

Fortuitous Volatilization and Steam-Enhanced Biodegradation of VOC-TPH NAPL Mixture Naval Air Station North Island

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Project Team



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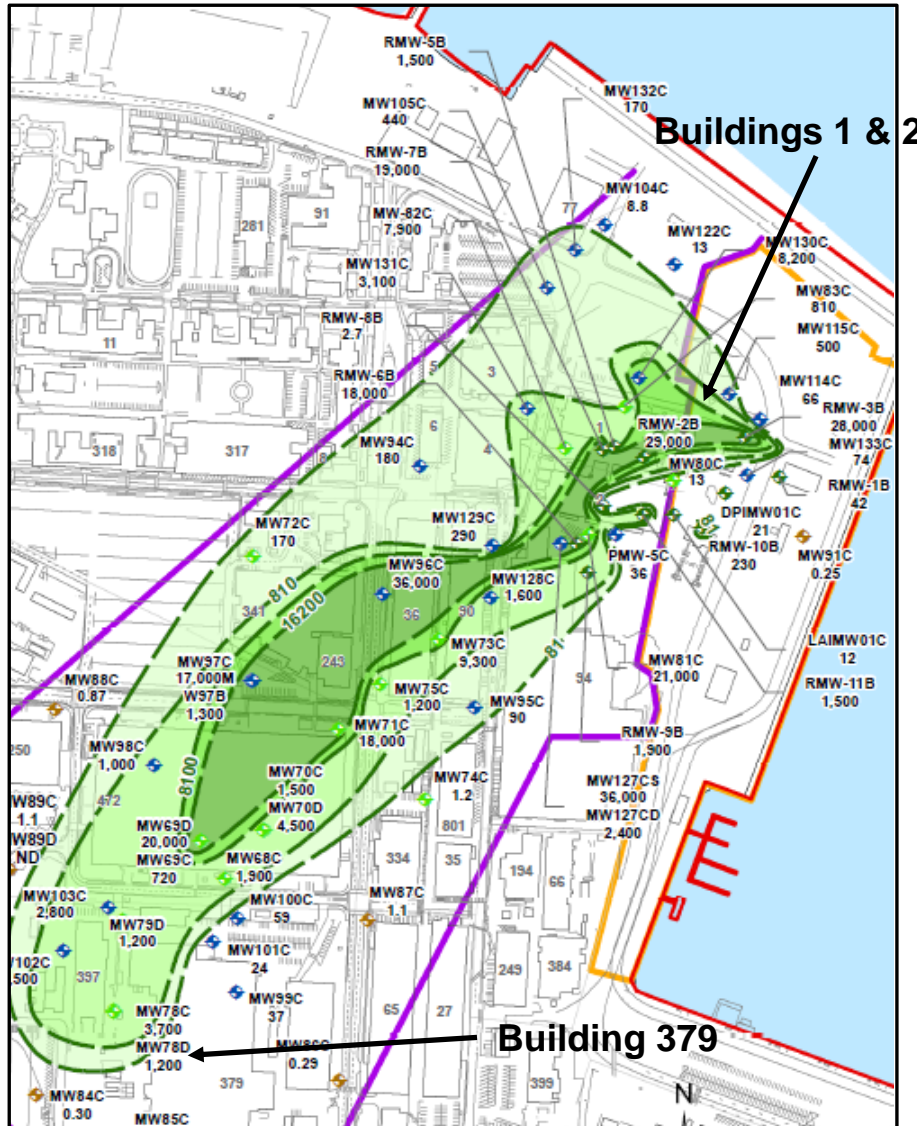
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Presentation Overview



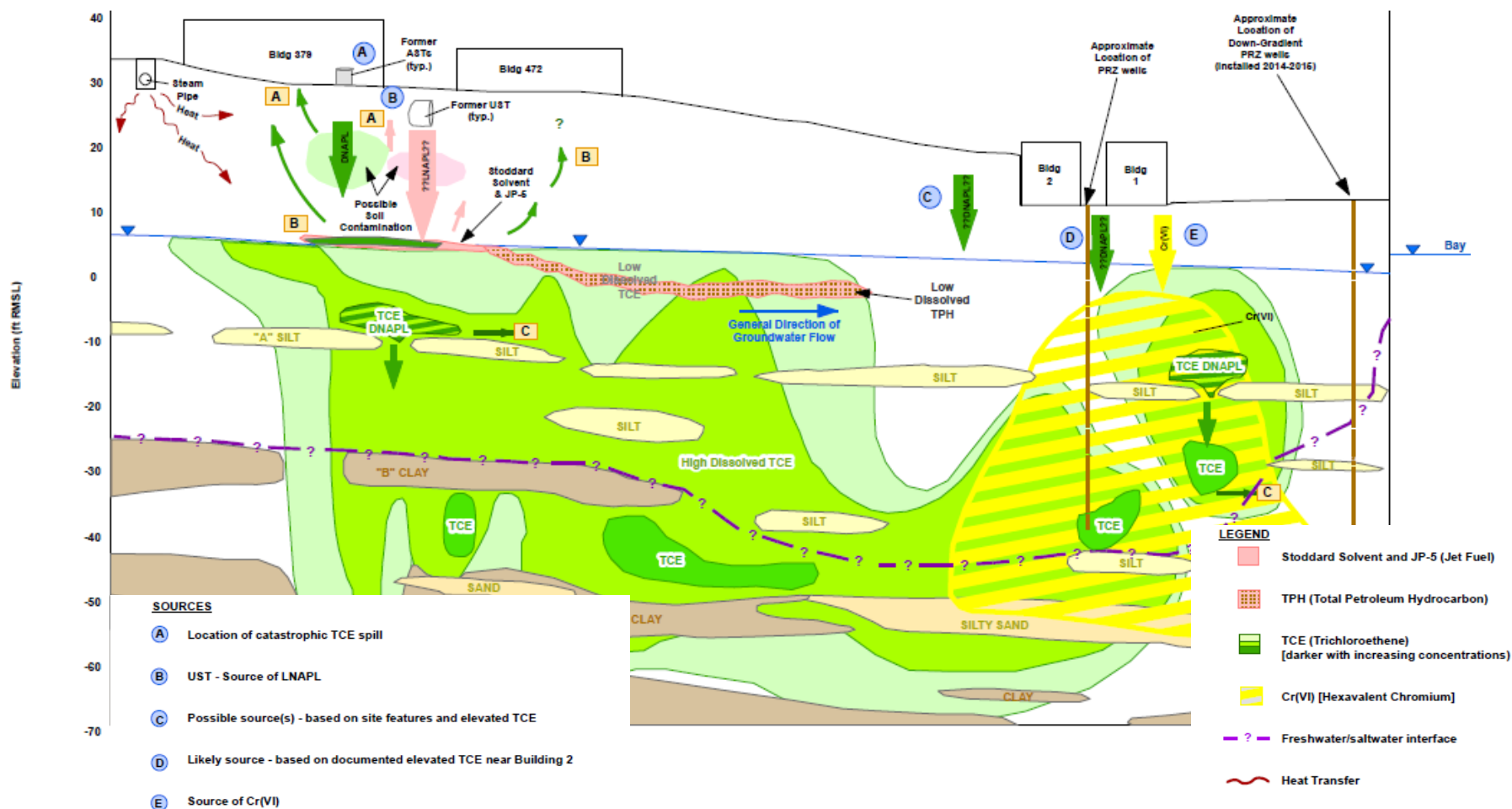
- 1. Introduction**
- 2. Objectives**
- 3. Approach**
- 4. Results**
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1. Introduction: Background

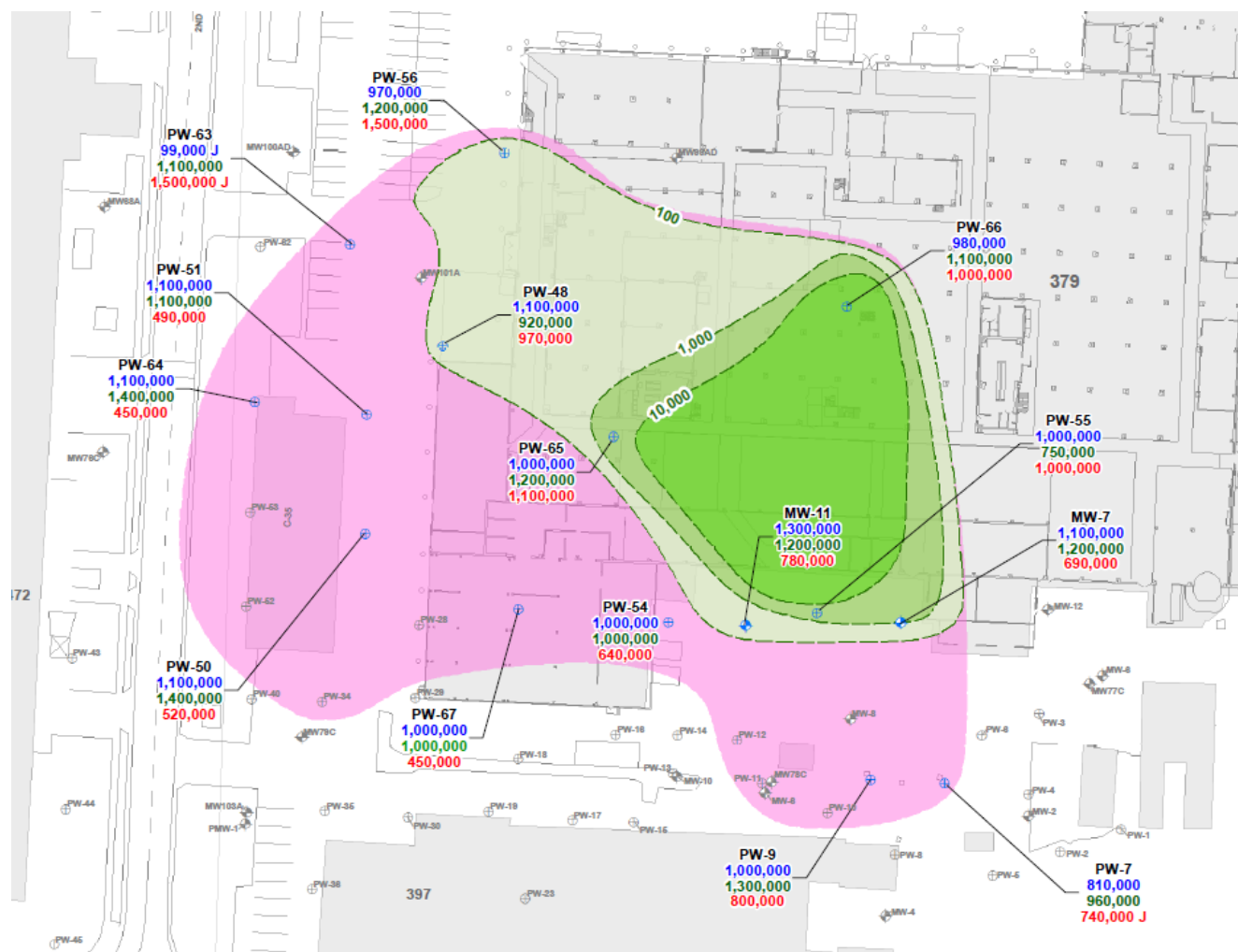


- Dissolved VOCs start at Building 379 and extend to Buildings 1 and 2 (~ 2,500 feet)
- Cr(VI) plume near Buildings 1 and 2
- Building 379 overlies a 2-foot thick Non Aqueous Phase Liquid plume, consisting of cVOCs, JP-5 and Stoddard solvent at 22 feet bgs
- There is a steam line near Building 379 that affects fate and transport of NAPL

1. Introduction: Conceptual Site Model



1. Introduction: Extent of NAPL

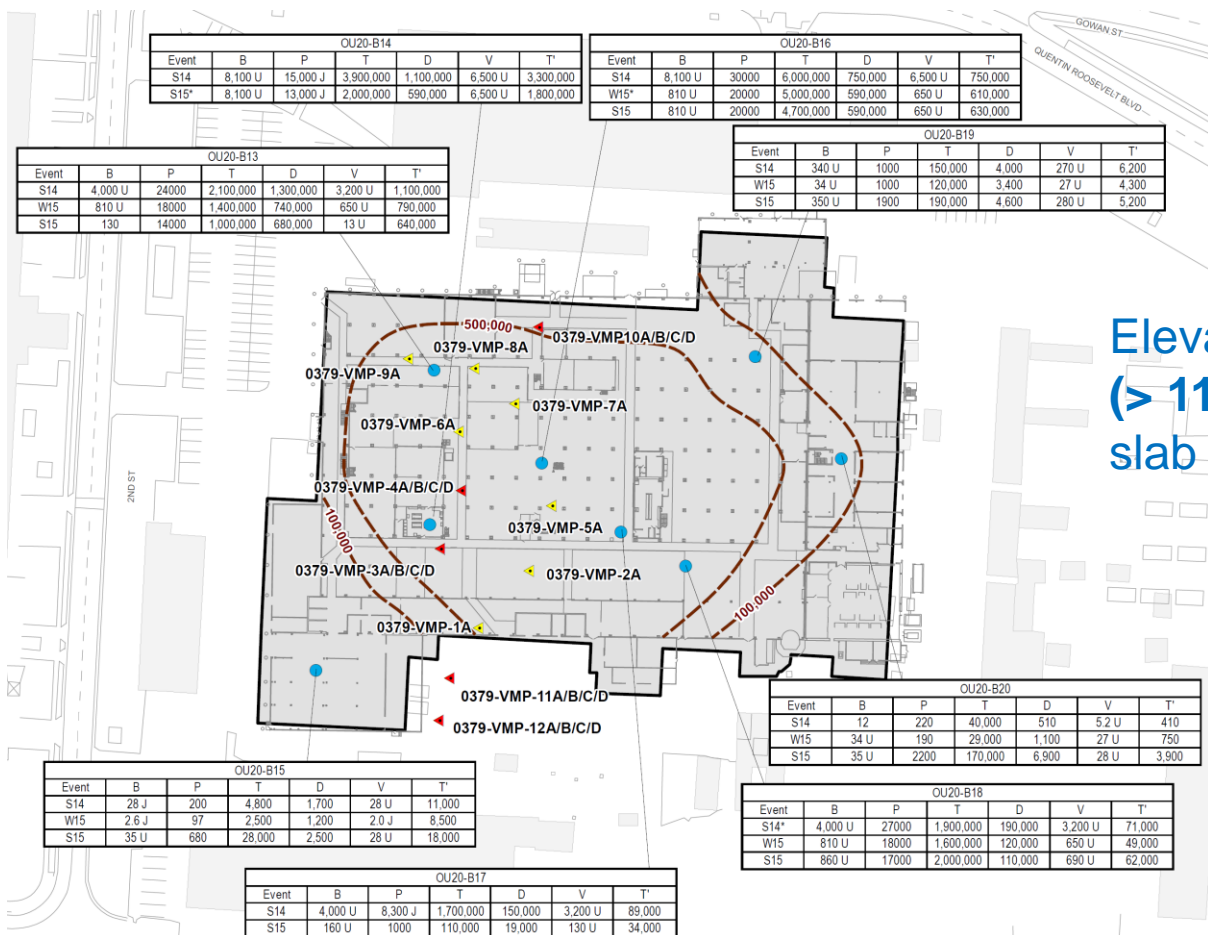


- TCE ISOCONCENTRATION IN LNAPL (mg/kg)
 - 10,000 mg/kg
 - 1,000 mg/kg
 - 100 mg/kg
- EXTENT OF LNAPL (2015)
- MONITORING WELL SAMPLED
- PRODUCT WELL SAMPLED
- MONITORING WELL NOT SAMPLED
- PRODUCT WELL NOT SAMPLED

Notes:

- 880,000 JP-5
- 740,000 TPH-d
- 920,000 Stoddard Solvent

1. Introduction: Extent of Sub-slab Soil Gas



Elevated levels of cVOCs/TPH
($> 11,000,000 \mu\text{g}/\text{m}^3$) in sub-slab soil gas

1.0 Introduction



- 2 Horizontal Wells, ~10 ft bgs, 140' well screens
- SVE is extracting ~ 1,000 lbs of chemicals (40% cVOCs per month*) since May 2017
- Mass estimates of NAPL are as high as 1 Million Gallons (~ 23 feet bgs)



** Note – although cVOCs represent 40% of mass in extracted vapor, they represent only 2% of the NAPL*

1. Introduction



- Temperatures of NAPL near the steam line have increased to as high as 45 °C
- The NAPL plume footprint has shrunk in past few years (but was stable for several years prior)
- Elevated temperature of NAPL **may** have intensified sub-slab soil gas cVOCs (and TPH) (Total > 11,000,000 µg/m³)
- Levels of cis-1,2-DCE in NAPL and sub-slab soil gas are elevated – this is likely due to biodegradation of TCE with the TPH serving as electron donor; which **may** have been “enhanced” by the elevated temperatures

2. Objectives



- What is the effect of steam on physical extent of NAPL over time?
- What is the effect of steam on NAPL composition over time?
- Are VOCs (and TPH) in the NAPL degrading?

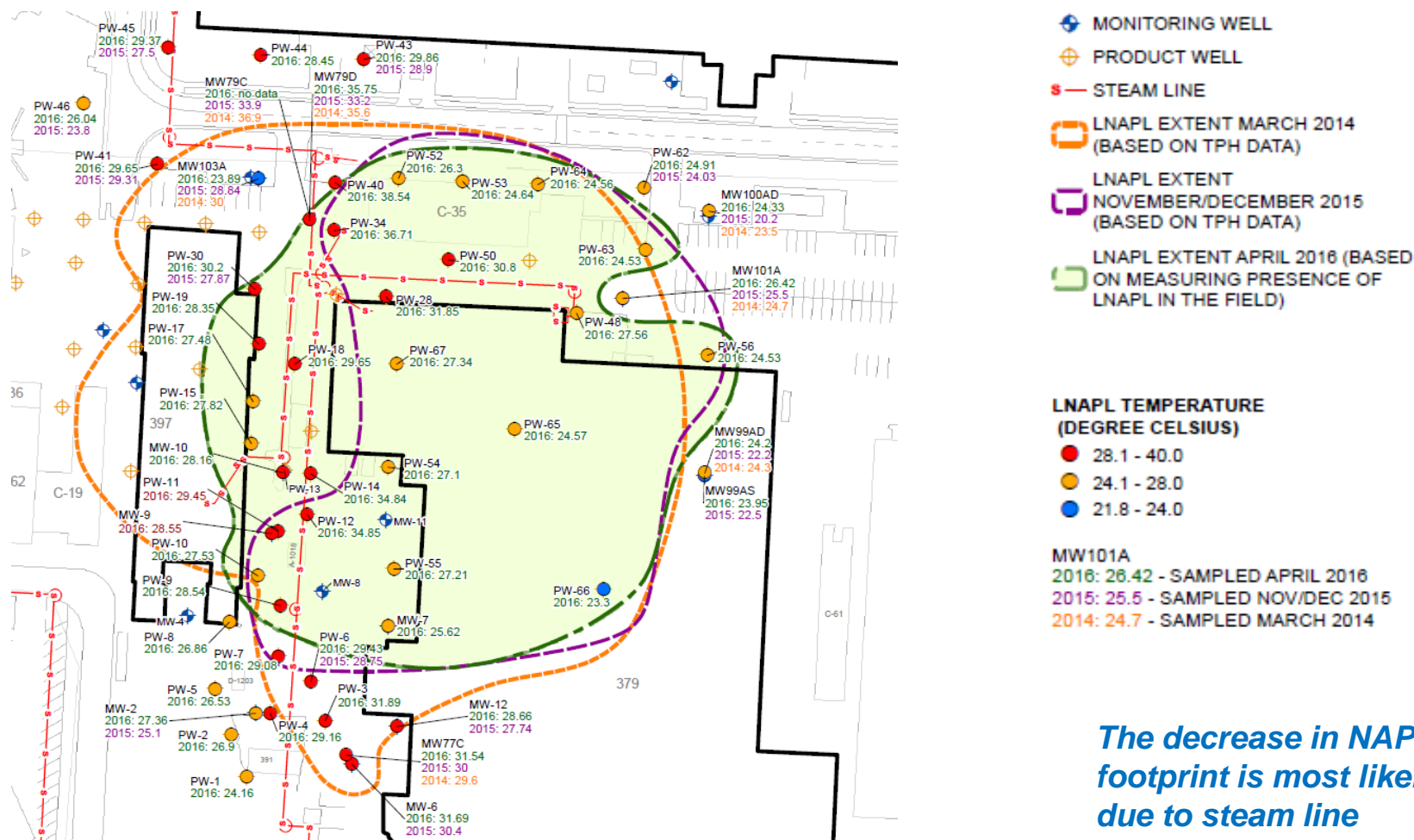
3. Approach



- Evaluate physical extent of NAPL over time (1998 to 2017), and extent of VOCs within NAPL
- Evaluate levels of TCE and cis-1,2-DCE within NAPL
- Microcosm studies to evaluate biodegradation
- Evaluate Fixed Gases in subsurface

4. Results: Effects of Steam on NAPL Extents

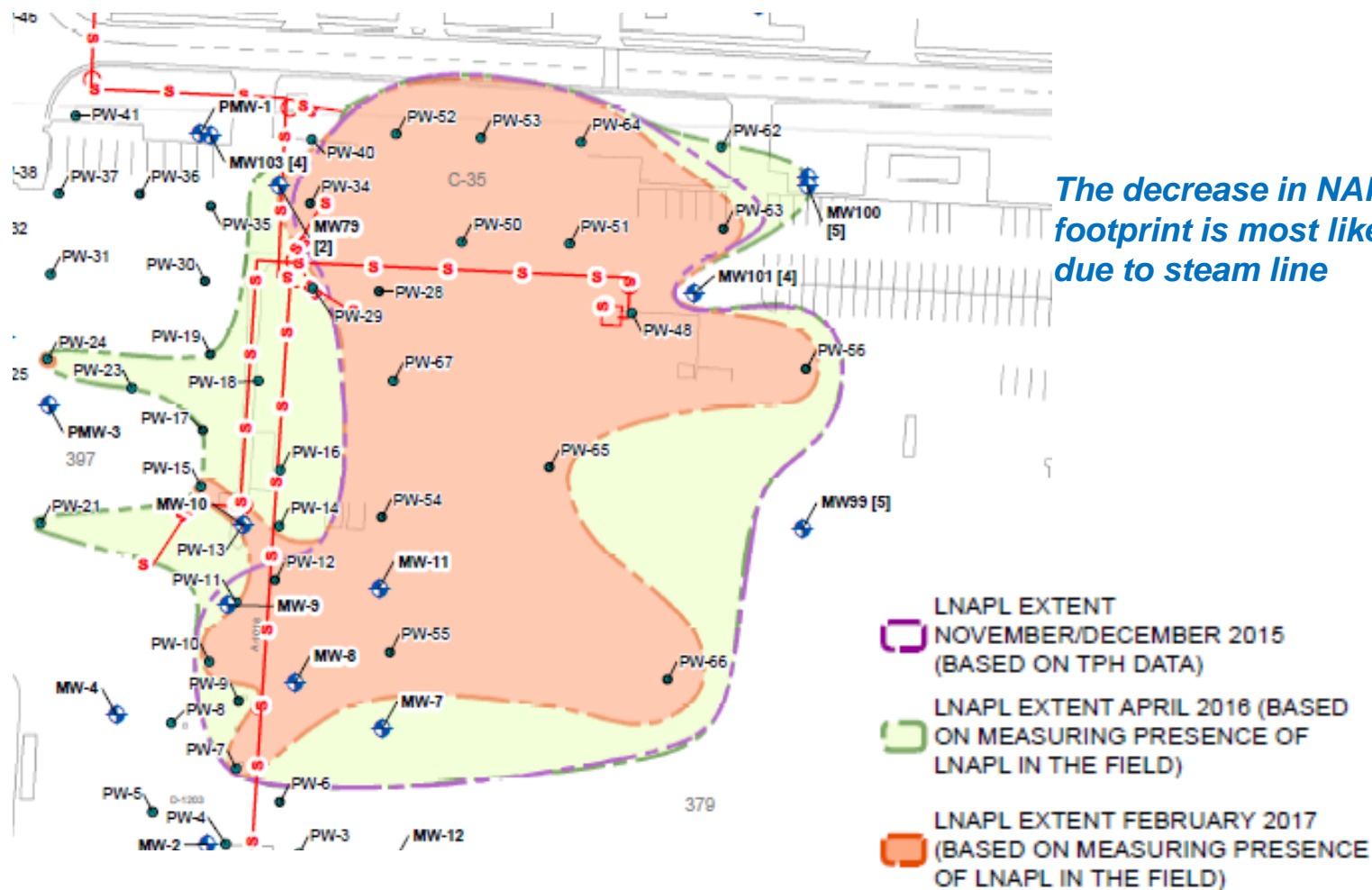
LNAPL Extent – 1998-2016



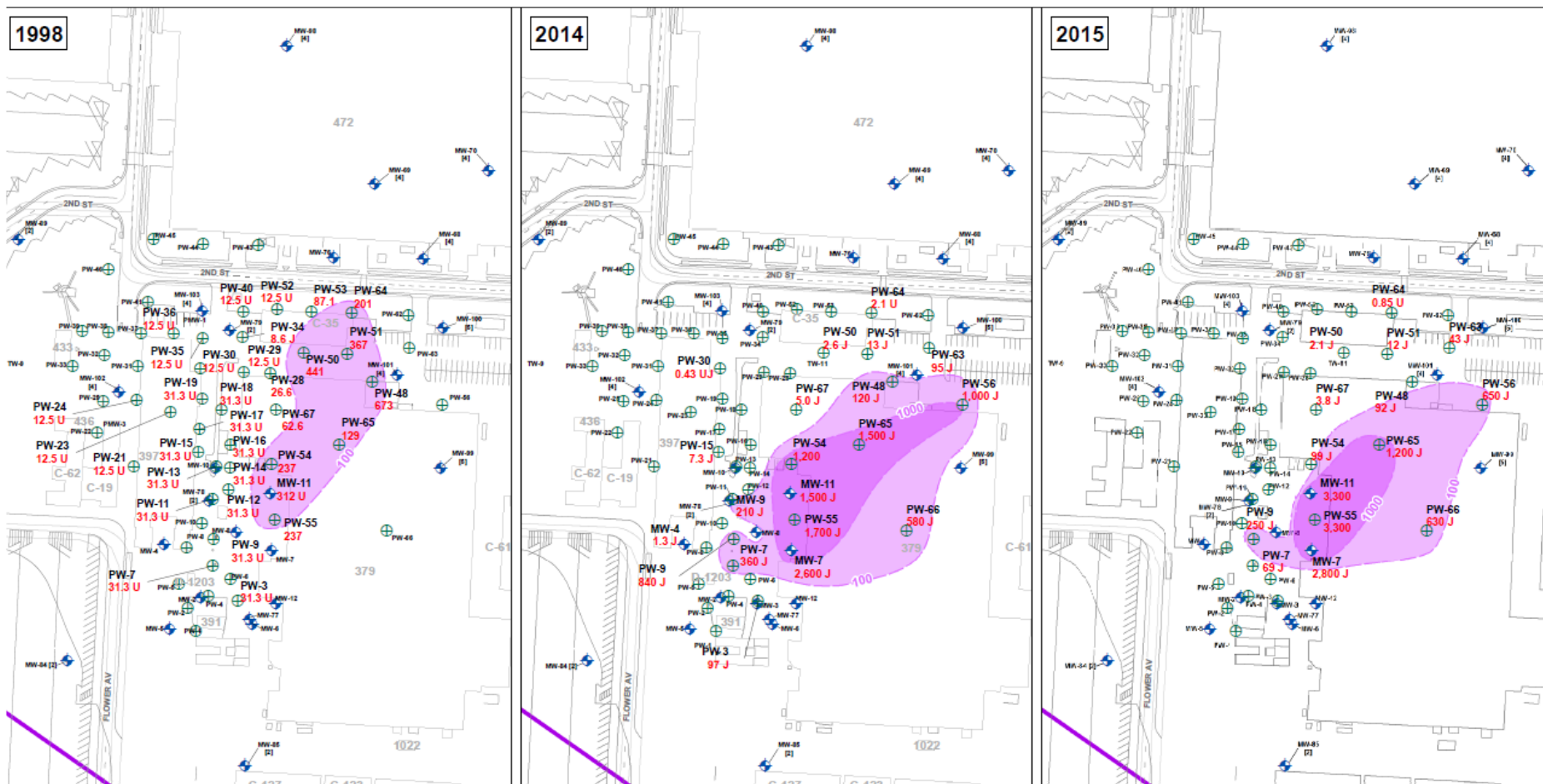
The decrease in NAPL footprint is most likely due to steam line

4. Results: Effects of Steam on NAPL Extents

LNAPL Extent – 2015 to 2017

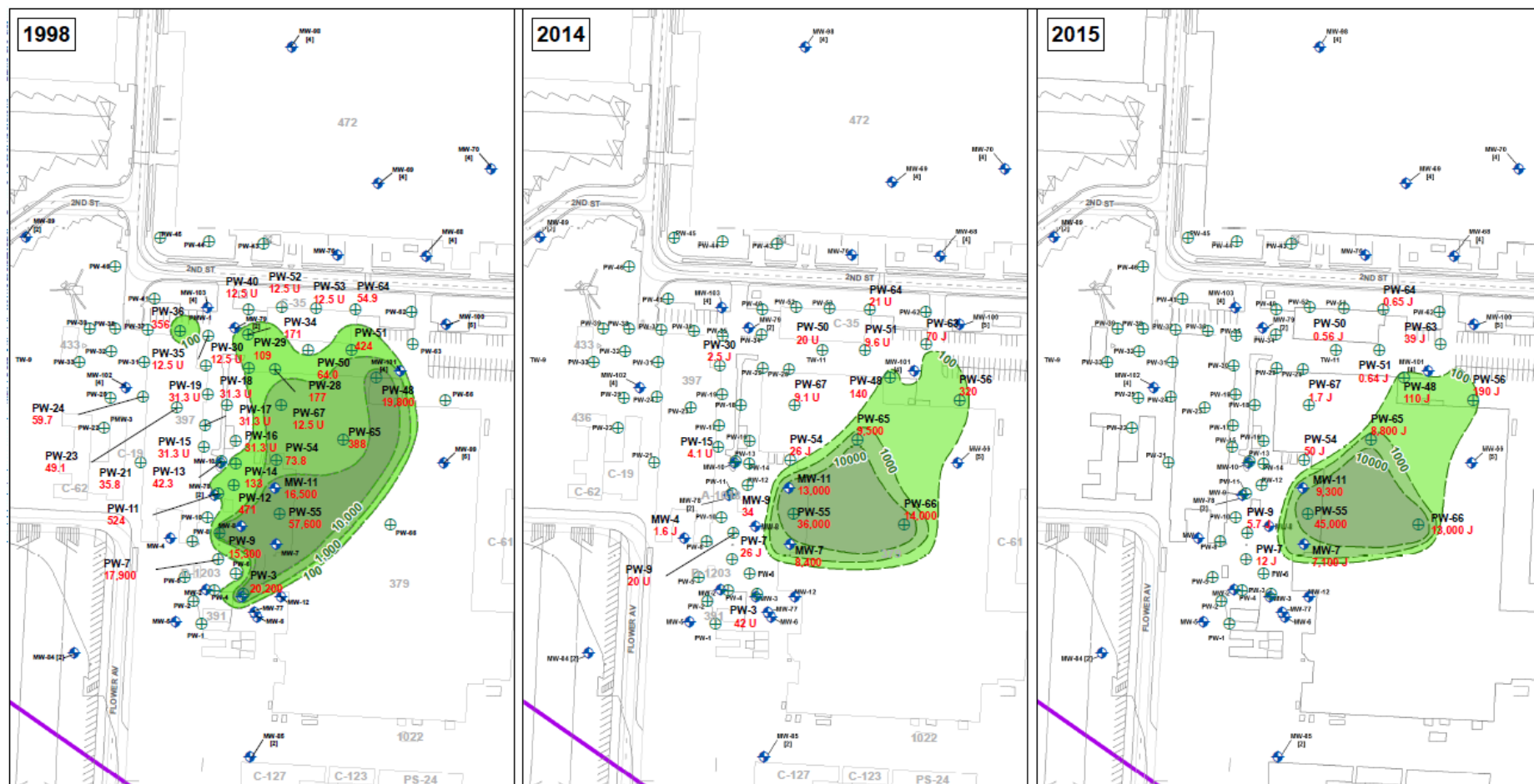


4. Results: Extent of cis-1,2-DCE in NAPL



Did steam enhance TCE biodegradation?

4. Results: Extent of TCE in NAPL



Did steam enhance TCE biodegradation?

4. Results: Microcosm Studies



Initial Concentration (mg/L)	
TCE	91
cDCE	83
1,1-DCE	0.3
1,1,1-TCA	8
1,4-Dioxane	0.4

TVOC \approx 182 mg/L

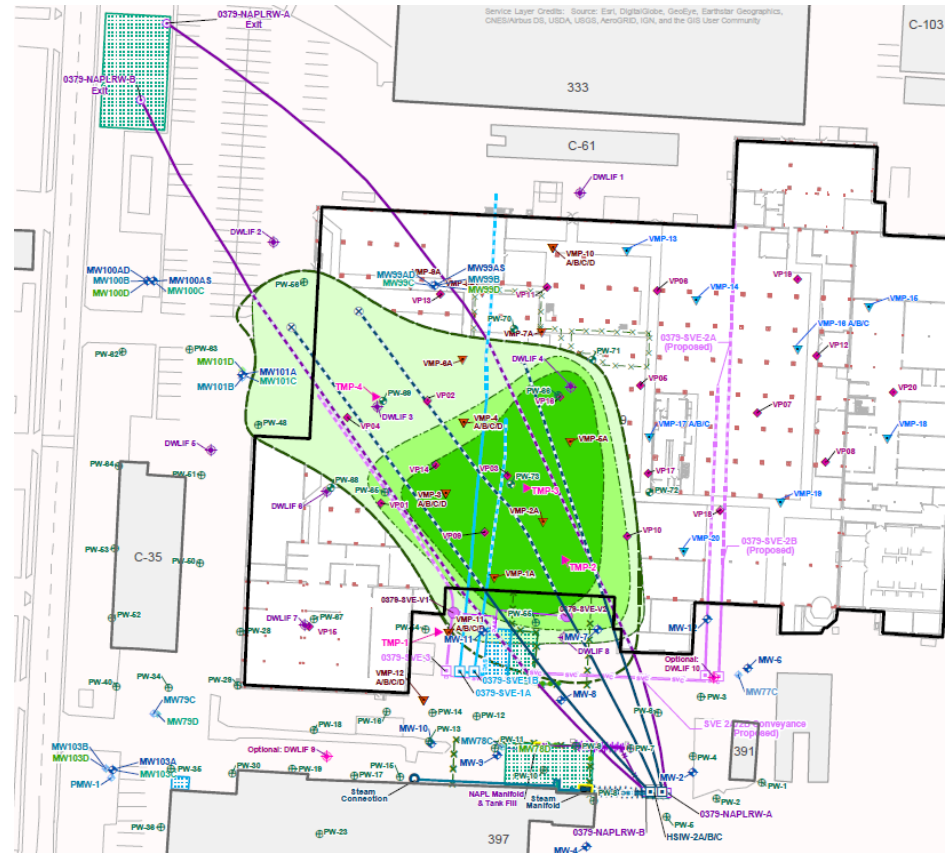
1. Analysis of LNAPL showed evidence of TCE dechlorination to cDCE in active controls (no amendments or bioaugmentation)
2. VOCs in LNAPL undergoing slow natural dechlorination, presumably at NAPL-water interface, possibly being enhanced by steam
3. Microcosm studies from other NASNI sites **did not show dechlorination** (even with levels lower than OU 19): these other sites did not have TPH present (or steam)

4. Results: CO₂/O₂ Levels in SVMPs

1. Soil gas samples at 15 and 20 feet bgs showed elevated CO₂ levels and low O₂ levels prior to SVE
2. This suggests that the TPH is degrading
3. Continued SVE has caused O₂ to increase, resulting in a dynamic or quasi equilibrium (any CO₂ that is generated is extracted by the SVE system)
4. Future studies being considered include:
 - Evaluate Natural Source Zone Depletion (NSZD)
 - Use Compound Specific Isotope Analysis (CSIA) to confirm degradation of TCE within LNAPL

4. Results: Effect of Findings on Future Remedial Strategy

- While steam was initially viewed as a foe, the project team decided it was a friend
- Planning to actively inject steam:
 - Inject steam below NAPL to Increase volatility of TCE portion of NAPL, with vapors being extracted by the SVE system
 - Extract NAPL (mobility enhanced by steam)
 - Fortuitous increase in biodegradation
- Planning to use Horizontal wells, due to access issues



5. Conclusions



- A 20 °C increase in temperature can have a significant impact on NAPL mobility and extent
- Degradation of cVOCs (and TPH) in a NAPL mixture is not a myth
- A 20 °C increase in temperature appears to be having a significant beneficial impact on biodegradation of cVOCs in NAPL