

# REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b> This slide presentation assesses the degree to which various types of engineered source-reduction efforts at selected fuel-contaminated sites have resulted in decreasing concentrations of fuel constituents dissolved in groundwater and describes a methodology for evaluating the potential effectiveness of source-reduction actions at reducing the magnitude and extent of dissolved fuel constituents.					
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# ***Source Reduction Effectiveness Technical Summary Report***

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***Presented by***  
**John R. Hicks**



**Parsons**

Parsons Engineering Science, Inc.

# ***Presentation Outline***

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- **Project Objectives and Site Locations**
- **Statistical Tools**
- **Case Histories**
- **Summary and Conclusions**

# ***Project Description and Objectives***

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- **Assess the degree to which various types of engineered source-reduction efforts at selected fuel-contaminated sites have resulted in decreasing concentrations of fuel constituents dissolved in groundwater; and**

# ***Project Description and Objectives***

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- **Describe a methodology for evaluating the potential effectiveness of source-reduction actions at reducing the magnitude and extent of dissolved fuel constituents**

# Source Reduction Sites



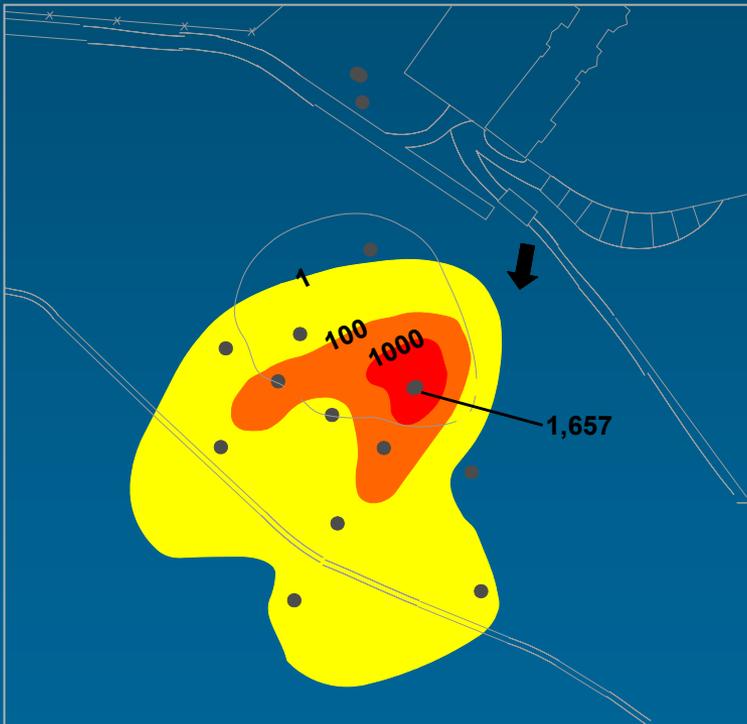
# ***Statistical Tools***

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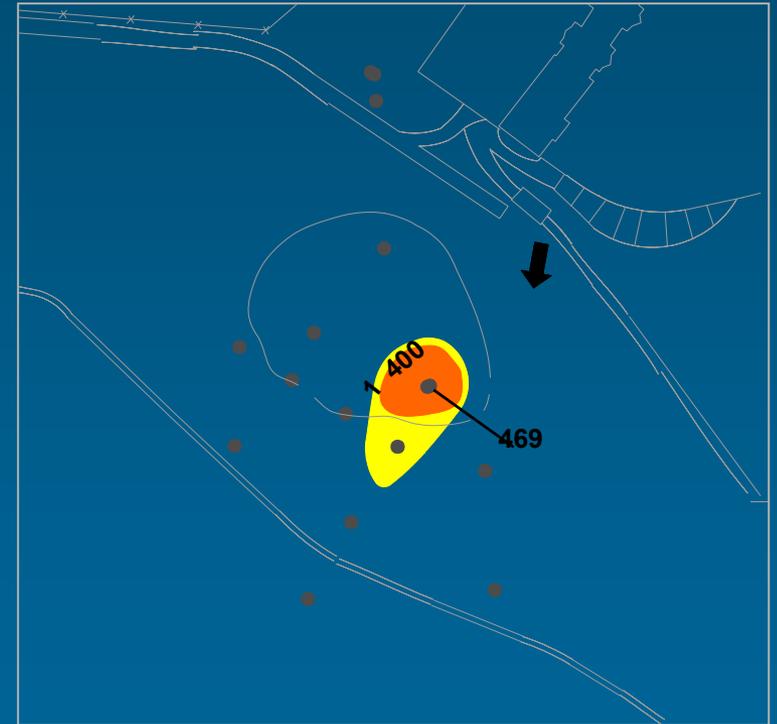
- **Mann-Kendall Test for Trend**
  - nonparametric
  - non-detects can be used
  - requires only small sample sizes
- **Sen's Nonparametric Estimator of Slope**
  - not greatly affected by outliers
  - magnitude of slope is indicator of rate of change

# BTEX in Groundwater

## Site FT-03, Westover AFB, MA



May 1975

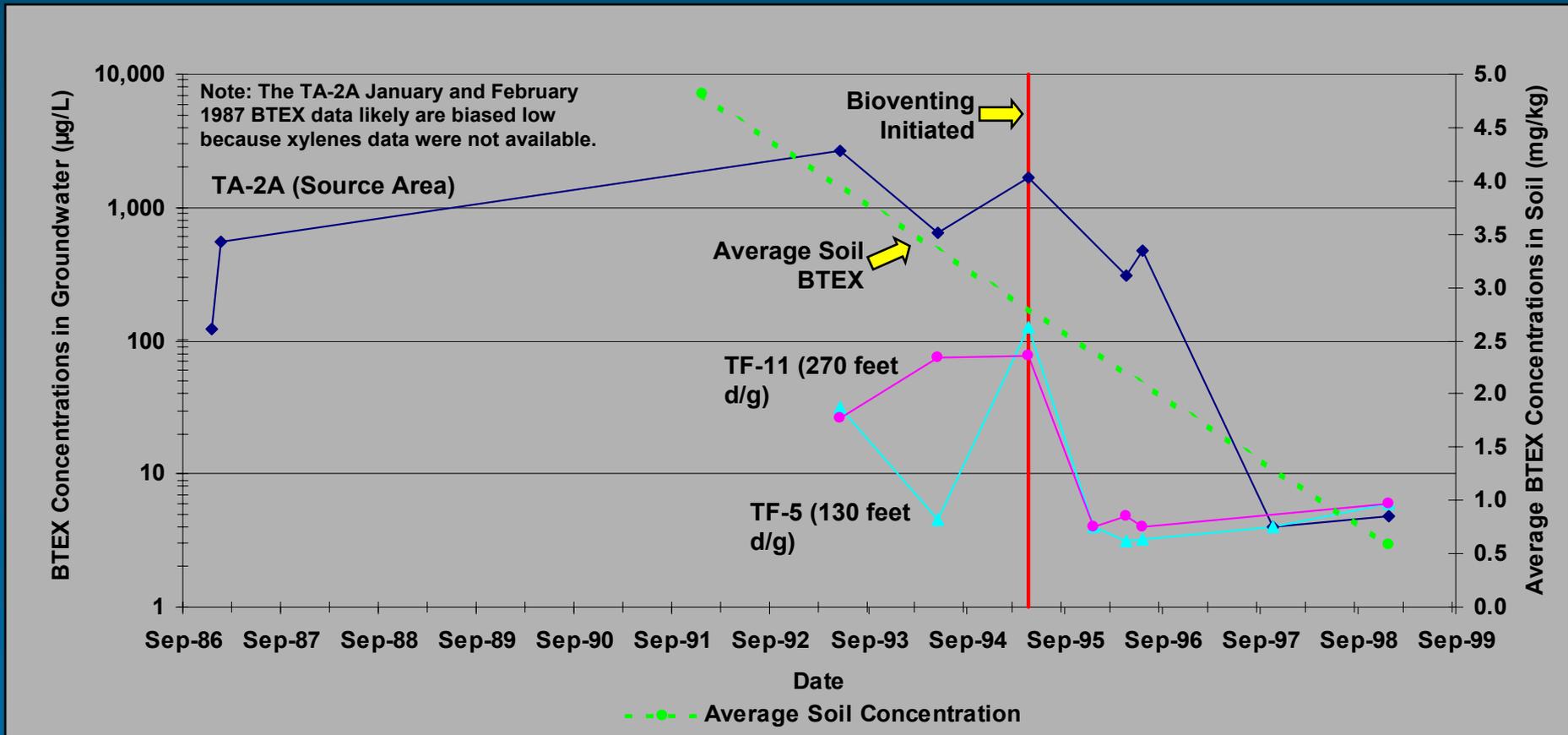


July 1996

■ >1000 µg/L    ■ 100-1000 µg/L    ■ 1-100 µg/L

# BTEX Concentrations in Groundwater and Soil

## Site FT-03 - Westover AFB, MA



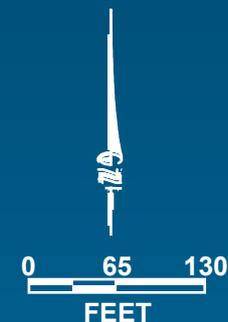
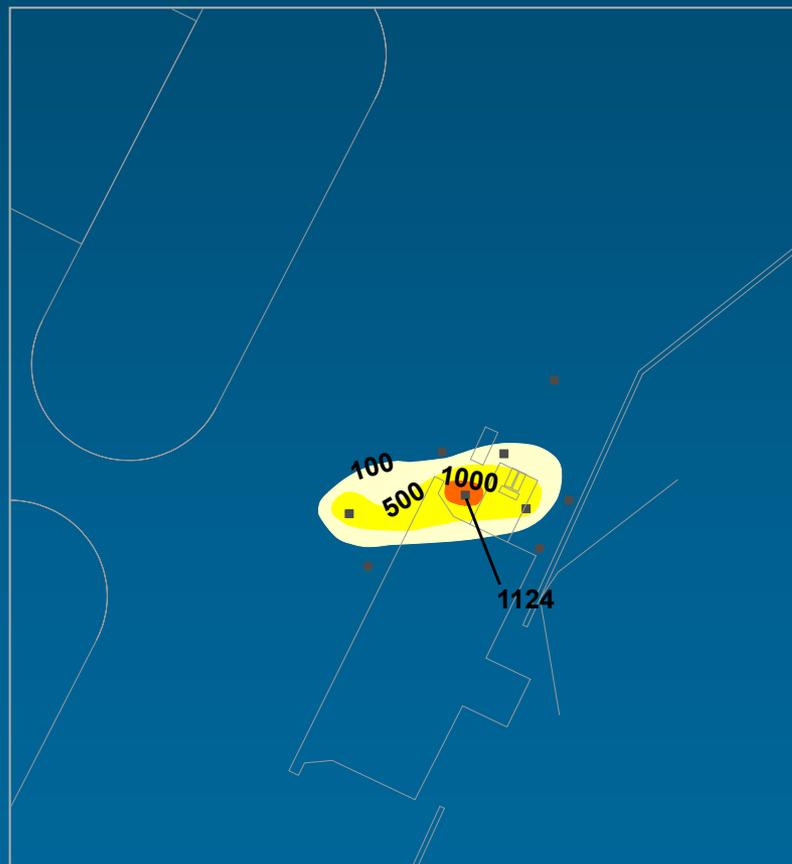
# Statistical Summary for BTEX

## Site FT-03 - Westover AFB, MA

<i>Well Location</i>	<i>Pre-Remed MK</i>	<i>Post-Remed MK</i>	<i>Pre-Remed Slope</i>	<i>Post-Remed Slope</i>	<i>Pre-Remed BTEX µg/L</i>	<i>Most recent BTEX µg/L</i>
<b>Source</b>	<b>-1</b>	<b>-6</b>	<b>-520</b>	<b>-323</b>	<b>1,657</b> <b>(0.0 yr)</b>	<b>4.9</b> <b>(3.7 yr)</b>
<b>130 feet d/g</b>	<b>1</b>	<b>0</b>	<b>46</b>	<b>0</b>	<b>124</b> <b>(0.0 yr)</b>	<b>6</b> <b>(3.7 yr)</b>
<b>270 feet d/g</b>	<b>3</b>	<b>-1</b>	<b>25</b>	<b>-0.4</b>	<b>77</b> <b>(0.0 yr)</b>	<b>&lt;6</b> <b>(3.7 yr)</b>

# Soil BTEX Concentrations, 4'-6' BGS

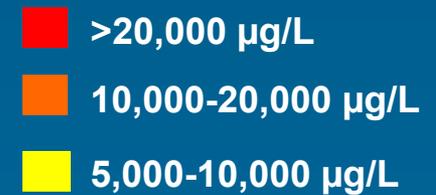
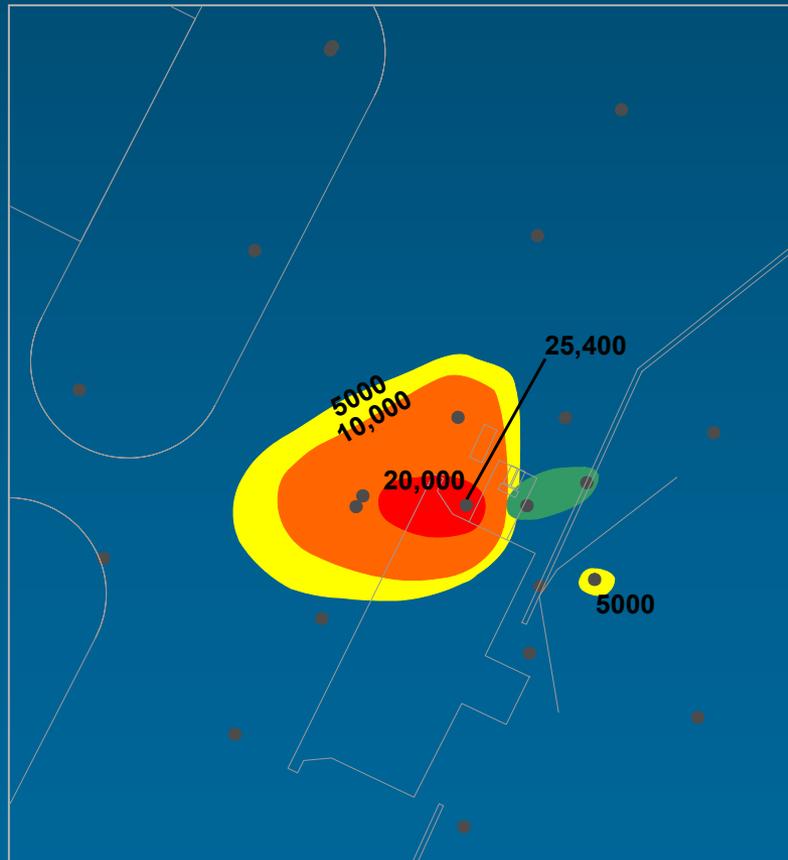
## Site ST-27, Charleston AFB, SC



- >1000 mg/kg
- 500-1000 mg/kg
- 100-500 mg/kg

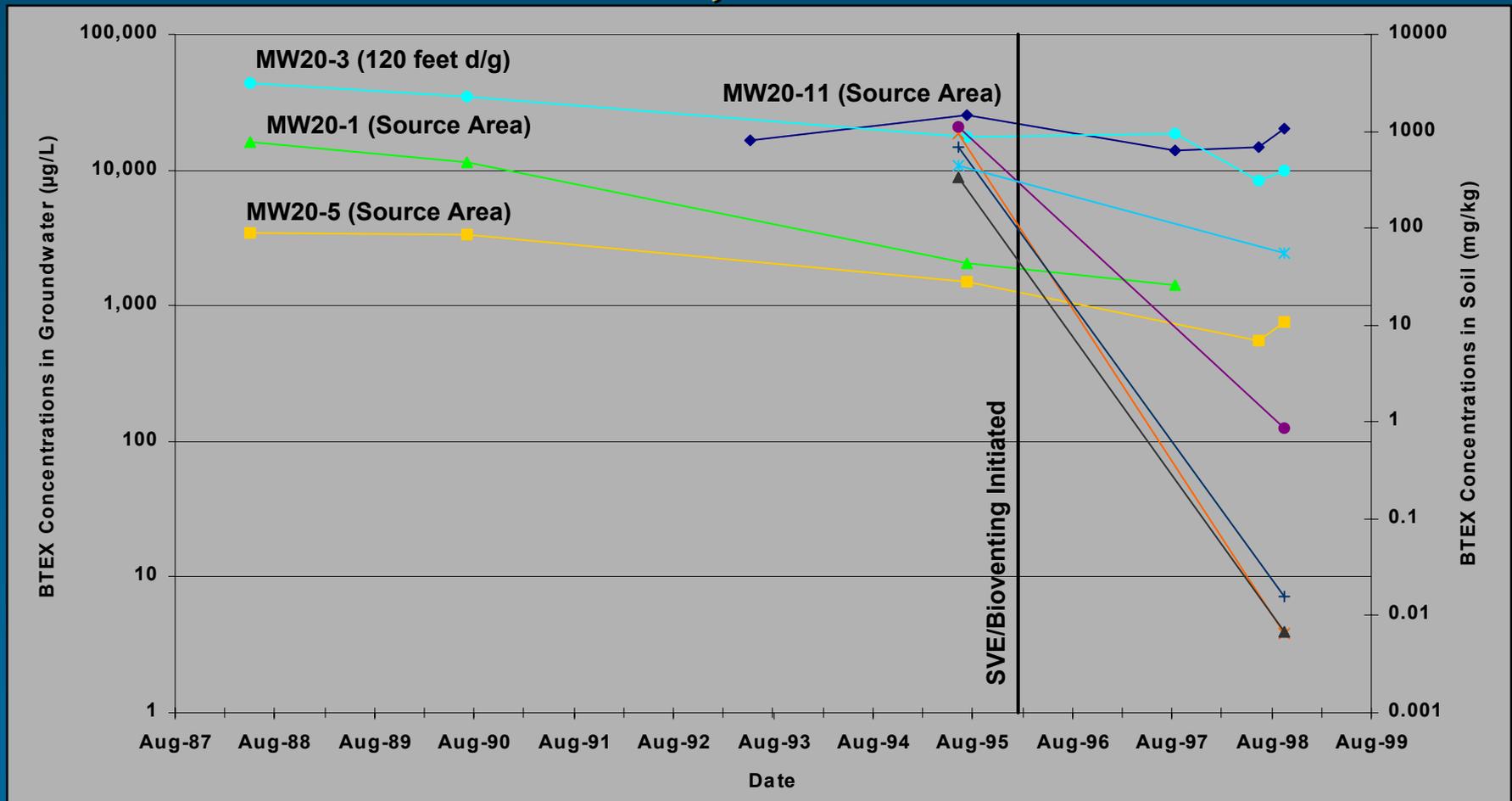
# BTEX in Groundwater, 1995

## Site ST-27, Charleston AFB, SC



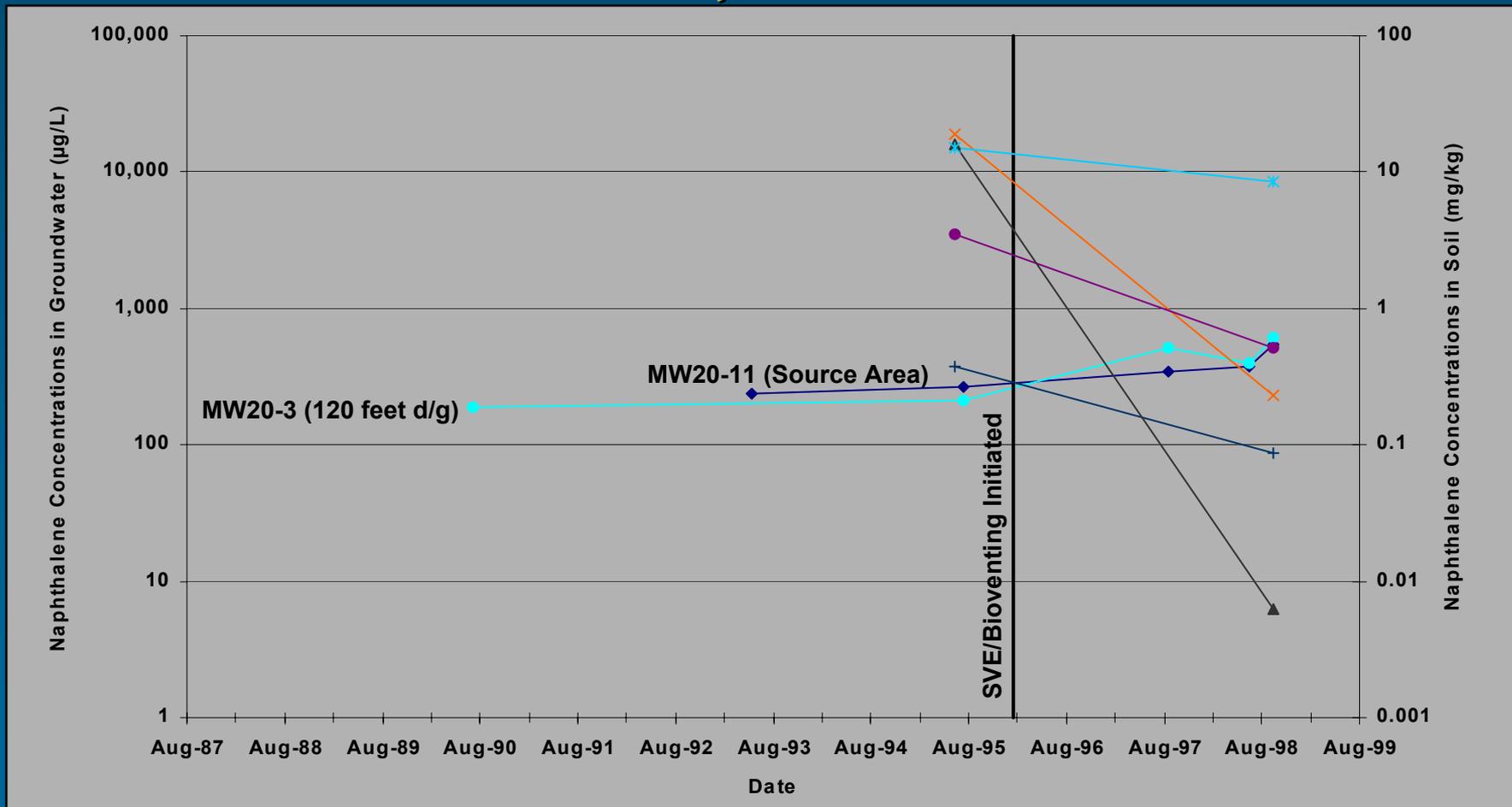
# BTEX Concentrations in Groundwater and Soil

## Site ST-27 - Charleston AFB, SC



# Naphthalene Concentrations in Groundwater

## Site ST-27 - Charleston AFB, SC



# Statistical Summary for BTEX

## Site ST-27 - Charleston AFB, SC

<i>Well Location</i>	<i>Pre-Remed MK</i>	<i>Post-Remed MK</i>	<i>Pre-Remed Slope</i>	<i>Post-Remed Slope</i>	<i>Pre-Remed BTEX μg/L</i>	<i>Most recent BTEX μg/L</i>
<b>Source</b>	<b>-3</b>	<b>-1</b>	<b>-971</b>	<b>-368</b>	<b>1,481 (0.5 yr)</b>	<b>746 (2.7 yr)</b>
<b>120 feet d/g</b>	<b>-3</b>	<b>-2</b>	<b>-13,065</b>	<b>-3,372</b>	<b>17,500 (0.5 yr)</b>	<b>9,888 (2.7 yr)</b>

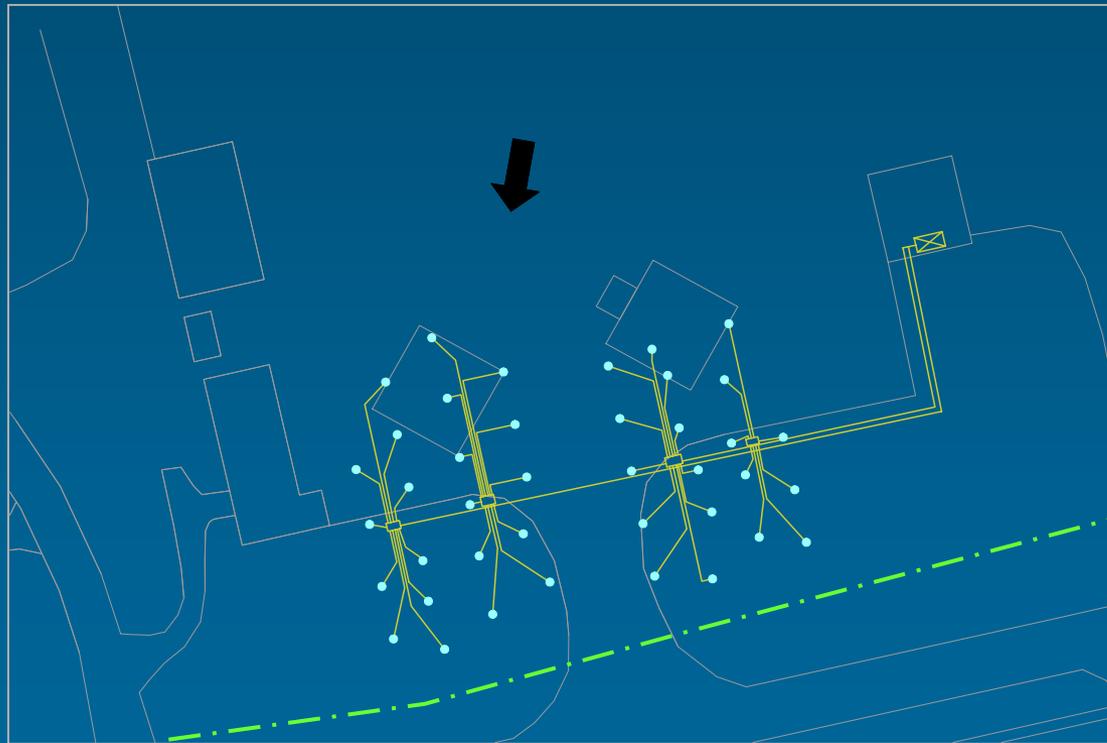
# Soil BTEX Concentrations - 1988-1995

## MOGAS Site - Myrtle Beach AFB, SC



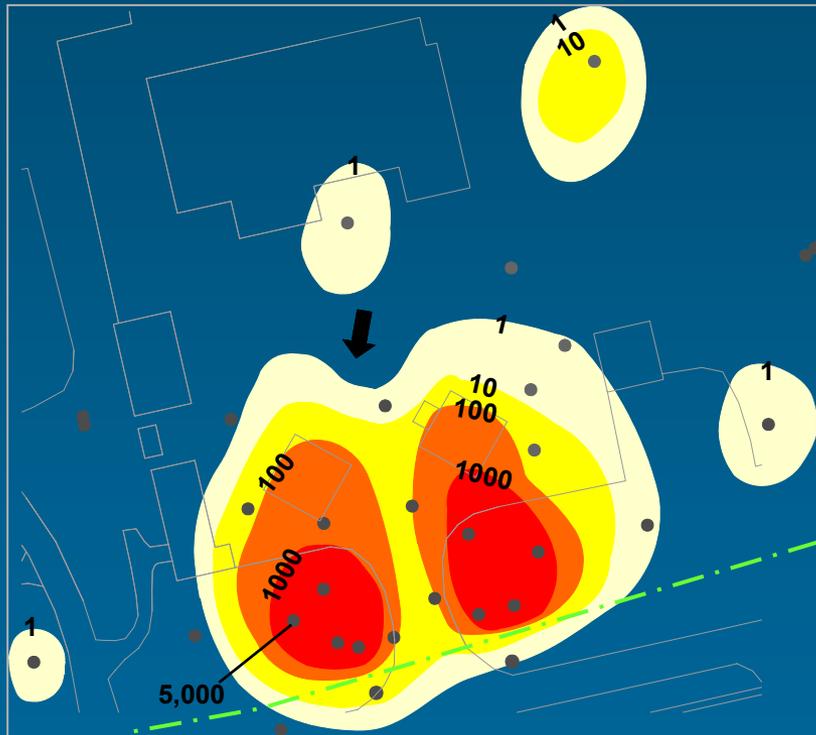
# Air Sparging System Layout

**MOGAS Site - Myrtle Beach AFB, SC**



# Benzene in Groundwater

## MOGAS Site - Myrtle Beach AFB, SC



August/September 1995

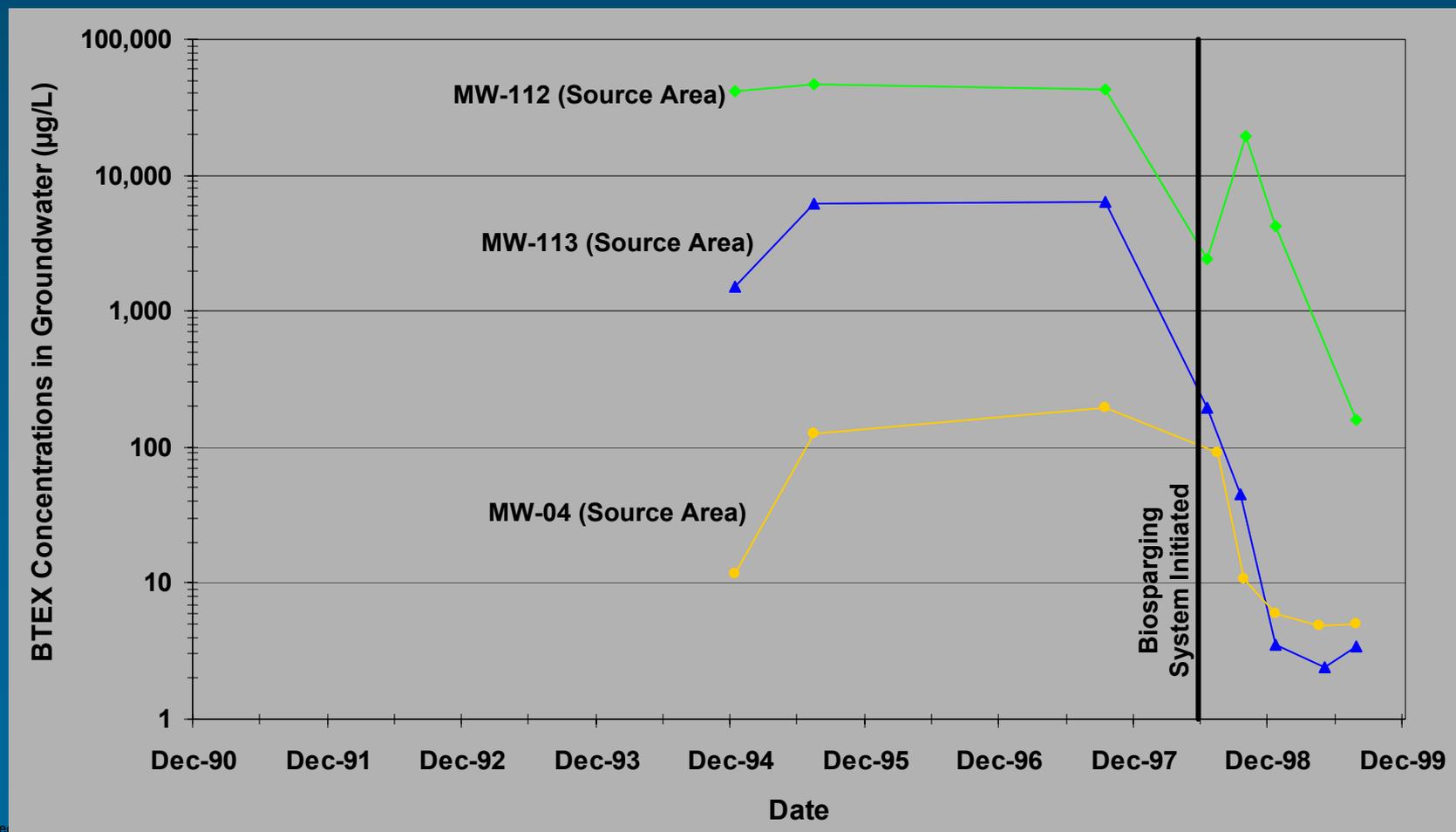


August/October 1999



# BTEX Concentrations in Groundwater

## MOGAS Site - Myrtle Beach AFB, SC



# Statistical Summary for BTEX

## MOGAS Site - Myrtle Beach AFB, SC

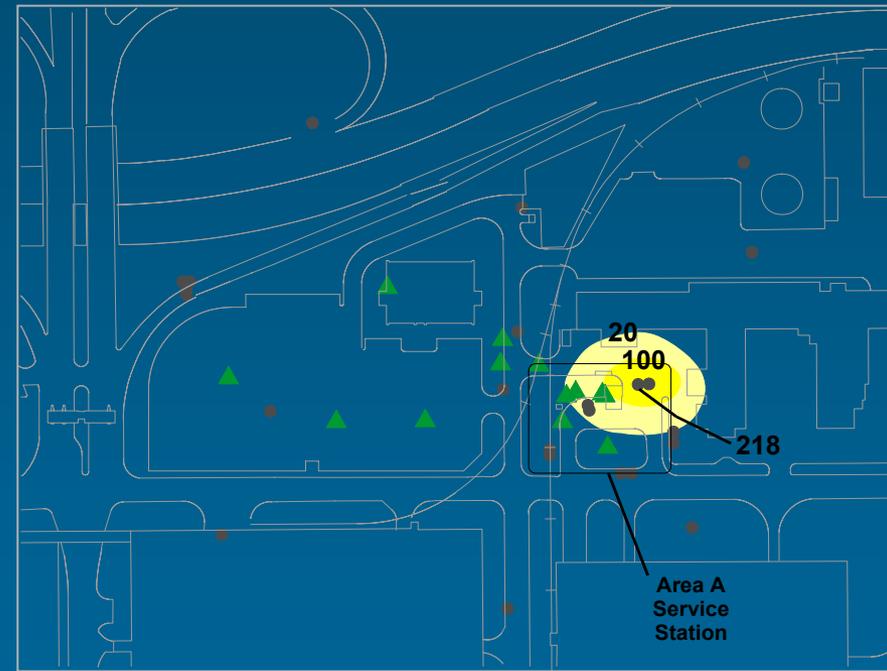
<i>Well Location</i>	<i>Pre-Remed MK</i>	<i>Post-Remed MK</i>	<i>Pre-Remed Slope</i>	<i>Post-Remed Slope</i>	<i>Pre-Remed BTEX µg/L</i>	<i>Most recent BTEX µg/L</i>
<b>Source</b>	<b>1</b>	<b>-2</b>	<b>498</b>	<b>-2,422</b>	<b>43,100 (0.5 yr)</b>	<b>160 (1.3 yr)</b>
<b>Source</b>	<b>3</b>	<b>-8</b>	<b>2,424</b>	<b>-32</b>	<b>6,380 (0.5 yr)</b>	<b>3 (1.3 yr)</b>
<b>Source</b>	<b>3</b>	<b>-8</b>	<b>91</b>	<b>-4</b>	<b>194 (0.5 yr)</b>	<b>5 (1.3 yr)</b>

# BTEX in Groundwater

## Area A Service Station - Tinker AFB, OK



May 1997

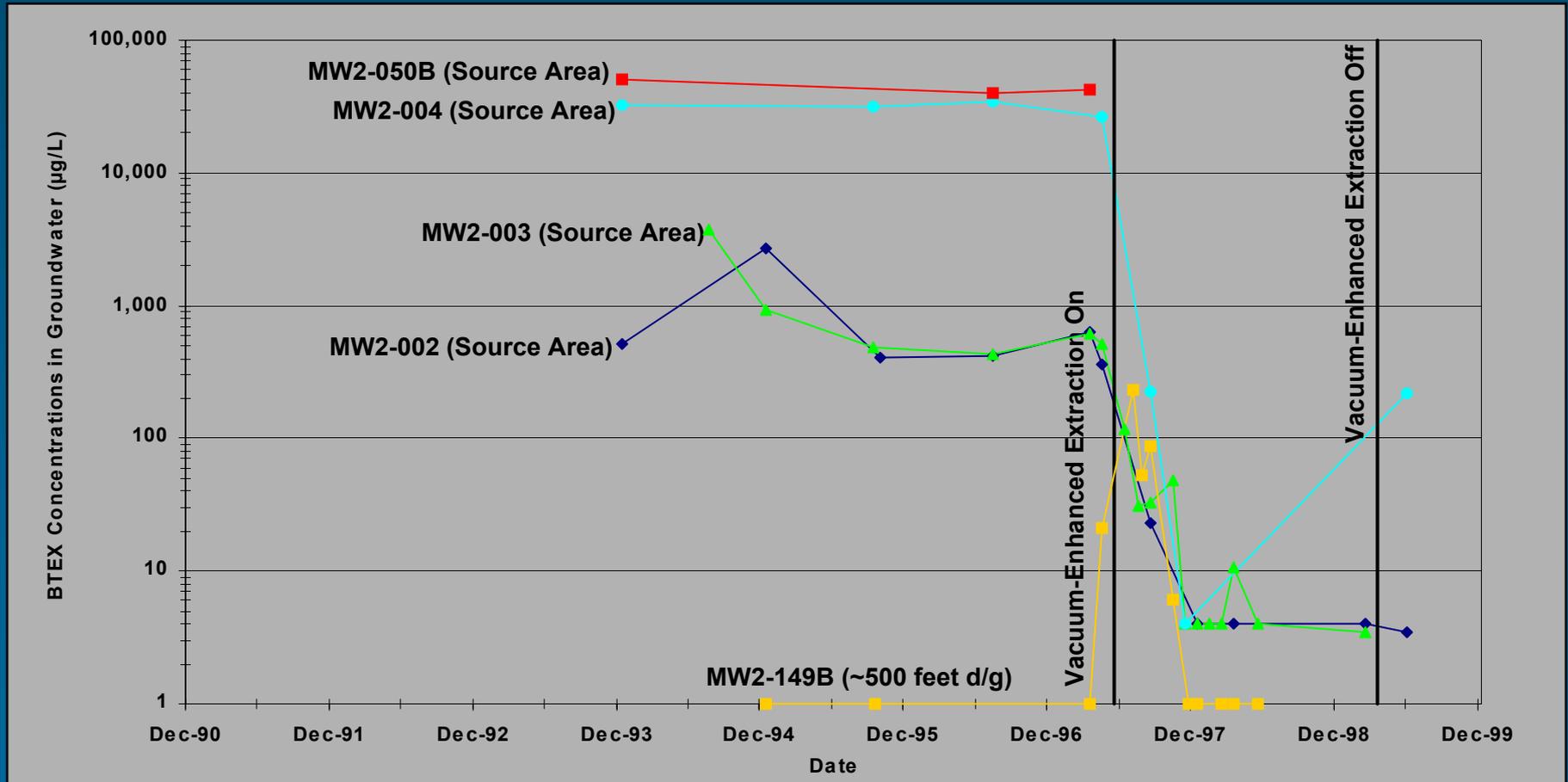


March/June 1999



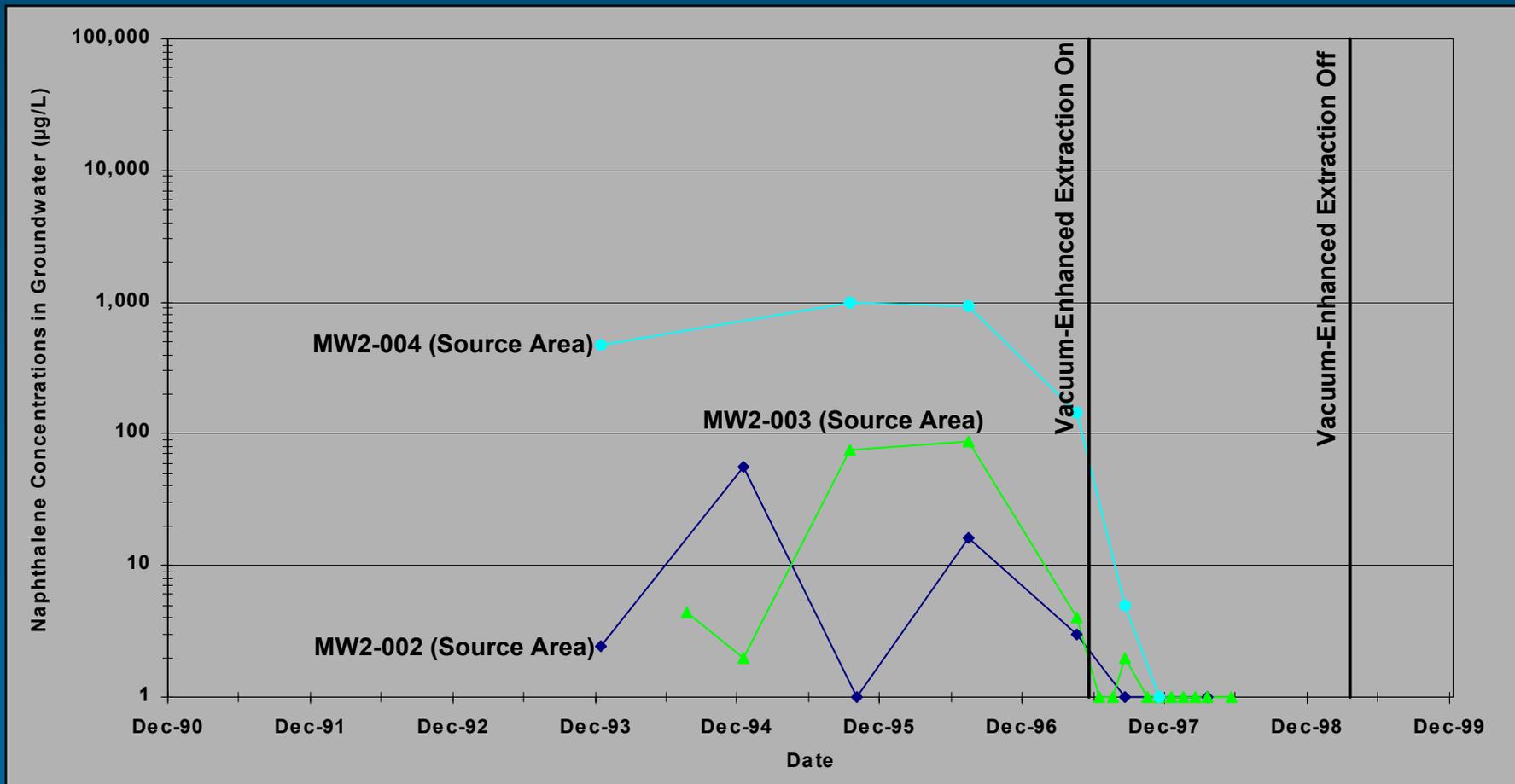
# BTEX Concentrations in Groundwater

## Area A Service Station - Tinker AFB, OK



# Naphthalene Concentrations in Groundwater

## Area A Service Station - Tinker AFB, OK



# Statistical Summary for BTEX

## Area A Service Station - Tinker AFB, OK

<i>Well Location</i>	<i>Pre-Remed MK</i>	<i>Post-Remed MK</i>	<i>Pre-Remed Slope</i>	<i>Post-Remed Slope</i>	<i>Pre-Remed BTEX <math>\mu\text{g/L}</math></i>	<i>Most recent BTEX <math>\mu\text{g/L}</math></i>
<b>Source</b>	<b>-2</b>	<b>-4</b>	<b>-1,925</b>	<b>-4,433</b>	<b>26,150 (0.1 yr)</b>	<b>217 (2.2 yr)</b>
<b>Source</b>	<b>-5</b>	<b>-3</b>	<b>-33</b>	<b>-178</b>	<b>359 (0.1 yr)</b>	<b>4 (2.2 yr)</b>
<b>20 feet d/g</b>	<b>-7</b>	<b>-9</b>	<b>-101</b>	<b>-42</b>	<b>618 (0.1 yr)</b>	<b>4 (1.9 yr)</b>

# ***Summary and Conclusions***

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- **Careful site characterization prior to selection of remedial method**
- **Borehole advancement below the water table**
- **Assessment of smear zone thickness**

# ***Bioventing and SVE***

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- **Primary factor = smear zone presence**
- **Smear zone persistence = plume persistence**
- **Mounding of water table at SVE sites**
- **Charleston AFB Site ST-27--less effective**

# ***Biosparging***

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- **Potential for smear zone remediation**
- **Sandy, homogeneous soils**
- **Rapid decreases of dissolved BTEX with depth**
- **Well spacing  $\leq$  20 feet**
- **Myrtle Beach AFB - rate increase of 101-586%**

# ***Vacuum-Enhanced Extraction***

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- **Aggressive method**
- **Thin saturated zones**
- **Low- to moderate-permeability soils**
- **Presence of free product**

# ***Vacuum-Enhanced Extraction***

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- **Dewatering of smear zone**
- **Tinker AFB Area A success**
- **130 to 439 % increase in BTEX removal rates**

# ***Excavation***

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- **Effectiveness on dissolved contamination function of thoroughness of excavation**
- **Excavation below the water table can be problematic**
- **Mixed success at Travis AFB N & S Gas Stations**

# ***Additional Fuel Compounds***

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- **Naphthalene**
- **MTBE**

# *Naphthalene*

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- **Source reduction less effective**
- **Charleston AFB**
  - **increasing concentrations following SVE/Bioventing**
- **Eglin and Myrtle Beach AFBs**
  - **75 to 99 % slower than BTEX reductions**

# ***Naphthalene***

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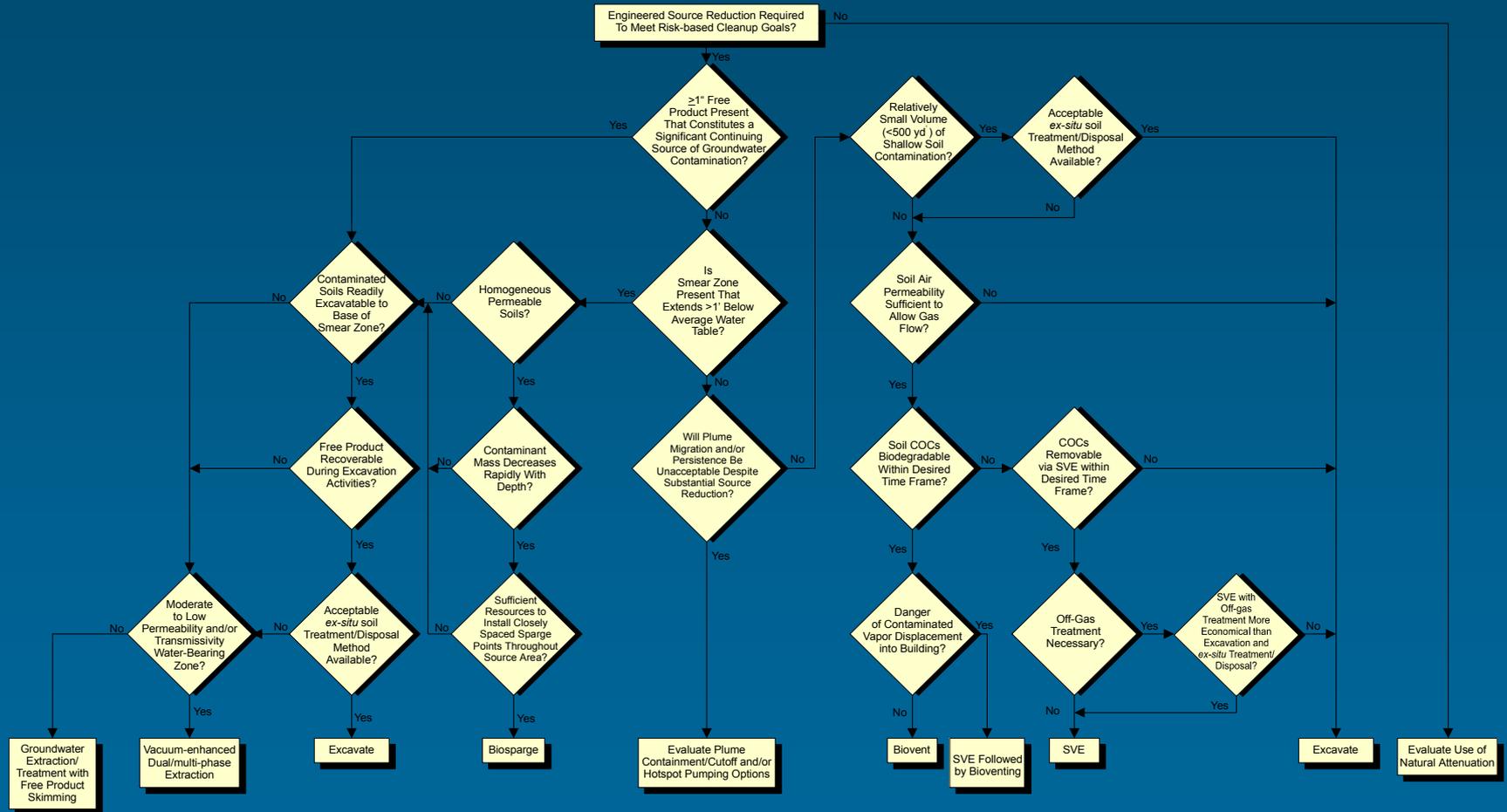
- **Lower volatility**
- **More recalcitrant to biodegradation**
- **Higher degree of sorption**
- **More success at Tinker AFB Area A**

# ***MTBE***

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- **Travis AFB**
  - **54 to 95 % slower than BTEX reductions**
- **Vadose zone source removal less likely to cause rapid reductions in dissolved concentrations**
- **Can be relatively recalcitrant**
- **Quickly leaches from soil**

# Methodology for Selecting an Engineered Source Reduction Technique



# Methodology for Selecting an Engineered Source Reduction Technique

