

**BENZENE VAPOR TRANSPORT: MEASUREMENT AND
MODELING TO EVALUATE REMEDIAL SYSTEM
PERFORMANCE & PREDICT POTENTIAL EXPOSURE TO
VOCs IN AMBIENT AIR**

**National Ground Water Association
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General Session III**

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**Presented by
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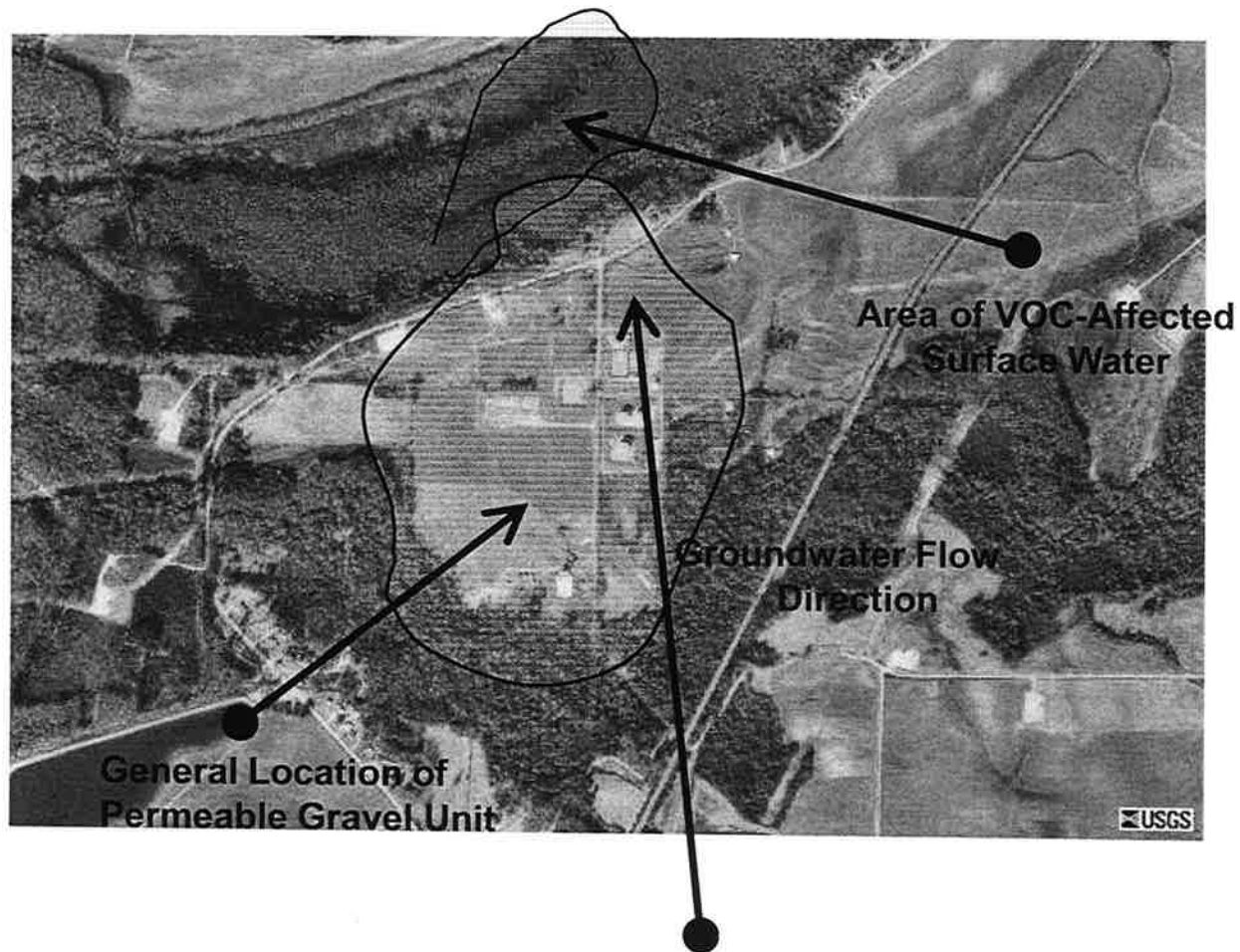
Presentation Outline

- ➔ Introduction and Background
- ➔ Contaminant Fate and Transport and Remediation Summary
- ➔ Modeling Benzene Transport in Ambient Air
- ➔ Model Predictions of Benzene Concentrations vs. Measured Ambient Air Values at Receptors
- ➔ Conclusions

Introduction and Background

- ➔ Pipeline Booster Station on About 60' of Alluvial Deposits Overlying Impermeable 50' Thick Shale
- ➔ Groundwater Flow Towards & into Adjacent Swamp
- ➔ Historic Leaks and Remediation
- ➔ Benzene Exceeds Regulatory Standards – Swamp & GW
- ➔ Suit by Nearby Residents Claiming Exposure to Benzene in Ambient Air from Swamp

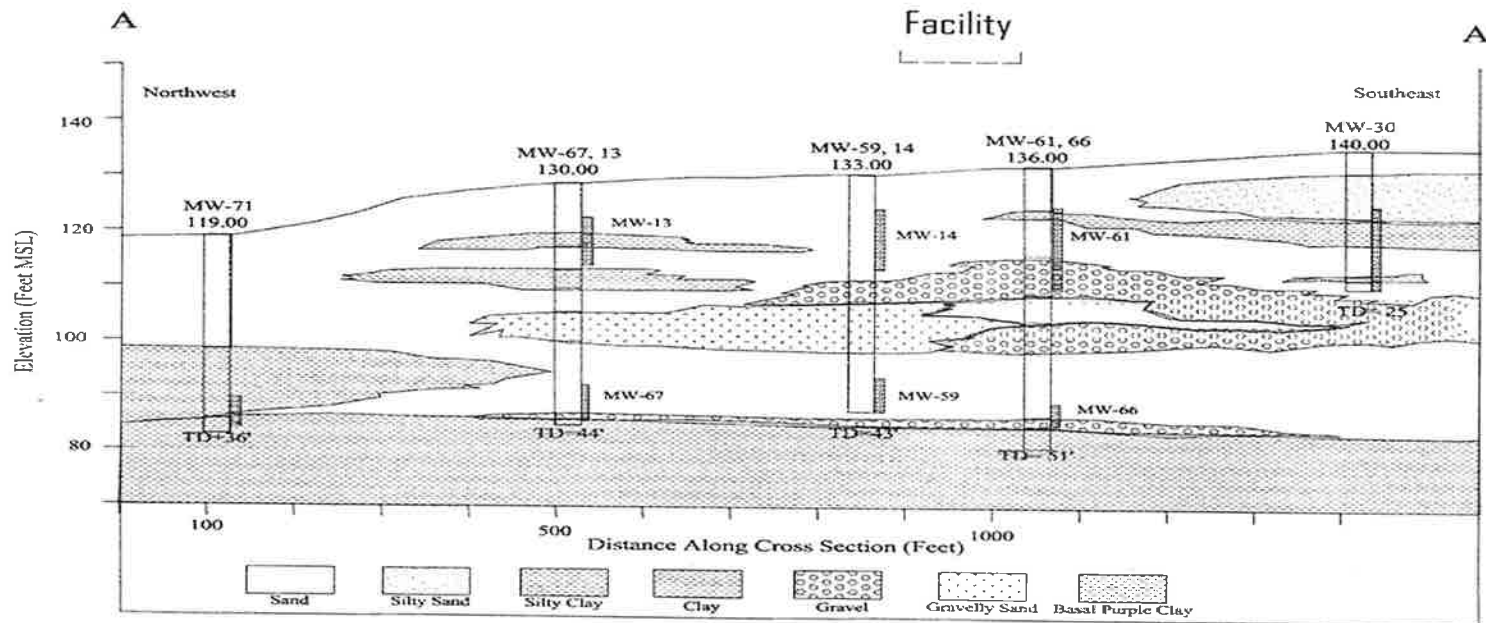
Contaminant Fate and Transport and Remediation Summary



Contaminant Fate and Transport and Remediation Summary

➔ Complicated Hydrogeology

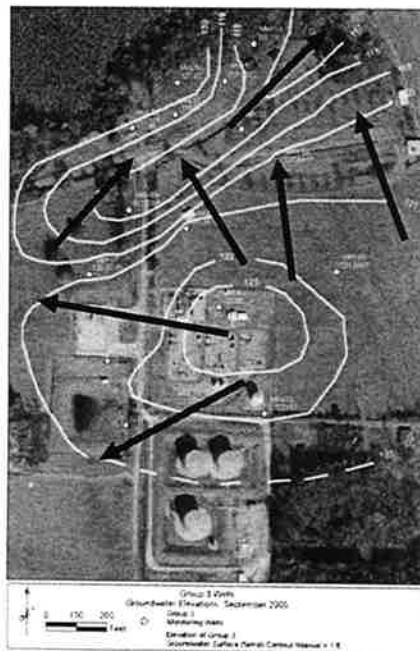
- Discontinuous, Variable-Permeability Lithology
- Multi-Layered GW Flow System
- Geometry of Materials Controls GW Flow & VOC Behavior



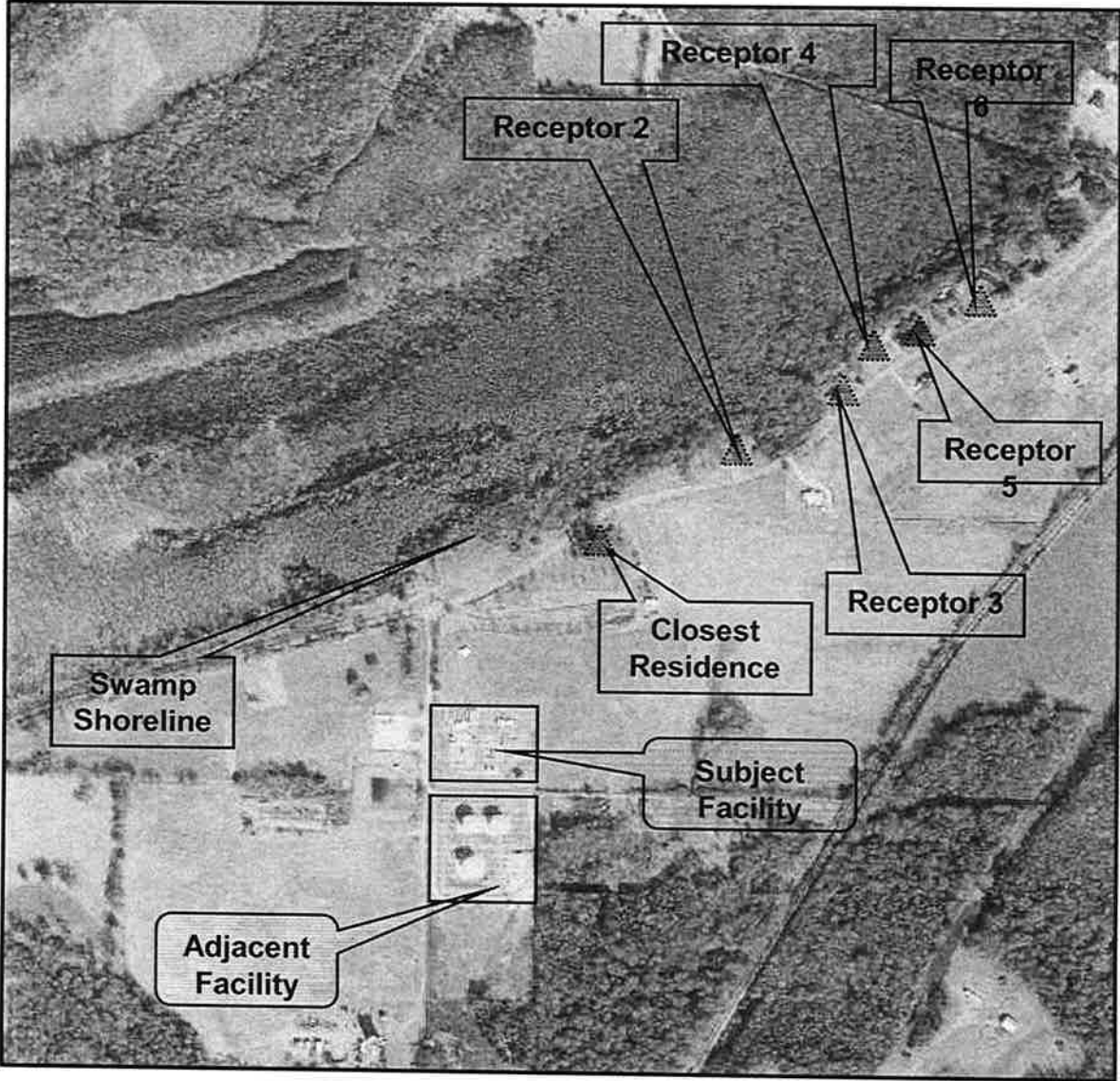
Cross Section A – A' (NW-SE, West Side of Site)

Contaminant Fate and Transport and Remediation Summary

- Continuing Contamination of GW due to GW Level Fluctuations at Facility (BTEX Compounds Remain in Subsurface)
- Potential Off-gassing of Benzene from Contaminated GW & Surface Water (Seeps and Swamp)



Location of Important Features in Area of Subject Facility



7 Steps for Modeling Benzene Transport in Ambient Air with Calculated Sources

1) Develop Ambient Air Dispersion Model of Study Area Using EPA-Approved ISCST 3 Model & Local Meteorological Data

- Construct Model Grid Over Entire Study Area
- Establish Key Receptor Points at Plaintiff Residences and Other Key Locations

2) Identify all Benzene Sources

- Point Source from Tanks/Facility (Fugitive Emissions)
- Point Source Emissions Remediation AS/SVE System
- Area Sources - Ground and Surface Water Off-Gassing
- Mobile Point Sources (Vehicle Emissions)

3) Calculate Benzene Emission Rates from Each Sources

- Fugitives from Tanks/Facility - used AP 42 Est. of Fugitives from EPA Guidance
- Remediation AS/SVE System – used Direct Stack Test Measurements
- Ground and Surface Water Off-Gassing – Estimated via EPA -454/R-92-024 Method for Calculating Off-gassing from Surface Waters
- Vehicle Emissions – not considered but traffic counter installed to count cars in event of anomalous results

7 Steps for Modeling Benzene Transport in Ambient Air with Calculated Sources (Cont.)

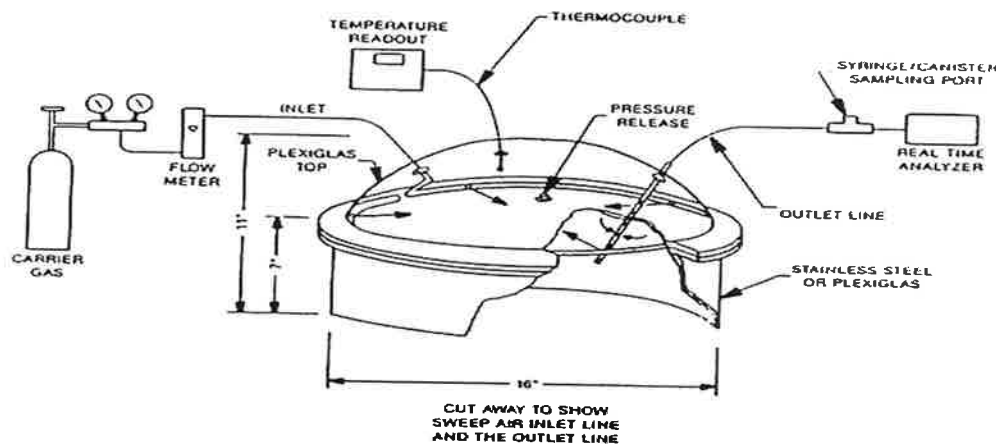
- 4) Run Model for Five Year Time Period (2000-2005)
- 5) Obtain Predicted Benzene Values at Each Receptor
- 6) Run Sensitivity Analysis on Model to Evaluate Performance
- 7) Verify Model by Comparing Results to Measured Benzene Values at Each Receptor

Modeling Benzene Transport in Ambient Air with Measured Flux from Area Sources

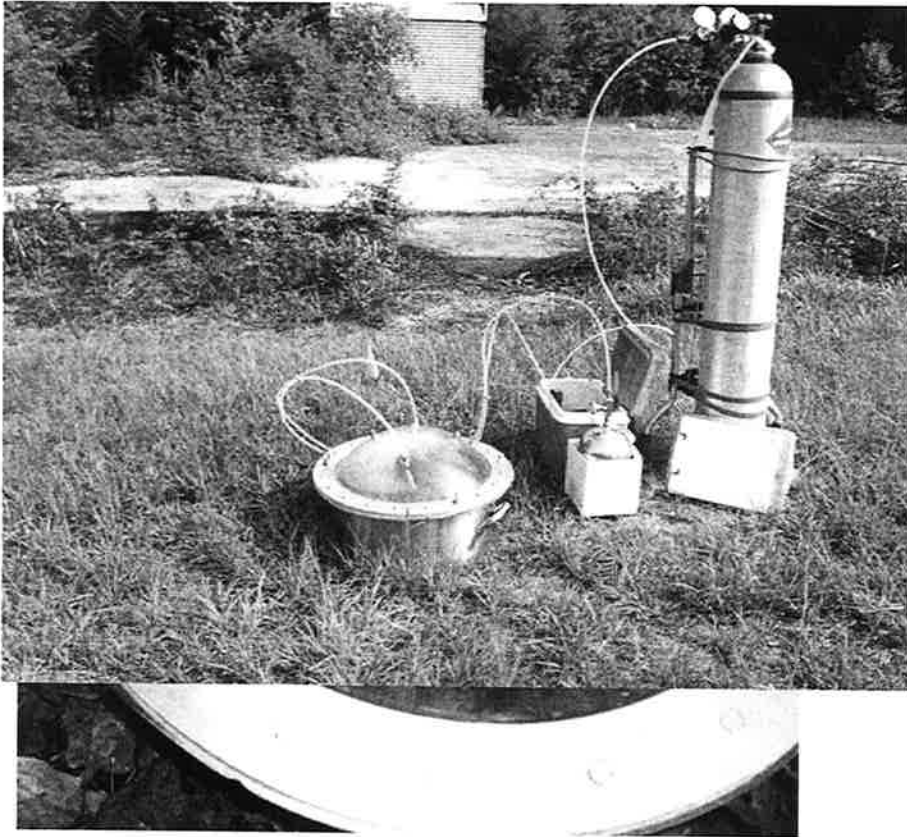
- ➔ All 7 Modeling Steps Identical to Initial Model Except Treatment of Emission Rates from Area Sources (swamp and seeps)
- ➔ Flux Measurements Used to:
 - Measure Area Source (swamp and seeps) Emission Rates
 - Replace Calculated Emission Rates for Area Sources from Step 3 in Original Model with Measured Flux Rates
 - Evaluate Effectiveness of Remedial System Modifications
- ➔ Swamp & Seep Sources Measured Directly by Flux Chamber
 - EPA- Approved Technology (1985 NTIS PB-223162)
- ➔ Flux Measurements Performed over:
 - Representative Areas of Seep/Swamp Source Areas
 - Facility & Site Areas Undergoing Remediation via Air Sparging/SVE
 - Prior to, During & After Sparge Rate Modifications

What is Flux Chamber Sampling & How Does it Work?

- ➔ Allows Direct Measurement of Emission Rate of VOCs from Area Sources in Their Natural Condition
- ➔ Technique:
 - Chamber Placed over Surface & Sealed to Surface
 - Swept with Ultrapure Air Until Steady State is Reached
 - Sample Withdrawn with a Summa Canister (same as used for Ambient Air Sampling)



Flux Chamber Sampling



Ambient Air Characterization Combined with Flux Sampling for Model Verification

➔ Air Modeling Study Results

- No Significant Concentrations of BTEX Predicted in Study Area & at Plaintiffs' Residences

➔ Initial Ambient Air Screening

- Passive Samplers at 11 Locations Over 10 Day Period
- Full QA/QC Completed – Including 100% Duplicate Samples, Spikes, Blanks & Independent Laboratory
- Very High Data Reliability

Flux & Ambient Air Measurements at Site

➔ Goals:

- Evaluate Effect of Increased Air Sparging Rate
- Obtain Better Reliability & Lower Detection Levels at Model Receptor Locations

➔ Sampling:

- Flux Chamber Sampling
- Ambient Air Sampling
- Three Separate Sampling Events over 9 Month Period
- Detection Limits at Parts Per Trillion Levels

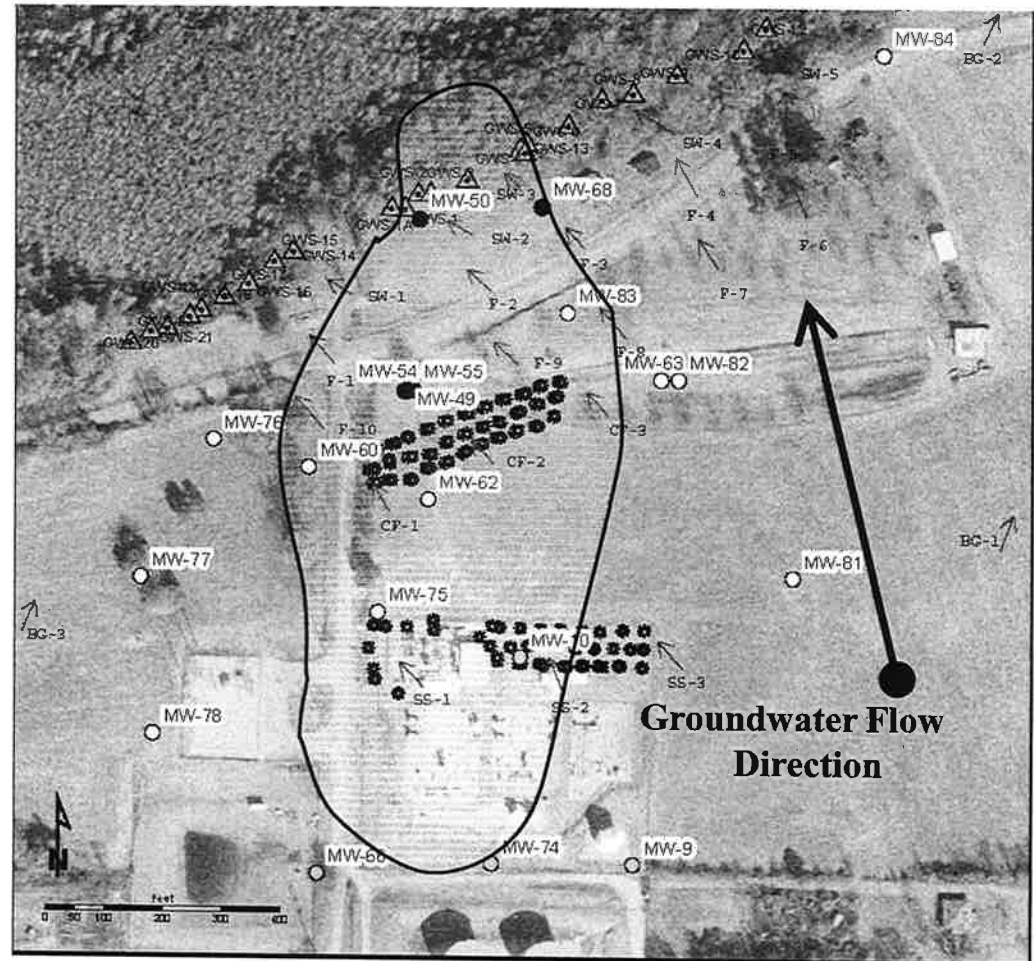


Figure 2-2 Groundwater Monitoring System to Evaluate Effects of Air Sparge System Modifications

- Up Gradient Wells
- Wells Between Air Sparge Systems
- Cross-Gradient Wells
- Down Gradient Wells
- ★ Air Sparge Points
- ▲ Groundwater Seep Samples
- ↗ Recommended Flux Chamber Points

Flux Chamber Sampling Results

⇒ Benzene Overlying GW

- 0.04 to 1.59 $\mu\text{g}/\text{m}^2$ per minute (Contaminated Area)
- 0.025 to 0.037 $\mu\text{g}/\text{m}^2$ per minute (Uncontaminated Area – Background)

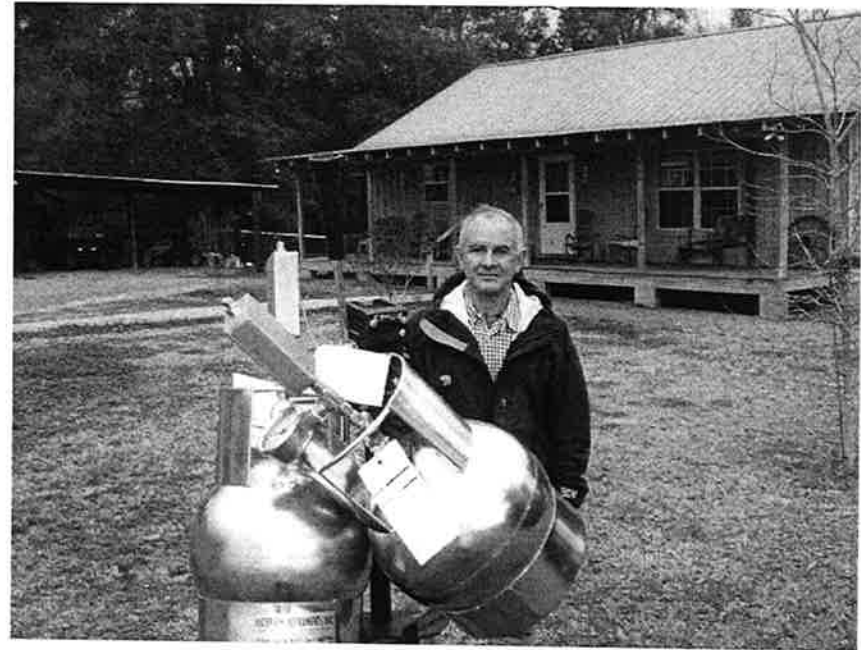
⇒ Benzene Over Surface Water Seeps & Swamp

- 0.47- 1.50 $\mu\text{g}/\text{m}^2$ per minute (Contaminated Areas)
- 0.013 to 0.042 $\mu\text{g}/\text{m}^2$ per minute (Uncontaminated Areas)

⇒ Benzene over Air Sparge Area

- Did not Change Measurably with Doubling of Sparging Rate
- Indicates that SVE was Adequate to Keep Pace with Increased Volatilization

Ambient Air Sampling



Ambient Air Sampling Results

➔ Benzene in Ambient Air at Receptor Locations

- 0.30 to 1.60 $\mu\text{g}/\text{m}^3$ (0.09 to 0.51 ppb)
- No Significant Difference Between Background & Potentially Impacted Locations

➔ Results Comparable to National Data on Benzene In Ambient Air in Rural Areas

- 0.50 to 10.9 $\mu\text{g}/\text{m}^3$ (0.16 – 3.5 ppb) in Rural Areas Such as the Study Area

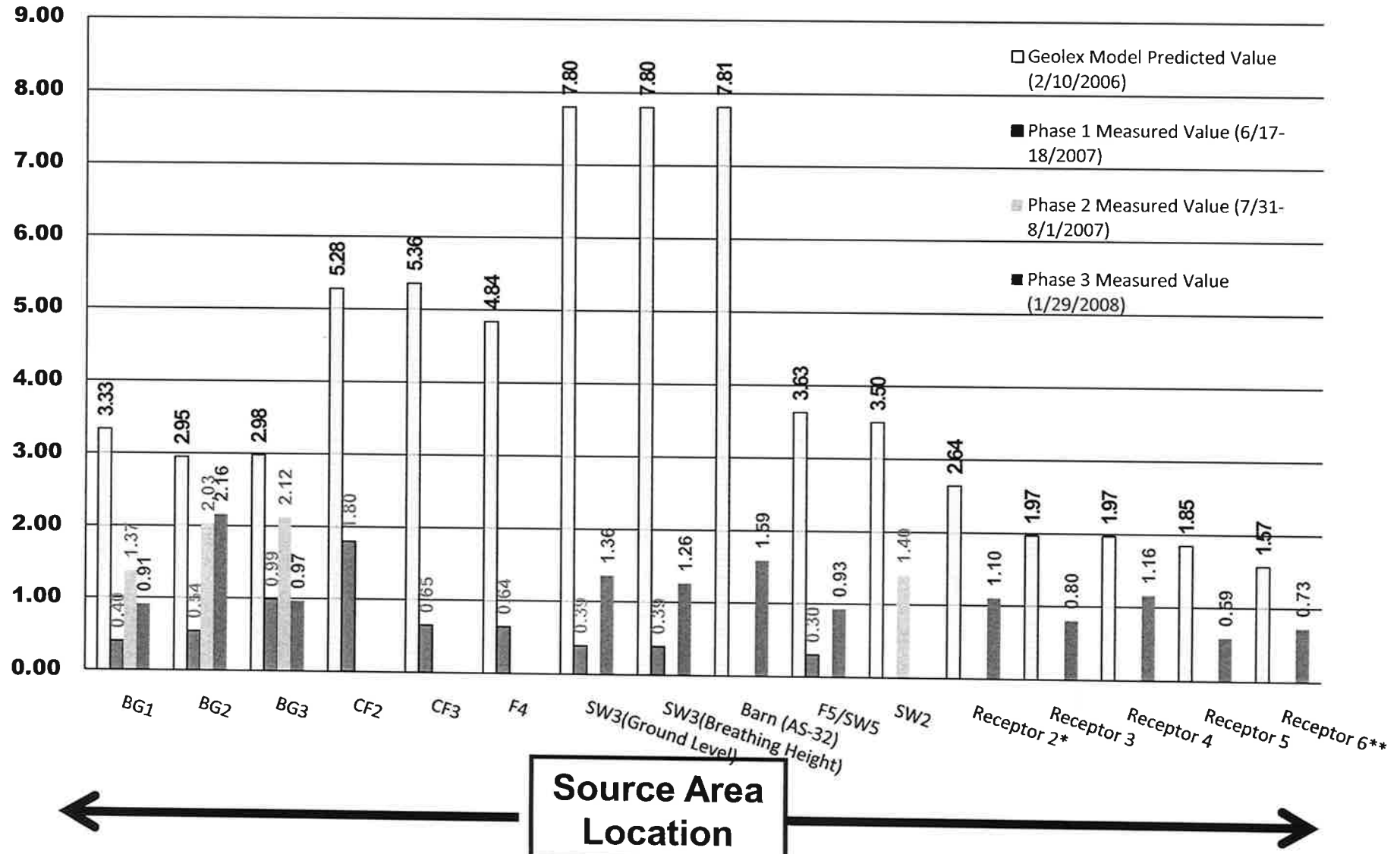
➔ Benzene Above Contaminated Swamp Surface

- 1.36 $\mu\text{g}/\text{m}^3$ (0.44 ppb)

Model Verification

- ➔ Model Predicted Conservative Ambient Air Values at Receptors Based on Calculated Sources
- ➔ When Sources in Model Adjusted Using Flux Data, Predicted Ambient Air Values Lower
- ➔ Measured Ambient Air Values Significantly Lower than Model Predictions at all Plaintiffs' Residences

Model Predicted 8hr Values vs Actual Measured 8hr Values Benzene in $\mu\text{g}/\text{m}^3$



Arrows Show Receptors at Increasing Distance Away from Source Area

Conclusions

- ➔ ISCST MODEL is a Conservative Predictor of Transport of Benzene & other Contaminants in Ambient Air

- ➔ Benzene Off Gassing only Occurs Directly over Contaminated Groundwater
 - Background Flux Measured when over 100 feet from Plume Edges

- ➔ Ambient Air VOC Concentrations Predicted by Model
 - Fully Protective of Health & Environment (conservative)
 - Measured Values Have Better Agreement with Predicted Values with Increasing Distance From Source
 - Predicted Values 2-3x Higher than Actual Measured Values in Immediate Vicinity of Source

- ➔ Flux Chamber Measurements are Excellent Method to Quantify VOC emissions to Evaluate Indoor Air Intrusion or Ambient Air Effects at VOC-Contaminated Sites