Naval Facilities Engineering Command
Southwest Division

Remediation Technologies Development Forum
NAPL Alliance
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LNAPL Sites
NAS North Island

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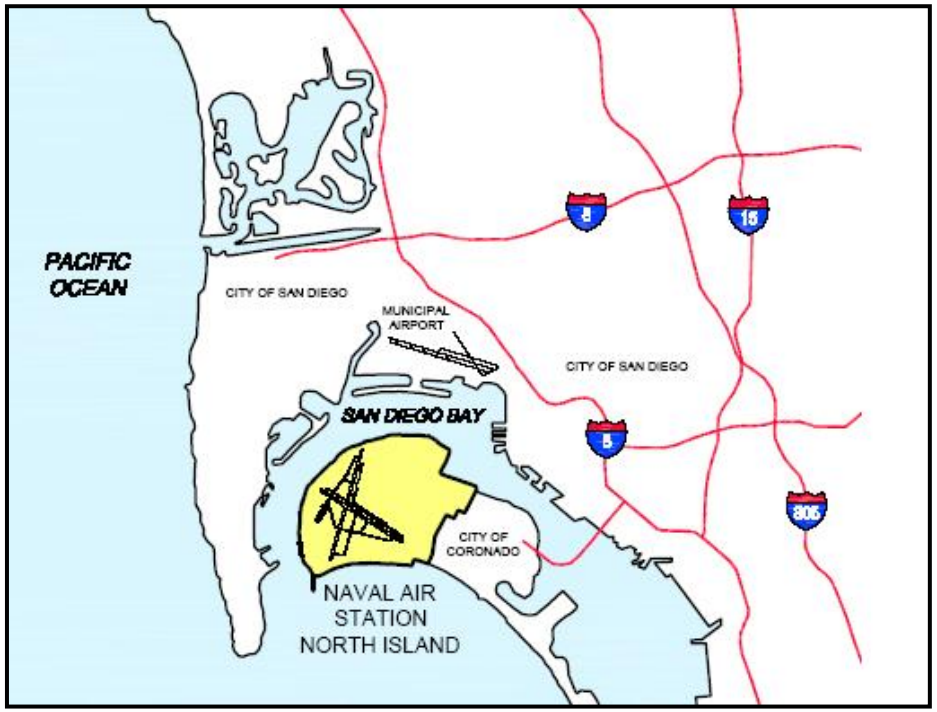
Presentation Overview

- Site Locations and Descriptions
- Project Backgrounds
- Technical Approaches
- Mass Removal
  - Quantities
  - Trends
- Optimization Activities
- Next Steps



LNAPL Sites at NAS North Island

OPERABLE UNIT 19

IR SITE 9

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Installation Restoration Site 9

- **Site Location and Description**
  - **Former Chemical Waste Disposal Area**
    - Operated 1940s to 1970s
    - Reported up to 32 M gallons of liquid waste disposed
    - Nick-named “the fiery marsh”
  - **Located in Southwest corner of NAS North Island**
  - **Partial man-made fill area**
  - **Groundwater at approx 10 ft bgs**
  - **Site assessments conducted 1983 to 1994**
    - TCE identified as major risk driver in soil

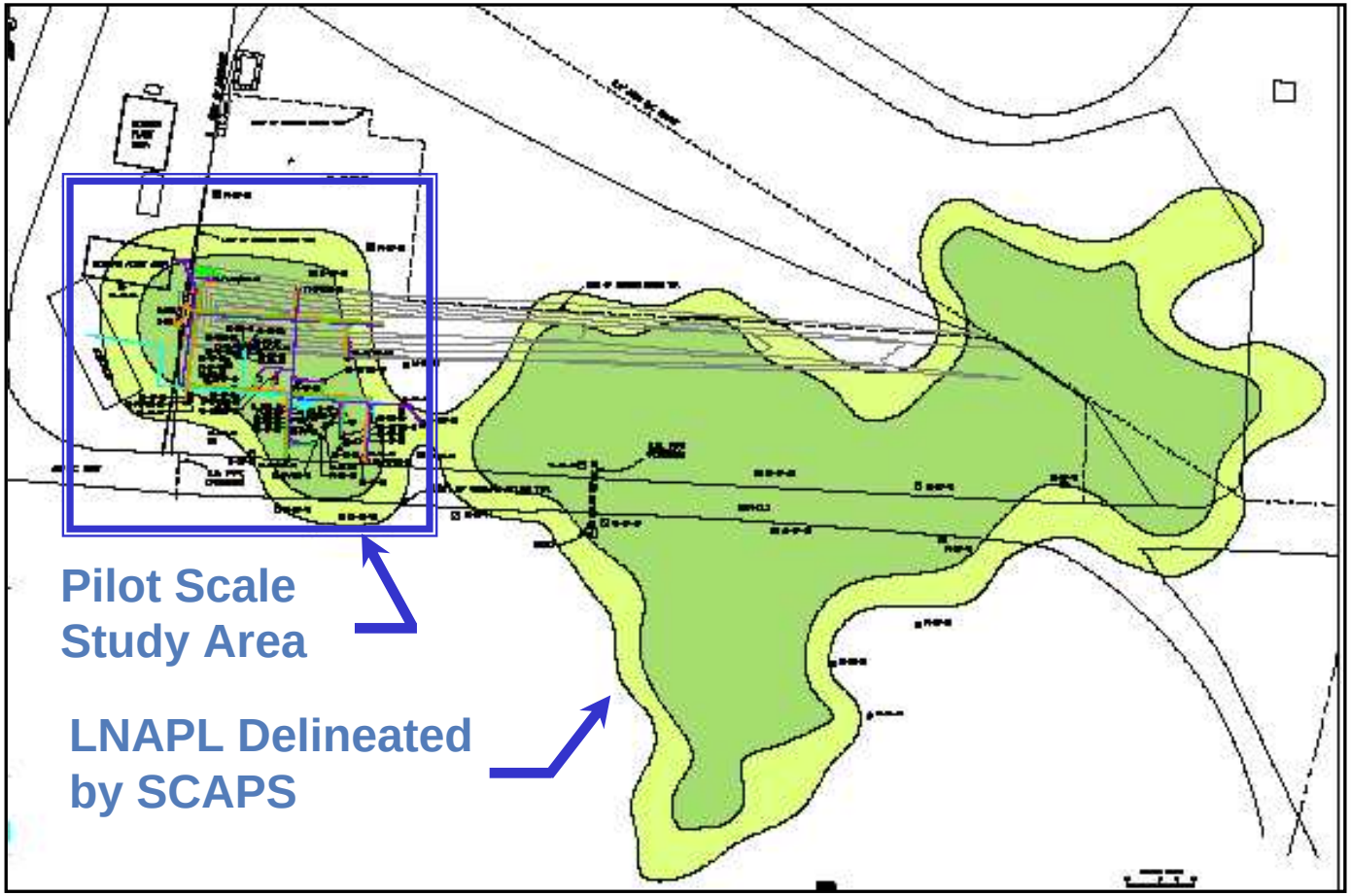
Installation Restoration Site 9

- **Project Background**
  - **March 97: Navy installed interim 3,000 scfm SVE system**
    - Non-Time Critical Removal Action (NTCRA) under CERCLA
    - Objective: REDUCE MASS of VOCs in soil
    - System operated for 26 months
    - A-typical response of SVE prompted additional investigation
  - **Sept 98: Site Characterization Analysis Penetrometer System (SCAPS) investigation**
    - LNAPL w/ commingled TCE identified underlying the site
    - Prompted technology review
  - **Sept 99: Initiated Pilot-scale steam injection to enhance SVE**
    - System operated for 7 months
  - **Sept 00: Began limited LNAPL recovery using 22 skimming wells**
  - **May 02: Initiated Full-scale SVE and total fluids extraction**
  - **Oct 02: Initiated Full-scale steam injection**

IR Site 9 – Pilot Scale Study

- **Technical Approach**
  - **–Pilot Scale Thermally Enhanced Operations**
    - Utilized Steam Injection
      - –Volatilize TCE: Capture using SVE
      - –Reduce LNAPL viscosity: Capture using product skimming
    - System Design
      - –Roughly one-tenth the areal extent of the original SVE
      - –Utilized vertical instead of the original SVE horizontal wells
    - System Components
      - –10 combination product skimming/ SVE wells,
      - – 3 steam injection wells, and
      - –10 sets of nested thermocouples

IR Site 9 – Pilot Study Area



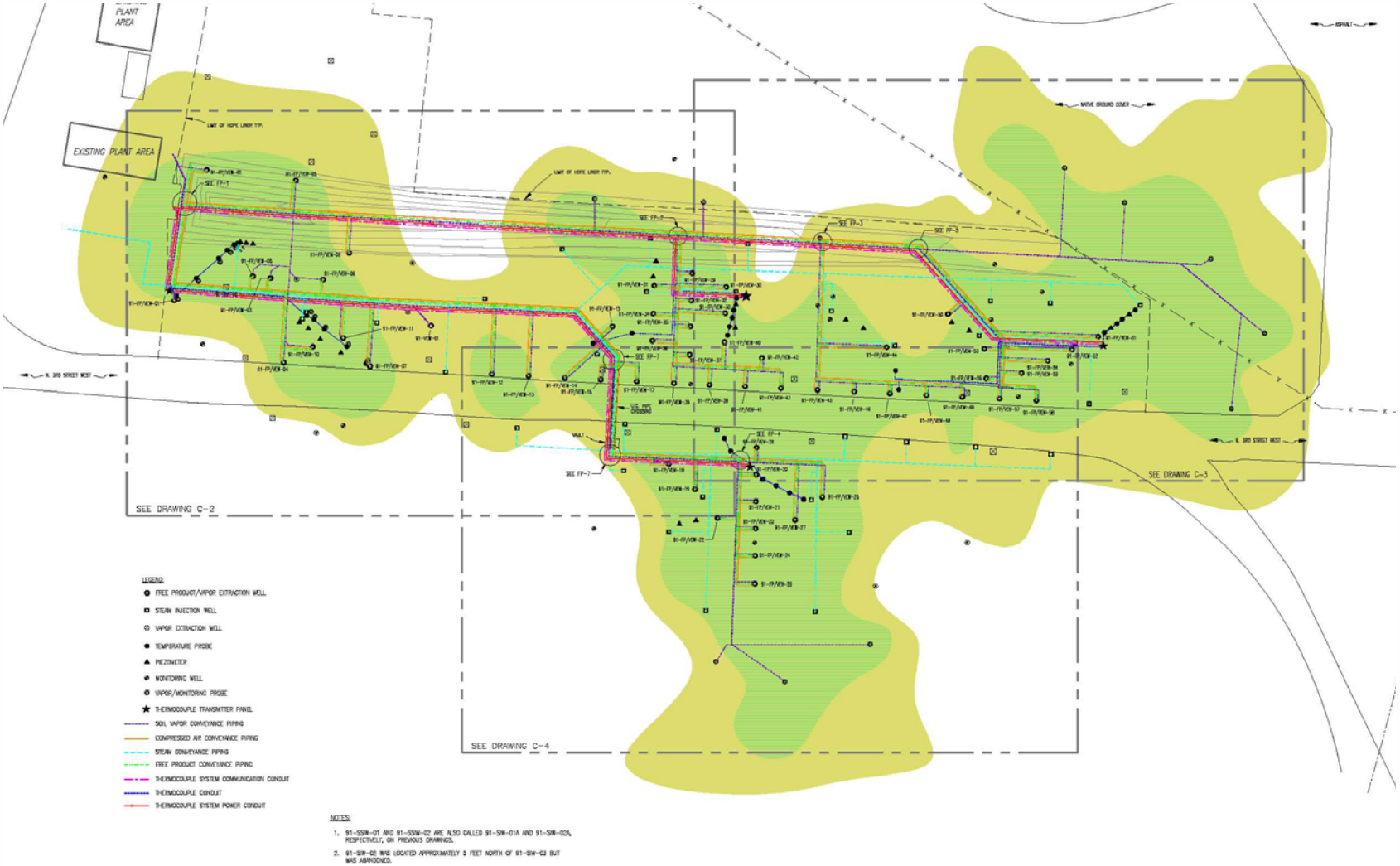
IR Site 9 – Pilot Scale Study

- **Technical Approach**
  - **Pilot Scale Findings**
    - Effectively mobilized LNAPL
      - Physical displacement away from steam injection wells observed
      - Residual hydrocarbon concentrations were decreased to non-detect levels near steam injection wells
    - Effectively mobilized TCE (dissolved phase)
      - in situ condensation of TCE toward recovery wells
      - concentrations increased with distance - able to capture at recovery wells
  - **Over 2,000 gallons FP removed and disposed off-site**

IR Site 9 – Full Scale Thermal

- **Technical Approach**
  - **–Full Scale Thermally Enhanced Operations**
    - Based on findings from Pilot, proceeded to Full Scale
    - Well Field System Components
      - –58 combination free-product recovery/ SVE wells,
      - –12 SVE-only wells, and
      - –34 steam injection wells
    - Treatment System Components
      - –Total fluids extraction/ separation
      - –Soil Vapor Extraction
      - –Groundwater Treatment

IR Site 9 – Technical Approach (Well Field)



IR Site 9 – Technical Approach (Treatment)

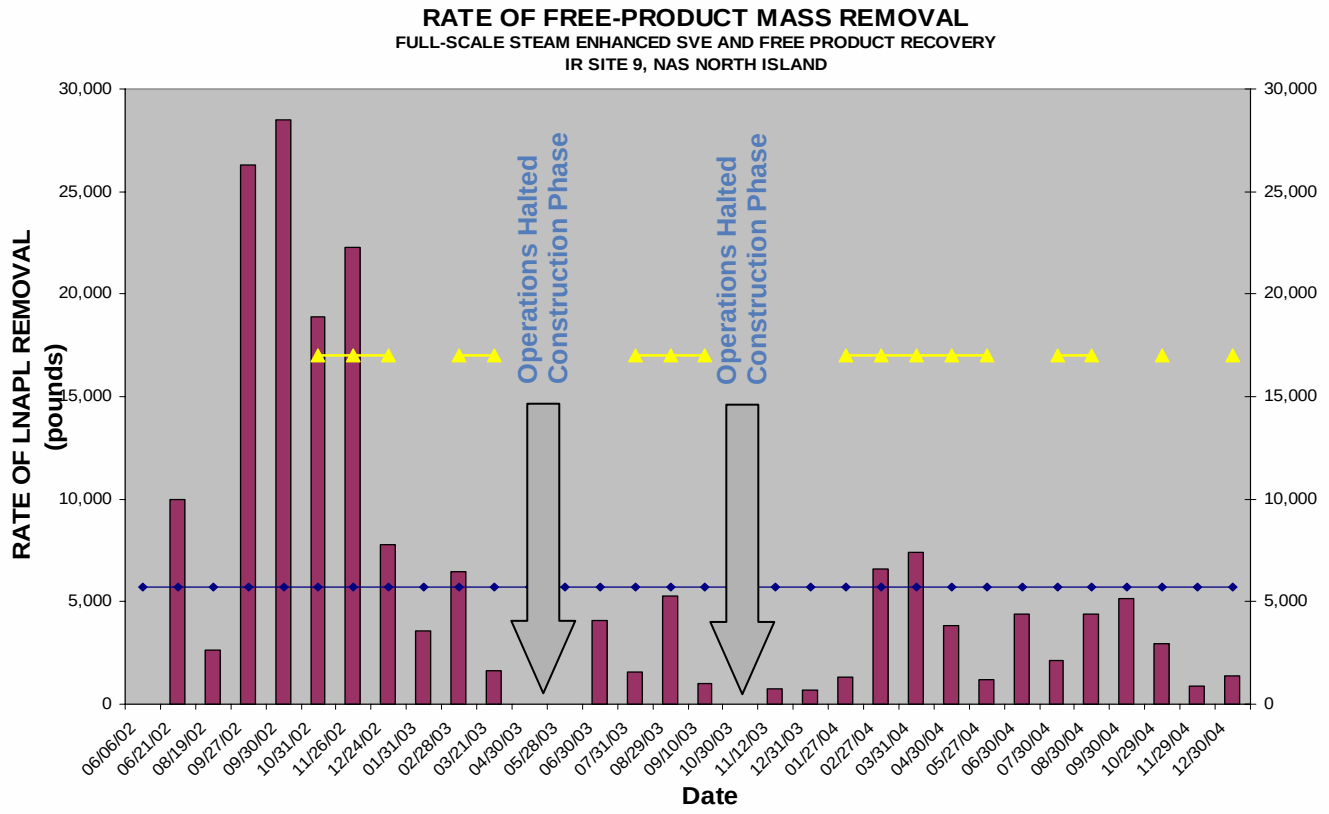
- **Total Fluids Treatment**
  - Gravity Separation for LNAPL
  - On-Site Storage of LNAPL
  - Off-site Disposal of LNAPL
- **Soil Vapor Extraction**
  - 1,200 scfm extraction system
  - Dual train carbon adsorption
  - On-site carbon regeneration
  - Gravity Separation of recovered DNAPL
  - On-Site Storage of DNAPL
  - Off-Site Disposal of DNAPL
- **Groundwater Treatment**
  - Biological Treatment Train
    - Two Fluidized Bed Reactors
    - Sequential Anaerobic Aerobic
  - Carbon Polishing
  - Discharge to POTW

IR Site 9 – Mass Removal Quantities

Media	Original SVE *26 mos* (lbs)	PS Steam SVE & FP Skimming *9 mos* (lbs)	FS FP Skimming *16 mos* (lbs)	CTO 0047 FS Steam SVE & FP Recovery *14 mos* (lbs)	CTO 0108 FS Steam SVE & FP Recovery *12 mos* (lbs)	Cum since Project Inception *77 mos* *(lbs)*
Free Product		14,600	82,000	139,975	39,791	276,336
Solvent (vapor)	80,000	14,000		66,368	19,627	179,995
Mixed VOCs in gw				8,997	14,983	23,980
Total	80,000	28,600	82,000	215,340	74,401	480,311

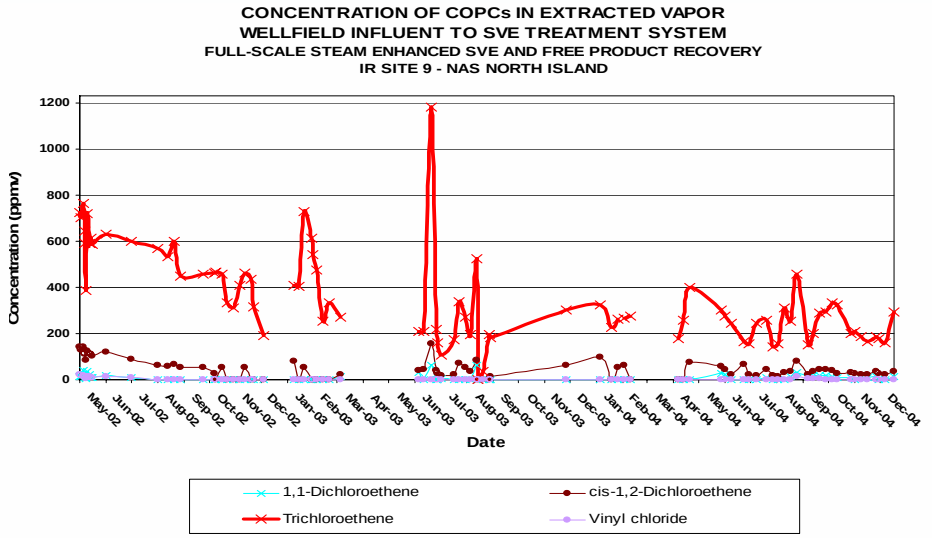
IR Site 9 – Mass Removal Trends

- **Recovery rates continue to indicate a slowing trend**

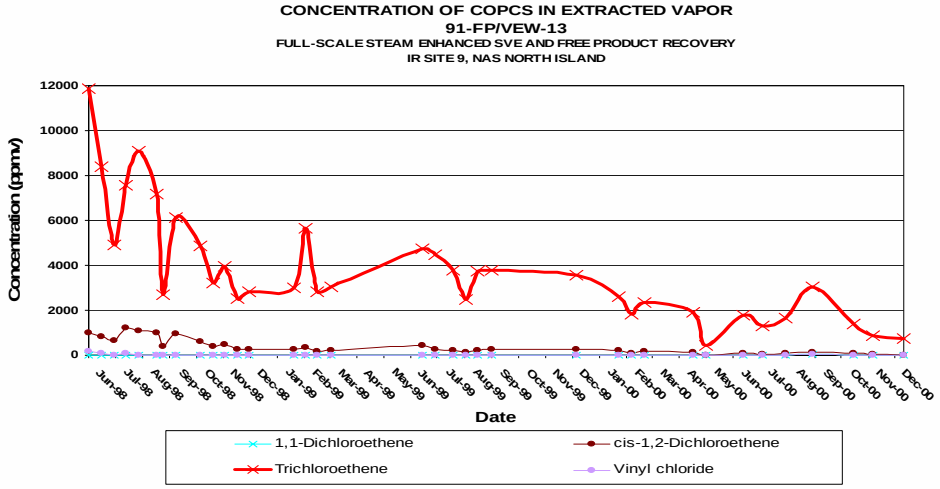


SVE Concentration Trends

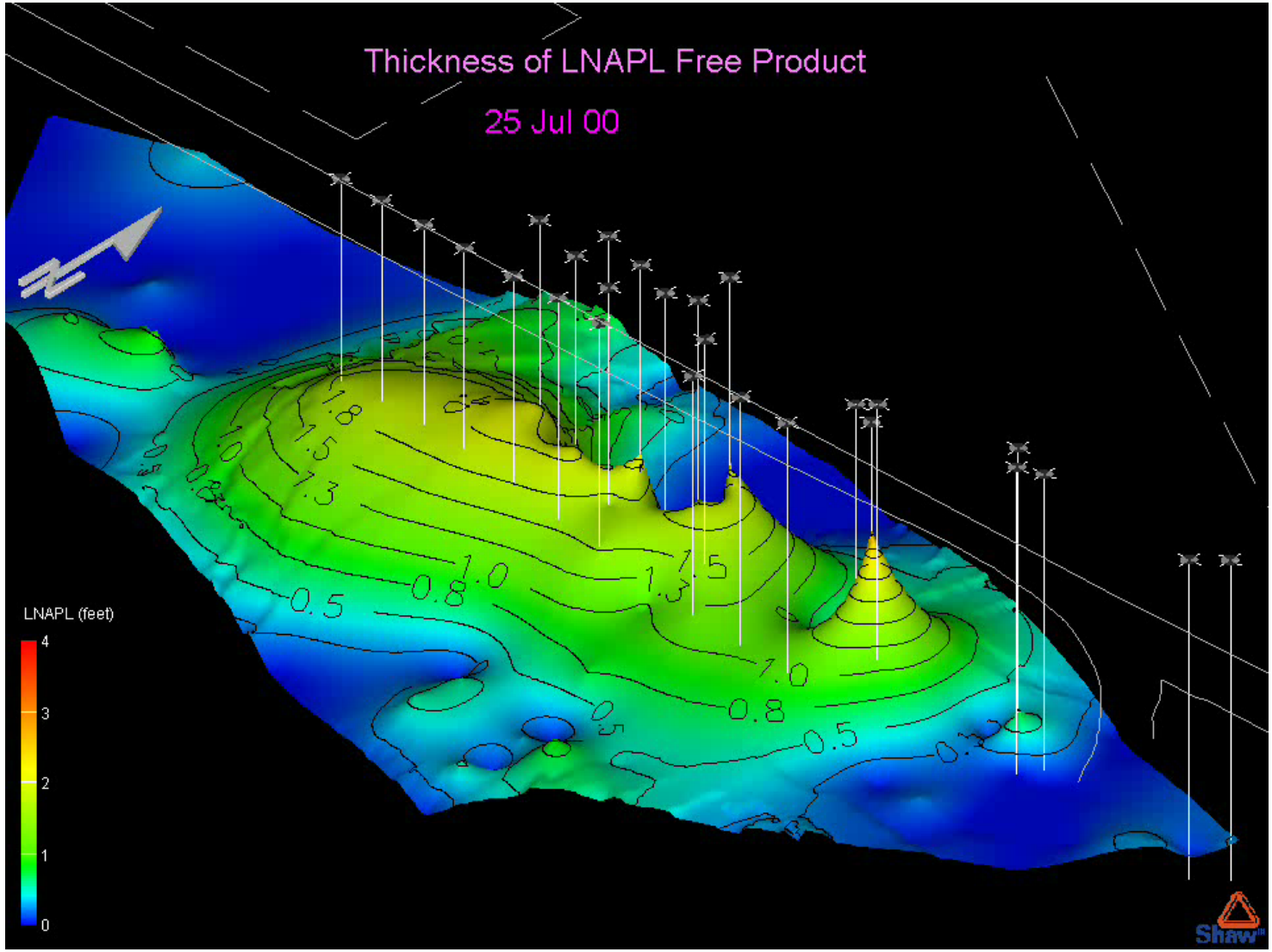
- **System influent concentrations continue in decreasing trend**



- **All wells show decreasing concentrations**
- **Some wells continue to show significant mass removal**

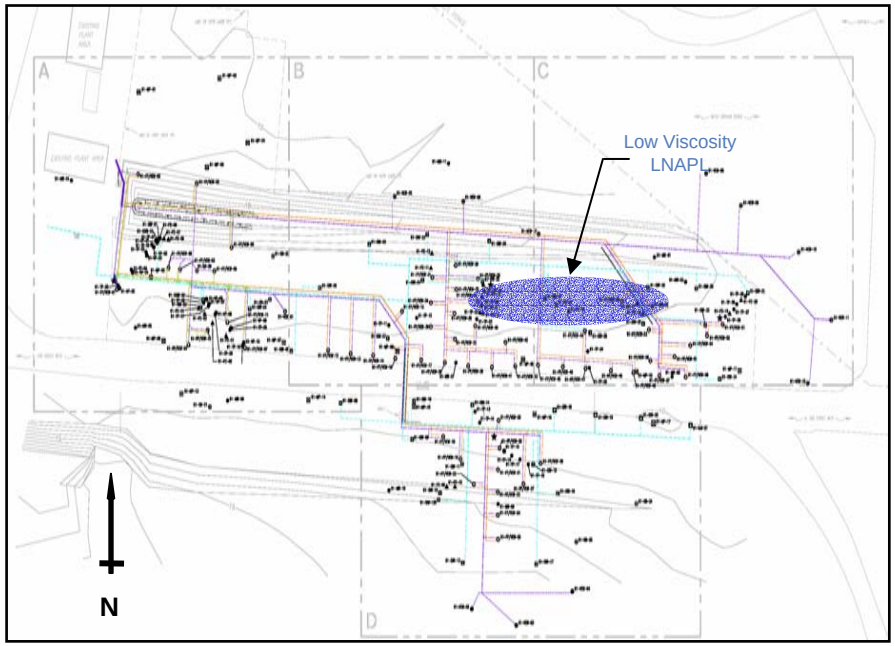


IR Site 9 – Mass Removal Trends



IR Site 9 – Optimization
Identification of Remaining LNAPL

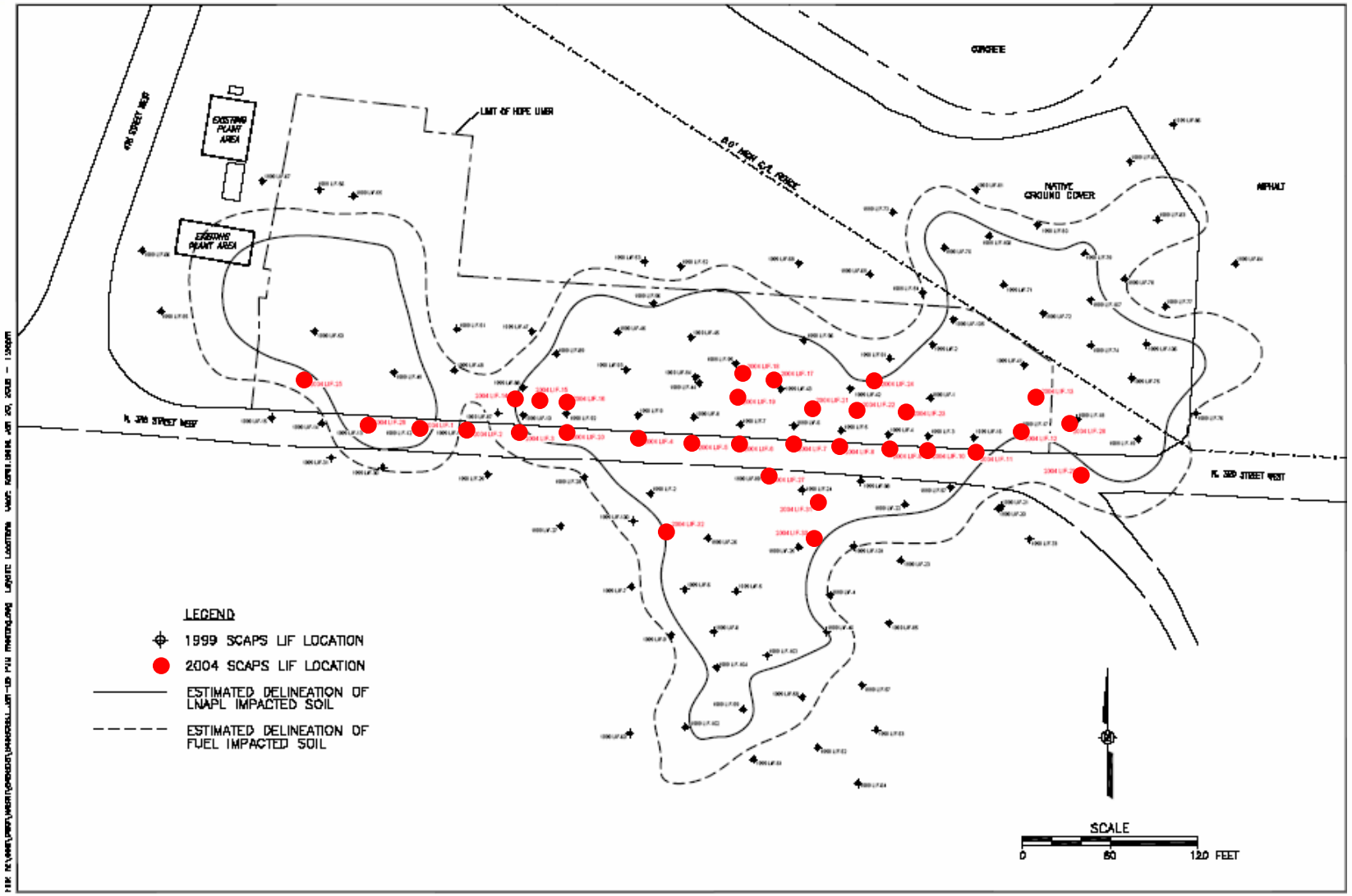
- **Low viscosity free product**
  - **Identified in the central portion of the site**
  - **Difficult to remove with current pumps**
  - **Makes up majority of LNAPL present in current extraction wells**
  - **Early analytical results indicate:**
    - Refined petroleum product
    - Extremely low viscosity at room temperature
    - High concentrations of TCE
  - **Could be Navy Special Fuel Oil (NSFO)**
- **Utilize SCAPS for Remaining LNAPL**
  - **Identify areas with potential mobile and immobile LANPL**
  - **Determine if LNAPL viscosity can be distinguished using SCAPS**



IR Site 9 – Optimization
SCAPS LIF Investigation

- **Located previous SCAPS LIF pushes using GPS**
  - **New push locations were selected as close as possible to support representative data comparison**
  - **Remediation system infrastructure limited access to portions the site.**
- **Thirty-two SCAPS pushes were advanced**
  - **Each push advanced to approximately 20 feet bgs.**
  - **SCAPS collected both CPT and LIF data at each location.**
  - **The data were evaluated and compared to the previous SCAPS data in the field.**
- **Five small diameter wells were constructed**

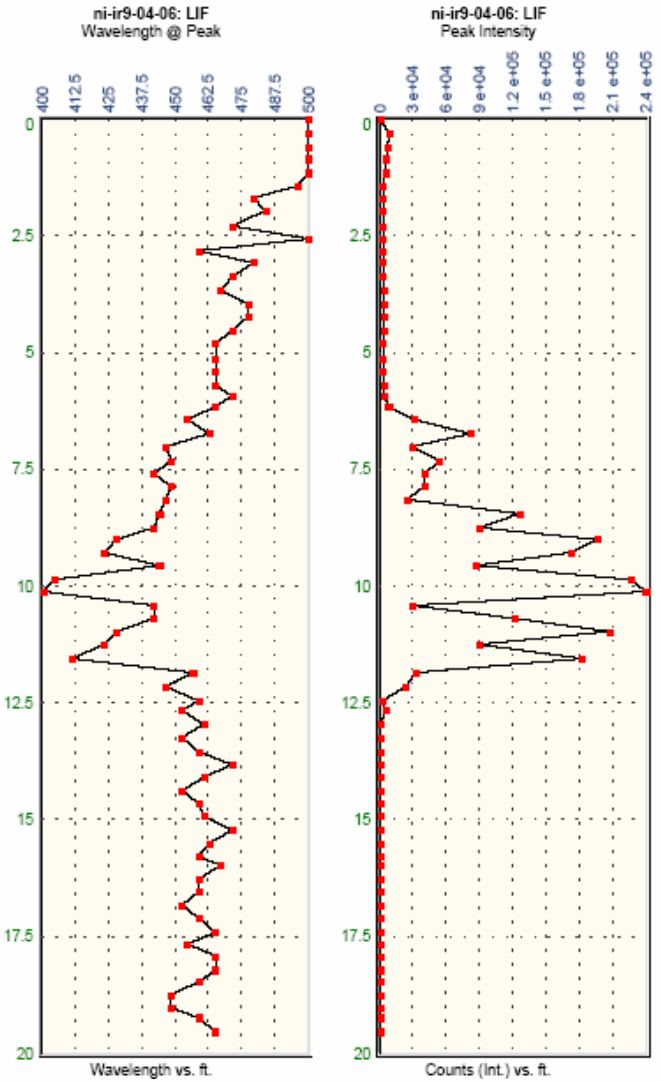
SCAPS LIF Investigation: Push Locations



SCAPS LIF Investigation: Data Analysis

- **LIF results are evaluated on intensity of fluorescence and wavelength**
  - **Greater intensity suggests greater volume of NAPL present**
  - **Shorter wavelength suggests "lighter" fuel components in the NAPL**

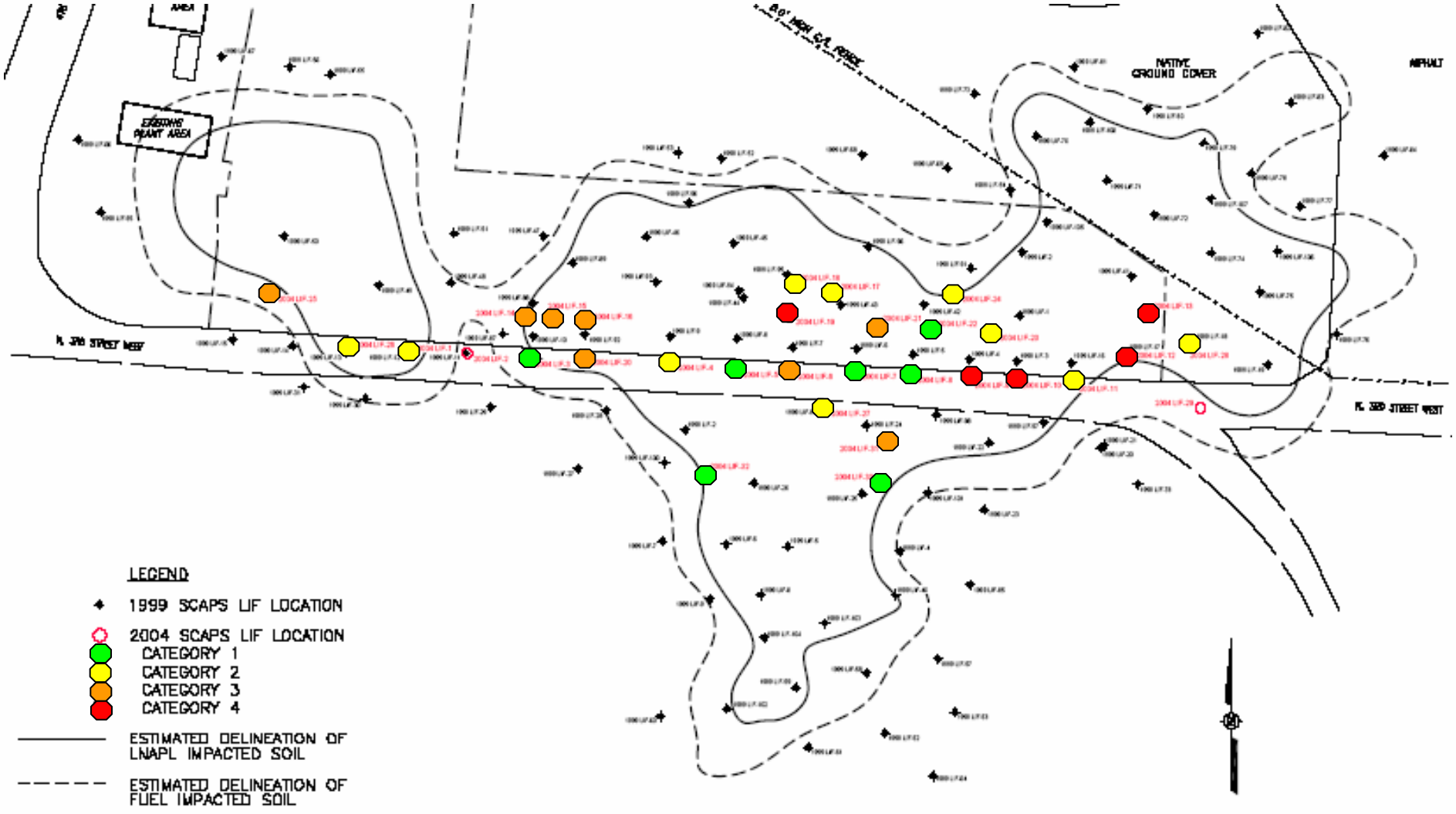
- **Of the 32 pushes:**
  - **5 show very low fluorescence intensity**
  - **20 showed fluorescence indicating fuel-impacted soil**
  - **7 show fluorescence indicating the potential presence of mobile LNAPL**



SCAPS LIF Investigation: Data Analysis

- **The results have been grouped into four broad categories that represent increasing fluorescence intensity**
  - **Category 1 has the weakest fluorescence;**
  - **Category 4 has the strongest fluorescence.**
  - **"Weak" and "strong" fluorescence are judgmental interpretations that reflect both the fluorescence intensity and the thickness of the fluorescence interval.**
- **The pushes are distributed in the categories as follows:**
  - **Category 1: 9 pushes**
  - **Category 2: 10 pushes**
  - **Category 3: 8 pushes**
  - **Category 4: 5 pushes**

SCAPS LIF Investigation: Categorized Pushes



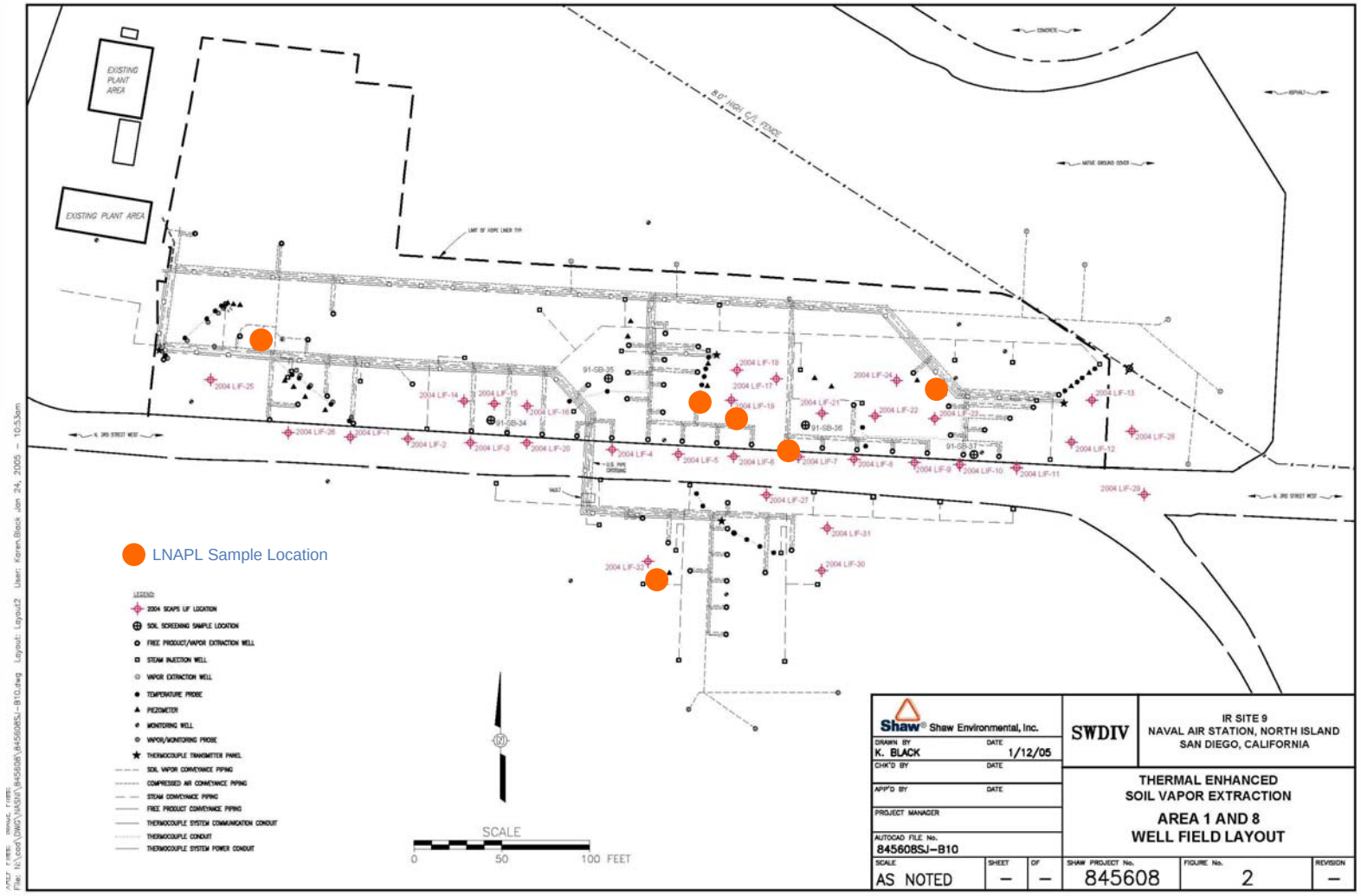
SCAPS LIF Investigation: Results and Discussion

- **Category 1 grouping represents locations where mobile and immobile NAPL appears to have been significantly reduced or eliminated.**
- **Most pushes in the other categories show at least a decrease in fluorescence from 1999.**
- **For all categories, the wavelengths are generally longer than before, which suggests the loss of "lighter" fuel components.**
- **The loss of "lighter" fuel components also suggests less VOCs potentially commingled in the remaining NAPL.**
- **The longest wavelengths are observed in the northern area of the site where NSFO has been tentatively identified.**
  - **Very long carbon-chain molecules masking VOC content**
  - **VOC analyses indicated high TCE concentration**

SCAPS LIF Investigation: Conclusions

- **In general, current LIF data suggests continued presence of NAPL at all but two of the SCAPS push locations.**
- **Only 7 LIF results indicate the potential presence of mobile/recoverable LNAPL**
- **The micro-wells installed near the assumed mobile LNAPL locations did not produce flowing, recoverable LNAPL. Suggests, that under current site conditions NAPL present is not mobile.**
- **Fluorescence wavelengths are higher now than they were during the previous investigation, which suggests VOCs have been removed from the site**
- **Distinctly higher wavelengths were measured in the area where NSFO is presumed**
- **In general, fluorescence intensity in the vadose zone, particularly within the upper six feet, is weaker than measured during previous investigations.**

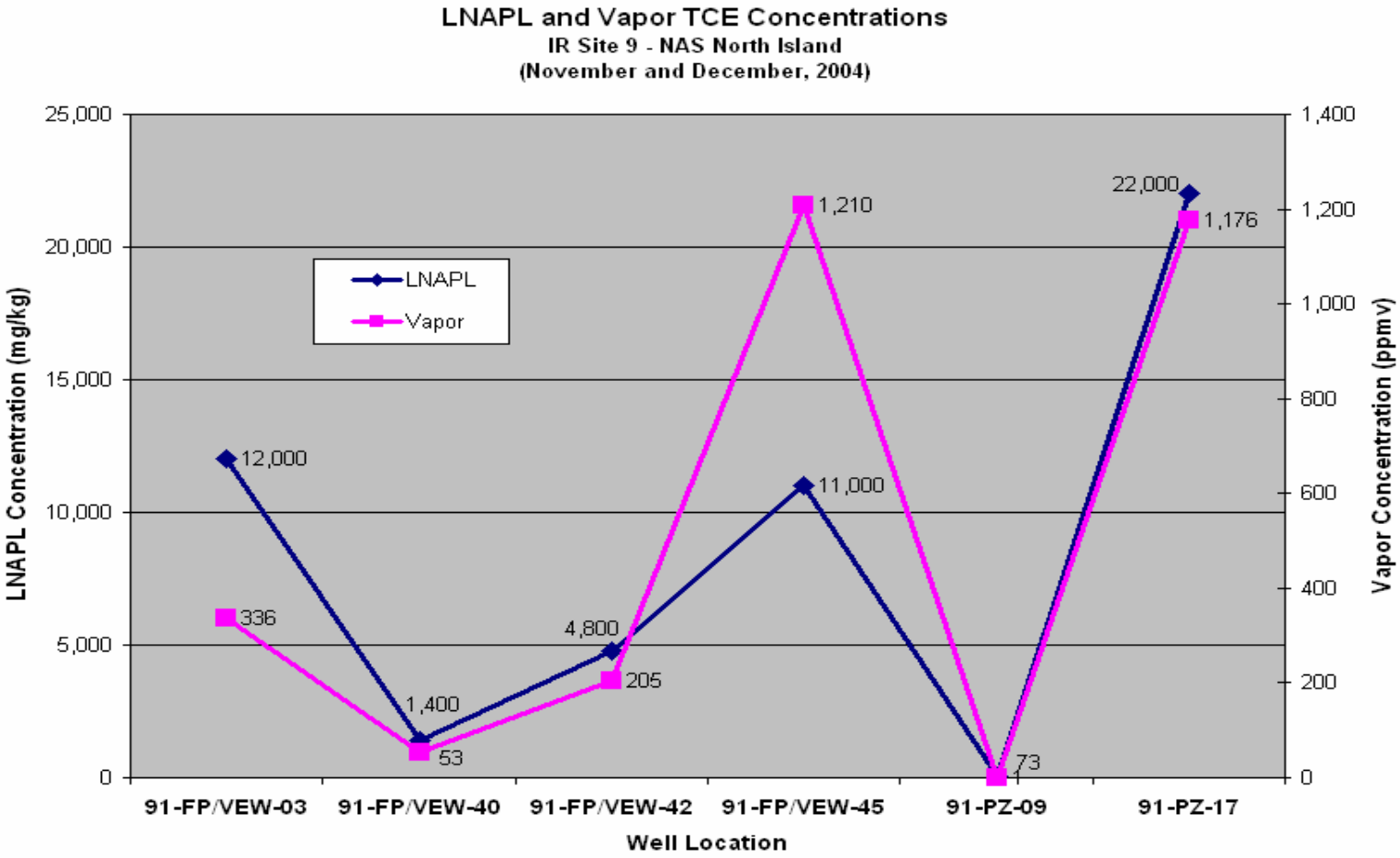
LNAPL Sample Locations



LNAPL Potential Effects on Clean UP

- **Areas SCAPS identified the presence of LNAPL,**
  - **Unable to collect representative LNAPL sample,**
    - LNAPL previously found in adjacent wells in these areas,
    - LNAPL appears to be immobile,
    - What reduced LNAPL mobility (e.g. increased water levels).
  - **What has been observed in areas with immobile LNAPL?**
    - Elevated soil vapor, but soil concentrations below target clean up levels.
- **Areas SCAPS did not initially identify the presence of LNAPL,**
  - **LNAPL sample collected from adjacent well (91-FP/VEW-45),**
    - LNAPL previously found in adjacent wells in this area,
    - LNAPL appears to remain mobile.
  - **What has been observed in areas with mobile LNAPL?**
    - Elevated soil vapor and soil concentrations potentially at or above target clean up levels.
- **LNAPL appears to continue contribution to soil vapor concentrations**
- **Mobile LNAPL appears to impact soil concentrations**

LNAPL and Soil Vapor Concentrations

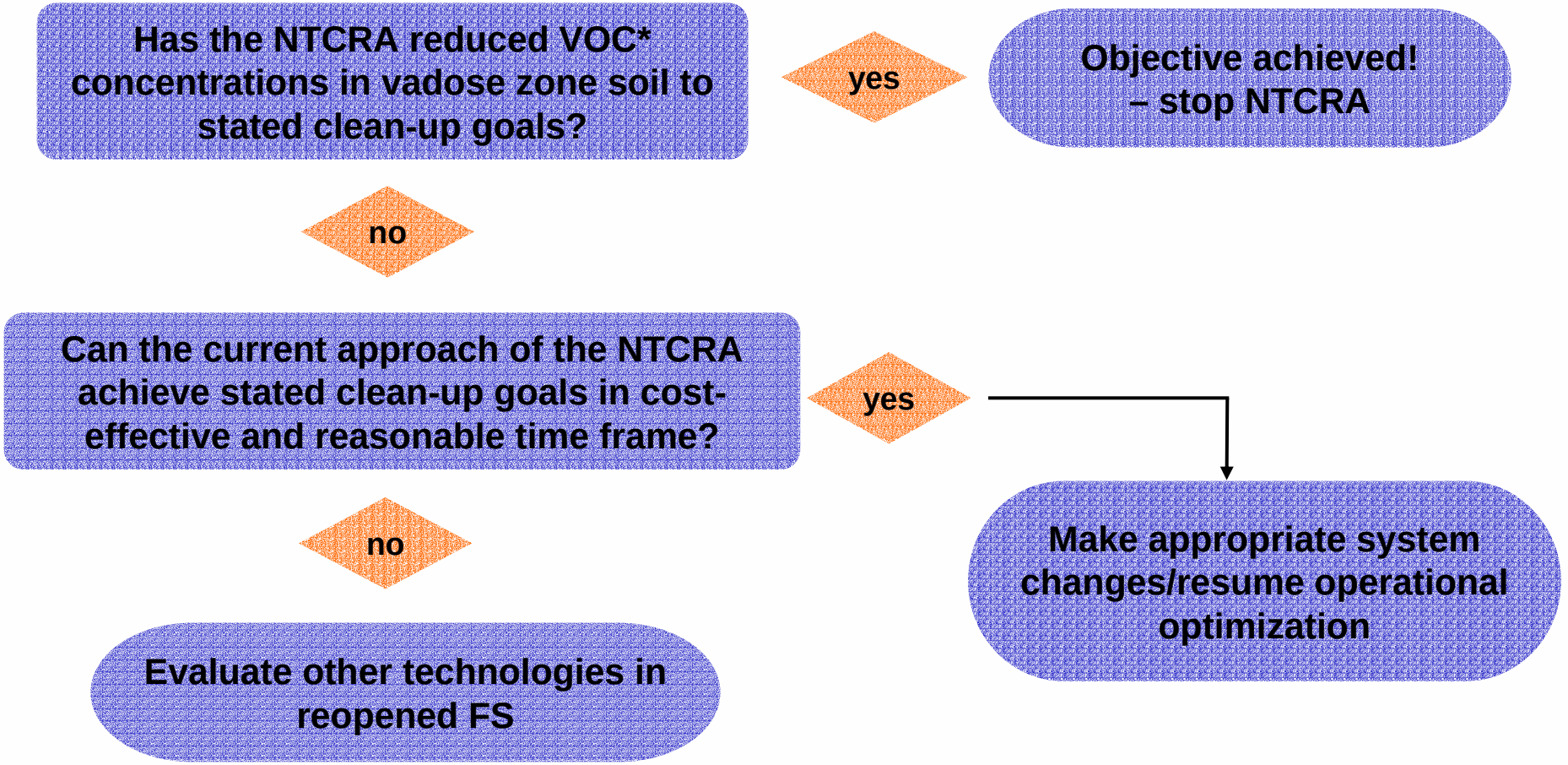


IR Site 9 – Next Steps

Application of DON Optimization Requirements

- System has been operating for 7+ years, since 1997
- Mass-removal tracking shows significant contaminant reduction in source area
- Data visualizations suggest significant improvement in site conditions
- Trends suggest the removal rates have declined and remain below initial rates
- Industry data suggest ease of mass removal decreases over time with a corresponding increase in cost
- Based on data tracking and analysis, and in accordance with DON Optimization Policy, *it is appropriate to evaluate the current NTRCA with respect to cost and continued effectiveness*
- Continue to optimize the full-scale maximize mass removal

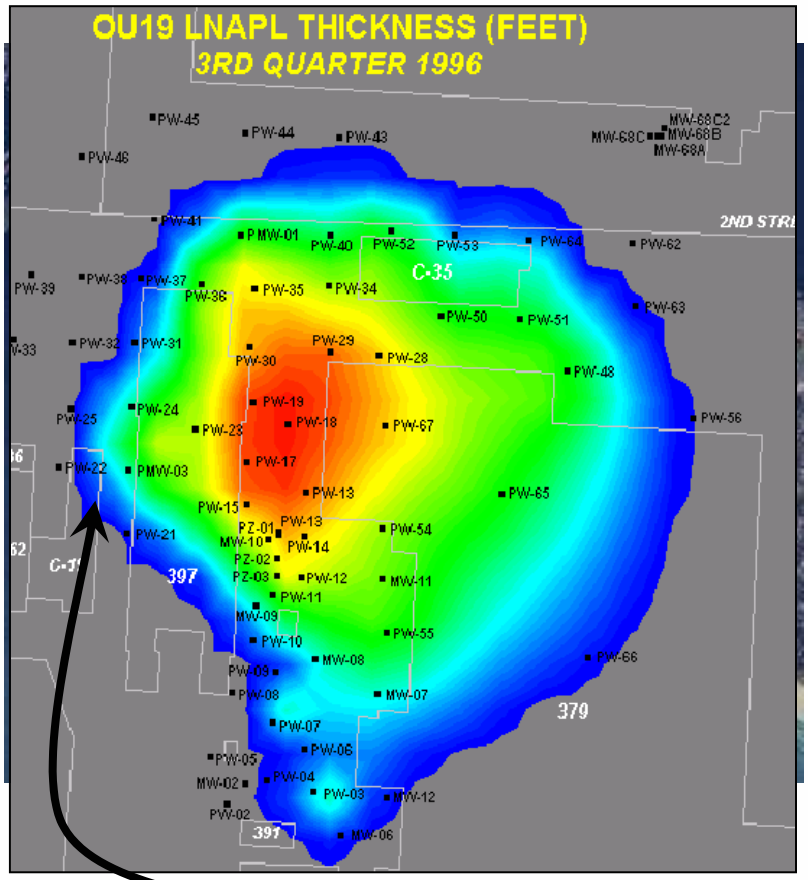
Optimization Decision Flow



*Specific VOCs: TCE, cis 1,2-DCE, 1,1-DCE, VC

Operable Unit 19

- **Site Location and Description**
  - –Located in North eastern portion of NAS North Island
  - –Heavily Industrialized Area
  - –Several former and existing ASTs and USTs in the area
  - – Groundwater at 25 feet bgs
  - –Soil is sand and silty sand to 35 feet bgs
- **LNAPL Description**
  - –LNAPL consists of JP-5 and Stoddard Solvent
  - –Relatively un-weathered
  - –Volume estimated between 30,000 to 350,000 gallons
  - –Thickness measured up to 4-feet in some wells
  - –TCE commingled in Stoddard solvent



Delineated LNAPL, 1996

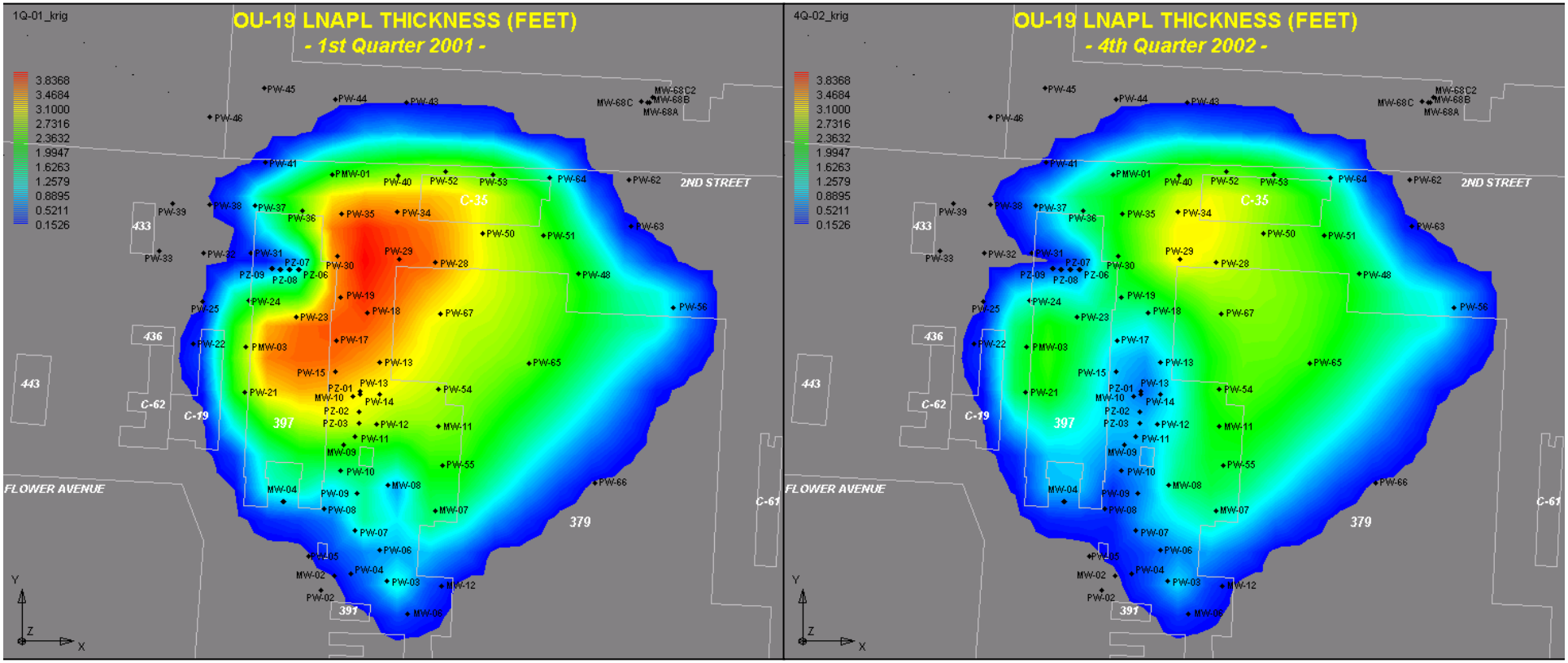
Operable Unit 19 – Project Background

- **Main objective of the Pilot Scale Remediation (PSR) is to determine if thermally enhanced LNAPL recovery would be an effective full-scale remedial alternative for OU19.**
- **PSR is being conducted in two phases:**
  - **Phase I consists of LNAPL skimming and SVE,**
  - **Phase II consists of steam injection, total fluids extraction, water treatment, and SVE.**
- **Phase I of the PSR operated from February 2001 to January 2003.**
- **Limited operation of Phase II from March to July 2003.**
- **Phase II of the PSR resumed in May 2004 to the present.**

OU19 – Technical Approach (Phase I)

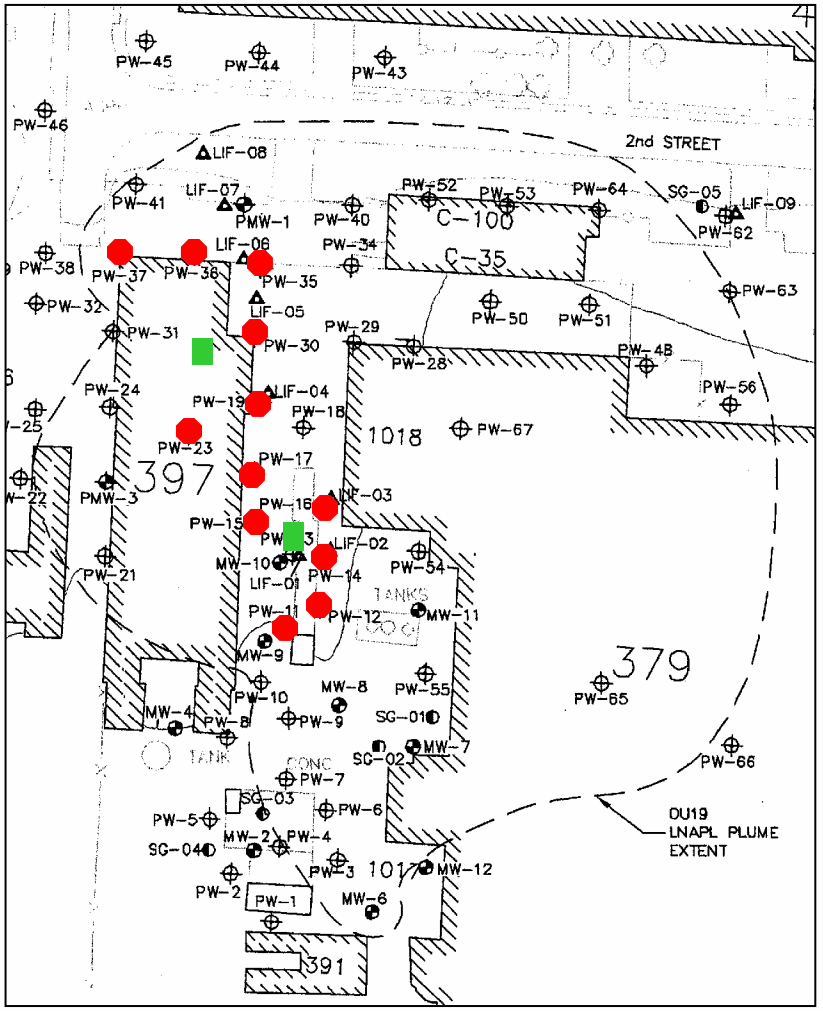
- **Phase I Objective**
  - **Utilize existing combination LNAPL recovery/ SVE wells**
  - **Evaluate the effectiveness of LNAPL removal using skimming only**
  - **Develop a population of data for comparison to steam enhanced recovery data**
- **Phase I pilot system operated for 23 months**
  - **February 2001 to January 2003**
- **Over 12,000 gallons of LNAPL recovered**
  - **Averaged 120 gallons per week**
  - **TCE 0.55% by weight of LNAPL (approximately 25 gallons)**
- **Approximately 475 pounds of vapor phase mixed VOCs extracted**
  - **TCE Approximately 70% by weight of VOCs removed**

OU19 – Technical Approach (Phase I Results)



OU19 – Technical Approach (Phase II)

- **Thermally enhanced PSR**
- **Comprised of two study areas (SIW-01 and SIW-02)**
  - **SIW-01 study area located in street between Buildings 379 and 397**
  - **SIW-02 study are located inside Building 397**
- **Four objectives for Phase II PSR**



OU19 – Technical Approach (Phase II)

- **Objective No. 1:**

  Evaluate effectiveness of steam to increase the mobility of LNAPL identified during the Phase I PSR as "low mobility" located under the north-east portion of Building 397 near SIW-02.

- **Objective No. 2:**

  Determine if steam can displace low mobility LNAPL from beneath Building 397 toward existing recovery wells near SIW-02.

- **Objective No. 3:**

  Evaluate the effect of steam injection on VOC concentrations in soil vapor, shallow groundwater, and LNAPL near SIW-01.

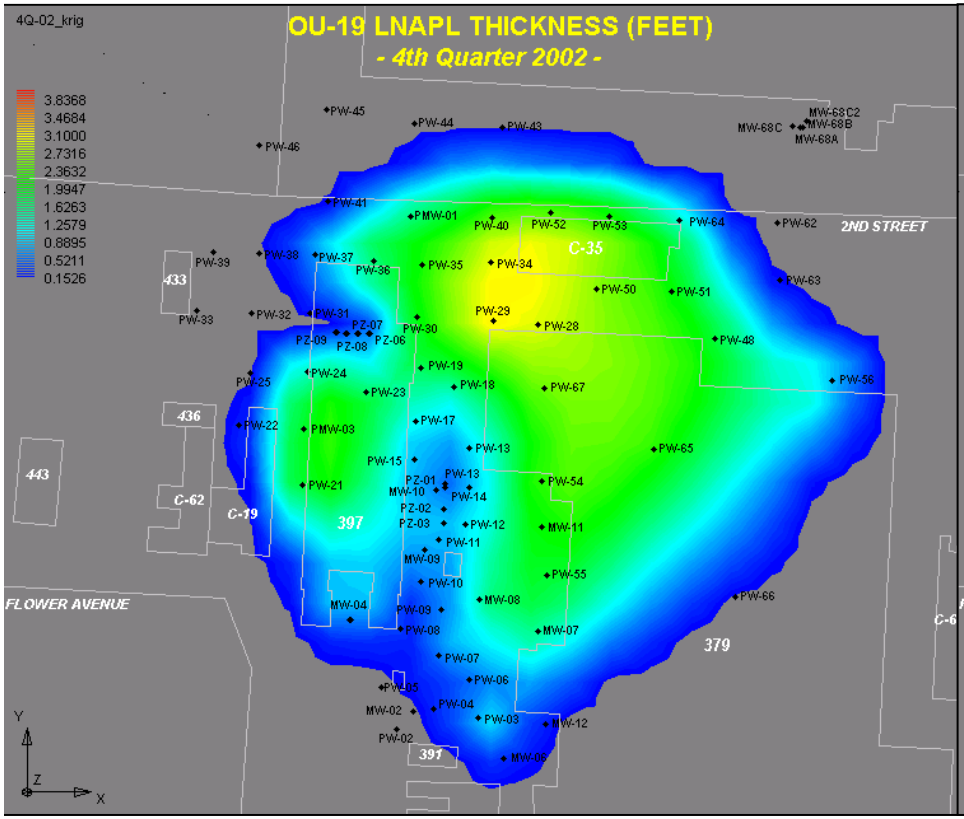
OU19 – Technical Approach (Phase II)

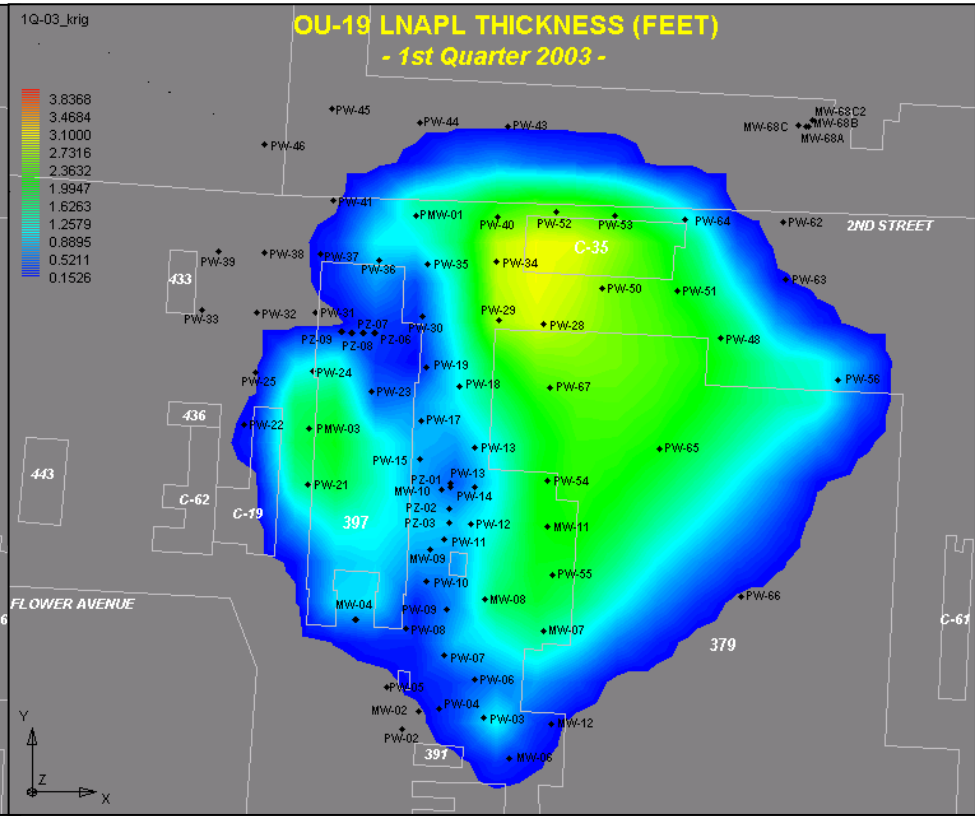
- **Phase II System Description**
  - **Total-fluids extraction**
  - **Soil vapor extraction**
  - **Oil/Water separation**
  - **Liquid phase treatment by carbon absorption**
  - **Vapor phase treatment by carbon absorption**
  - **Treated discharge to up gradient infiltration well**

OU19 – Technical Approach (Phase II Results)

- **Pilot Study Test Results:**
  - **<u>Objective No. 1</u>: LNAPL Mobility**
    - LNAPL rate of recovery test results indicate mobility increased in wells up to 36 feet from SIW-02.
  - **<u>Objective No. 2</u>: LNAPL Displacement**
    - Thickness measurements indicate steam injection effectively displaced LNAPL beneath Building 397.
  - **<u>Objective No. 3</u>: VOC Concentration**
    - Groundwater data do not indicate a significant change in concentrations with increased temperatures
    - Vapor data do not indicate a significant change in concentrations or temperature
    - LNAPL data do not indicate a significant change in concentrations with increased temperature

OU19 – Technical Approach (Phase II Results)





OU19 – Mass Removal Quantities

Media	Phase I Pilot-Scale		Phase II Pilot-Scale		Total Removal	
Free Product (LNAPL)	(lbs)	(gals)	(lbs)	(gals)	(lbs)	(gals)
	96,190	12,935	18,192	2,455	114,382	15,390
Mixed VOCs in Vapor	(lbs)		(lbs)		(lbs)	
	550		122		672	

OU19 – Next Steps

- **Continue operation of the pilot scale system at SIW-01 until mid-September 2004.**
- **Transition to SIW-02 study area at the end of September 2004.**
- **Dependent on data obtained, continue operations at SIW-02 or transition to SIW-01 mid-December.**
- **Current pilot scale field operations area scheduled for completion in February 2005.**
- **Next time:**
  - **Update on results for Phase II Objective No. 3 – VOC**
  - **Update on results for Phase II Objective No. 4 – Infiltration**

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