Headquarters U.S. Air Force

Integrity - Service - Excellence

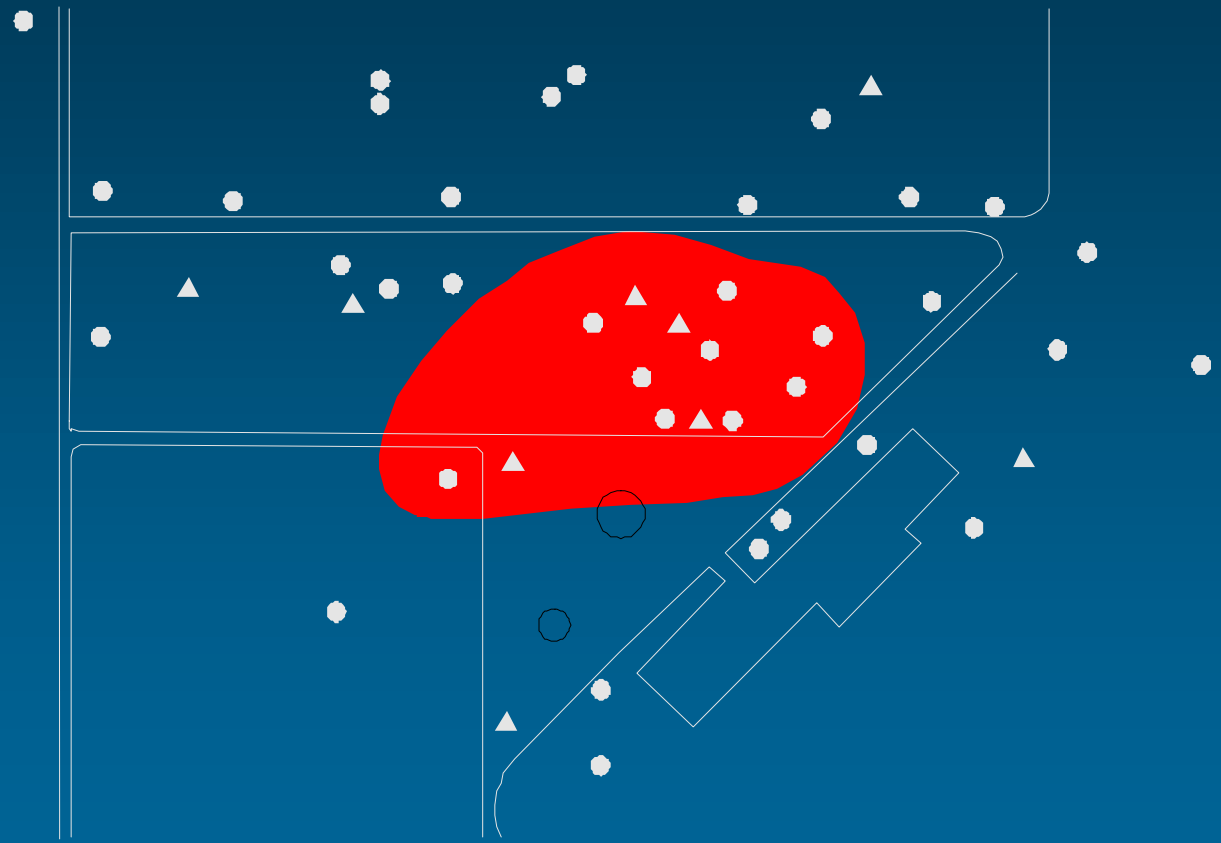
Section 4
Case Study – Williams AFB

Presented by

Todd Wiedemeier
Parsons Engineering Science, Inc.

todd.wiedemeier@parsons.com
(303) 831-8100

Extent of Mobile LNAPL



Estimated Extent of Mobile LNAPL In Contact with Groundwater

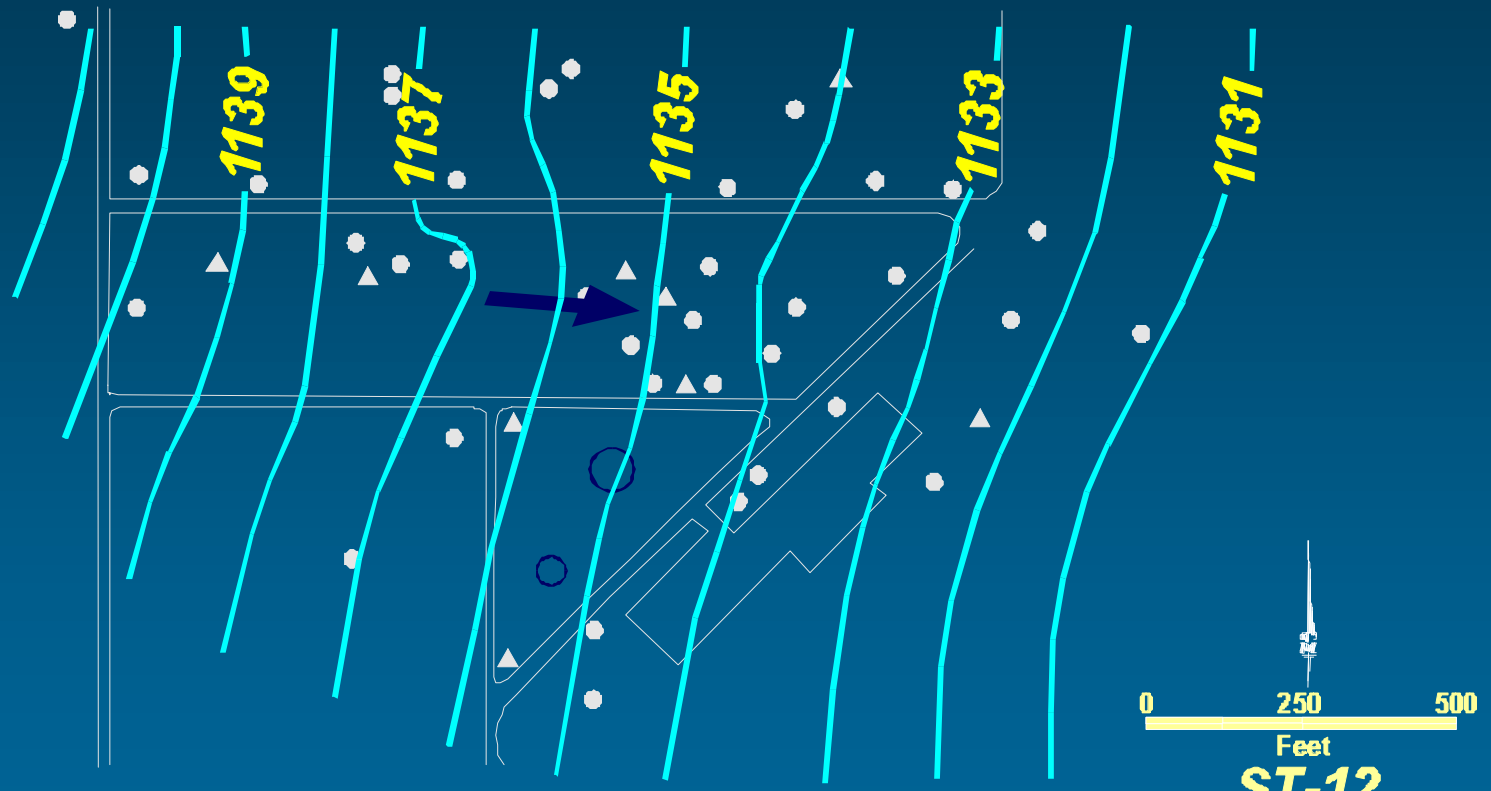
0 250 500

Feet

ST-12

Williams Air Force Base

Water Table Elevation Map



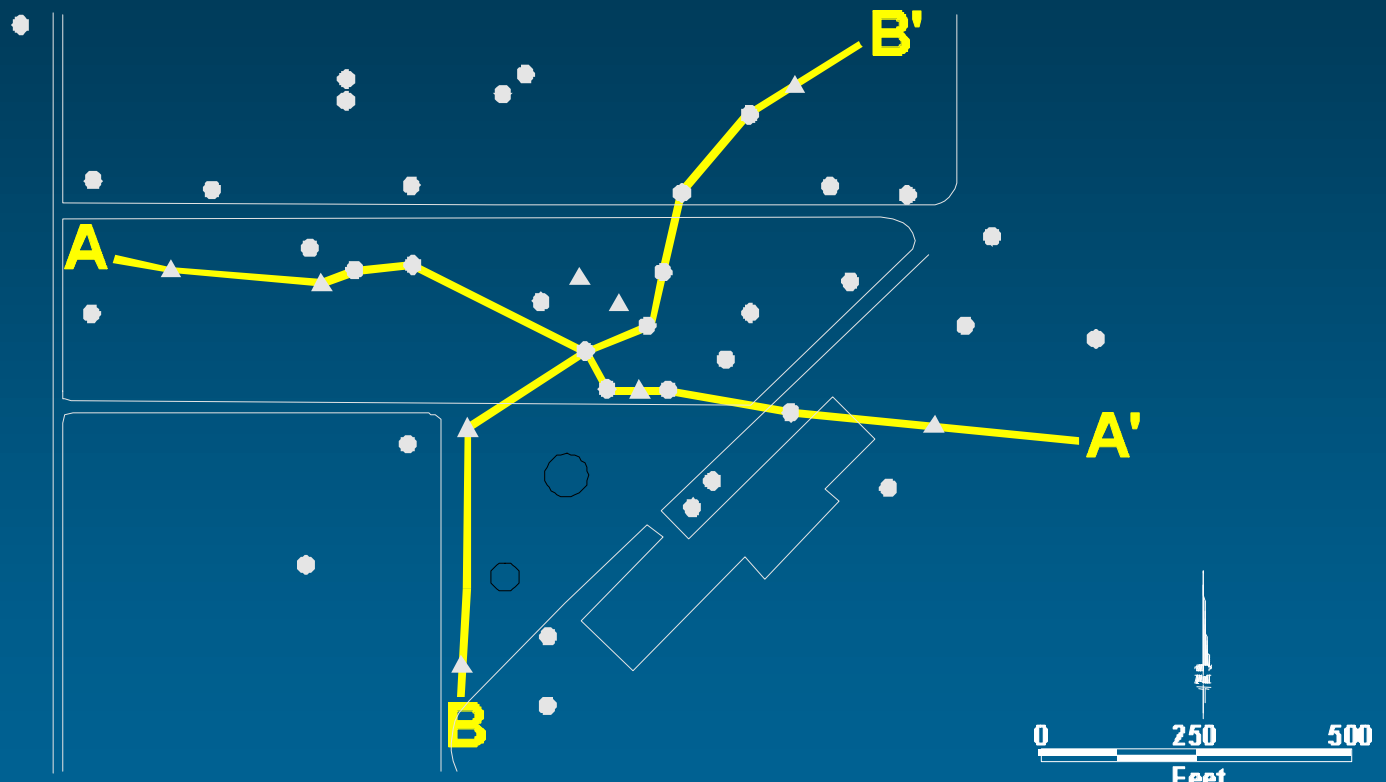
ST-12

Williams Air Force Base

Hydrogeologic Characteristics

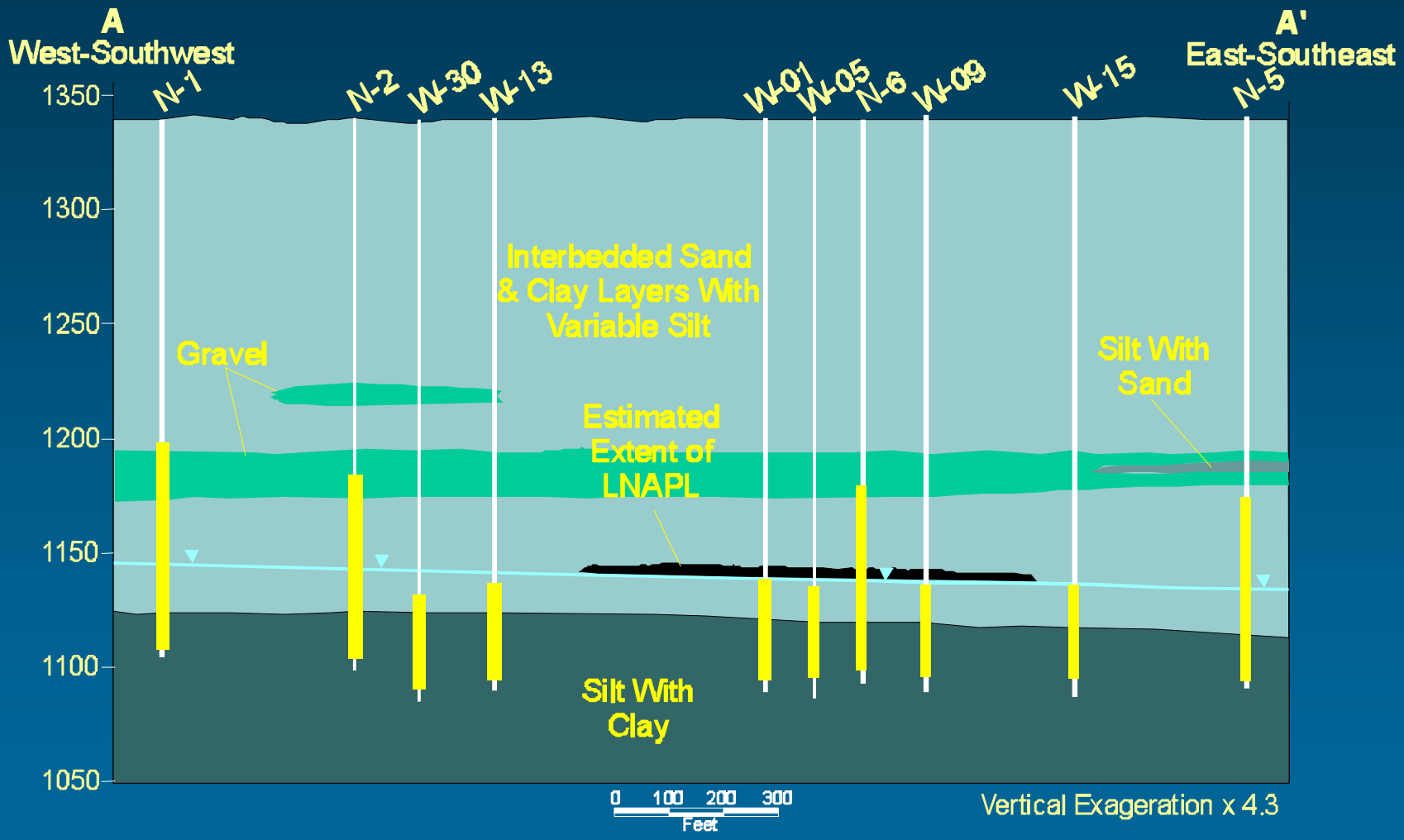
- **Aquifer Matrix - Dominated by Sand With Interbedded Clay Layers**
- **Hydraulic Conductivity = 15 ft/day**
- **Horizontal Gradient = 0.006**
- **Vertical Gradient = 0.04 (upward)**
- **Effective Porosity = 0.25 (assumed)**
- **Seepage Velocity = 120 ft/yr**

Location of Hydrogeologic Sections

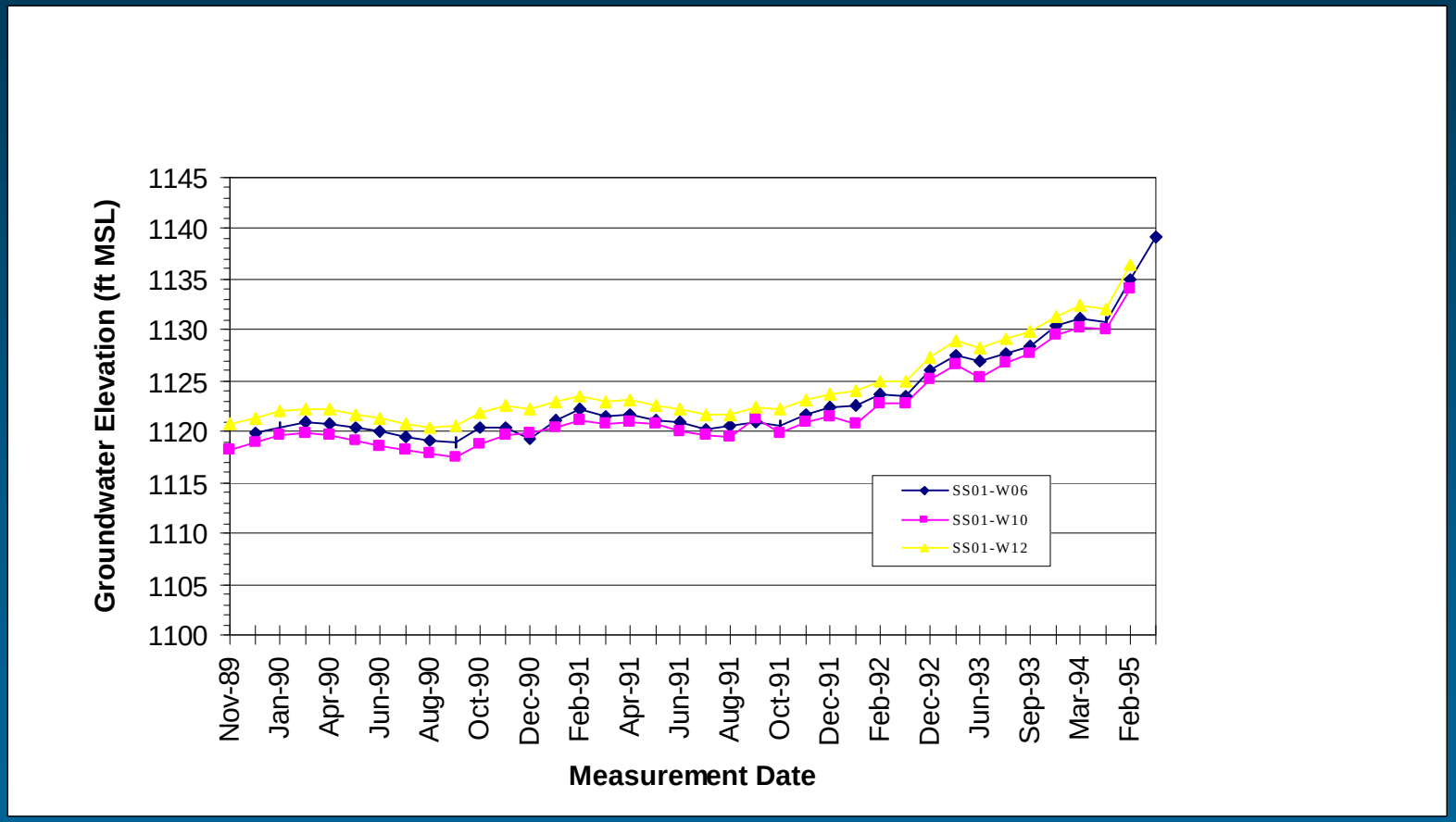


ST-12
Williams Air Force Base

Geologic Section A-A’



Shallow Well Hydrograph



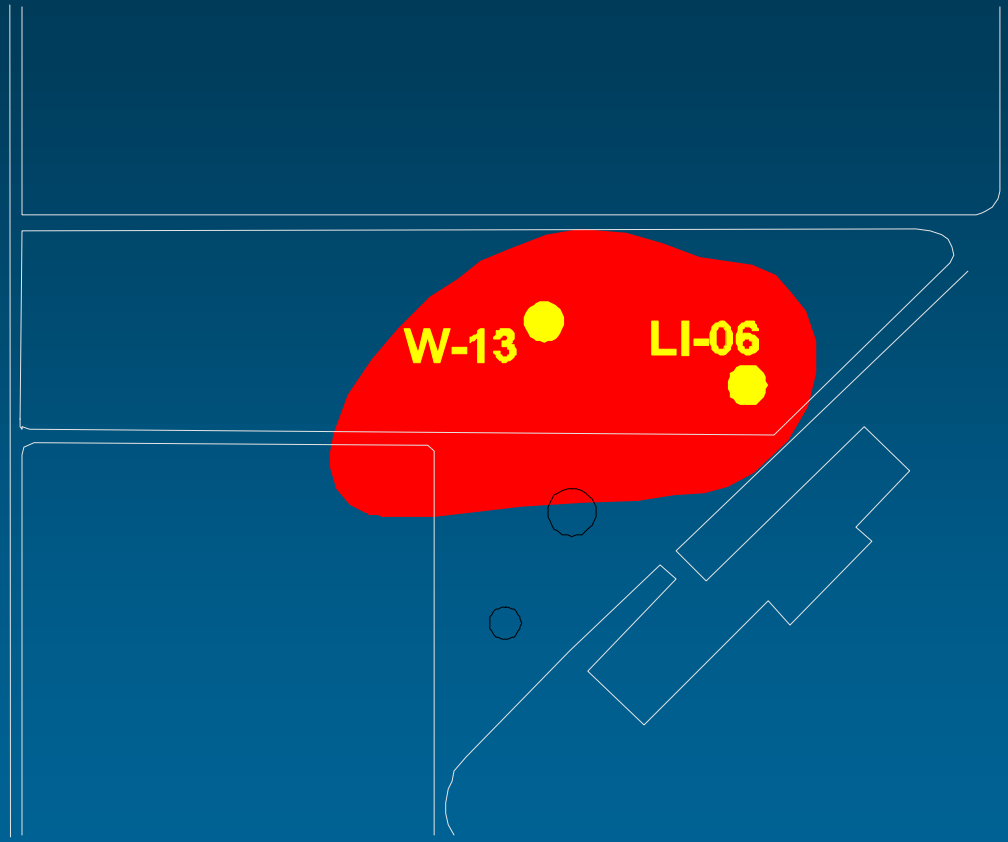
Major Processes Affecting NAPL In the Subsurface

- Flow Due to Gravity and Buoyancy
- Microscale Entrapment
- Dissolution Caused By:
  - Diffusion
  - Percolating Precipitation
- Volatilization
- Sorption
- Hydrolysis
- Biodegradation

Effect of Rising Water Table

- **Redistibution of Product Into Inaccessible Residuals (Smear Zone) Below Water Table**
- **Mobile LNAPL Thickness Decreasing**
- **Increasing Dissolution of BTEX into Groundwater**
- **Increasing Mass Flux of Electron Acceptors**
- **Increased Source Depletion**

Well Locations for LNAPL Thickness Analysis

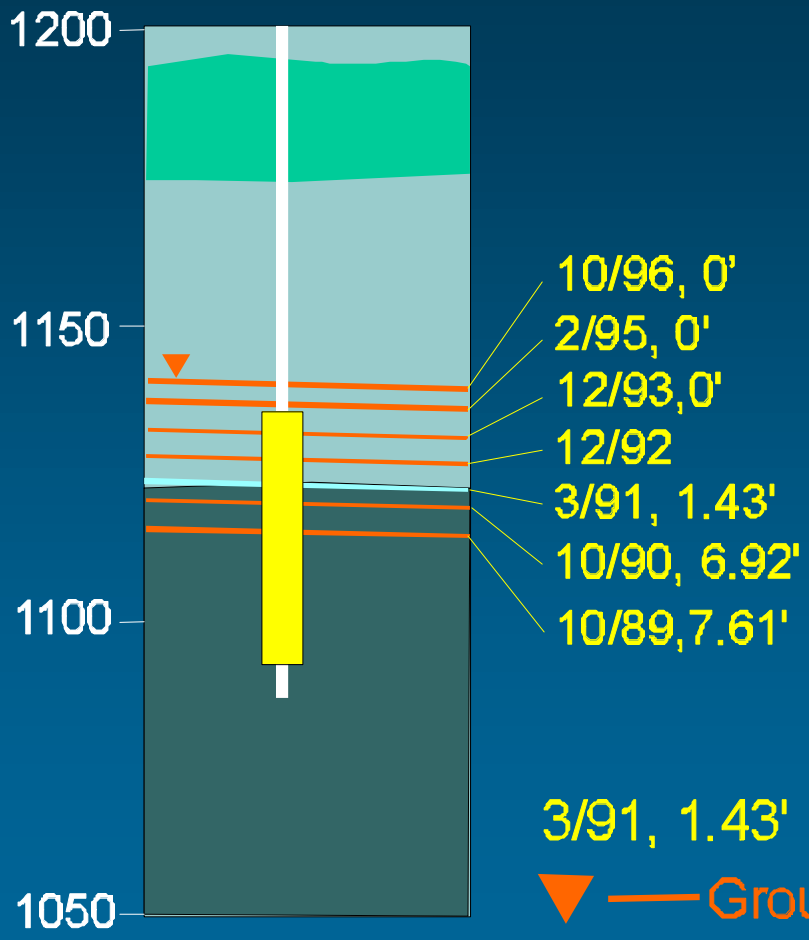


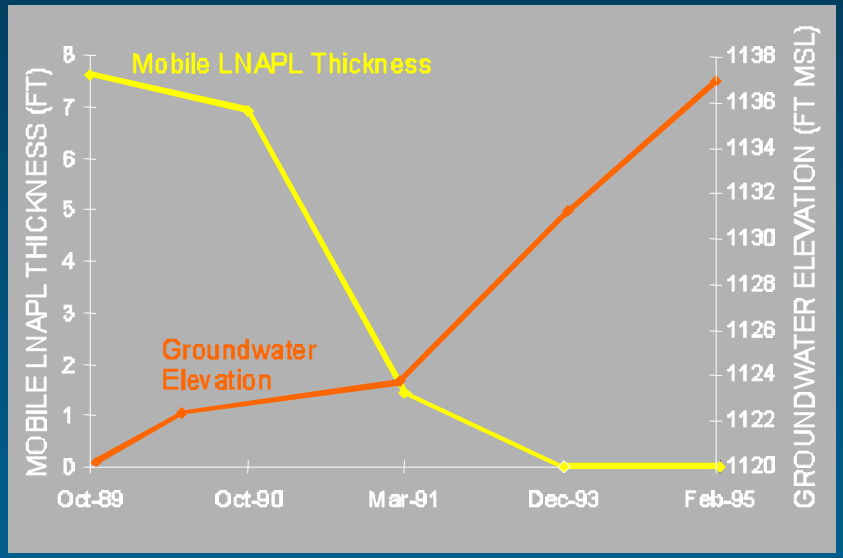
Estimated Extent of Mobile LNAPL In Contact with Groundwater

0 250 500
Feet

ST-12
Williams Air Force Base

Mobile LNAPL Thickness and Water Table Elevation - W-13

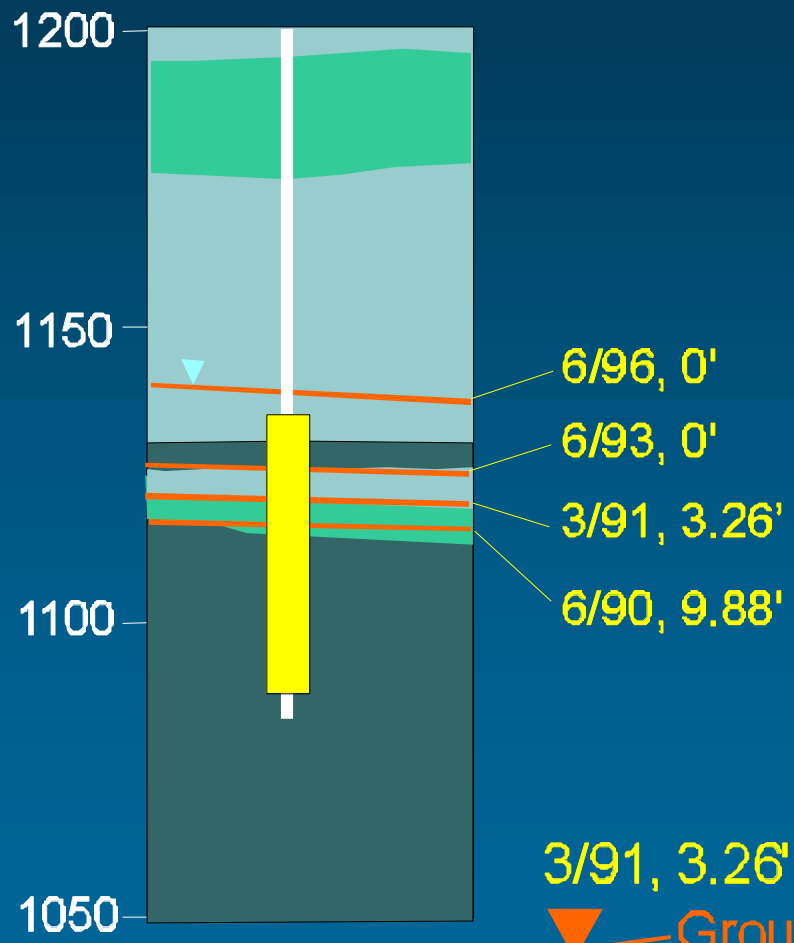


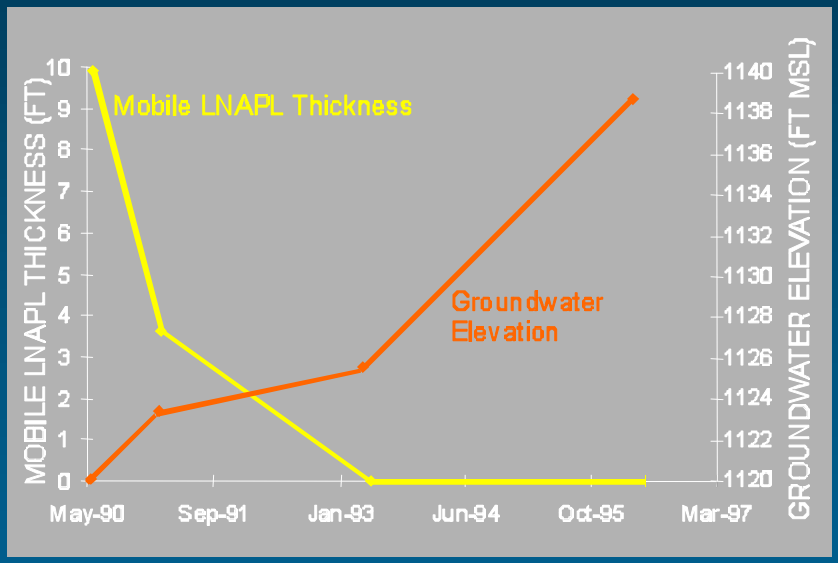


3/91, 1.43' Mobile LNAPL Thickness and Date

Groundwater Level

Mobile LNAPL Thickness and Water Table Elevation - LI-06

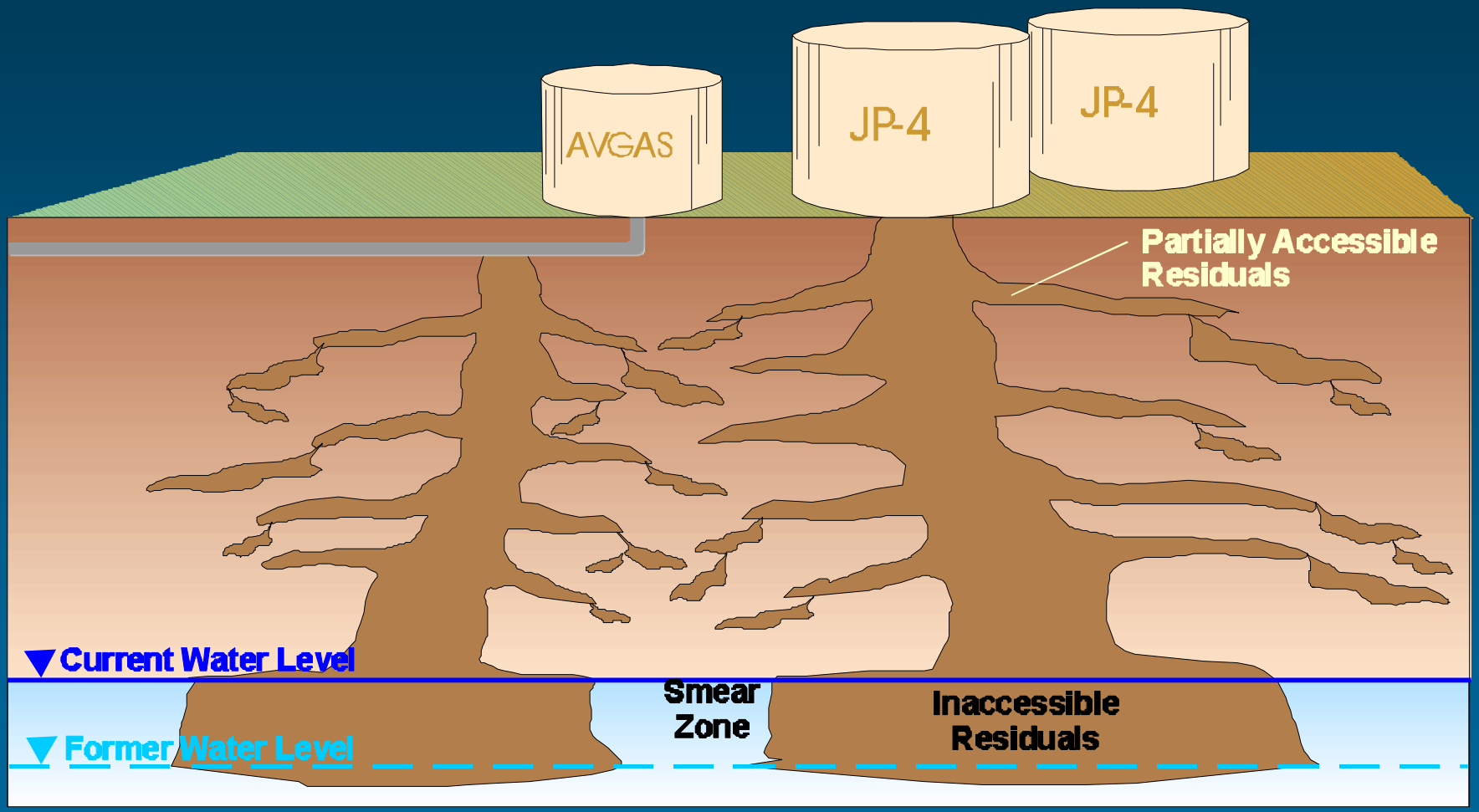




3/91, 3.26' Mobile LNAPL Thickness and Date

▼ Groundwater Level

Conceptual Site Model



LNAPL Characteristics

Composition:	Average % Weight In 3 Site Samples	% Weight In Fresh Gasoline
Benzene	0.87%	0.34 - 5.62%
Toluene	3.2%	1.32 - 21.0%
Ethylbenzene	1.1%	0.36 - 3.53%
Xylenes	2.8%	2.1 - 18.2%

Weathered AVGAS

Volume Estimates

0.65 -1.4 Million Gallons, IT Corporation, Dec. 1992.

Calculated vs. Observed BTEX Concentrations

Compound	Average Concentration in Site LNAPL	Calculated Concentration in Groundwater	Measured Concentration in Groundwater*
Benzene	6,525	28.2	30
Toluene	24,000	26.8	24
Ethylbenzene	8,250	2.4	2.9
Xylene	21,225	6.6	6.2
	Total BTEX	64.0	63.1

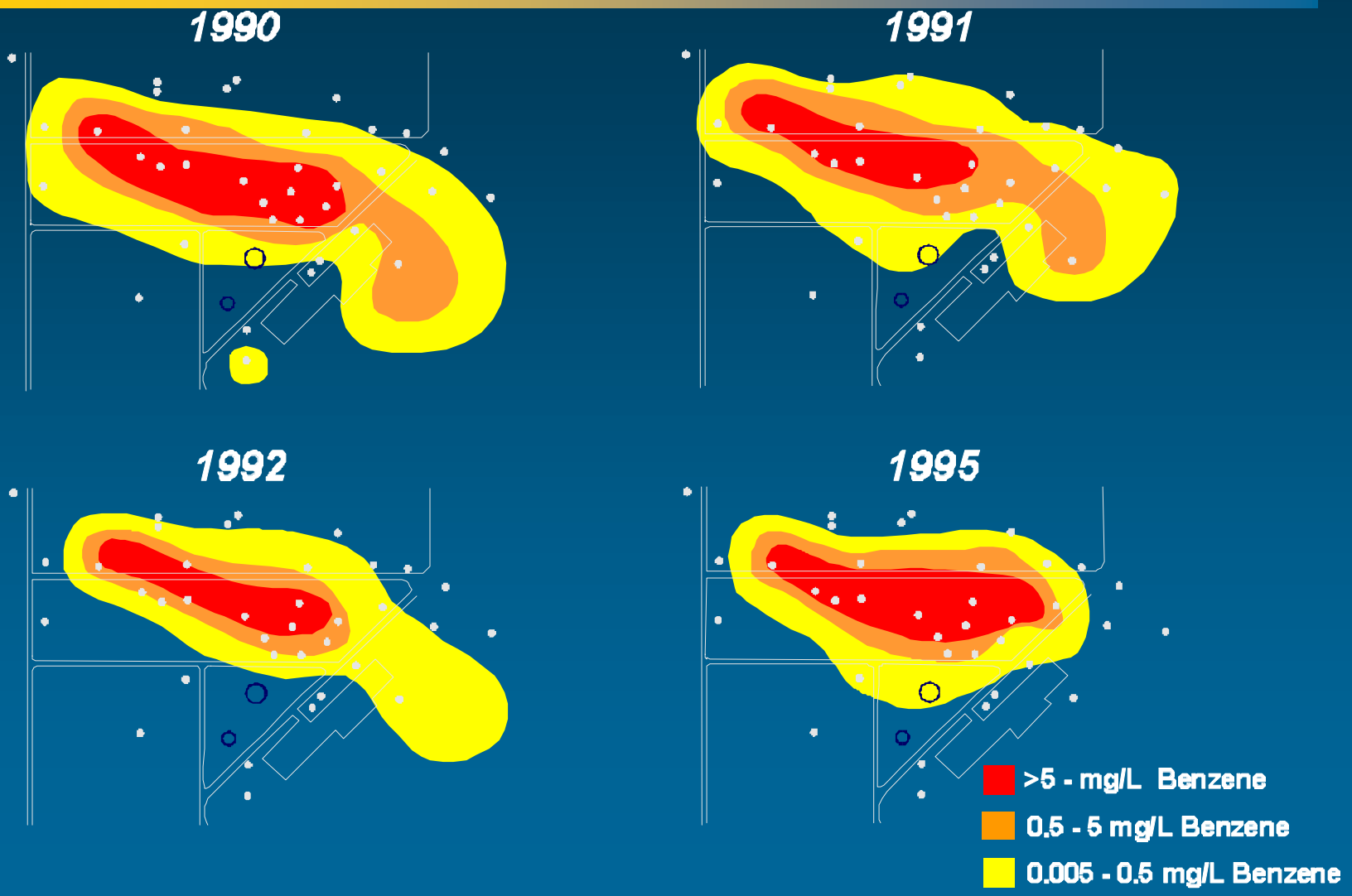
Concentration in mg/L

*Data from W-09, March 1996

First Line of Evidence - Site ST-12

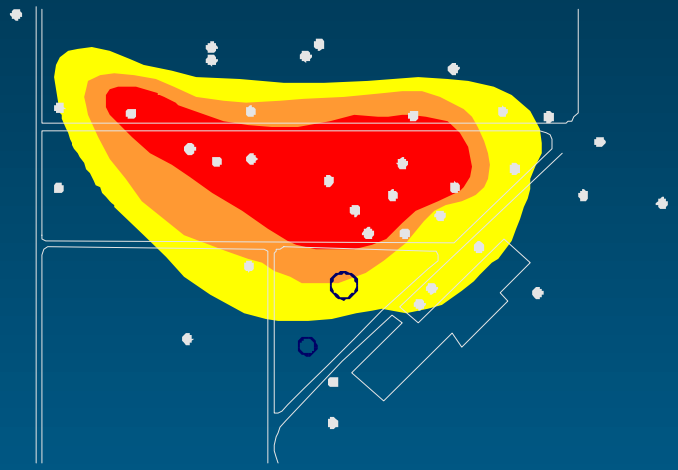
- Plume Should Have Migrated About 720 feet Since 1991
- Plume Appears Stable Although Source is Saturating Groundwater With BTEX
- BTEX Concentrations in Leading-Edge Wells Have Remained Constant Over Time

Benzene Concentrations

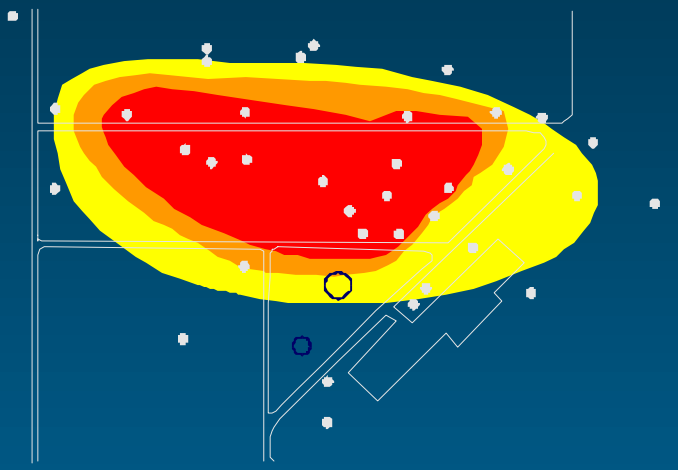


Benzene Concentrations

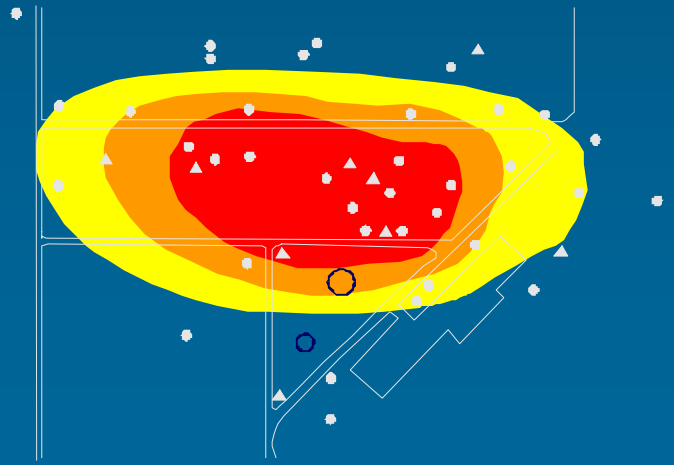
February 1995



March 1996



October 1996

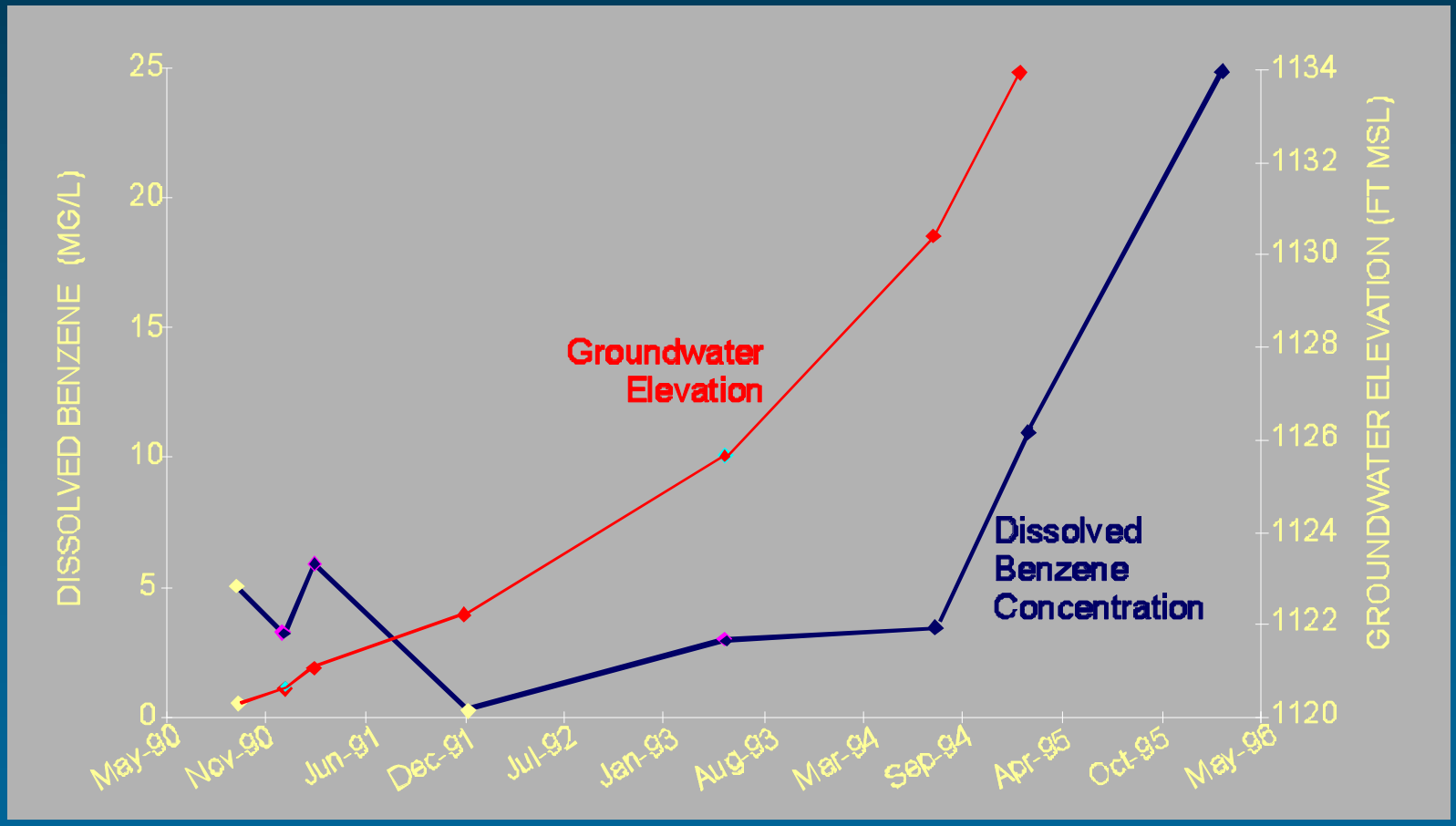


> 5 mg/L Benzene

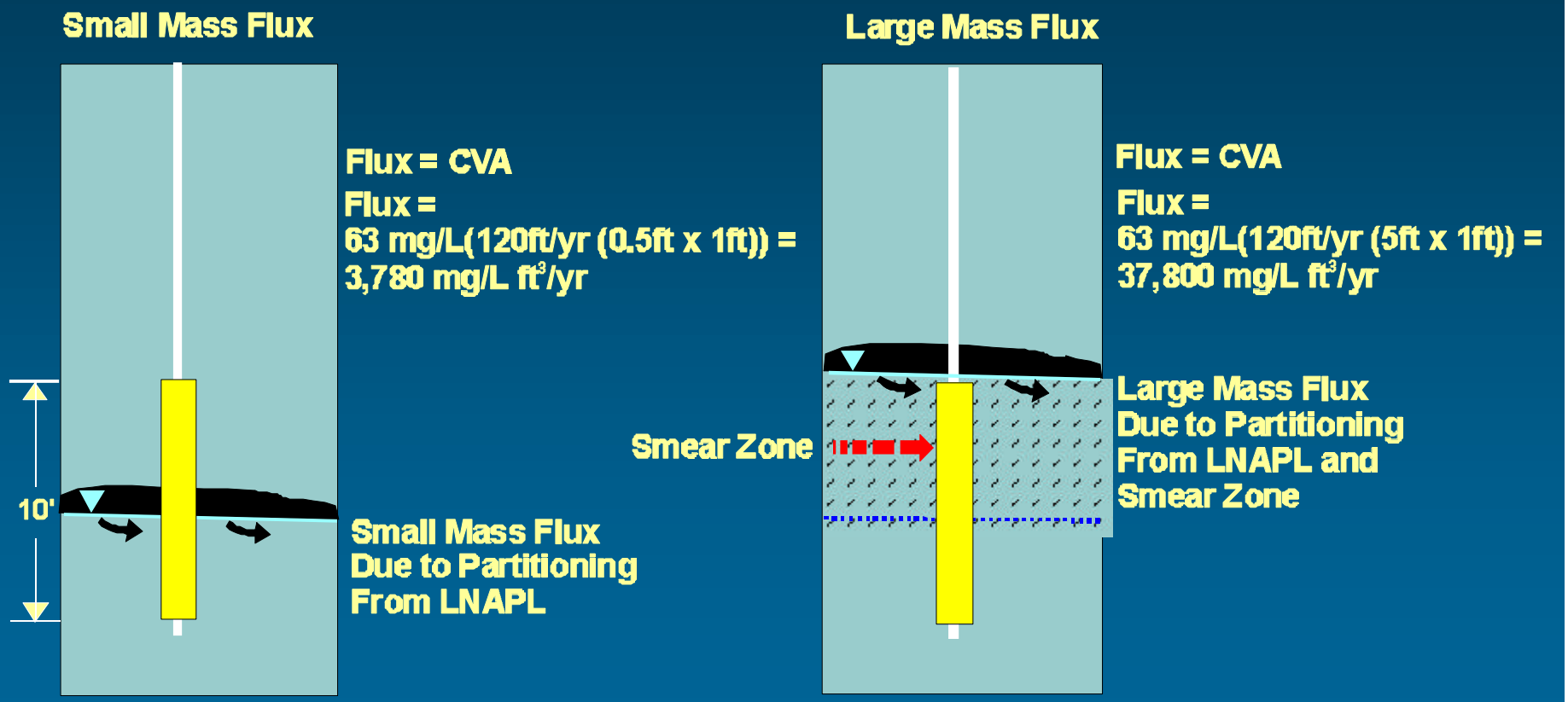
0.5 - 5 mg/L Benzene

0.001 - 1.0 mg/L Benzene

Dissolved BTEX Concentration vs Groundwater Elevation



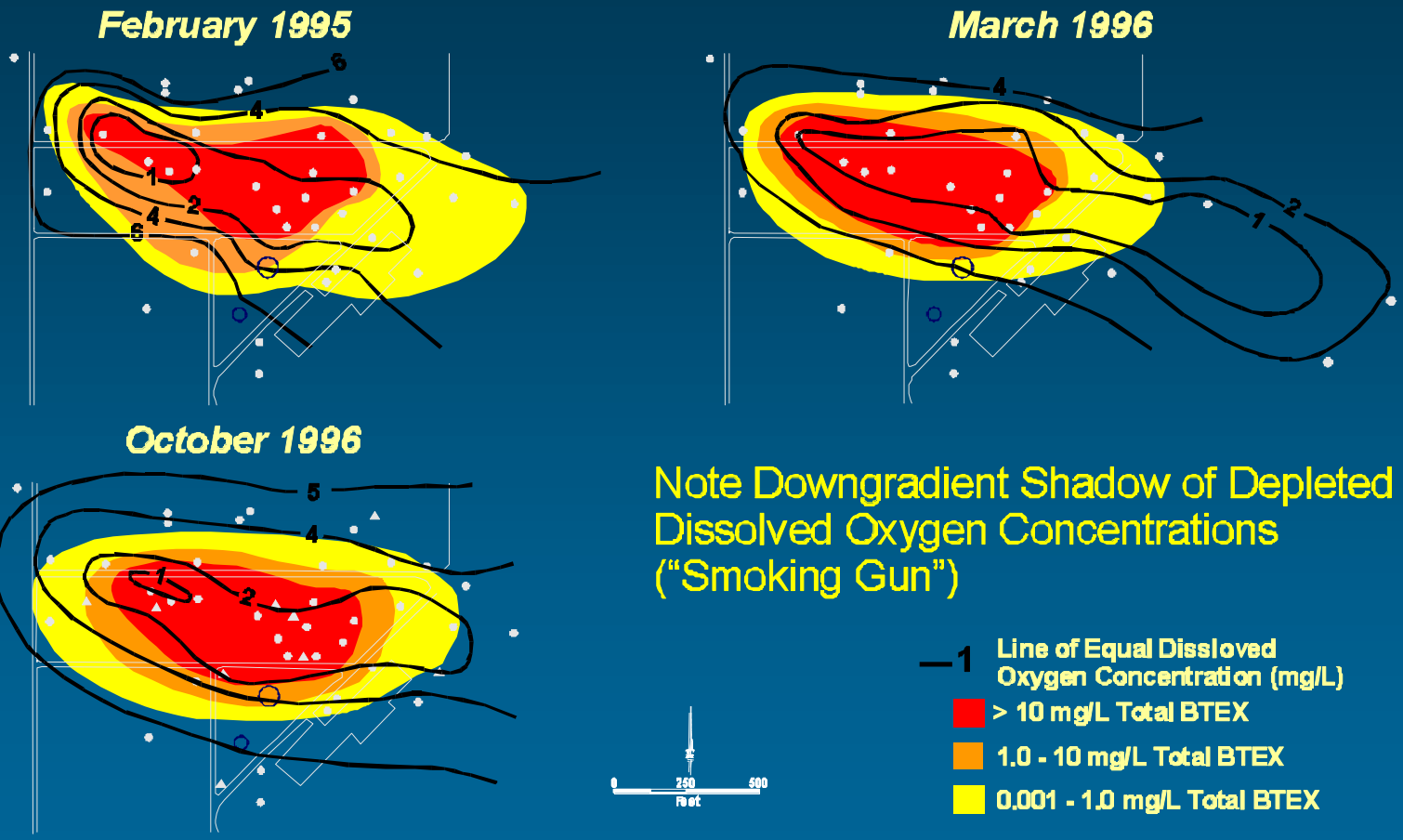
Contaminant Flux Calculations



Biodegradation Reactions

- **Sulfate Reduction**
- **Nitrate Reduction**
- **Aerobic Respiration**
- **Methanogenesis**
- **Minor Iron and Manganese Reduction**

Total BTEX and Dissolved Oxygen



Note Downgradient Shadow of Depleted Dissolved Oxygen Concentrations ("Smoking Gun")

—1 Line of Equal Dissloved Oxygen Concentration (mg/L)

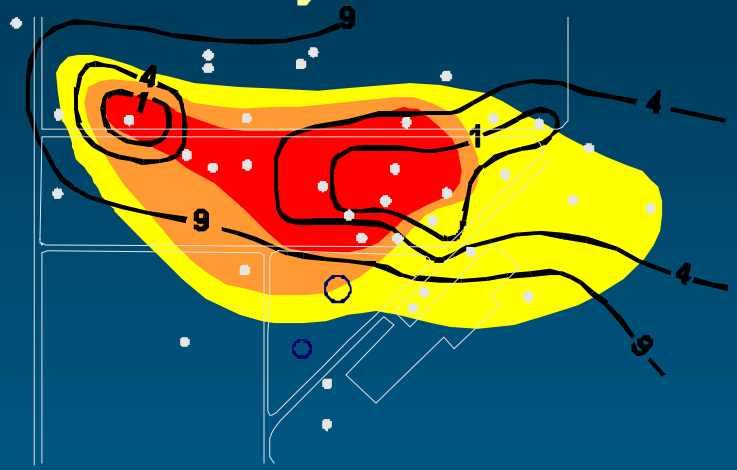
> 10 mg/L Total BTEX

1.0 - 10 mg/L Total BTEX

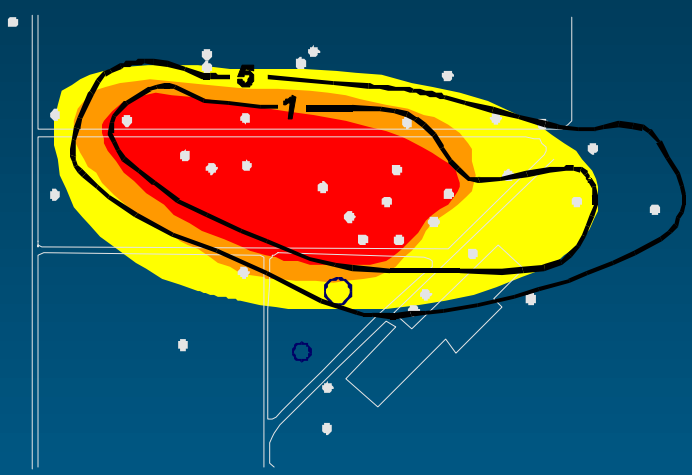
0.001 - 1.0 mg/L Total BTEX

Total BTEX and Nitrate

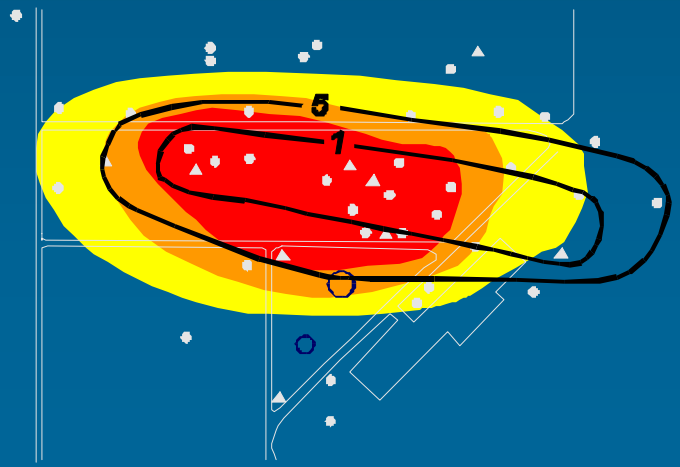
February 1995



March 1996



October 1996



Note Downgradient Shadow of Depleted Nitrate Concentrations ("Smoking Gun")

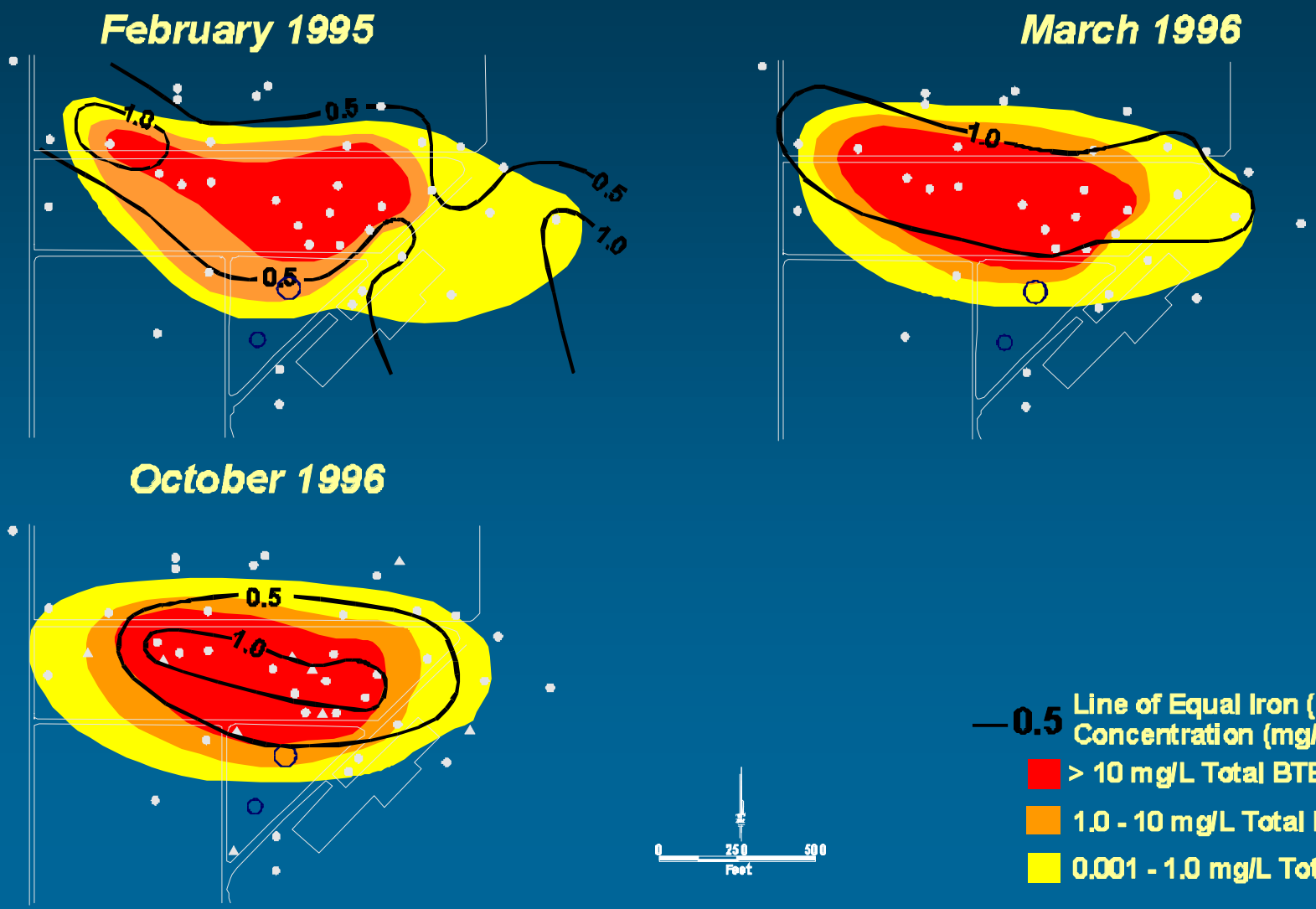
—1 Line of Equal Nitrate Concentration (mg/L)

> 10 mg/L Total BTEX

1.0 - 10 mg/L Total BTEX

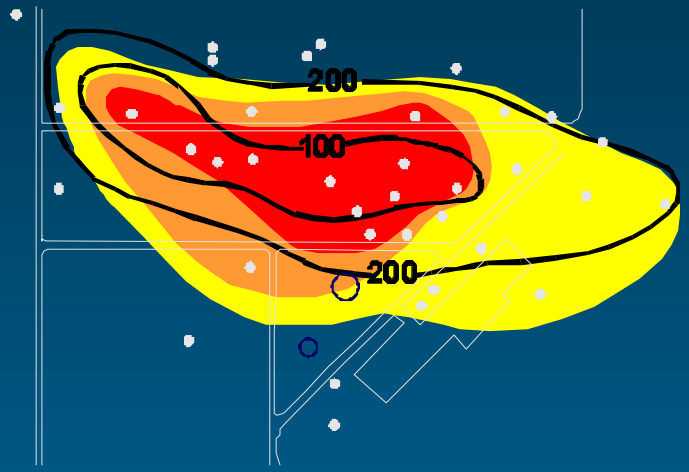
0.001 - 1.0 mg/L Total BTEX

Total BTEX and Fe(II)

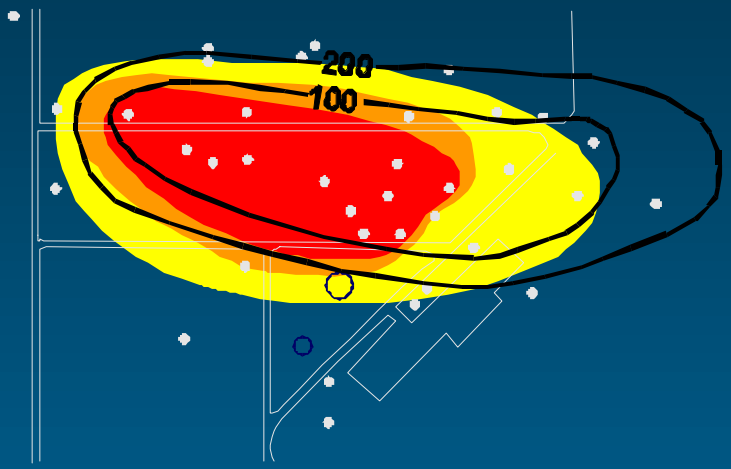


Total BTEX and Sulfate

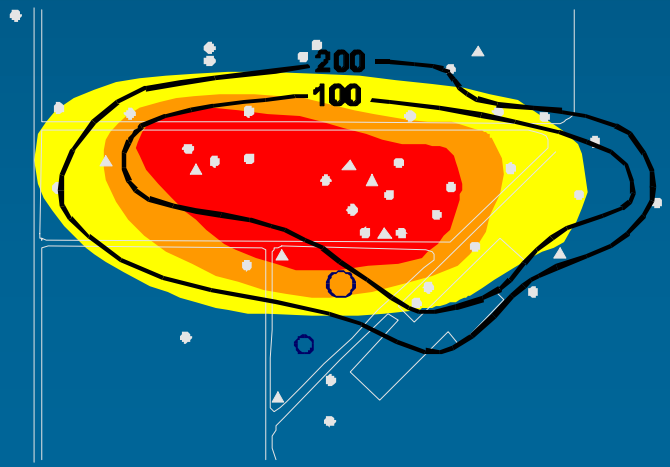
February 1995



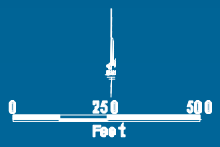
March 1996



October 1996



Note Downgradient Shadow of Depleted Sulfate Concentrations ("Smoking Gun")



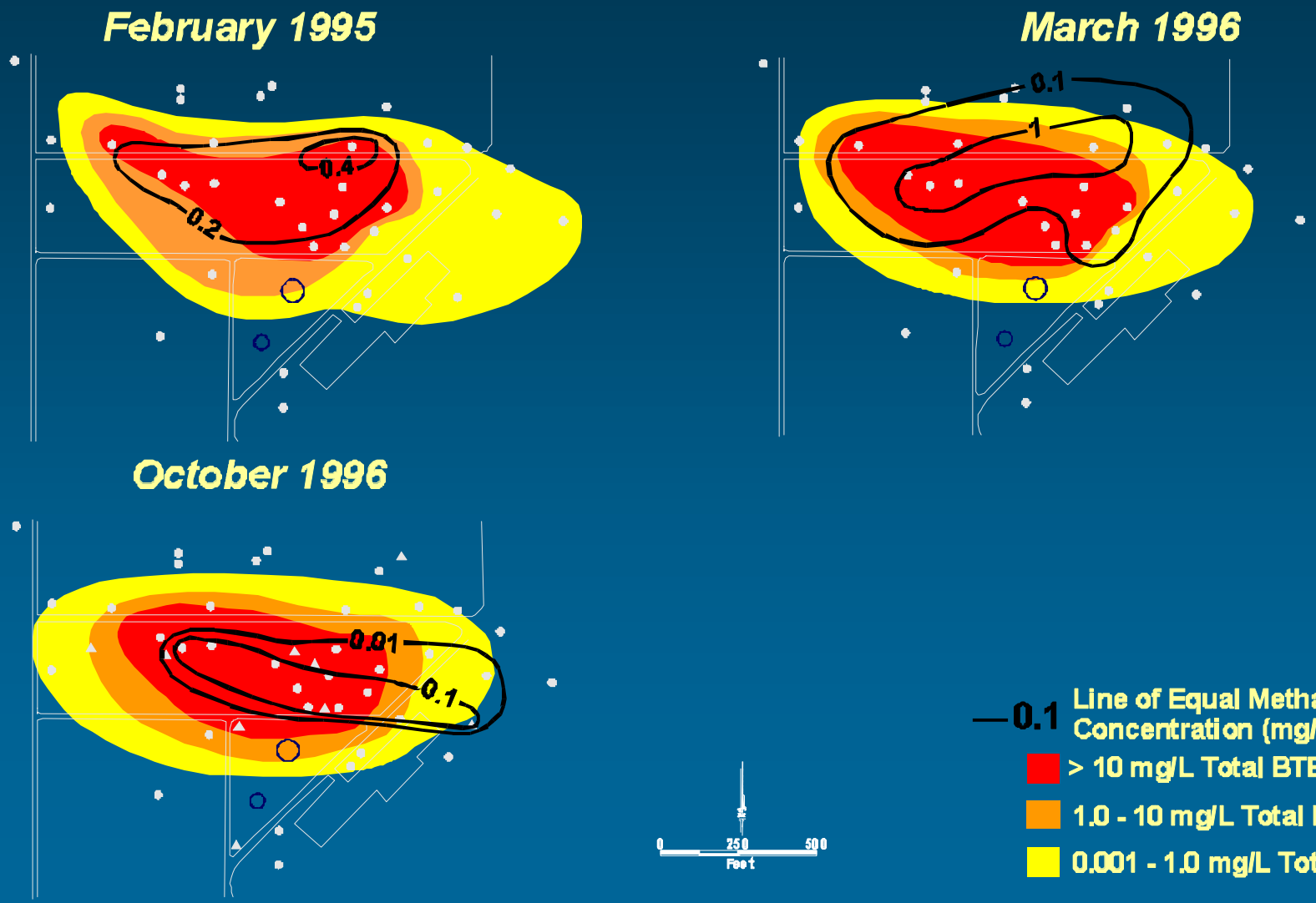
—100 Line of Equal Sulfate Concentration (mg/L)

> 10 mg/L Total BTEX

1.0 - 10 mg/L Total BTEX

0.001 - 1.0 mg/L Total BTEX

Total BTEX and Methane



Groundwater Characteristics

	Plume Interior (W-09)	Background (W-27)
Dissolved Oxygen	0.22 mg/L	8.04 mg/L
Nitrate	ND	7.7 mg/L
Ferrous Iron	0.74 mg/L	0.75 mg/l
Sulfate	5.0 mg/L	250 mg/L
Methane	0.43 mg/L	ND
Temperature	28.0°C	22.9°C
pH	7.19	6.62
Alkalinity	178 mg/L $CaCO_3$	91 mg/L $CaCO_3$
Redox	- 296 mV	164 mV
Conductivity	0.94 mV/cm	3.9 mV/cm

Note: Data from 3/96 IT sampling event
ND - Not Detected

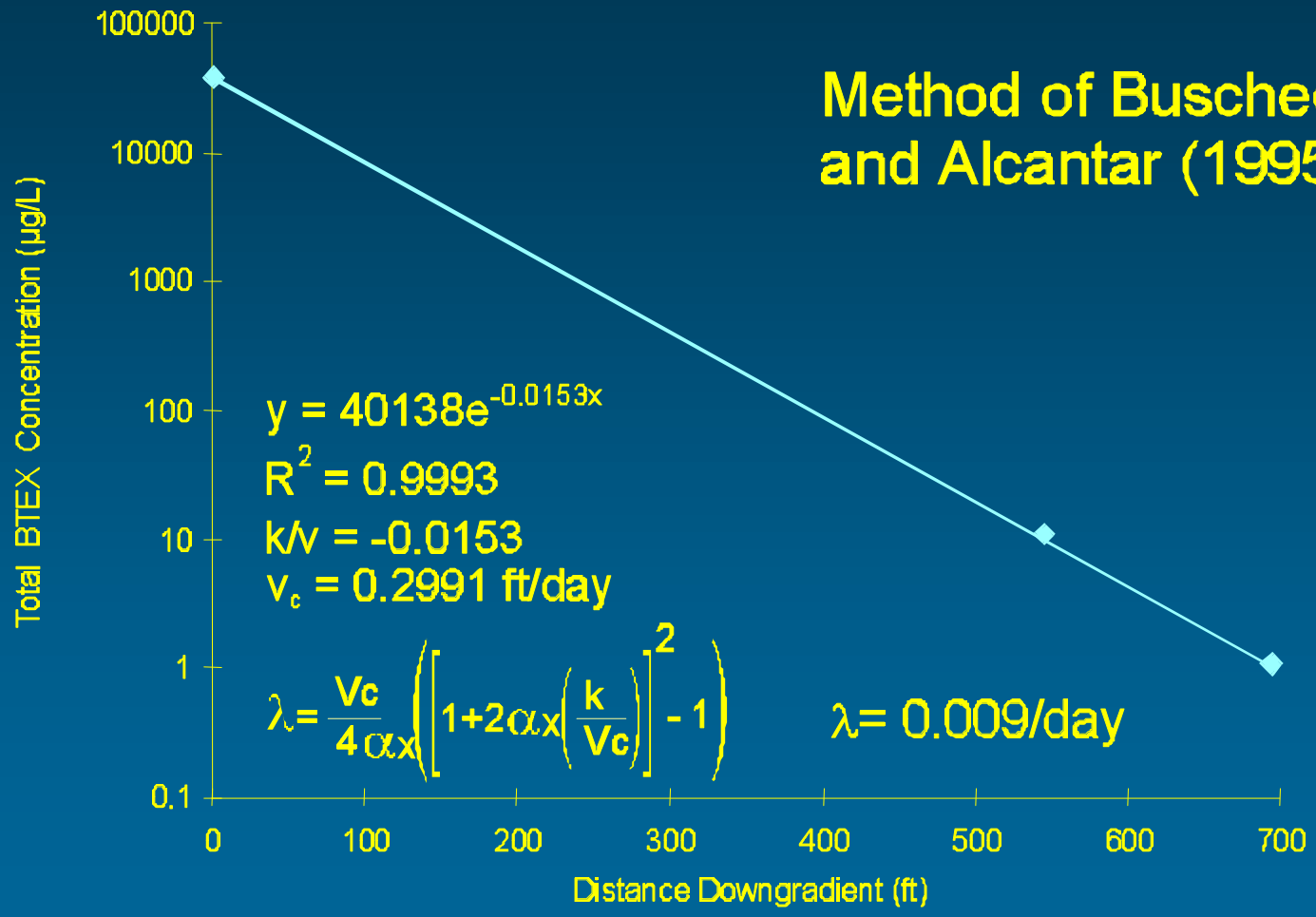
Biodegradation Capacity

	February 1995	March 1996	October 1996
Aerobic Respiration	2,300	1,750	1,880
Denitrification	8,310	8,750	7,060
Iron Reduction	50	57	160
Sulfate Reduction	52,500	49,900	48,090
Methanogenesis	380	3,100	650
Manganese Reduction	-	-	410
Total Capacity	63,540	63,557	58,250

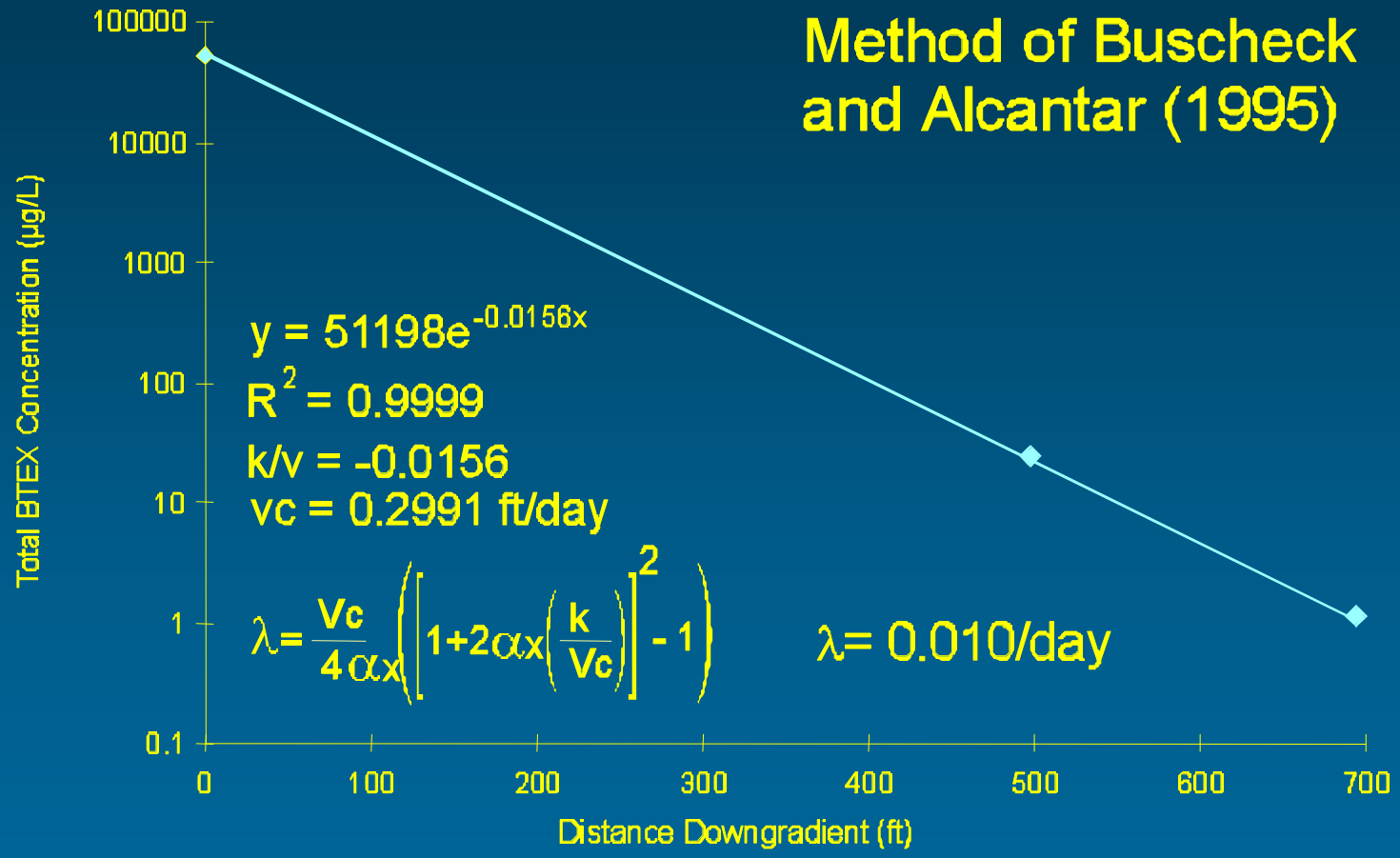
Units in µg/L

Note: Highest BTEX concentration observed at ST12 During This Period = 63,100 µg/L (3/96)

Total BTEX Biodegradation Rate Constant Calculation, March 1996



Total BTEX Biodegradation Rate Constant Calculation, Oct. 1996



Modeling Results Suggest

- Biodegradation is Occurring
- Natural Attenuation Processes Are Limiting Downgradient Contaminant Migration
- Dissolved BTEX Data From March and October Fit First Order Decay Model
- Contaminant Plume is Steady or Receding

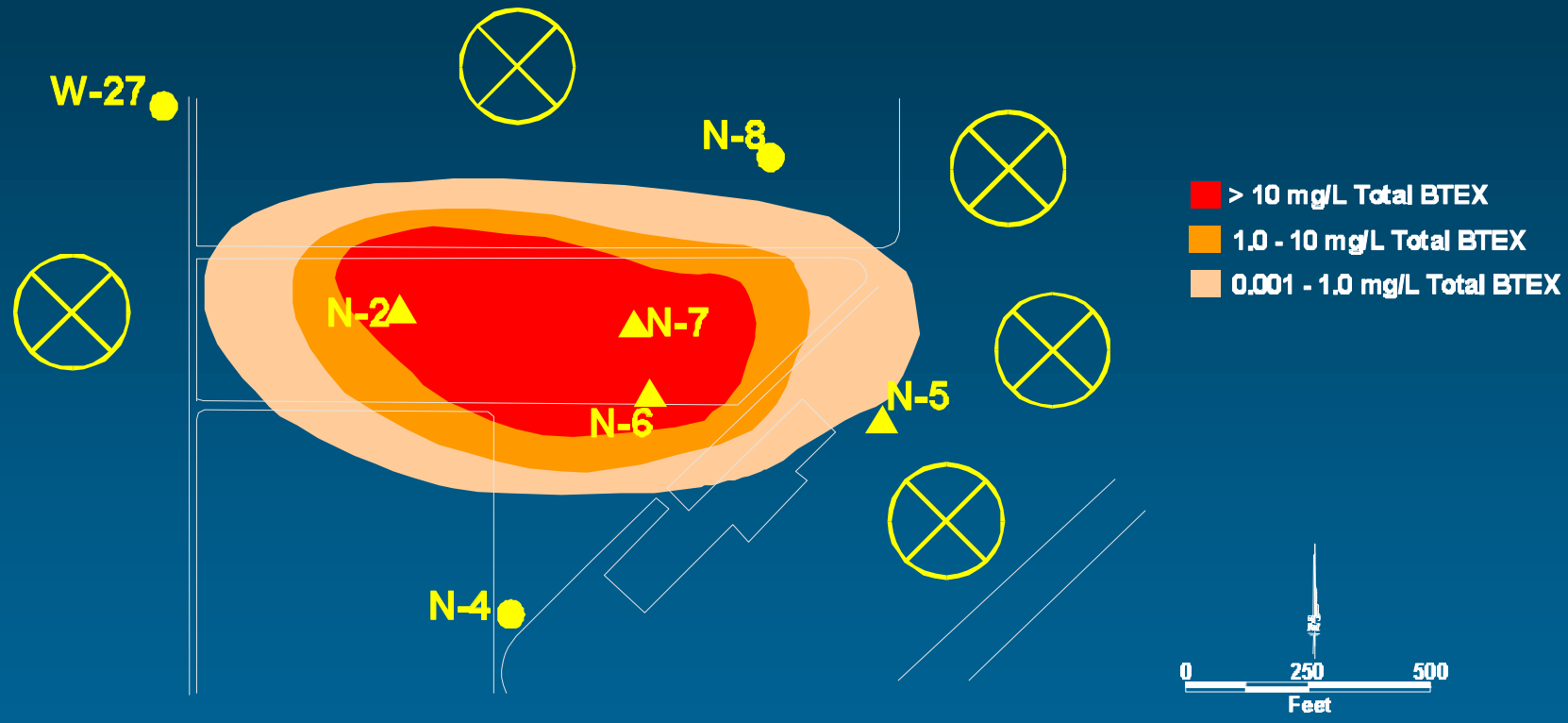
Groundwater Analytical Protocol for Long-Term Monitoring

- **Recommended Long-Term Monitoring Analytical Protocol**
  - **VOC Analysis (SW8020)**
  - **Dissolved Oxygen**
  - **Sulfate**
  - **ORP**
  - **Temperature**
  - **pH**

Groundwater Analytical Protocol for Long-Term Monitoring

- **Sample Annually for the First 5 Years**
- **Sample Free Product Annually for Fraction BTEX to Determine Total Remediation Time**
- **Designed to Monitor Plume**

Proposed Long-Term Monitoring Plan



▲ Proposed Long-Term Monitoring Well

● Proposed Point-of-Action Well

⊗ Proposed General Location for Additional Point-of-Action Well

Conclusions and Recommendations

- **Historical Evidence Shows Contaminant Plume is Not Migrating**
- **Chemical Indicators Show that Biodegradation of BTEX is Occurring and Will Continue Until BTEX is Depleted**
- **Time Frame for Complete Remediation Dependent on Source**

Petroleum Hydrocarbon Sites with Regulatory Approval

- **Wurtsmith AFB – KC-135 Crash Site**
- **Carswell AFB - Site14**
- **Ellsworth AFB - POL Yard**
- **Homestead AFB - Site 15**