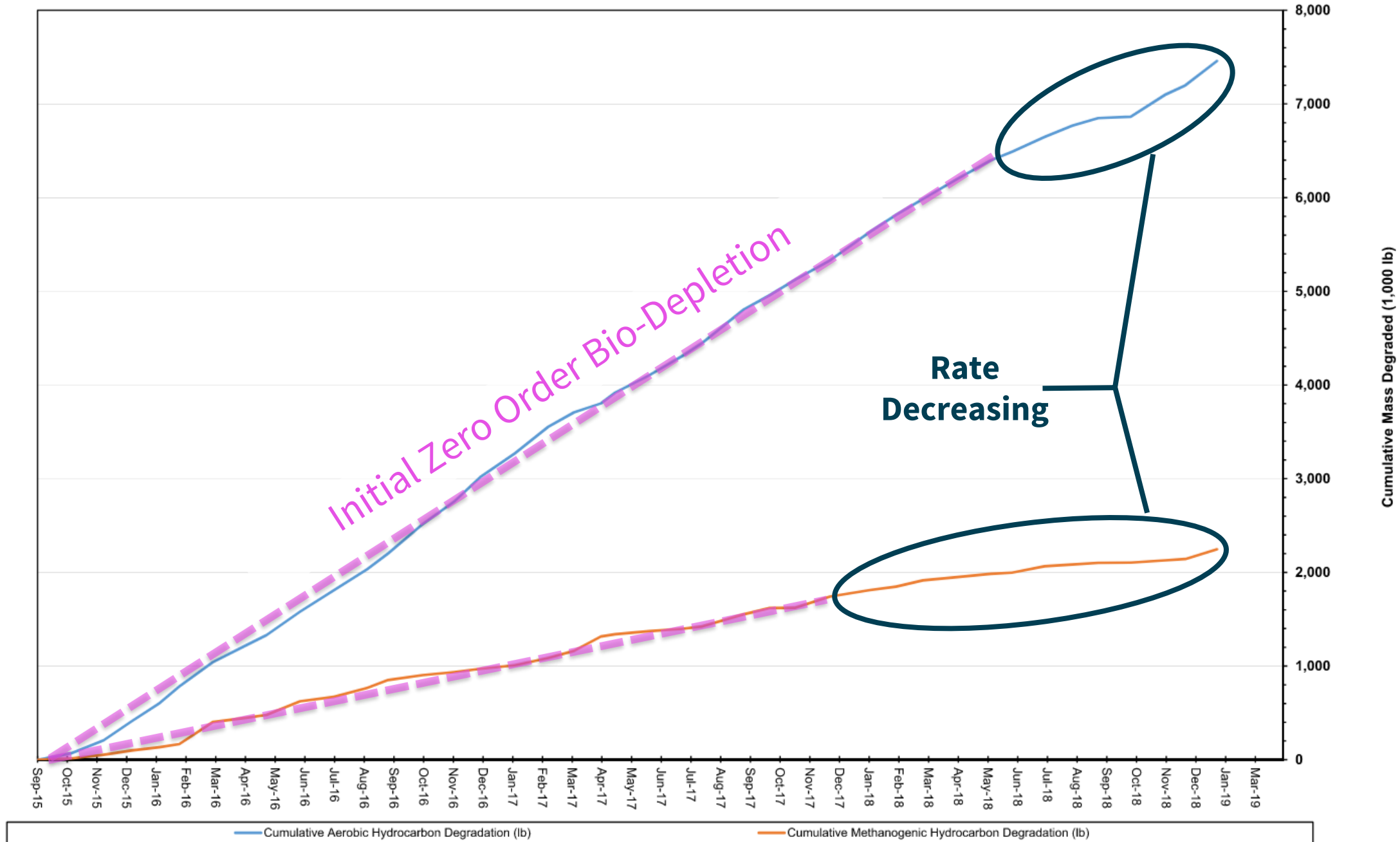






# Site 4

Area of LNAPL Zone	~3 acres
Thickness of LNAPL Zone	100 ft
Depth to Water Table	130 ft
Type of LNAPL	Crude Oil & Refined Products
Remedial Technology	Soil Vapor Extraction
Volume Depleted	550,000 gallons/acre (~90% biodegraded)
Endpoint(s)	<10x MCLs in groundwater <110x MCLs in leachate Meet soil vapor risk-based levels



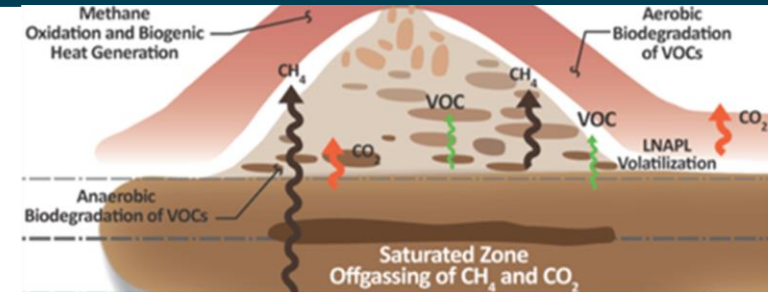
# Conclusions

- Bioventing/Biosparging (AS/SVE) is a reasonable analog for NSZD.
- Zero order for earlier endpoints
- First order for later endpoints
- Specific mass depleted (per acre) somewhat correlated to LNAPL zone thickness

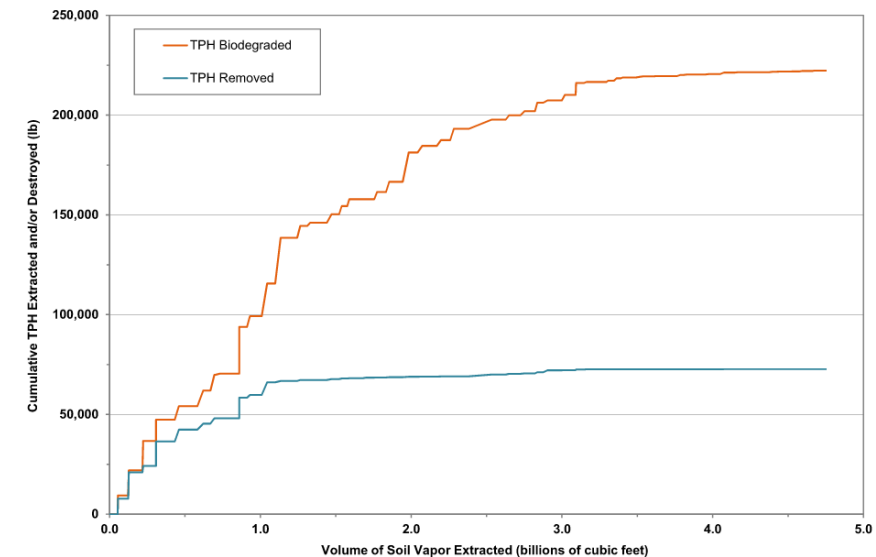
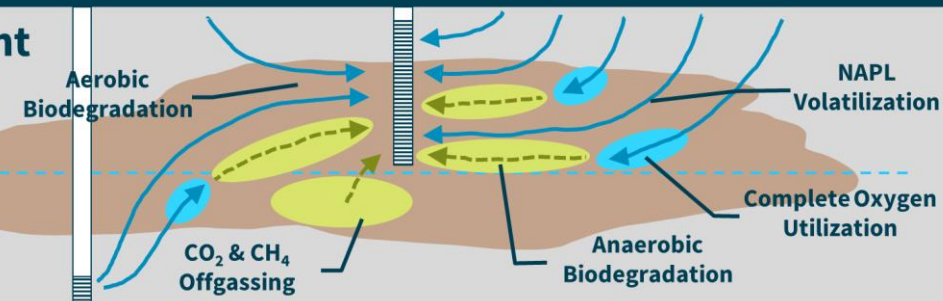
## Next Steps:

- Model kinetics
  - LNAPL type
  - Initial LNAPL volatilization
  - Independent estimates of specific mass

### NSZD



### Biosparge/Biovent (AS/SVE)







Questions?