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

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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

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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

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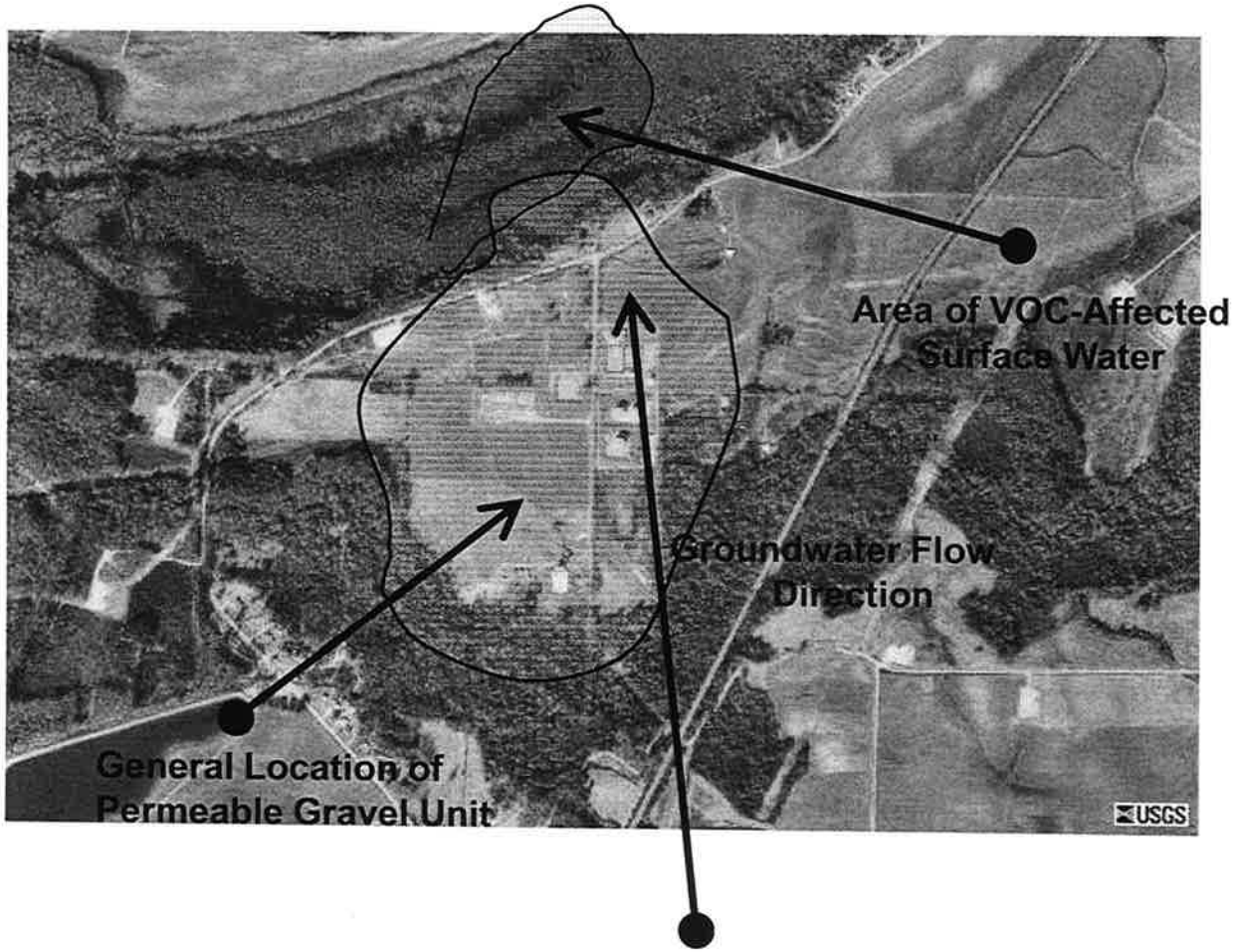
Contaminant Fate and Transport and Remediation Summary



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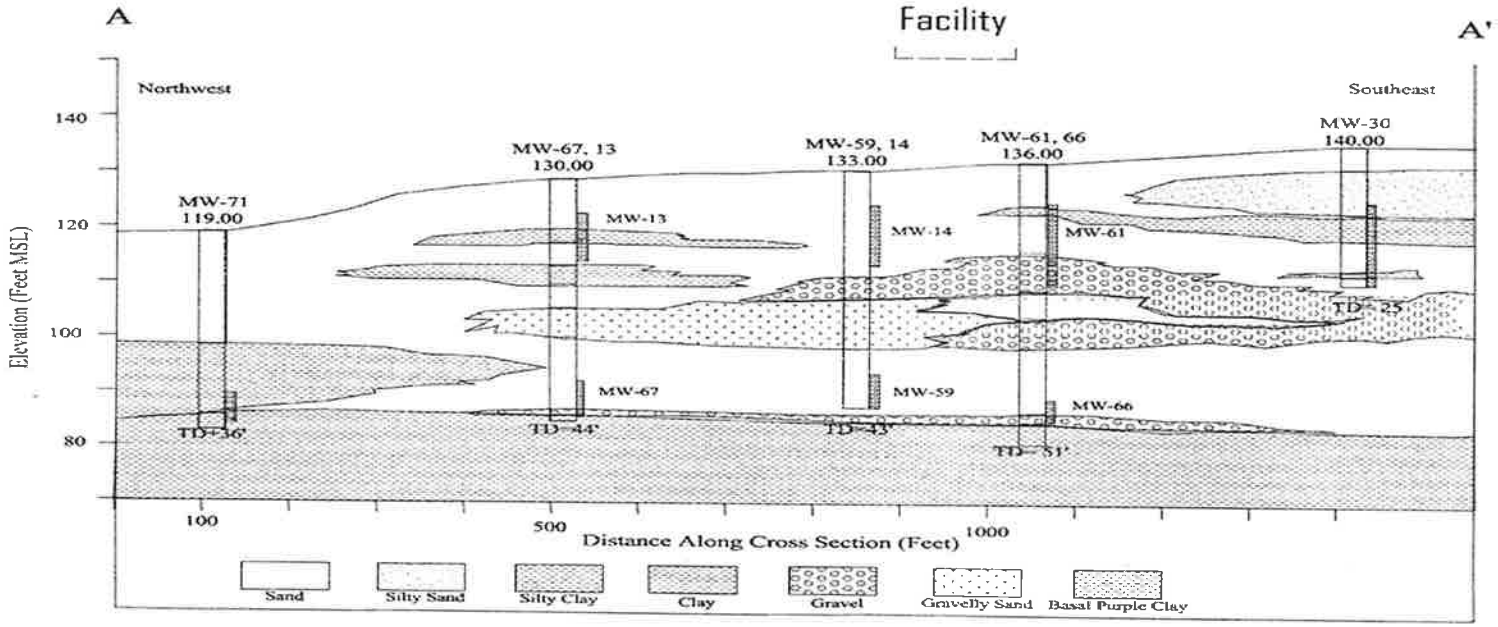
Contaminant Fate and Transport and Remediation Summary

- 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)

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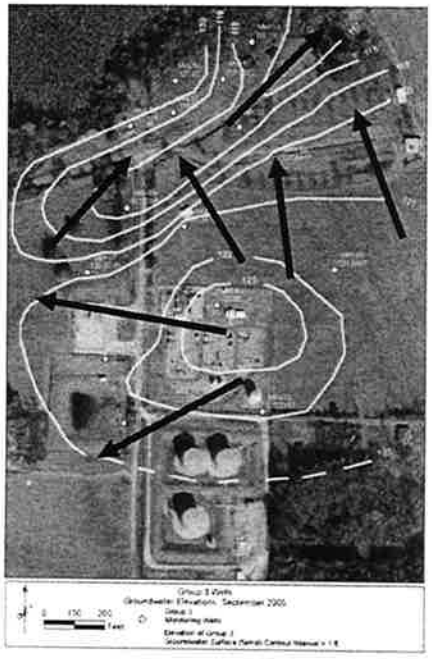
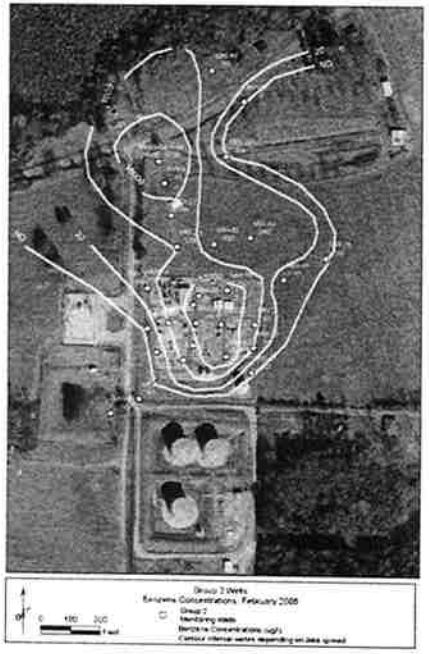
Contaminant Fate and Transport and Remediation Summary

- 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)





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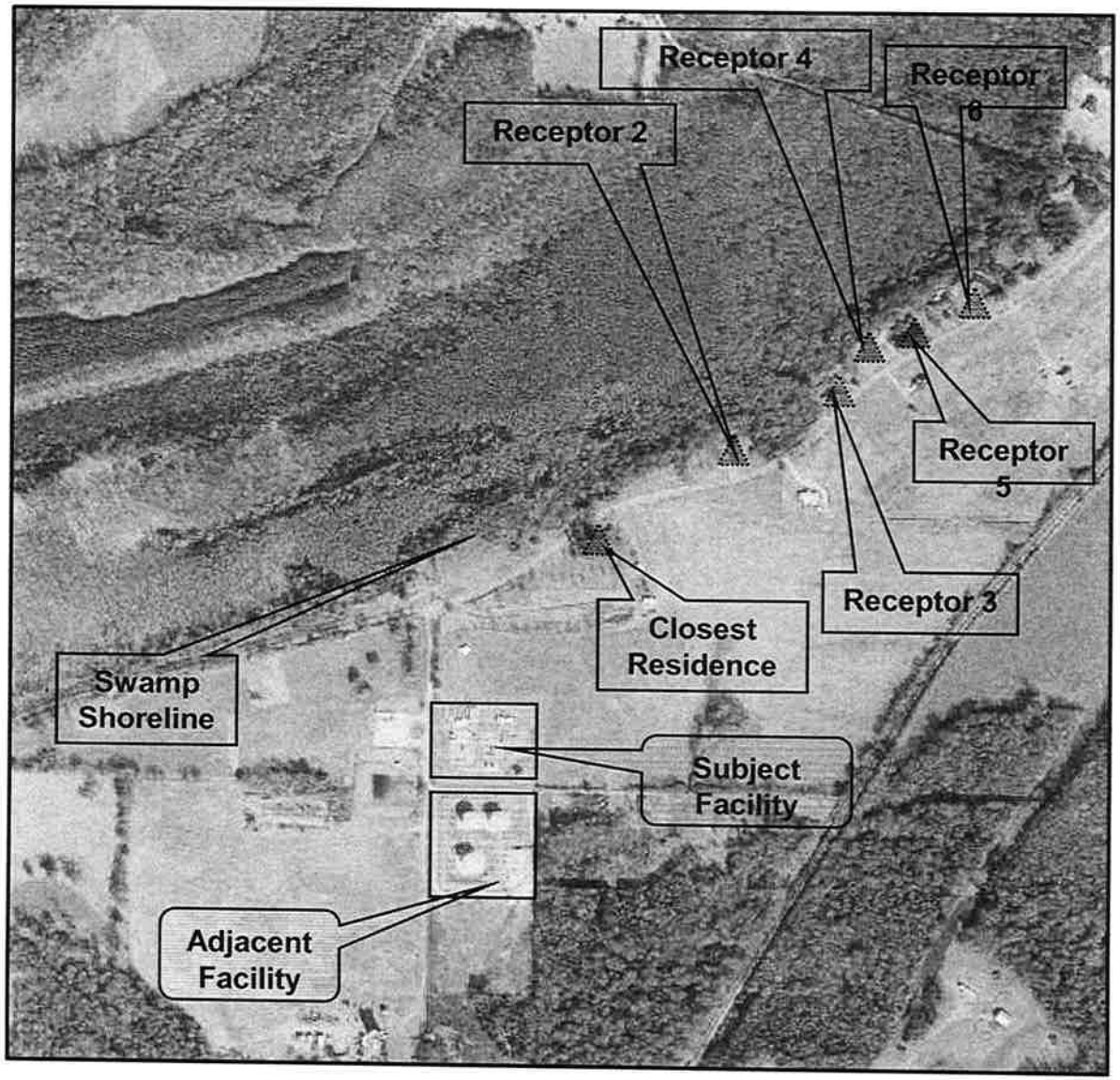
Location of Important Features in Area of Subject Facility



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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

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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

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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

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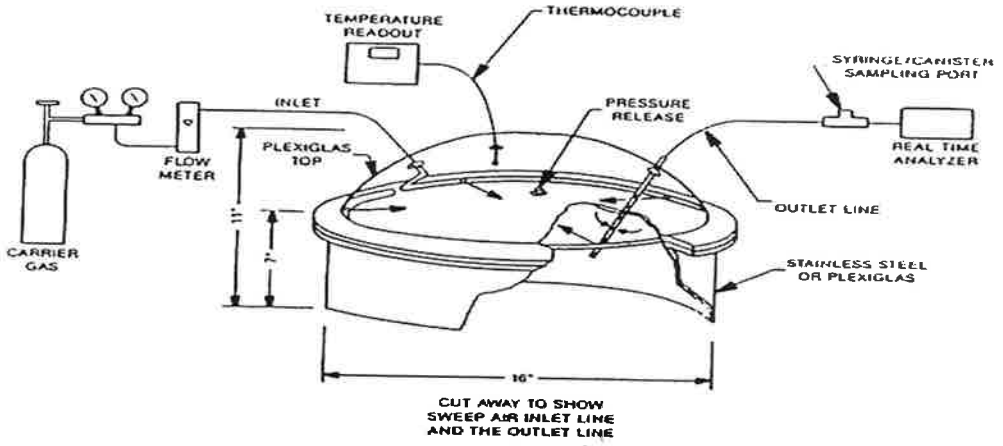
What is Flux Chamber Sampling & How Does it Work?

- 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)



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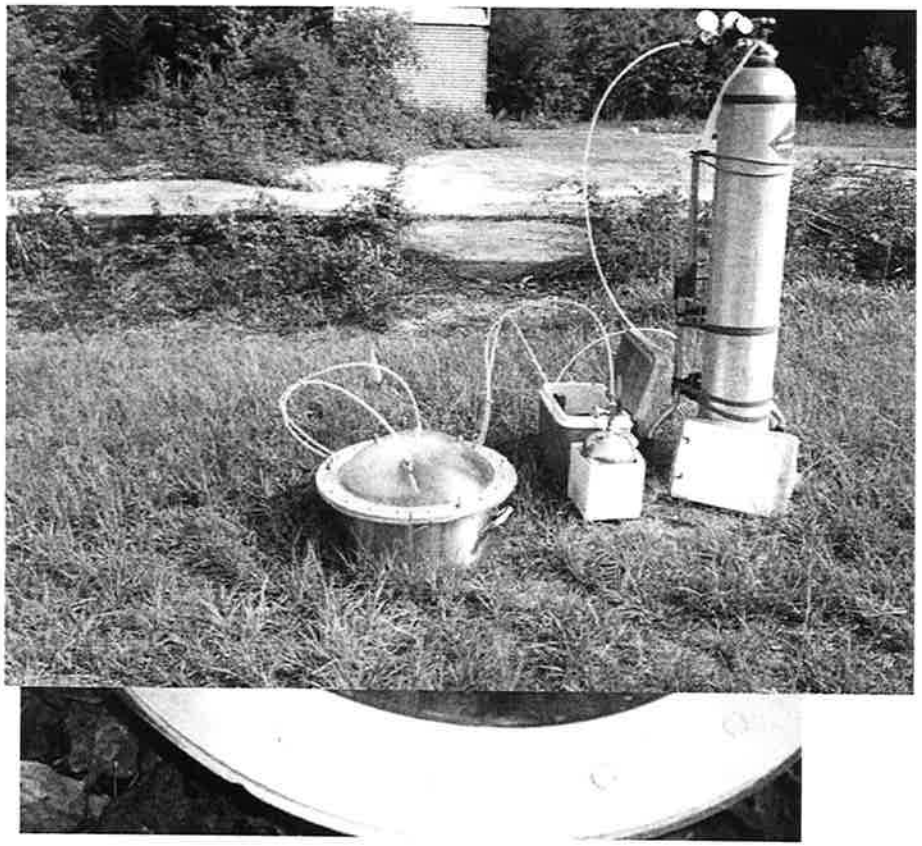
Flux Chamber Sampling



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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

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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

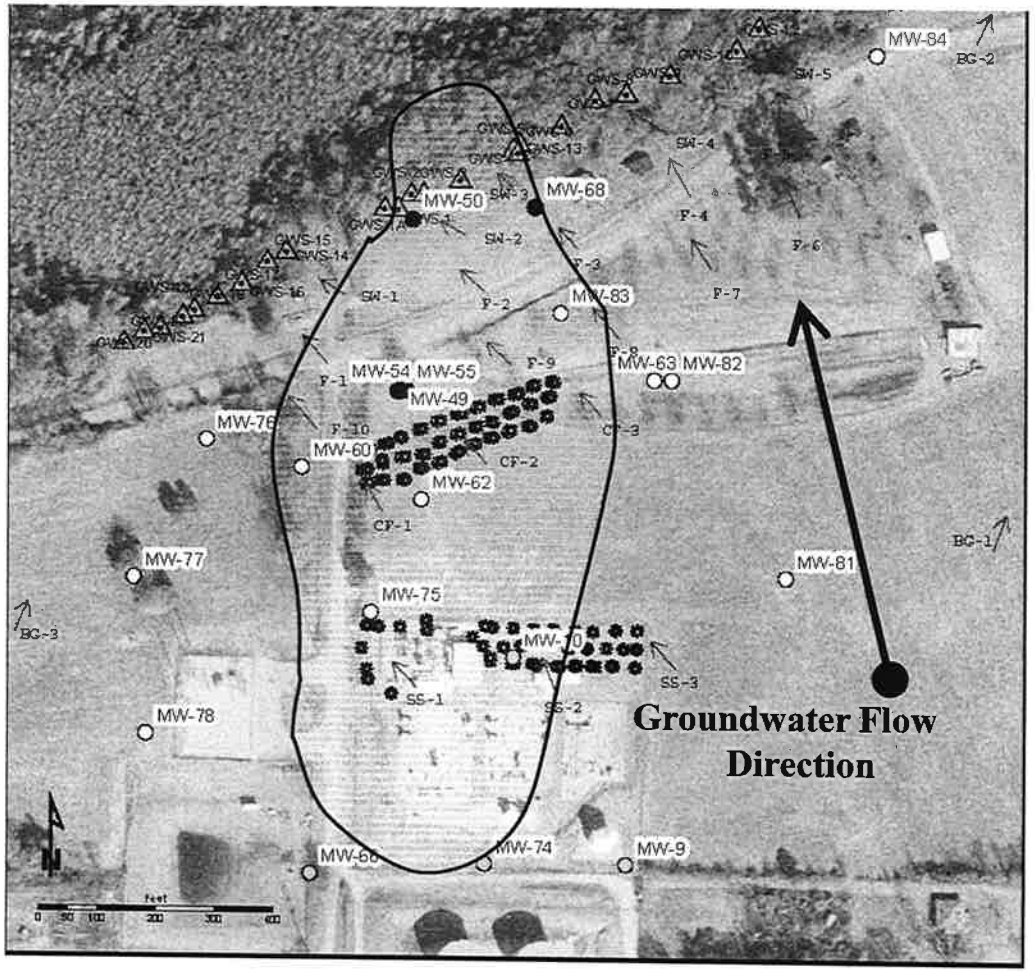

Figure 2-2 Groundwater Monitoring System to Evaluate Effects of Air Sparge System Modifications

- Up Gradient Wells
- Wells Between Air Sparge Systems
- Cross-Gradient Wells
- Down Gradient Wells
- Air Sparge Points
- Groundwater Seep Samples

Recommended Flux Chamber Points

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Flux Chamber Sampling Results

- Benzene Overlying GW
  - 0.04 to 1.59 µg/m^2 per minute (Contaminated Area)
  - 0.025 to 0.037 µg/m^2 per minute (Uncontaminated Area – Background)
- Benzene Over Surface Water Seeps & Swamp
  - 0.47- 1.50 µg/m^2 per minute (Contaminated Areas)
  - 0.013 to 0.042µg/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

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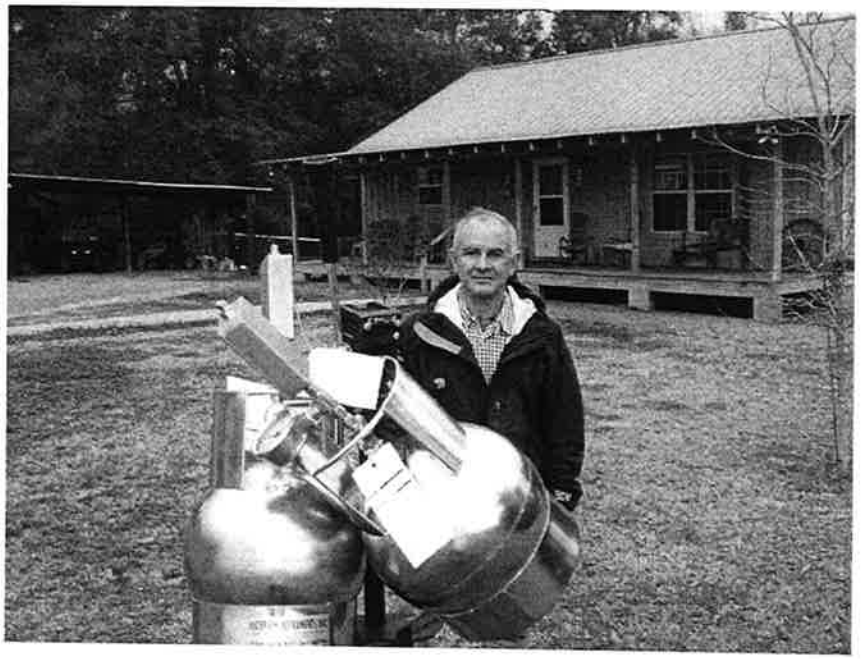
Ambient Air Sampling



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Ambient Air Sampling Results

- Benzene in Ambient Air at Receptor Locations
  - 0.30 to 1.60 µg/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 µg/m^3 (0.16 – 3.5 ppb) in Rural Areas Such as the Study Area
- Benzene Above Contaminated Swamp Surface
  - 1.36 µg/m^3 (0.44 ppb)

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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

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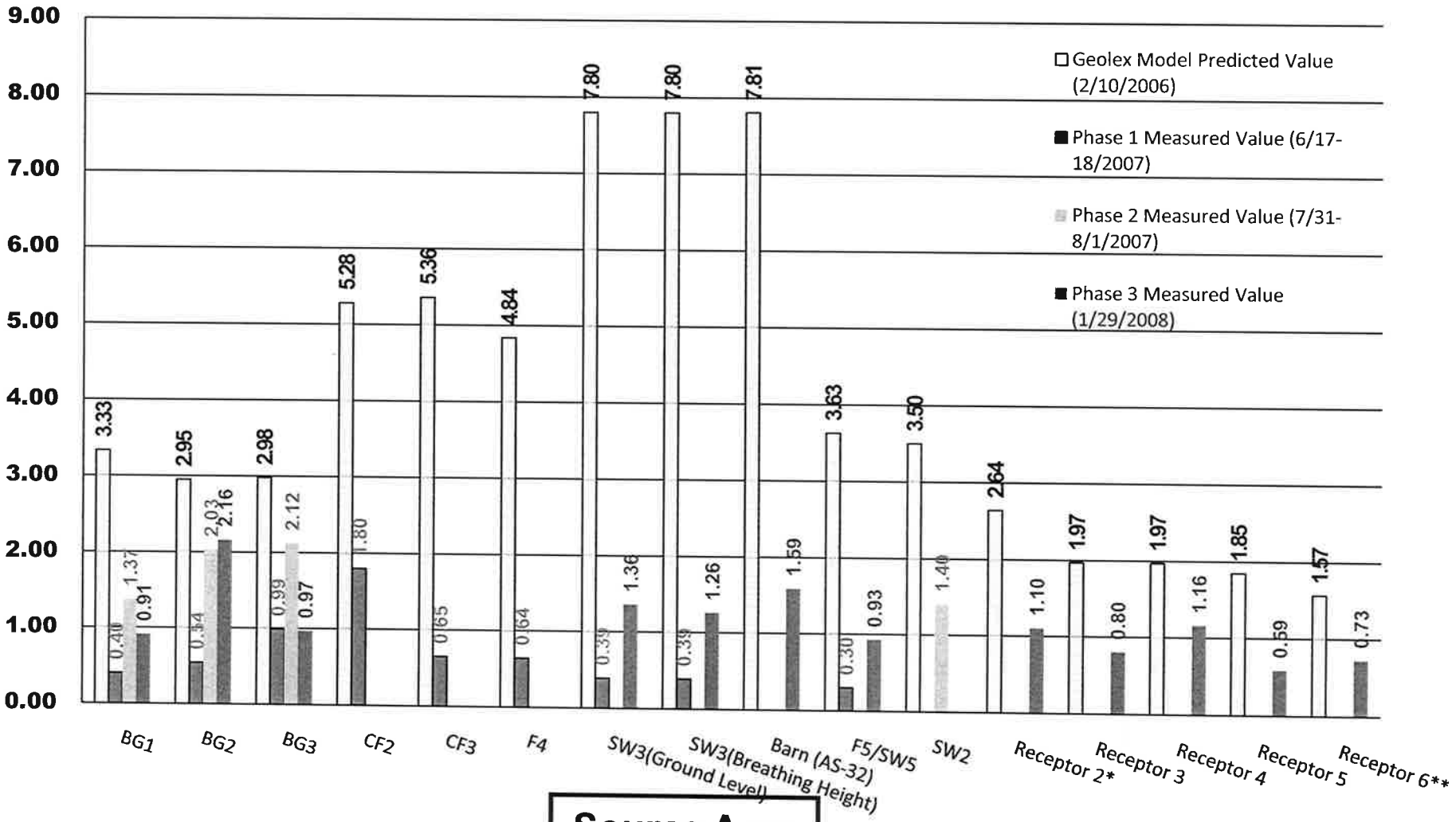
Model Predicted 8hr Values vs Actual Measured 8hr Values Benzene in µg/m³



Source Area Location

Arrows Show Receptors at Increasing Distance Away from Source Area

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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

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