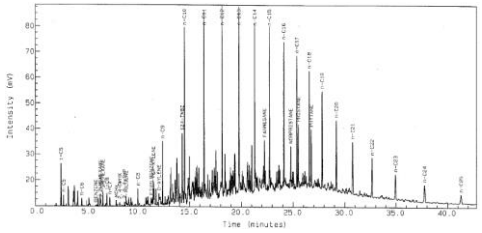
HIGH RESOLUTION SITE CHARACTERIZATION AND INTEGRATION WITH ENVIRONMENTAL FORENSICS:
Case Study

National Environmental Monitoring Conference
Washington, DC

GSI ENVIRONMENTAL



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August 2017

ACKNOWLEDGEMENTS

- **Shell Global Solutions (US) Inc.**

  The work was completed prior to 2007 while authors were employed by Shell Global Solutions (US) Inc. and previously presented at the 2011 INEF Conference, King's College, Cambridge, UK. The information is included as a paper in the Royal Society of Chemistry book "Environmental Forensics: Proceedings of the 2011 INEF Conference", 14 May 2012

- **Sam Williams, RG, CHG, CEM – Geosyntec Consultants**
- **Allen Uhler, PhD – Newfields Forensics Practice**
- **G.D. Beckett, RG, CHG – Aqui-Ver, Inc.**

OVERVIEW

Large LNAPL plume extending off the terminal area

Significant dissolved constituents in a plume extending over a mile offsite under a stadium and beneath a river

Several companies operate facilities and pipelines within terminal complex but our facility is nearest to stadium

SITE MAP


Upper canyon facilities
Lower canyon facility
River
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APPROACH

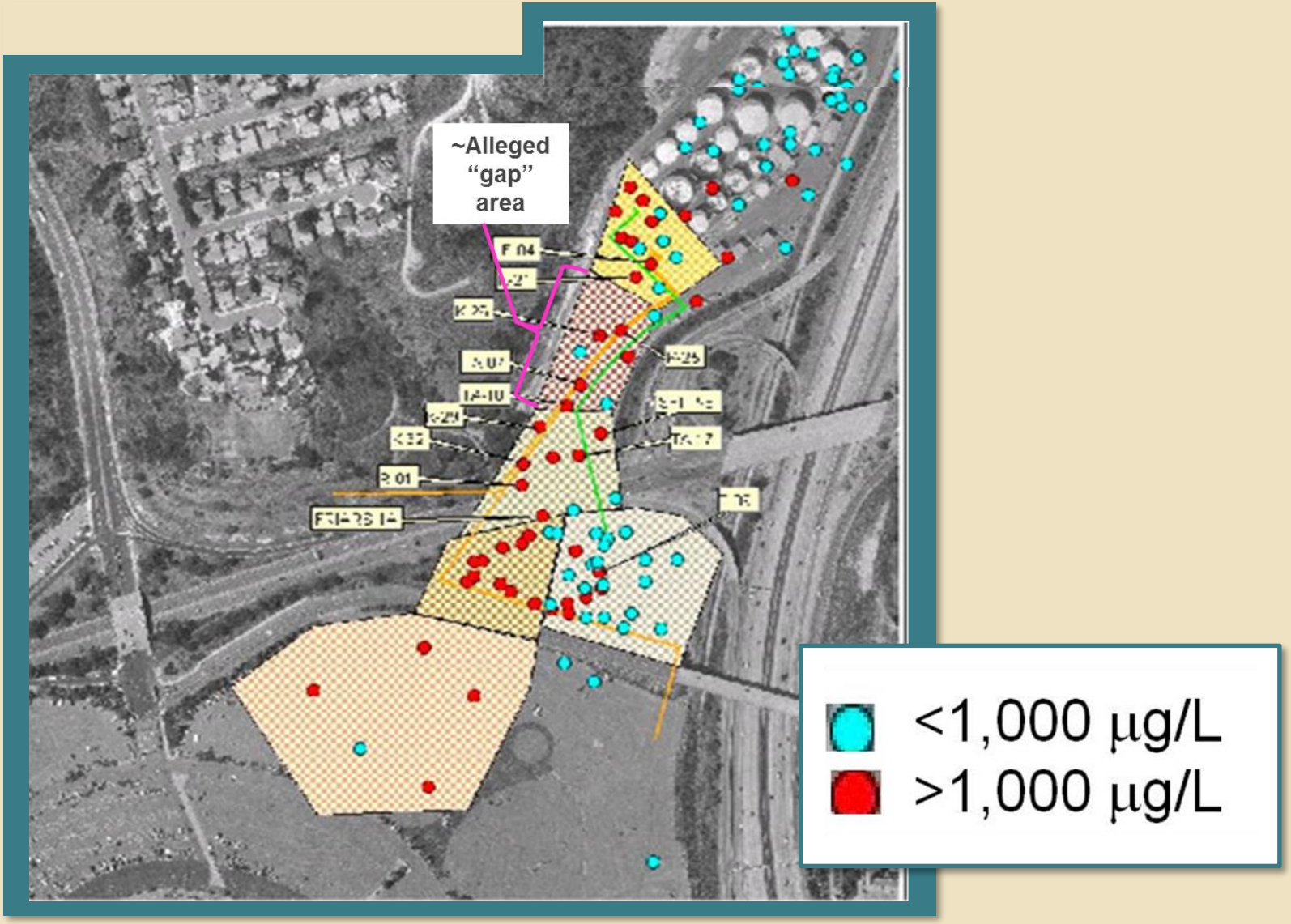
- Integration of conventional and innovative investigation and forensic tools to develop a technically accurate and scientifically defensible conceptual site model (CSM)
- Independent multiple lines of evidence were used to develop and verify the conceptual site model including:
  - Hydrogeologic conditions investigation
    - Soil borings
    - Cone penetrometer testing
    - Hydraulic testing
- Vapor, soil, and groundwater analyses
- Laser induced fluorescence (LIF) and Sudan Red field analysis
- Detailed forensic chemistry analyses of LNAPL

GROUNDWATER FLOW DIRECTION

V_{GW} = ~210 to 750 m/year (determined through use of various pump and slug tests)

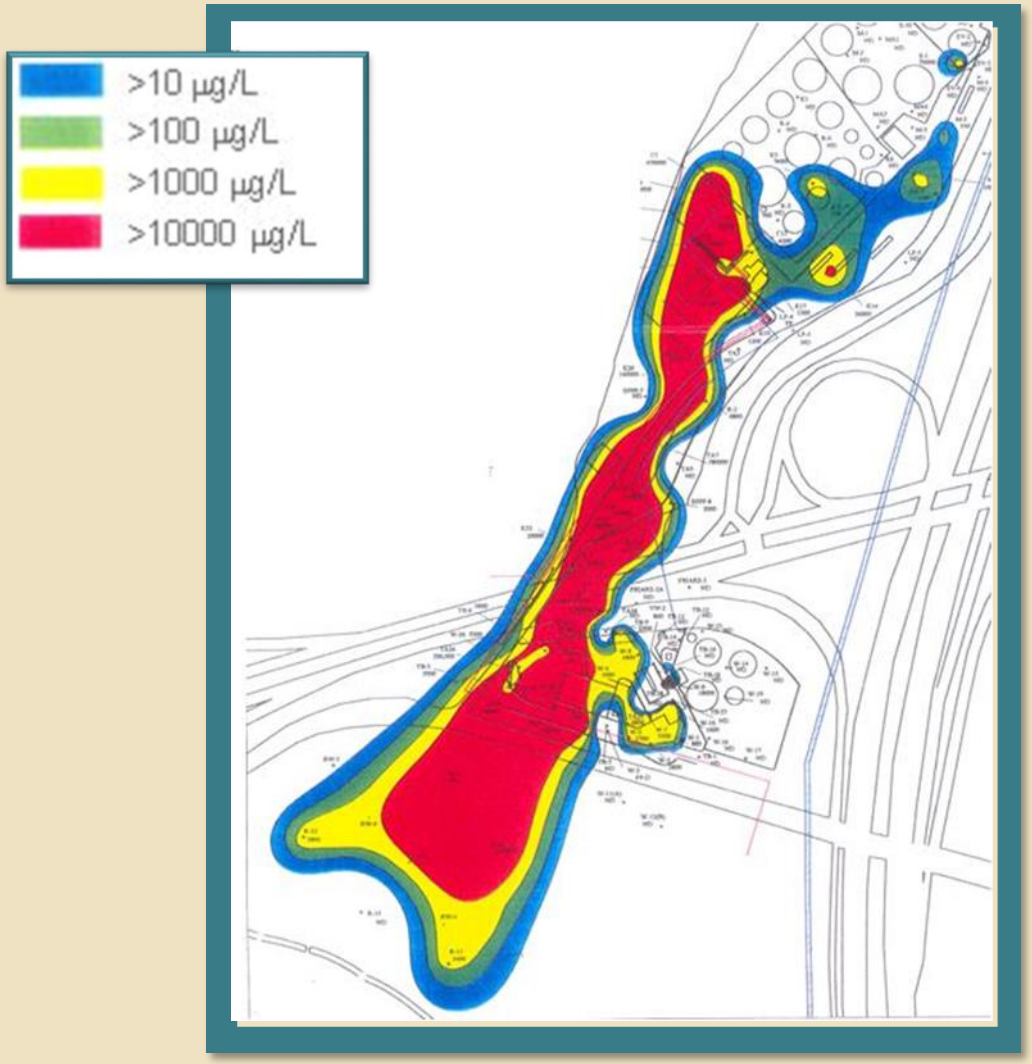
Southerly direction from the upper canyon area to the stadium parking lot with a westerly flow component once within the stadium area valley

GASOLINE RANGE ORGANICS IN GROUNDWATER

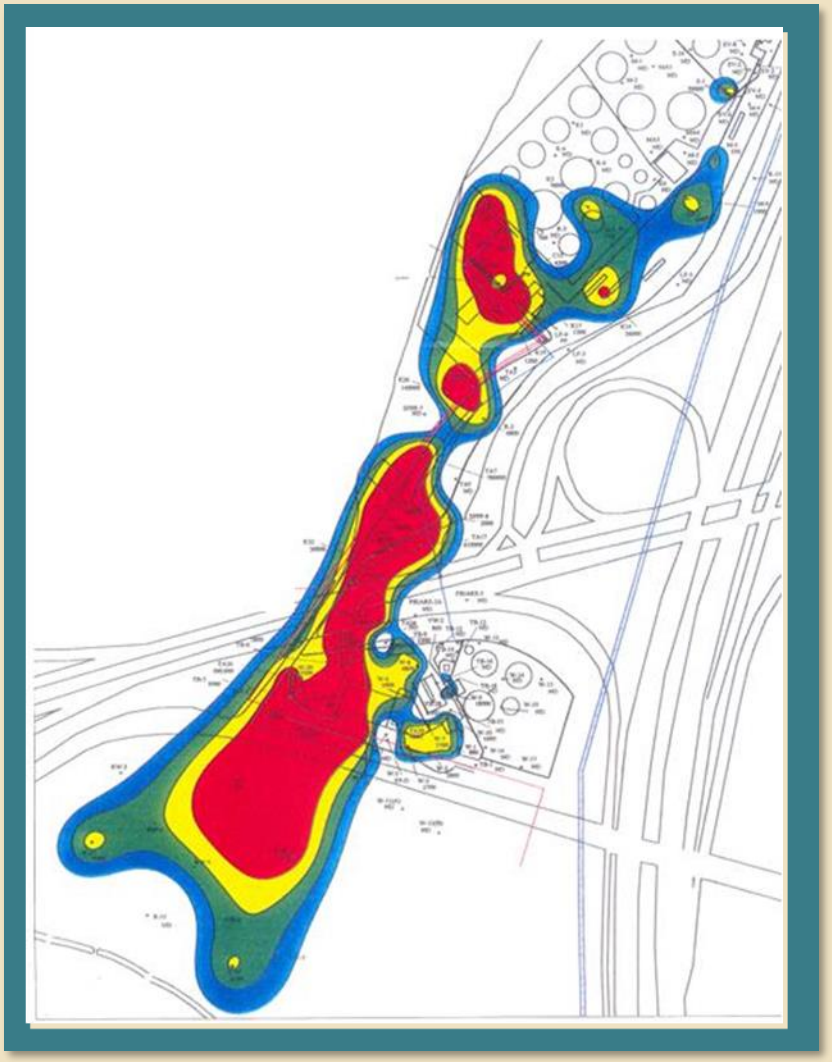


GASOLINE RANGE ORGANICS IN GROUNDWATER

Interpretive



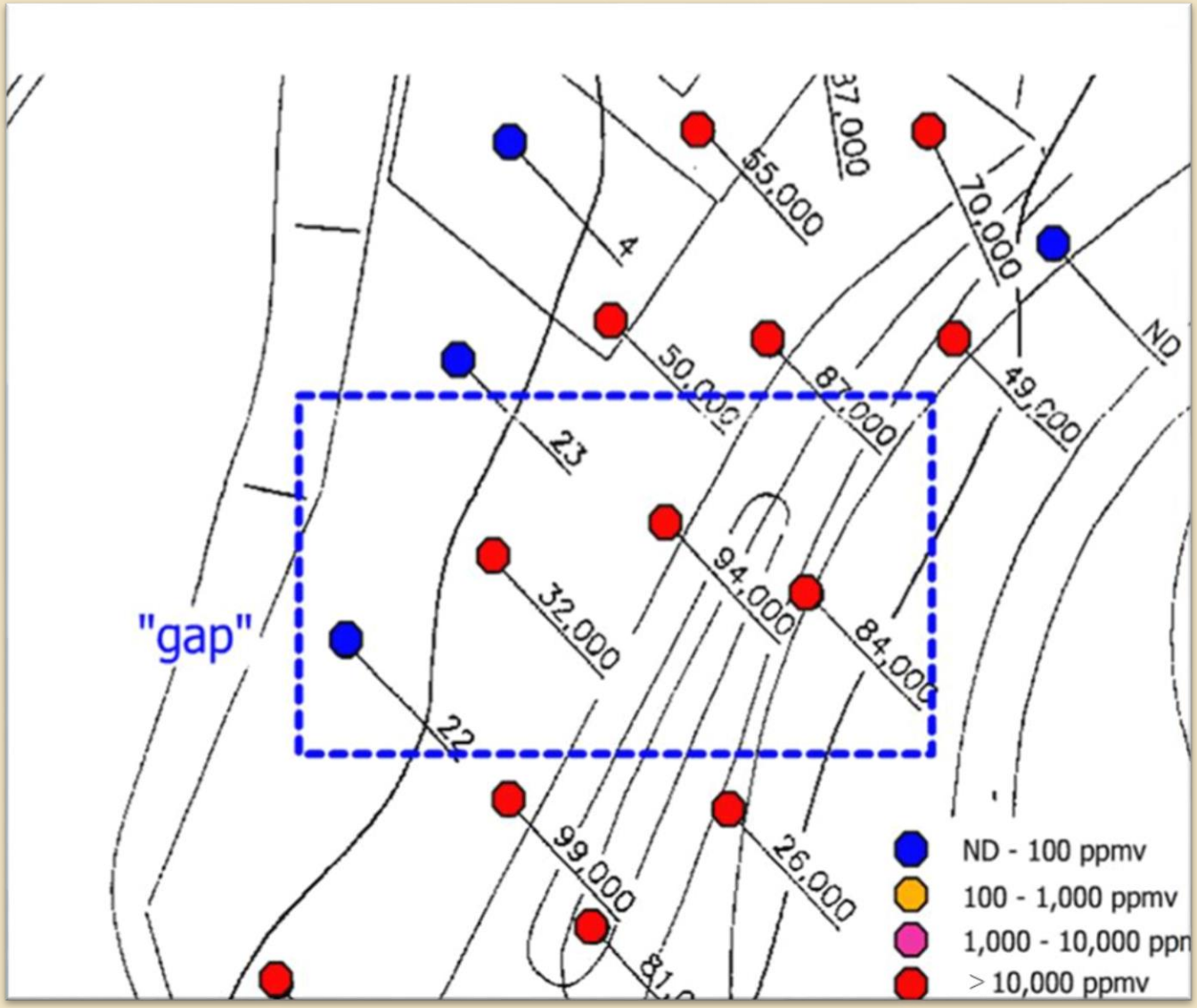
Statistical



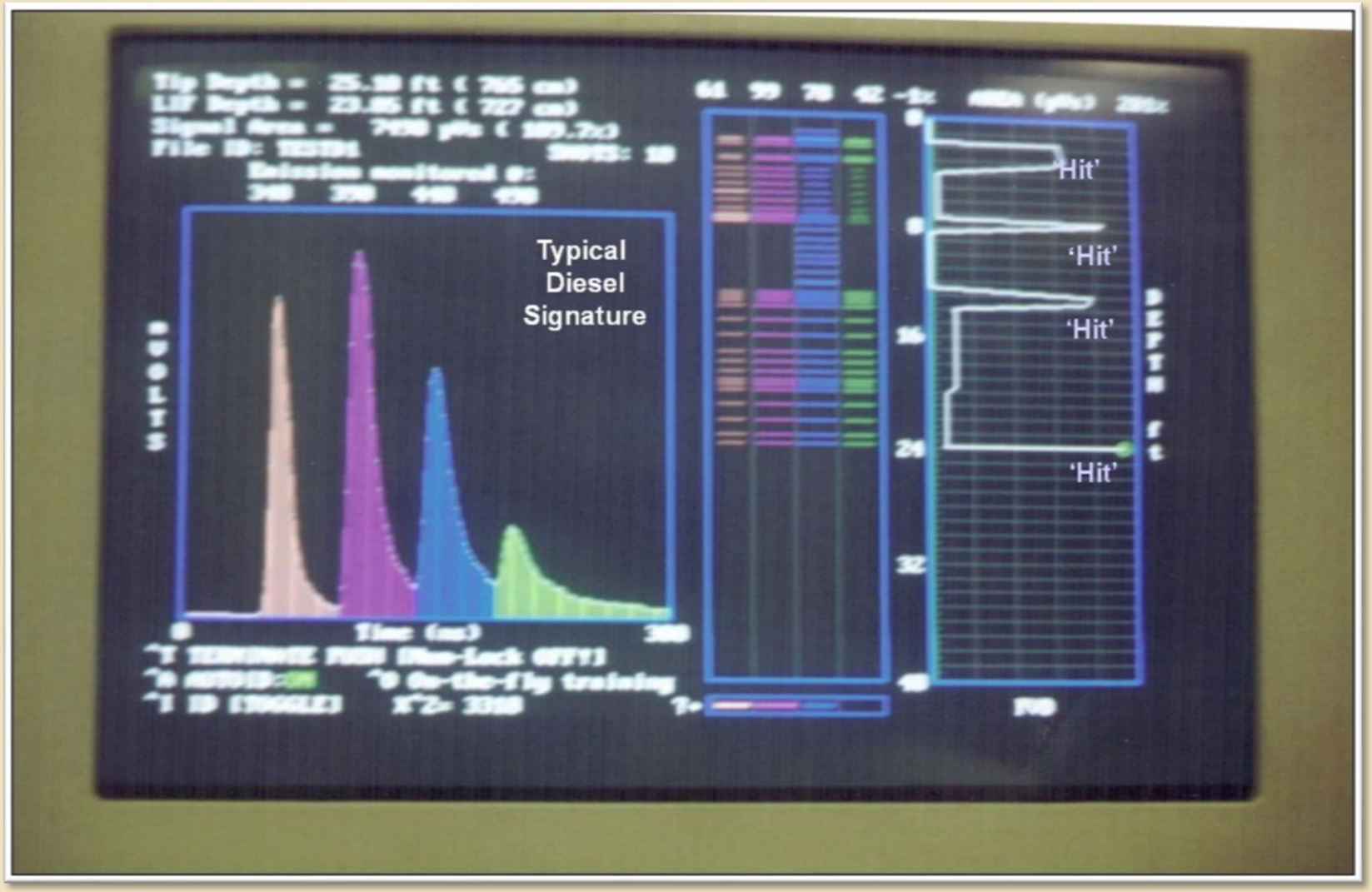
SOIL CONTAMINATION CHARACTERISTICS

TOTAL VOLATILE HYDROCARBONS IN SOIL GAS

Total TVH in Soil Gas



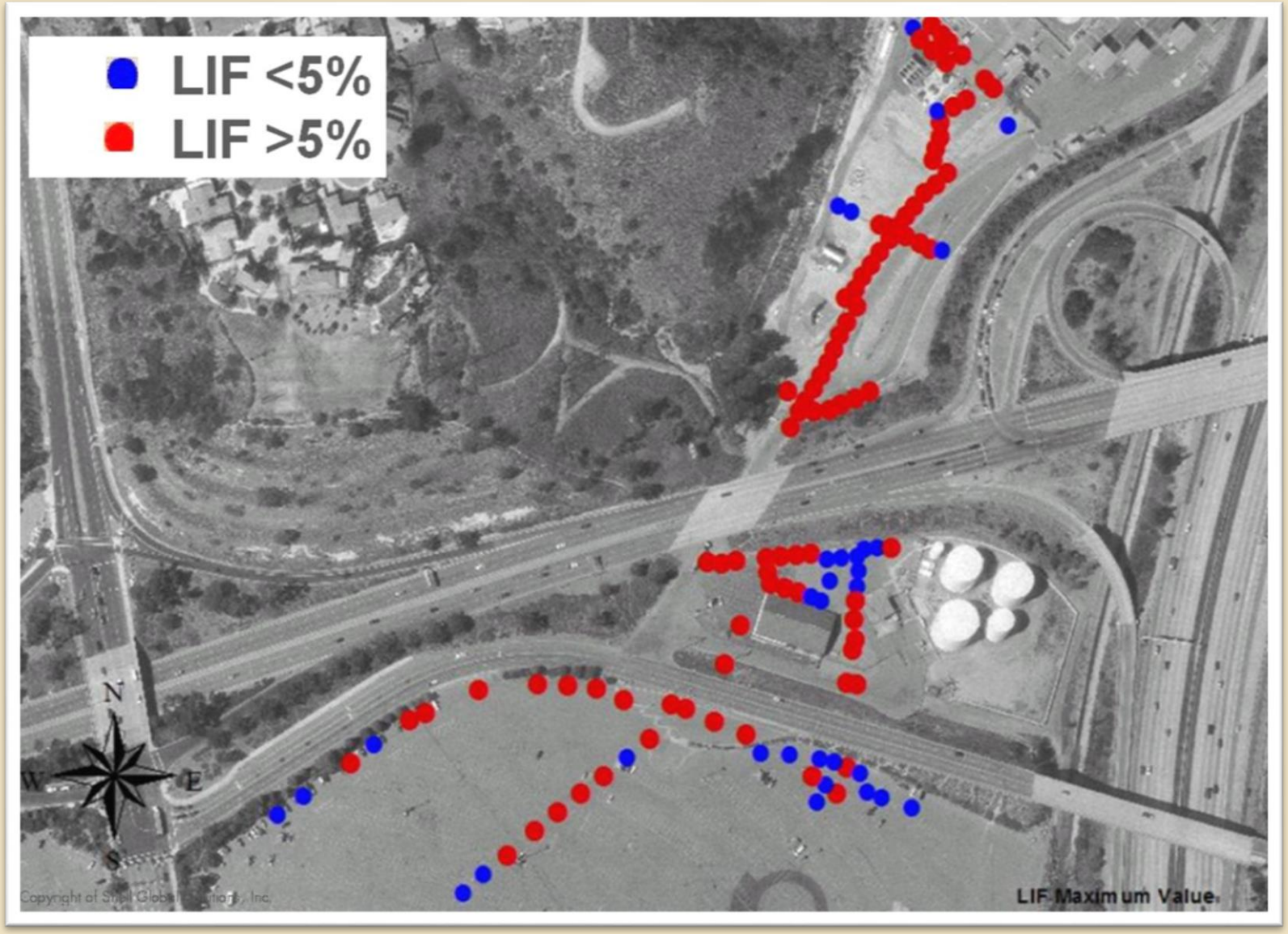
REAL TIME MONITORING



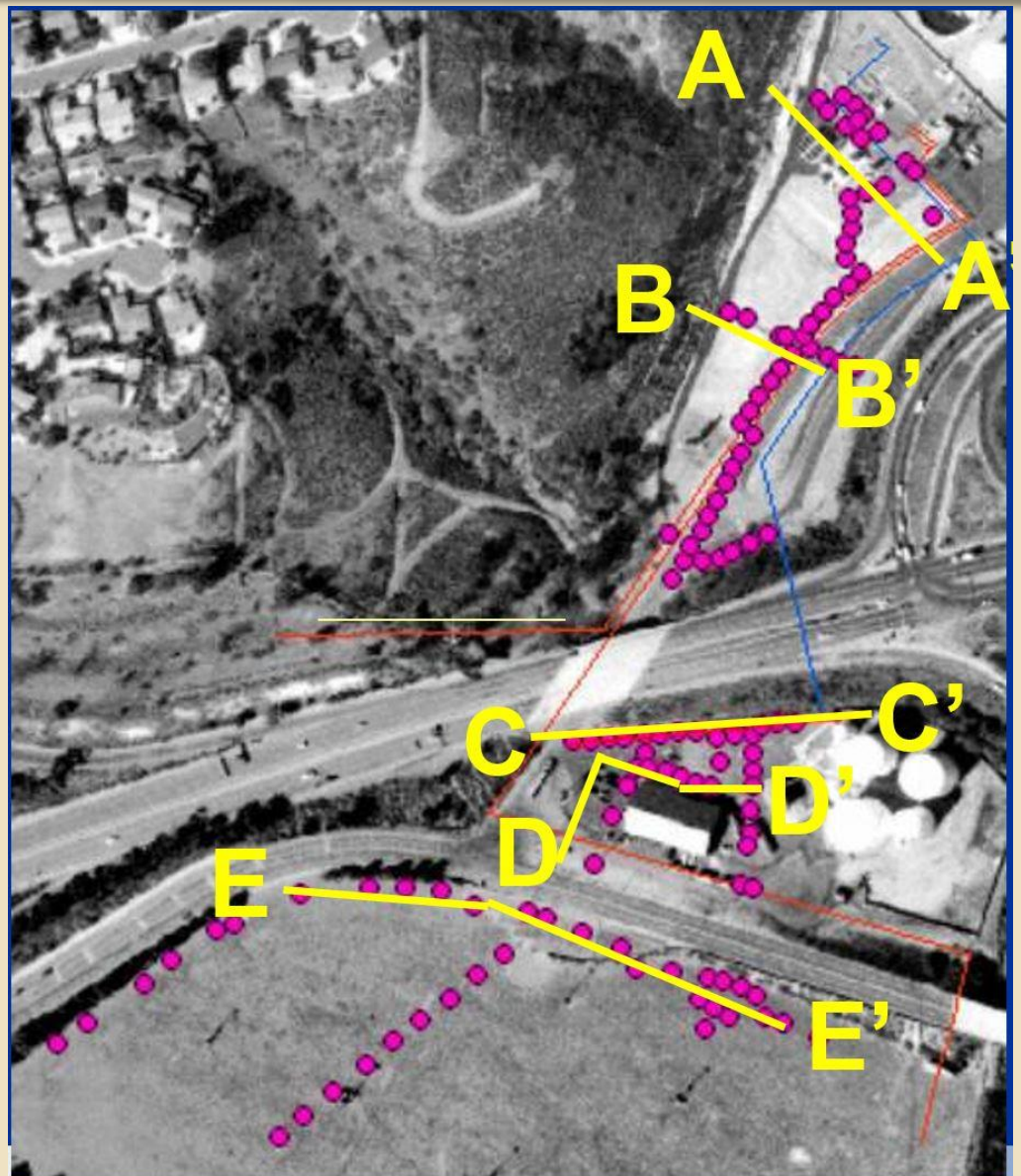
LASER INDUCED FLUORESCENCE

- 132 CPT points advanced in 3 weeks
- LIF combined with CPT
- Defined extent of NAPL and coarse-grained deposits
- Confirmed continuous plume
- Showed and confirmed separation between core plume and small plume in lower canyon facility

LASER INDUCED FLUORESCENCE



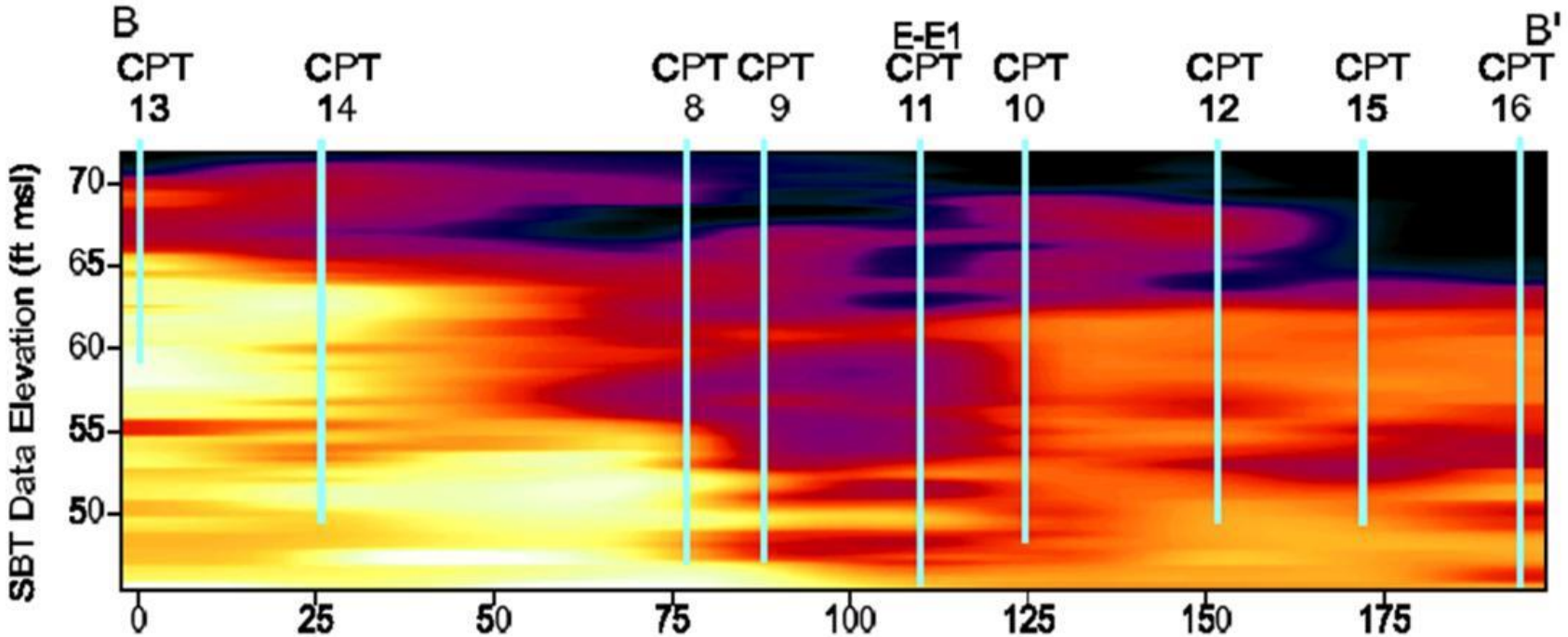
LIF CROSS SECTION LOCATIONS



CPT INVESTIGATION
Relative Permeability

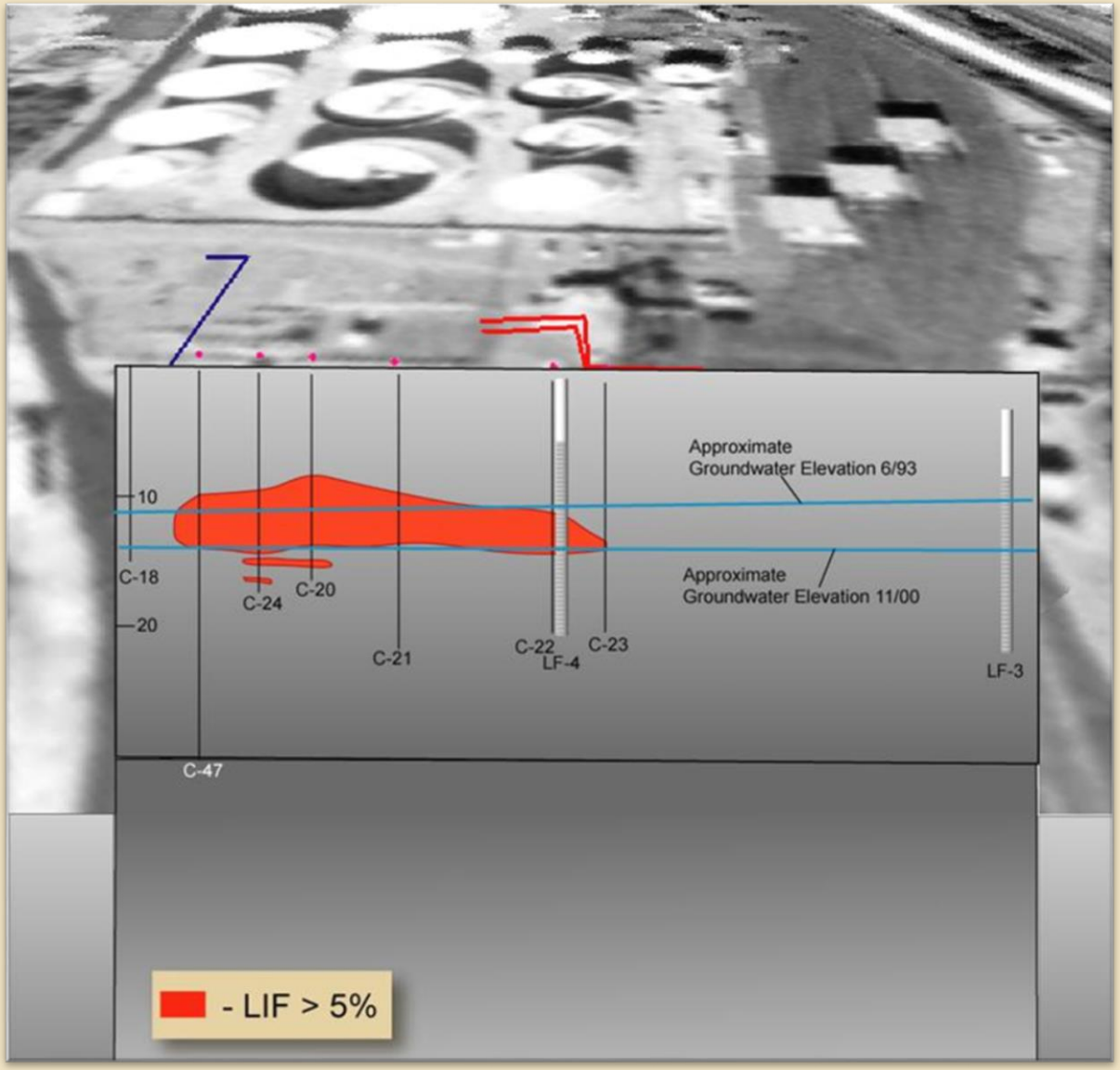
CPT (4 – Channel Piezocone)

Cobbles deposited in the braided stream environment



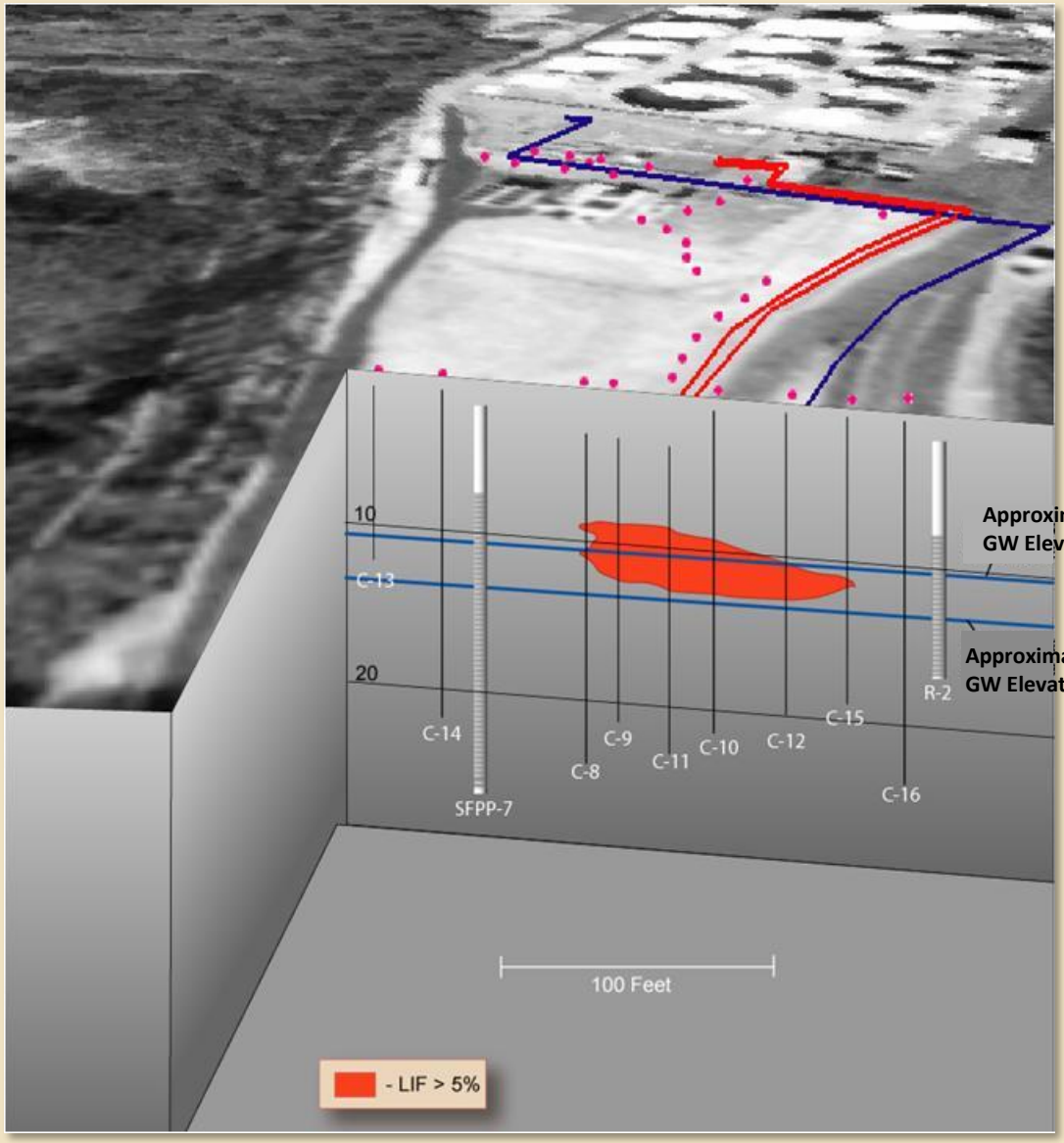
SBT Number:
low – fines, high coarse

CROSS SECTION A-A' LIF RESPONSE



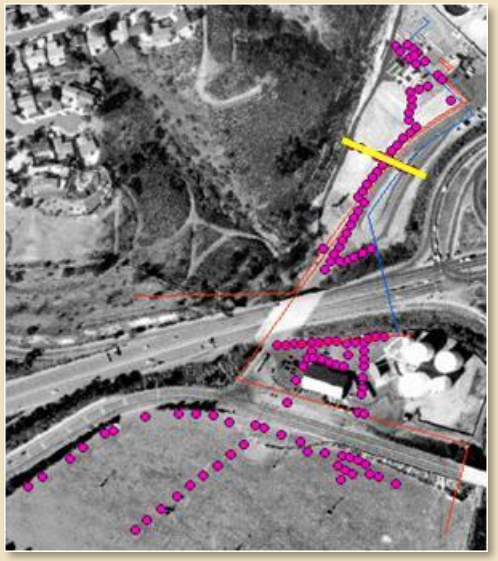
MANIFOLD AREA

CROSS SECTION B-B' LIF RESPONSE

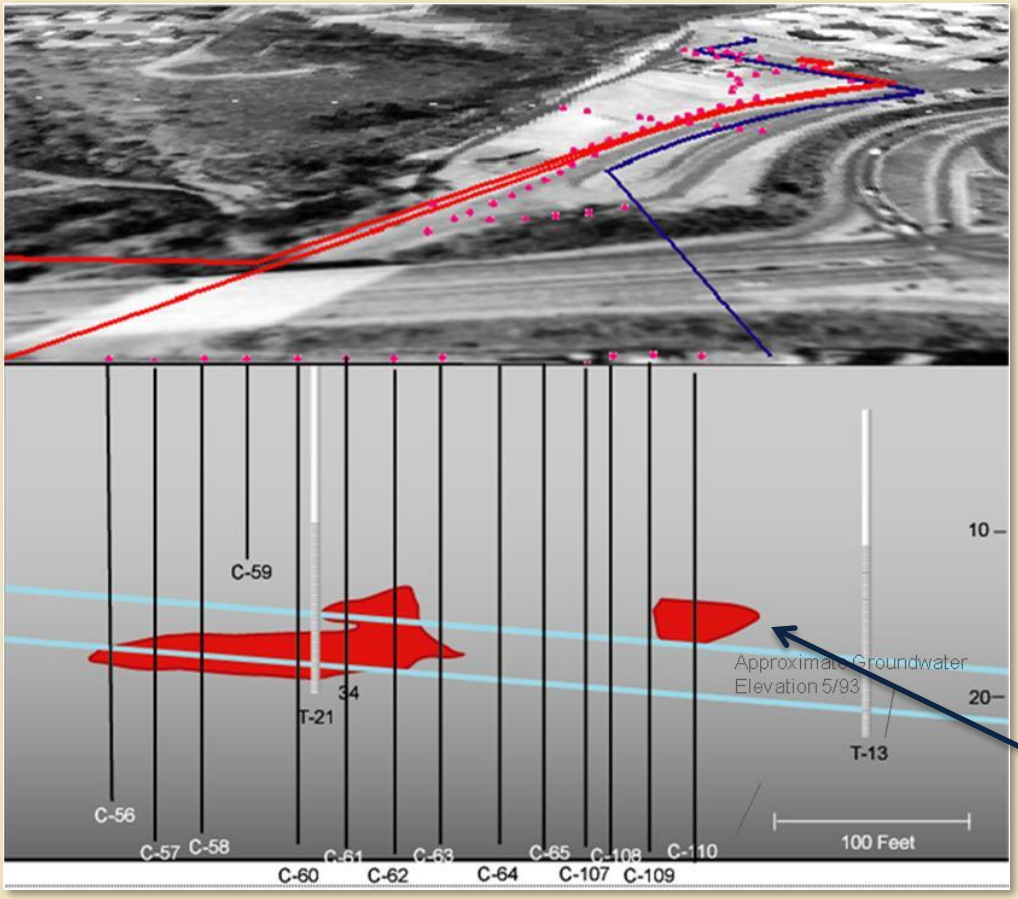


Downgradient from Manifold Area

- Elevated LIF responses concentrated along incoming/outgoing pipelines and in the area of the alleged gap.



CROSS SECTION C-C' LIF RESPONSE

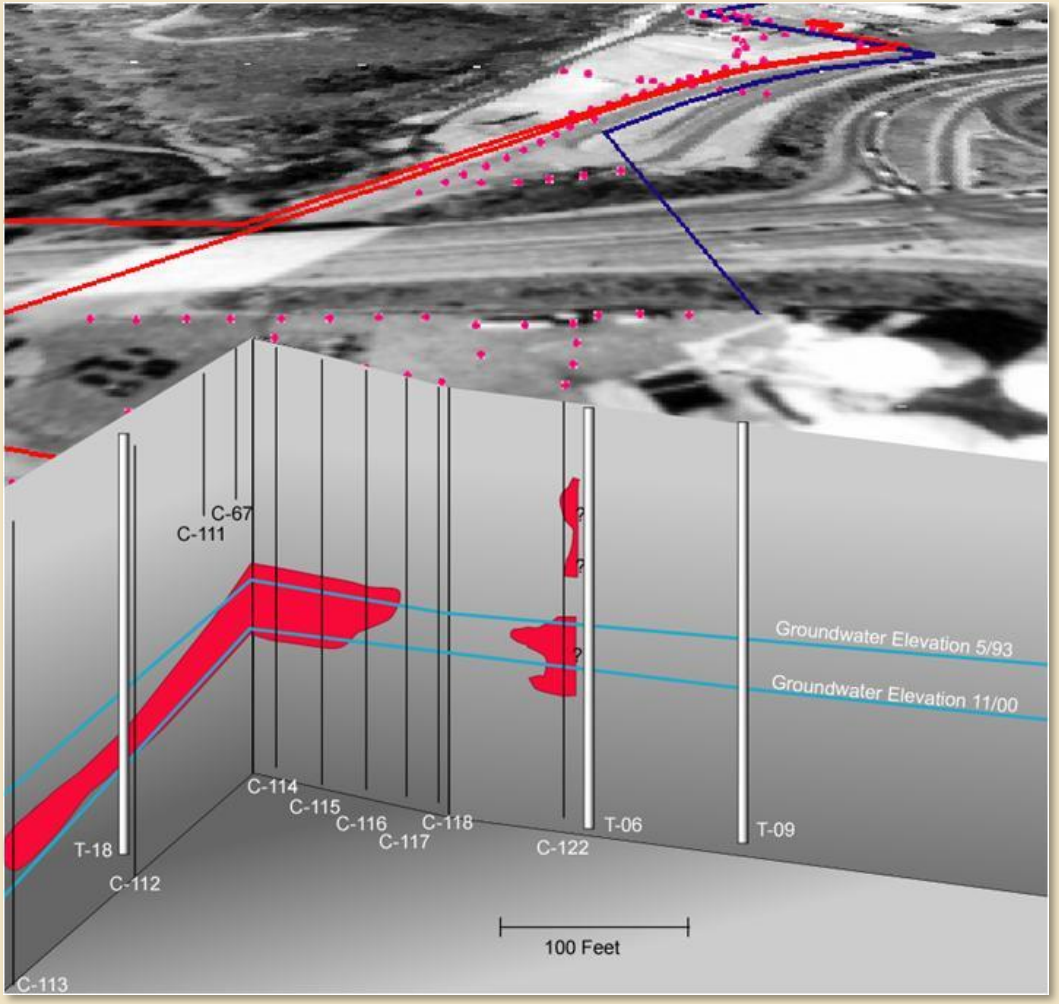


Lateral extent of core plume

North lower canyon facility boundary

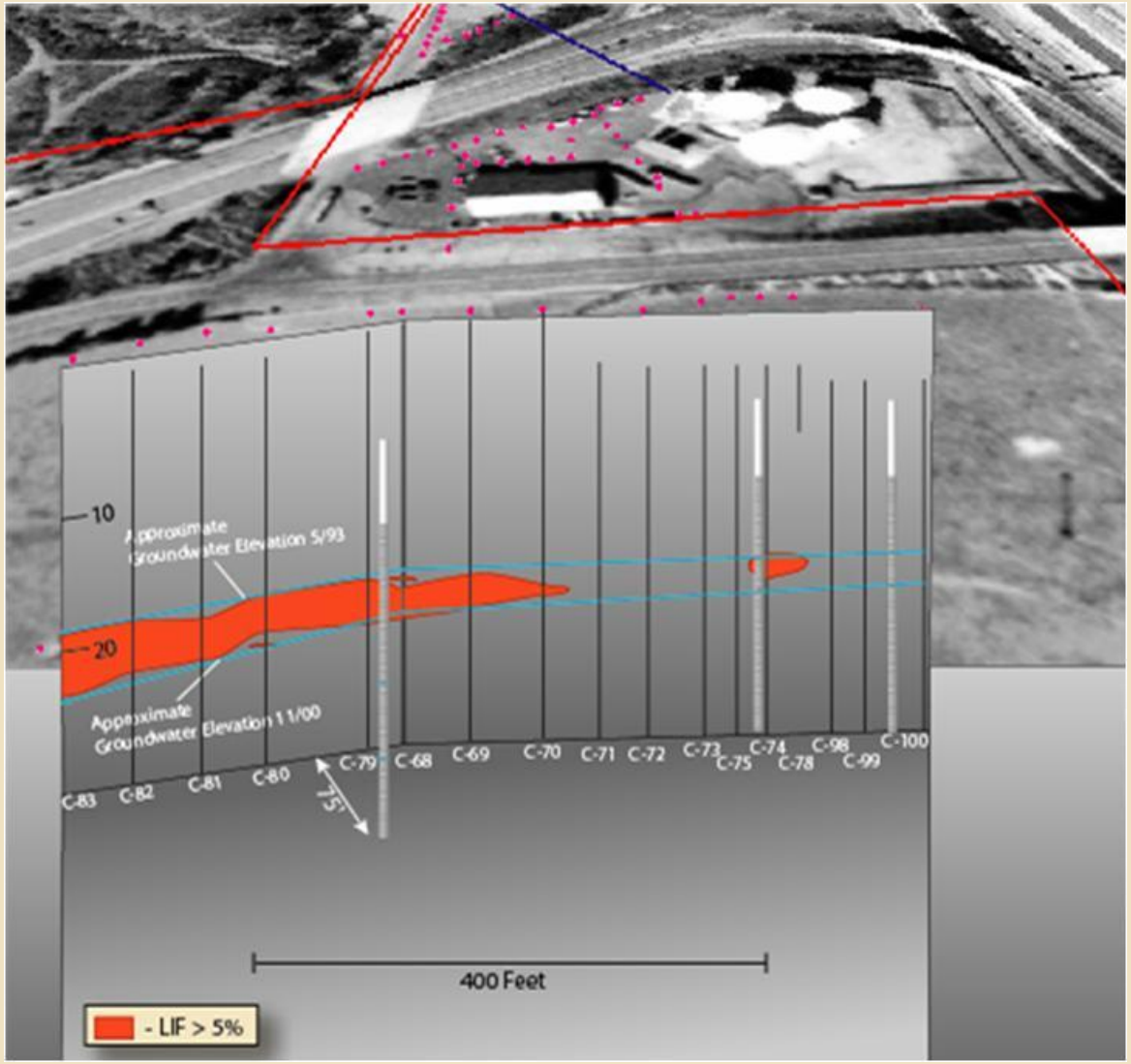
- Small and isolated area in the operational area on the lower canyon facility.
- Same location of a documented diesel release.

CROSS SECTION D-D' LIF RESPONSE



Central lower canyon facility area

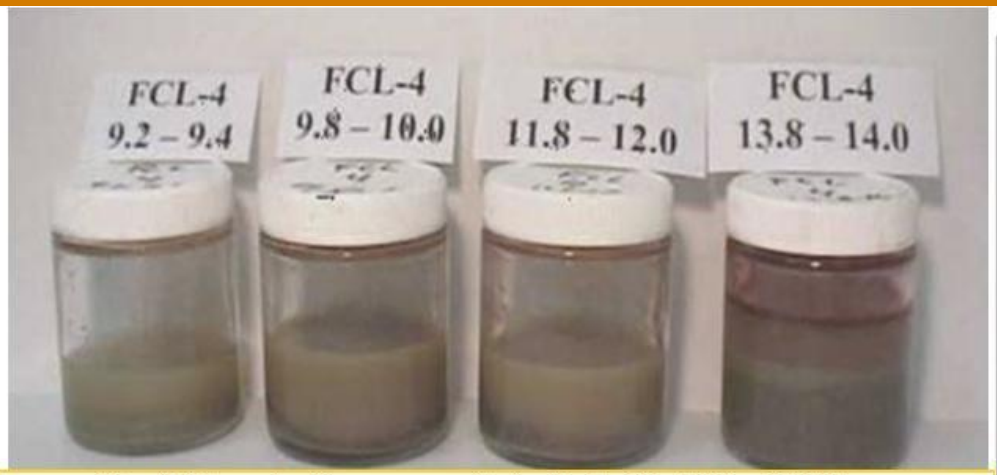
CROSS SECTION E-E' LIF RESPONSE



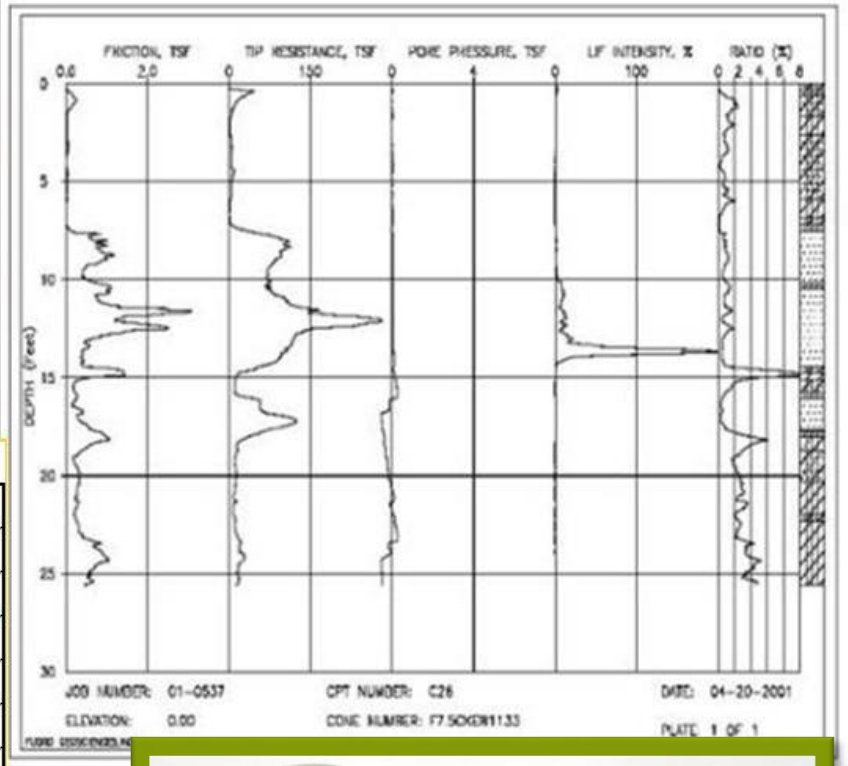
North parking lot area

Two distinctly different plumes are defined by the LIF responses: A large continuous NAPL plume is present in the northern stadium parking lot with a smaller well-defined plume downgradient of the lower canyon operations area.

SUDAN RED VS. LIF READINGS



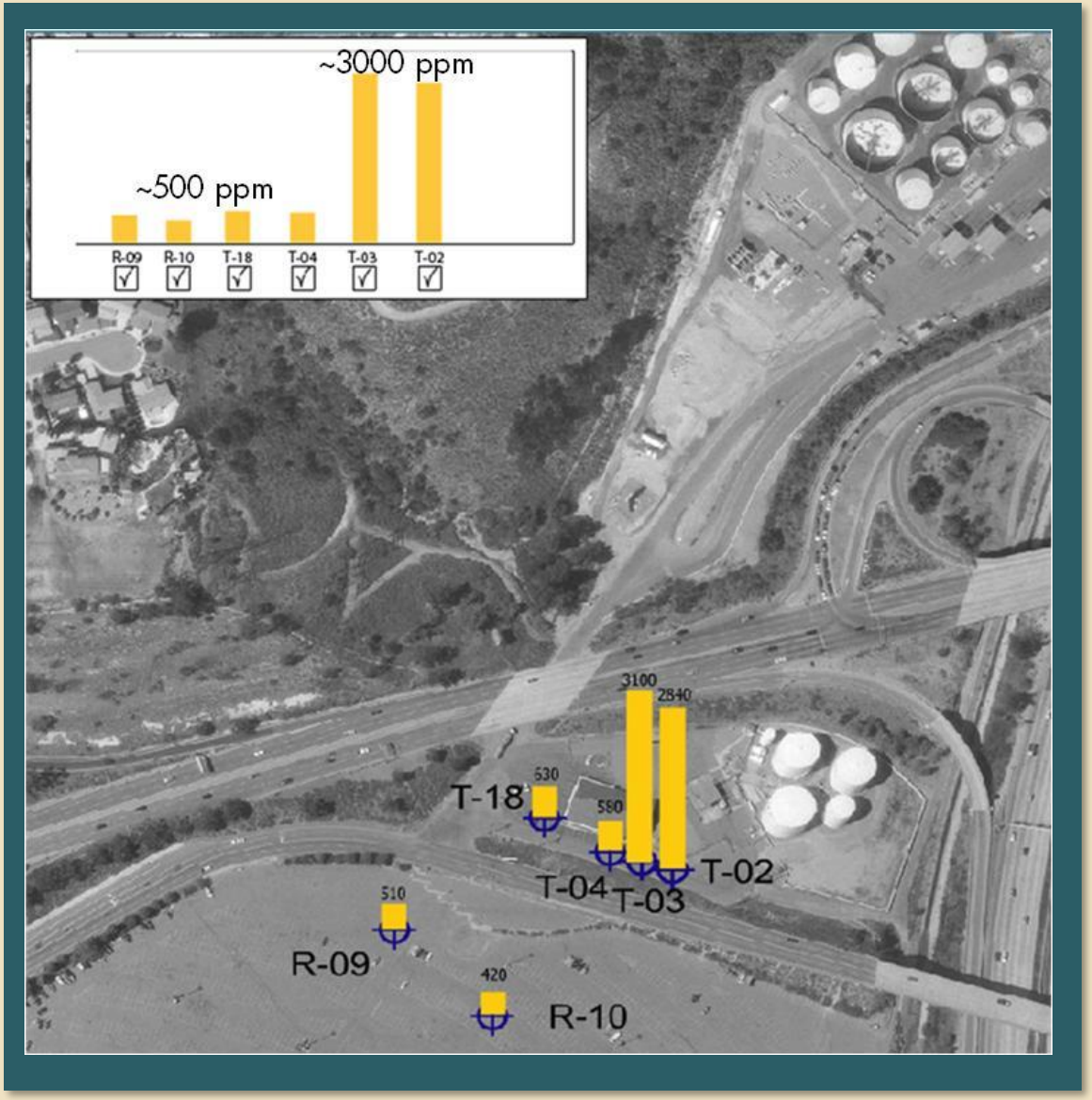
Depth Interval - ft		Sudan Red - Yes/No?	LIF Response
9.2	9.4	No	0.6
9.4	9.6	No	2
9.6	9.8	Yes	2
9.8	10.0	Yes	2
11.8	12.0	Yes	11
13.2	13.4	Yes	23
13.4	13.6	Yes	58



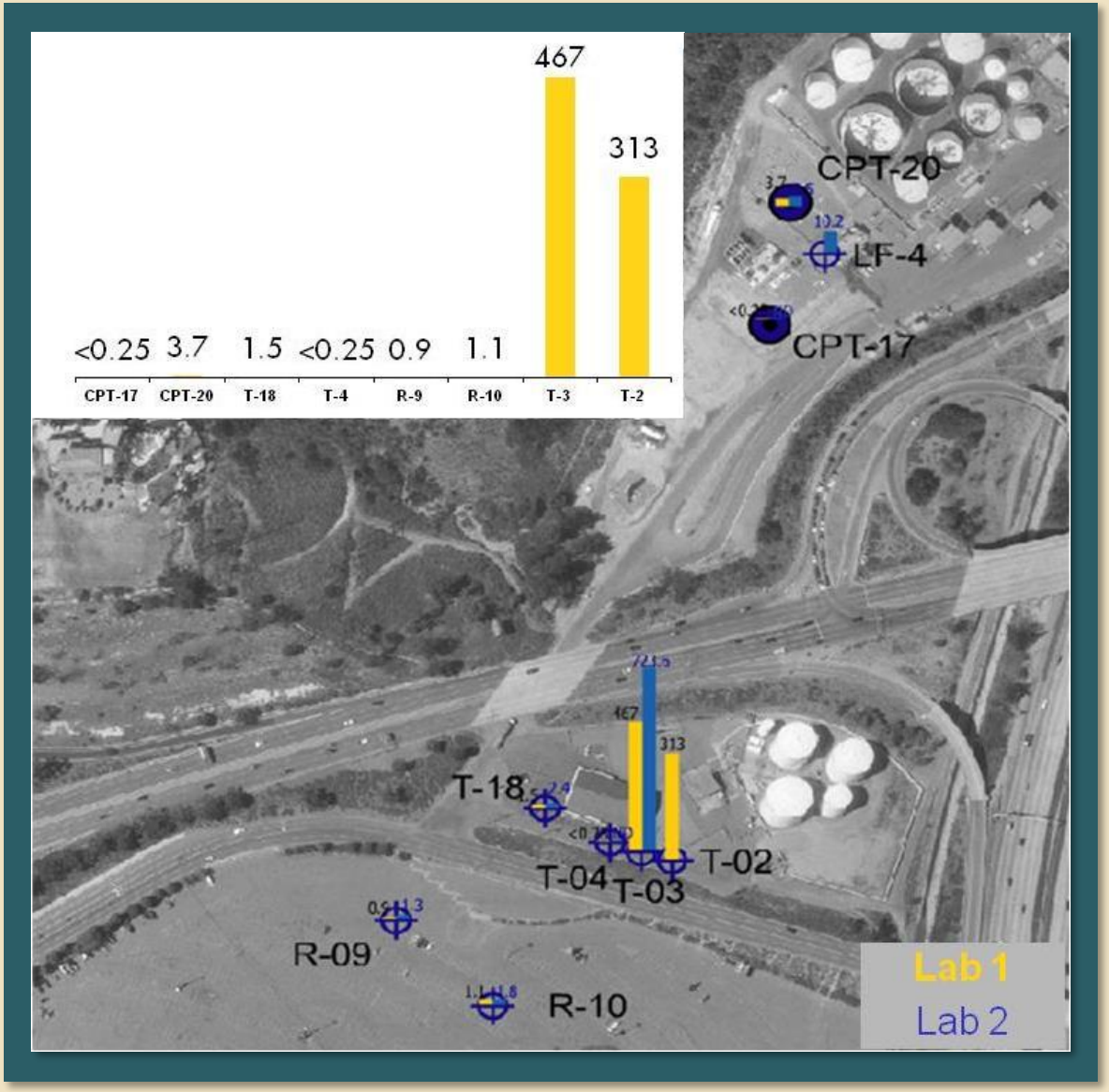
FORENSIC CHEMICAL ANALYSIS

- Total Sulfur
- Total Organic Lead
- Fingerprinting / Hydrocarbon Distribution
- Diagnostic Ratios

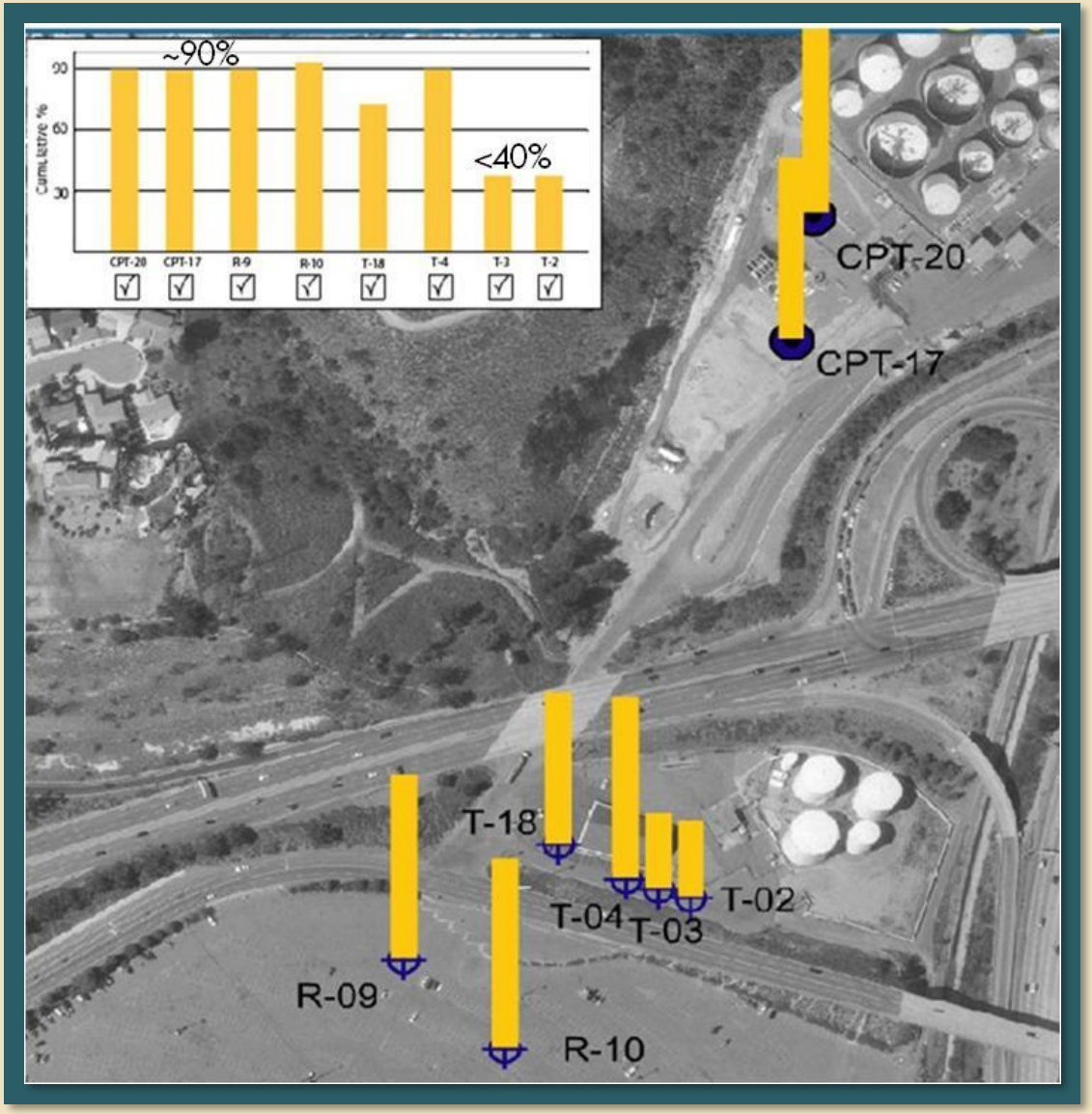
TOTAL SULFUR - LNAPL



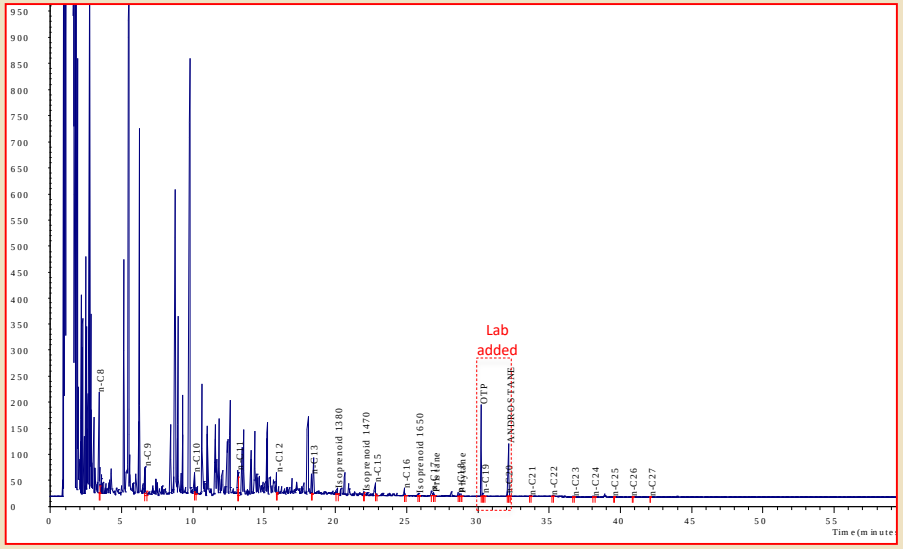
TOTAL ORGANIC LEAD - LNAPL



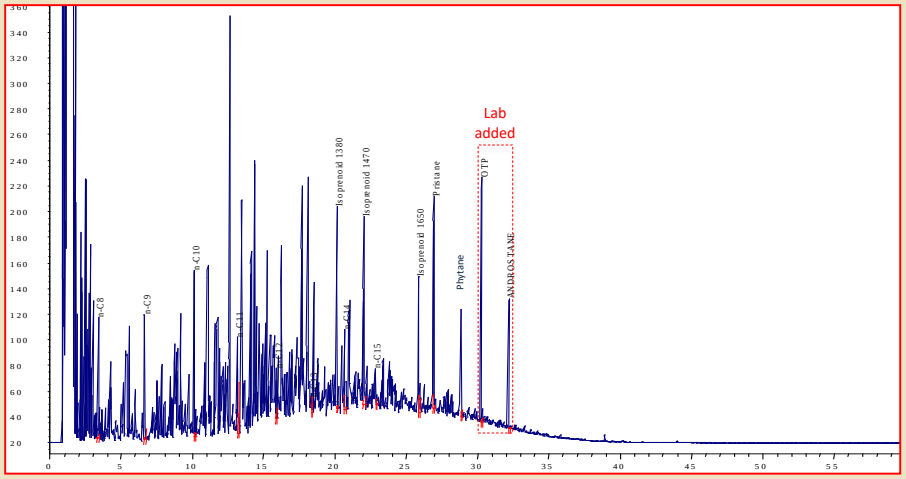
RELATIVE % GASOLINE - LNAPL



CHROMATOGRAPHIC FEATURES - LNAPL

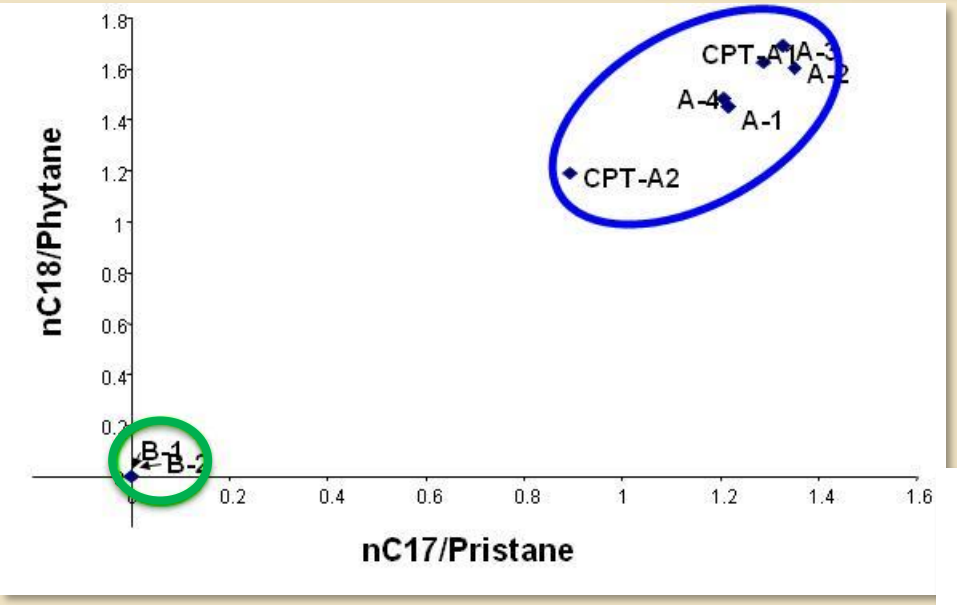


Representative of LNAPL from wells from the upper canyon facilities down to the offsite parking lot
- Dominated by gasoline.



Representative of LNAPL from wells at the lower canyon facility
- Dominated by weathered diesel and some gasoline.

DIESEL RANGE

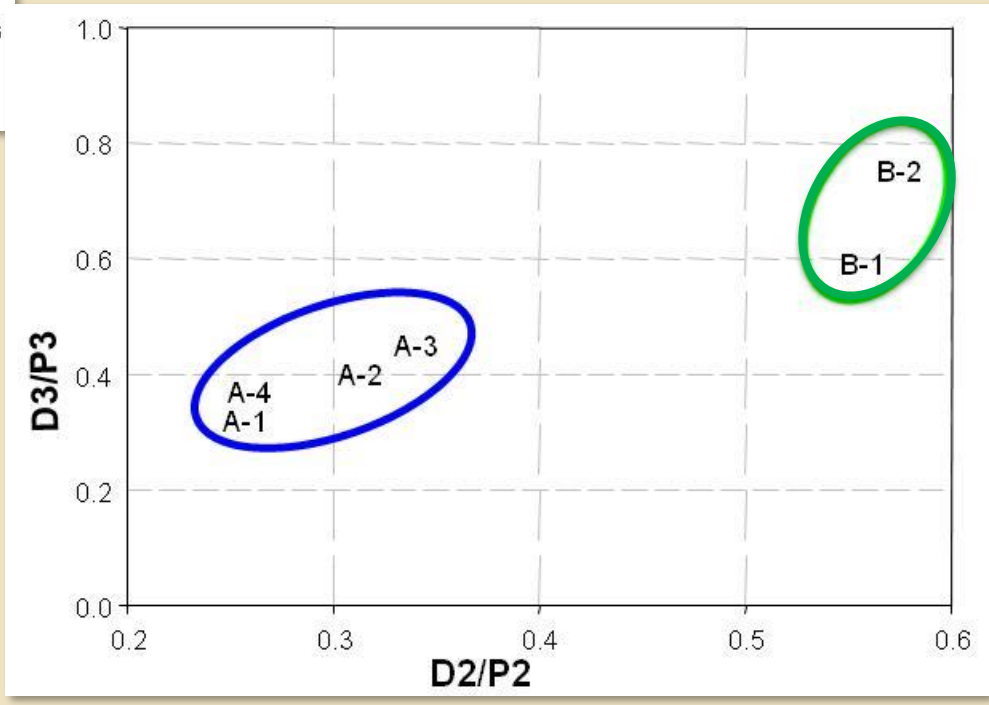


Weathering Analysis

Diesel in LNAPL samples from Group B are substantially more weathered than diesels in samples from Group A

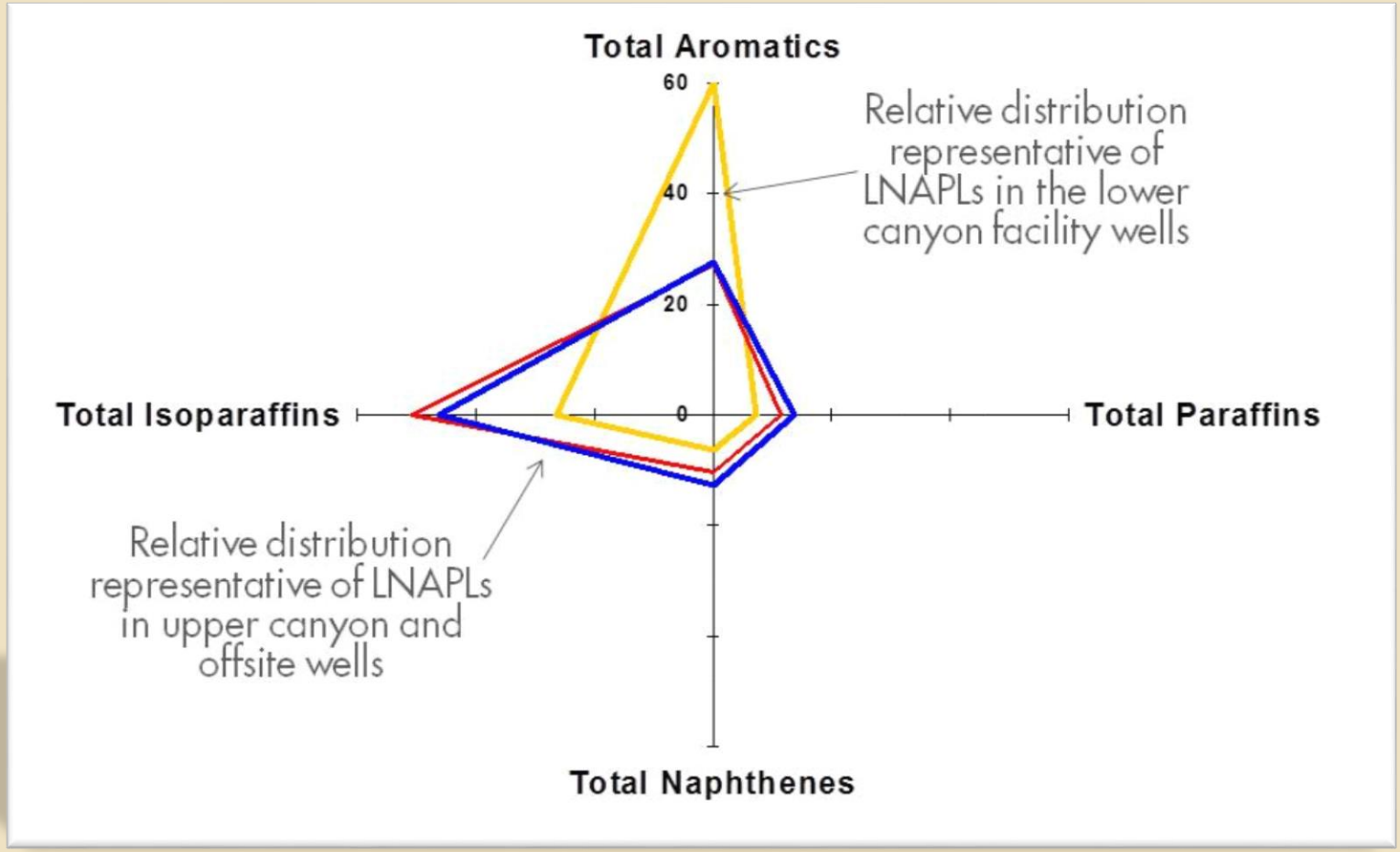
Compositional Analysis

Diagnostic source ratio analysis shows two distinct groupings of diesel: Group A and Group B

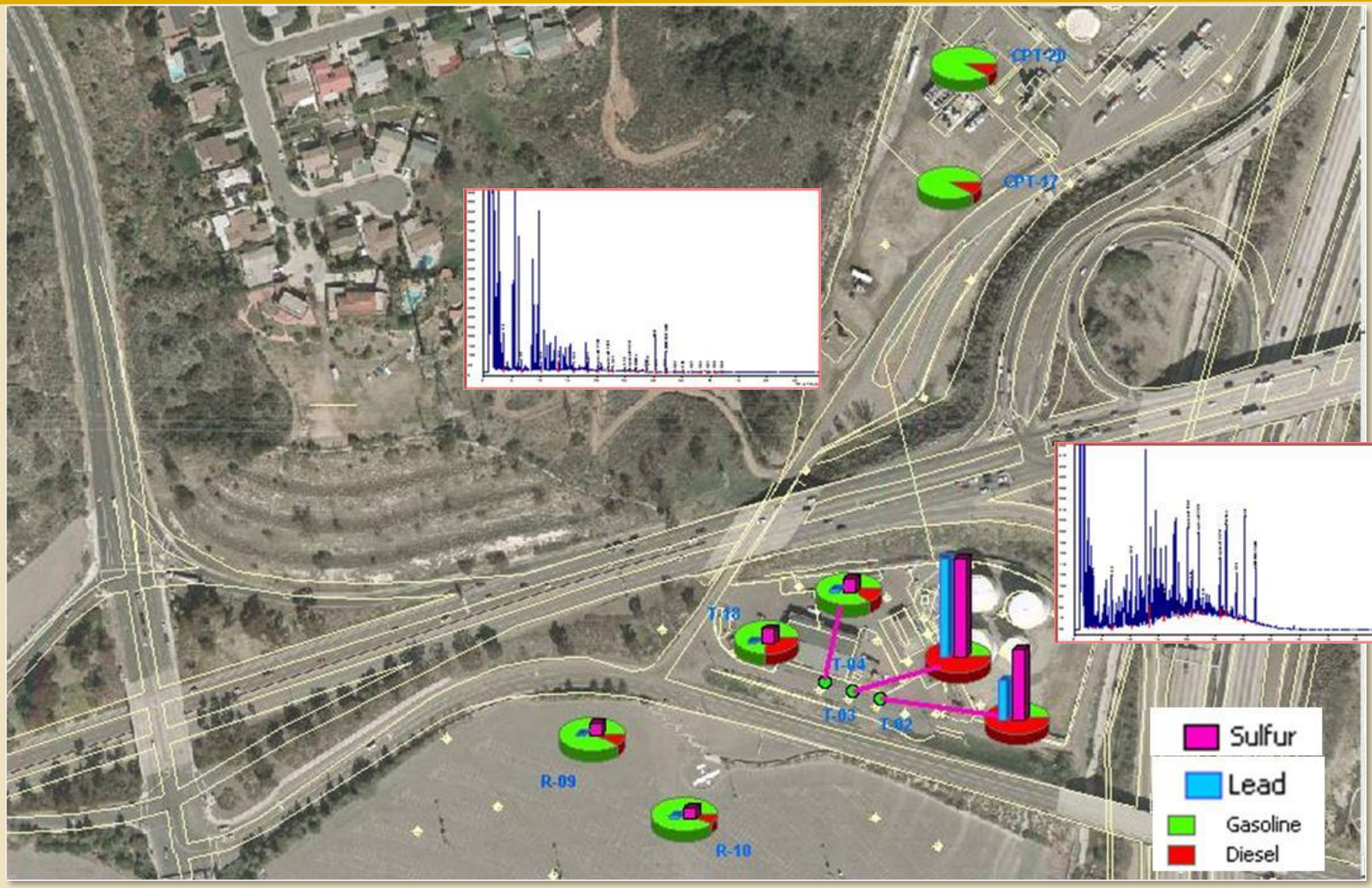


DIAGNOSTIC CHEMICAL FEATURES - GASOLINE RANGE

Relative distribution of bulk gasoline-range Paraffins, Isoparaffins, Aromatics and Naphthenes



TOTAL SULFUR, TOTAL LEAD AND RELATIVE PROPORTION OF GASOLINE/DIESEL



CONCEPTUAL SITE MODEL

- Combination of conventional and innovative investigate tools used to develop the CSM
- Independent, multiple lines of evidence were used to develop and confirm
  - Hydrogeologic conditions
  - Soil vapor, soil and GW analysis
  - Laser induced fluorescence in-situ investigation
  - Detailed forensic analyses
- Innovative tools work best when data can be confirmed with conventional methods