COMPUTER MODELING OF THE AIR QUALITY IMPACTS RELEASED FROM AN INDUSTRIAL WASTEWATER TREATMENT FACILITY

Tinker Air Force Base, Oklahoma

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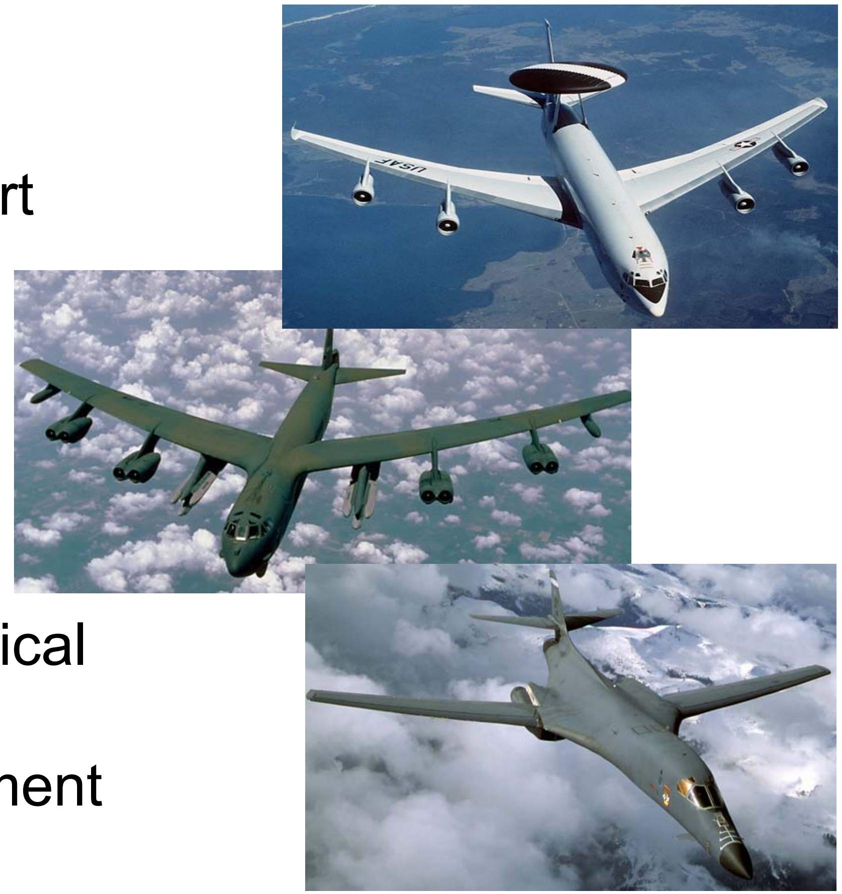
INVESTIGATION OVERVIEW

Outline

- Introduction
- Project Overview
- Distinctive Elements of Effort
- Air Emission Model
- Air Dispersion Model
- Coupled Model Validation / Calibration Process
- Coupled Model Results
- Comparison to Remote Optical Monitoring System
- Application to Risk Assessment
- Summary and Conclusions



TINKER AFB, OKLAHOMA
Introduction

- Tinker AFB covers 5,031 acres
    - *Only 200 acres are undeveloped*
- 765 Facilities
    - *15.3M $feet^2$ of industrial operations*
- Three Creek Systems
- 700-plus Air Emission Sources
- 200 Underground Storage Tanks
- 11-Miles Industrial Wastewater Lines
- Three Wastewater Treatment Plants
- 36 Restoration Sites
- Provides Logistics Support to USAF Weapon Systems
    - *B-1, B-52, E-3 Sentry, C/KC-135 aircraft*

TINKER AFB, OKLAHOMA

Introduction [CONTD]

- Tinker AFB performs Depot Level Maintenance
- Process Assessment identified four Primary Processes
  - *Depainting, Painting, Electroplating & Cleaning*
  - *Majority of processes discharge to an on-base treatment facility*
- Regulatory Requirement to quantify Air Emissions from Industrial Wastewater Treatment Facility [IWTF]
  - *Toxic Release Inventory and Air Emission Inventory*
  - *Clean Air Act Title V permit requires source & emission information*
  - *POTW NESHAP requirement*
- Efforts focus on Methylene Chloride and Phenol
  - *Both are CAA Title III Listed Hazardous Air Pollutants [HAPs]*
  - *VOC and semi-VOC examples*
  - *These chemicals account for majority of purchases / releases*

COUPLED MODELING METHOD

Project Overview

- Investigation will be presented in four Major Tasks
- Coupling of Emission and Dispersion Models represents a Cost-Effective and Environmentally-Responsible Approach
  - *Coupling refers to sequential use of models [output is input]*
  - *Meet impact predictions, regulatory reporting requirements, and pollution prevention needs*
  - *Estimate emissions from IWTP process units*
    - *WATER8 air emission model developed by EPA*
  - *Estimate atmospheric dispersion concentrations*
    - *ISC-ST3 air dispersion model designed by EPA*

  Coupled Model

  - *Validate predictive accuracy of the coupled model*
    - *Comparison of coupled model predictions to field data*
    - *Comparison of coupled model predictions to OP-FTIR data*
  - *Demonstrate potential applications to include Risk Assessment*

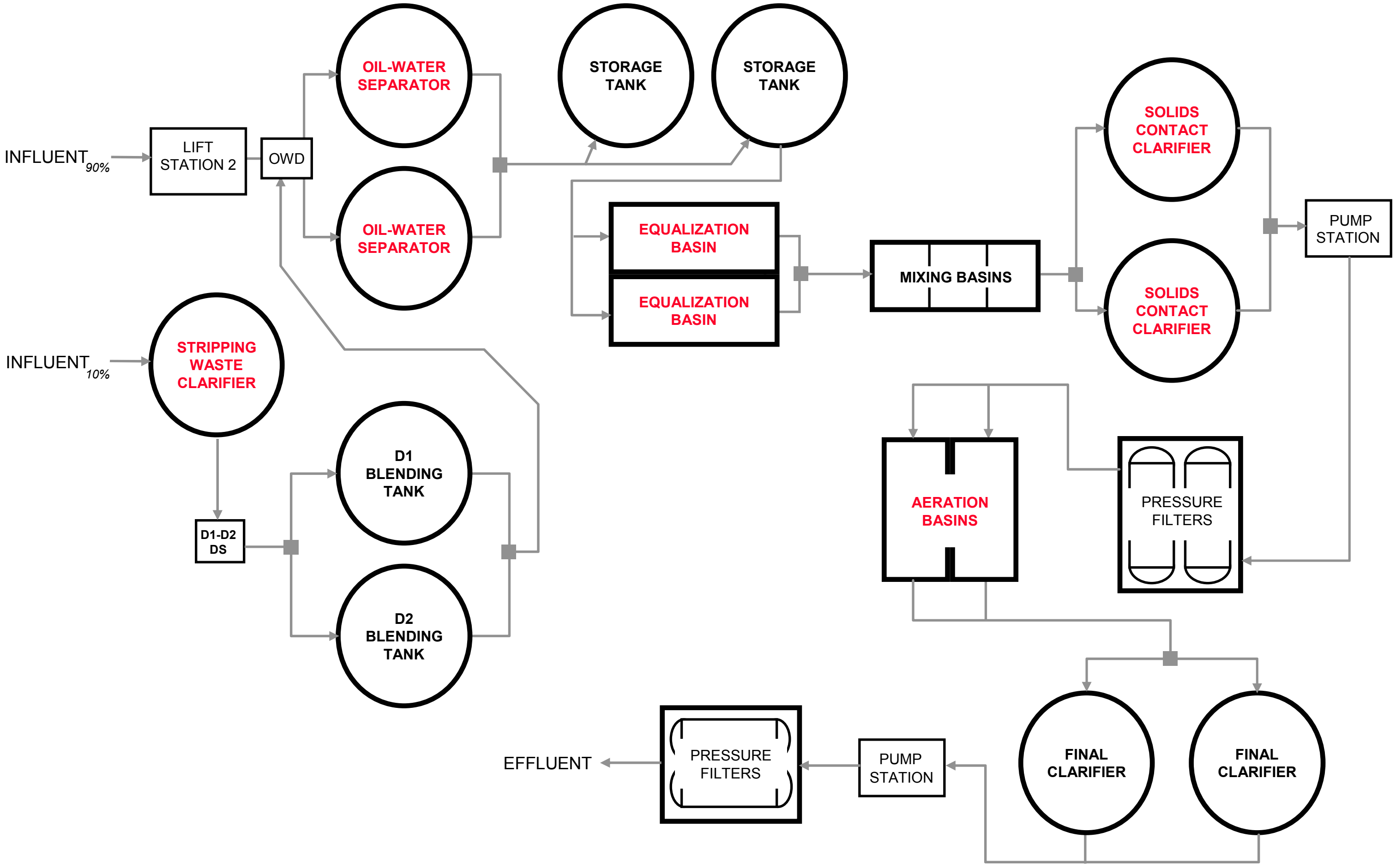
COUPLED MODELING METHOD

Uniqueness of Investigation

- Distinctive Elements of Investigation
  - *Combined use of WATER8 and ISC-ST3*
  - *Literature directed to specific applications*
  - *Coupled model compared to MAAC*
  - *Literature limited to single emission sources*
  - *Literature focused at municipal wastewater treatment*
  - *Detail and size of periodic canister data*
  - *Investigation of three remote optical paths*
  - *Multiple retroreflectors along optical path*
  - *Evaluation of chemical depainting agents*
  - *Coupled model used in risk assessment*
  - *Completeness and comparative analysis*

IWTP PROCESS FLOW DIAGRAM

Primary, Secondary, & Tertiary Treatment



AIR EMISSION MODEL

WATER8

- Predictive Source Emission Model developed by EPA
  - *Recommended for estimating emission rate from IWTF process units [surface impoundments, etc.]*
  - *Only GFM developed for industrial wastewater collection and treatment processes*
  - *Adjusts Henrys Law constants with temperature*
- Major Competing Mechanisms / Pathways
  - *Volatilization and biological degradation*
- Emission Model based on Mass Transfer Principles
  - *Equilibrium drives mass transfer across phase interface*
- Requires Minimal Amount of Process Unit Information and Wastewater Influent Properties
  - *Constituent concentrations, flow rates, unit physical dimensions, operating conditions, detention times, etc.*

AIR EMISSION MODEL

WATER8--Governing Equations

- Governing equation:

$$E = K_O \; A \; C_L$$

- Overall mass transfer expression:

$$\left[\frac{1}{K_O}\right] = \left[\frac{1}{K_L}\right] + \left[\frac{1}{K_E \; K_G}\right]$$

- Liquid phase mass transfer equation:

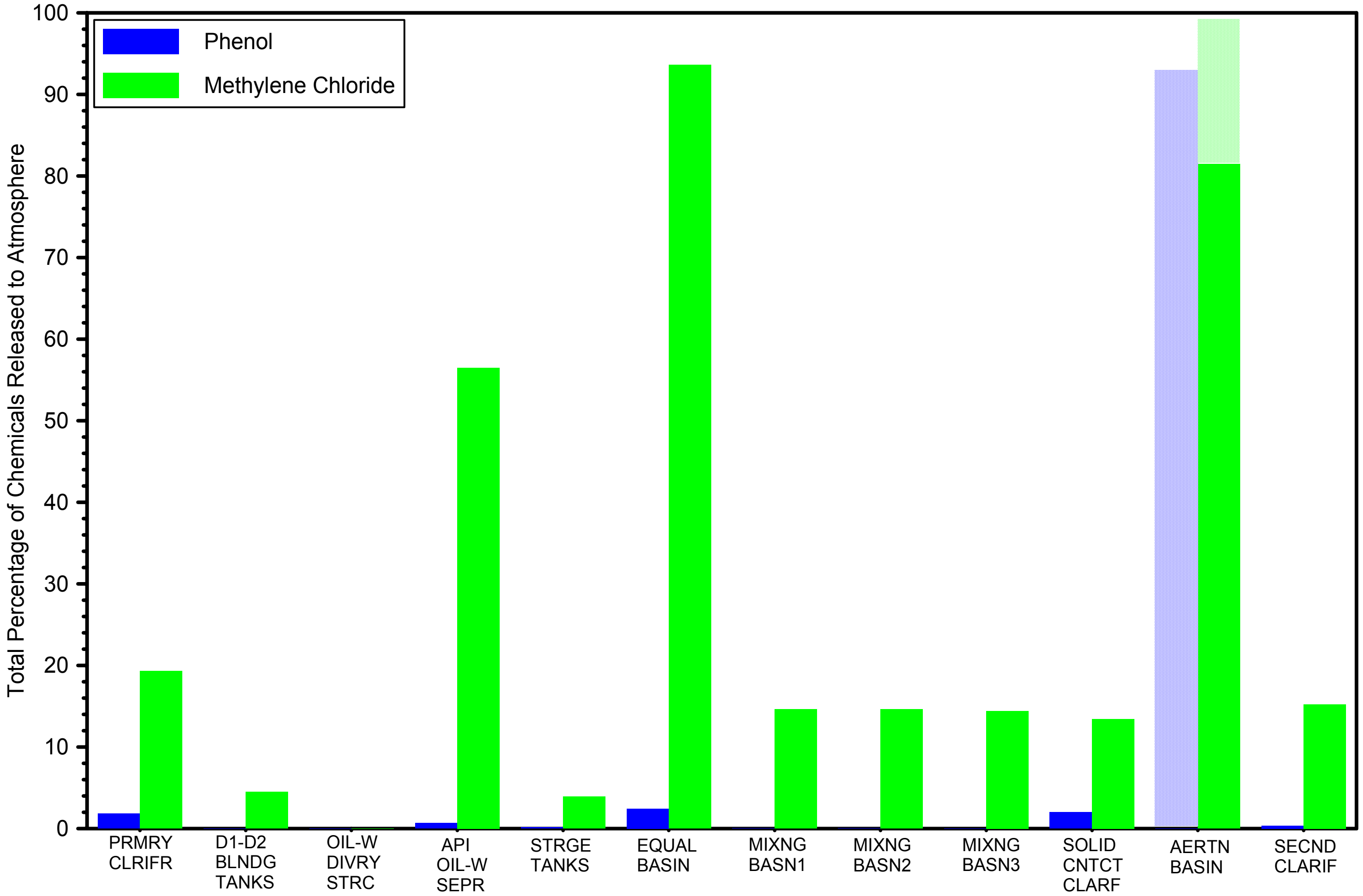
$$K_L = 0.00445 \;\; MW^{-0.5} \left[1.025\right]^{t-20} U_{10}^{0.67} \;\; H_d^{-0.85} \left[\frac{D_w}{D_{ether}}\right]^{0.67}$$

- Gas phase mass transfer expression:

$$K_G = 0.0008 \, MW^{-1} \, W^{0.78} \; Z^{-0.11} \; N_{Sc}^{-0.67}$$

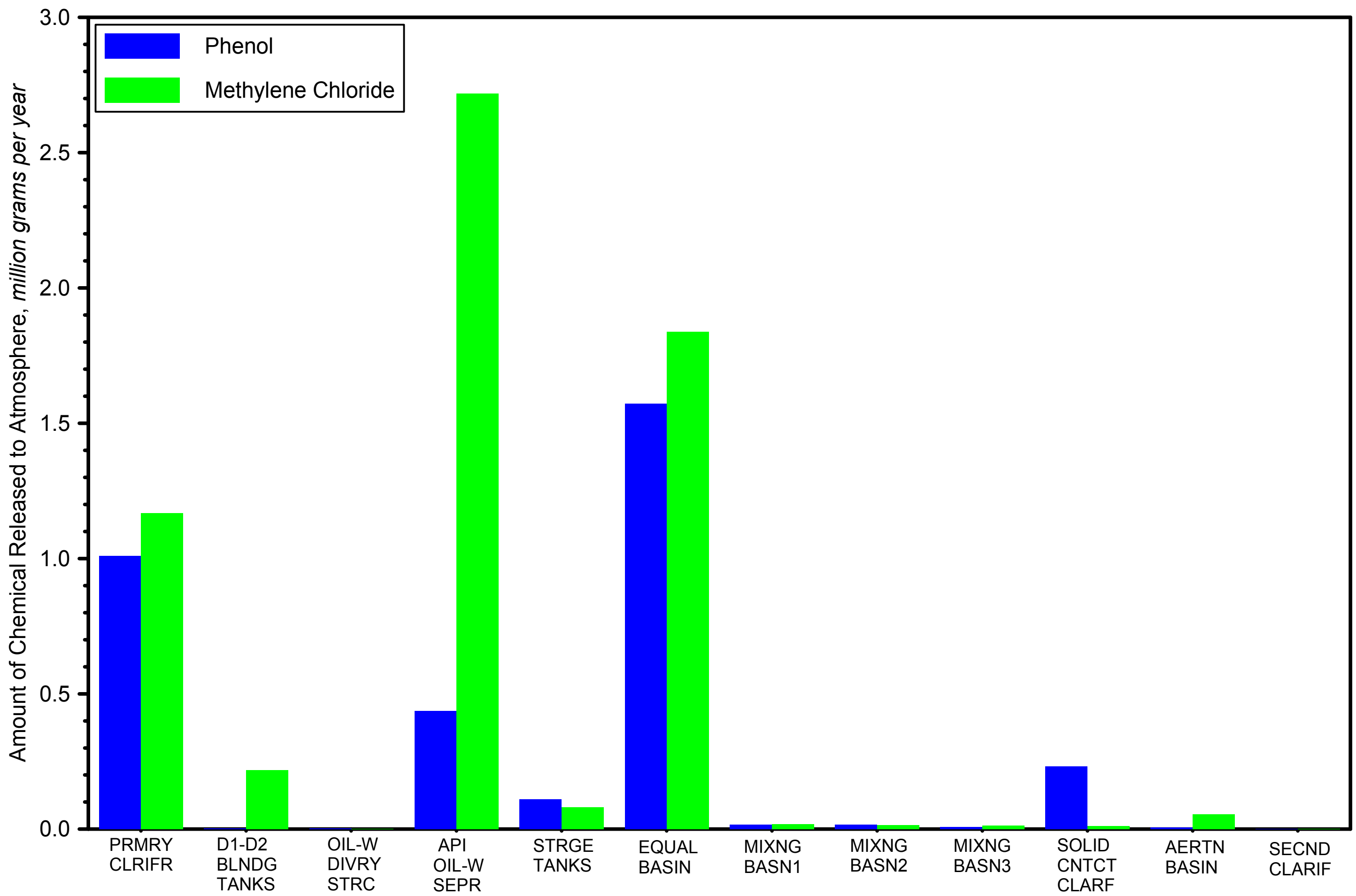
AIR EMISSION MODEL OUTPUT

Percent Chemical Distribution



AIR EMISSION MODEL OUTPUT

Mass of Chemical Released



AIR DISPERSION MODEL
Industrial Source Complex--Short Term

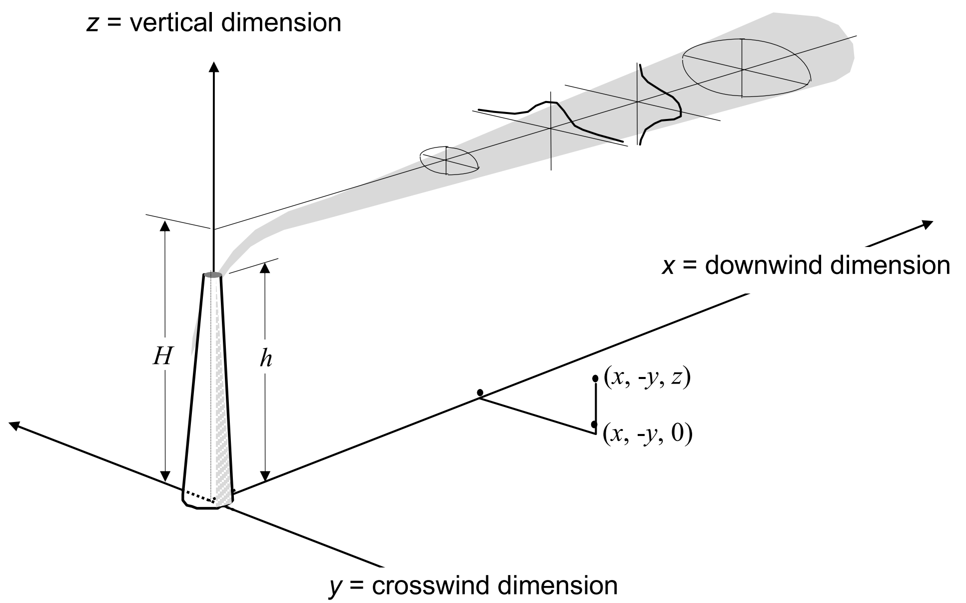
- Atmospheric Dispersion Model developed by EPA
  - *WATER8 emission rates input into ISC-ST3 model*
  - *Generates annual-average & 24-hour maximum concentrations*
  - *ISC dictated by state protocol for air dispersion modeling*
- Governing Mechanism
  - *Gaussian bi-normal distribution of constituents*
- Air Dispersion Model Information Requirements
  - *Emission source data*
    - *Need emission rate [factor] for individual process units*
  - *Meteorology data*
    - *Wind speed, direction, surface conditions, mixing height, etc.*
  - *Receptor data*
    - *Determine impact region, develop grid system, grid spacing, etc.*

AIR DISPERSION MODEL

Industrial Source Complex--Governing Equations

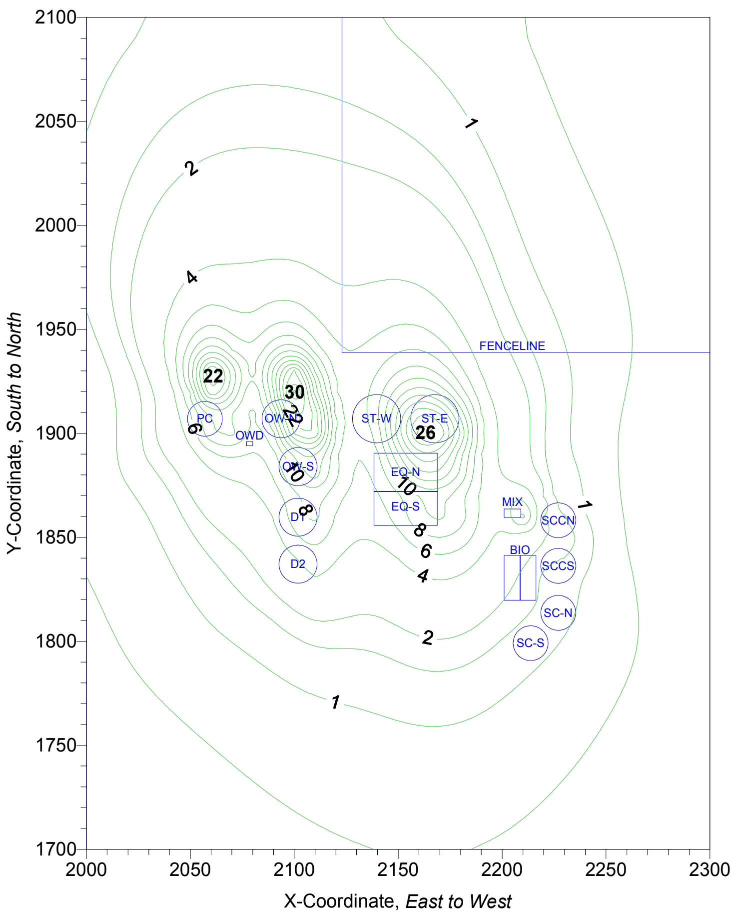
- Gaussian dispersion equation:

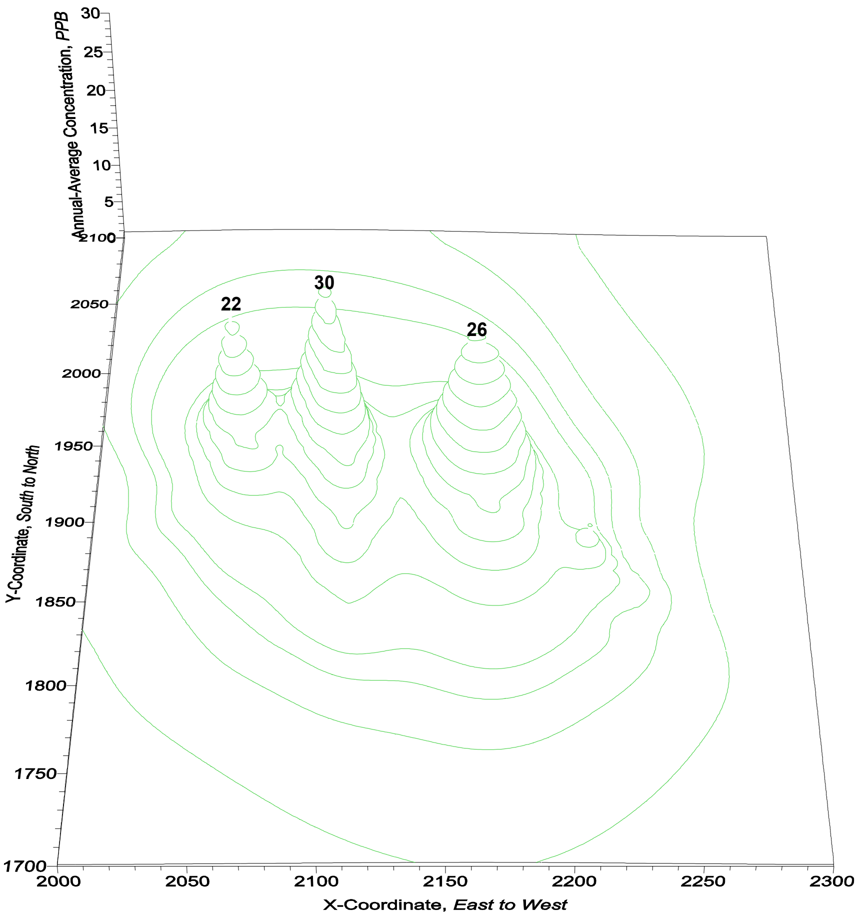
$$\chi(x, y, z; H) = \left[\frac{Q}{2\, u\, \pi\, \sigma_y\, \sigma_z}\right] \exp\left[\frac{-y^2}{2\,\sigma_y^2}\right] \left\{ \exp\left[\frac{-(H-z)^2}{2\,\sigma_z^2}\right] + \exp\left[\frac{-(H+z)^2}{2\,\sigma_z^2}\right] \right\}$$



COUPLED MODEL OUTPUT

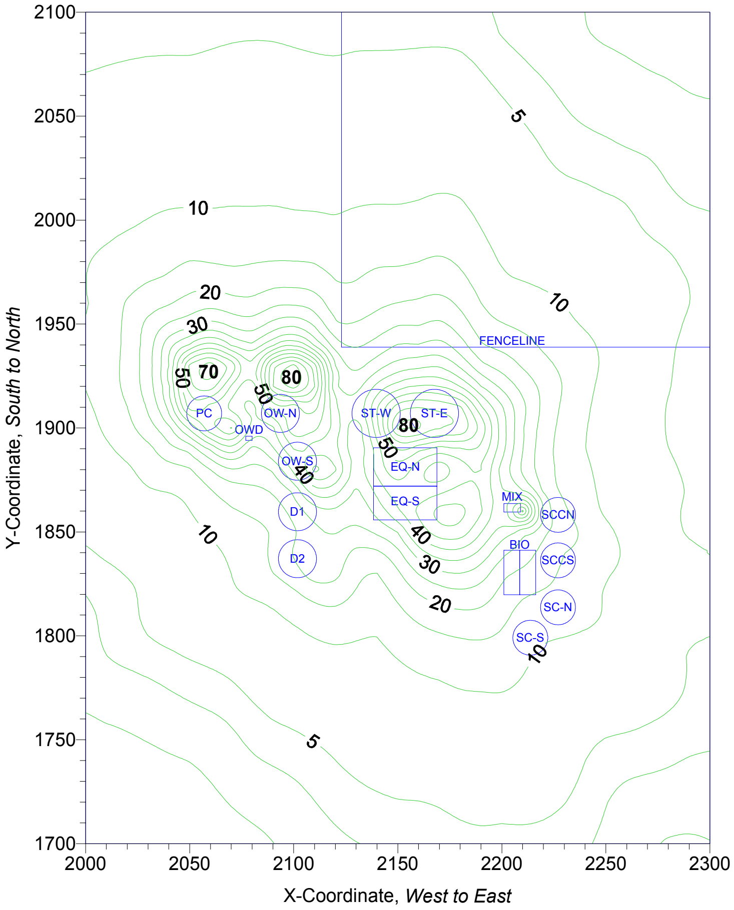
Average Methylene Chloride Concentrations, PPB

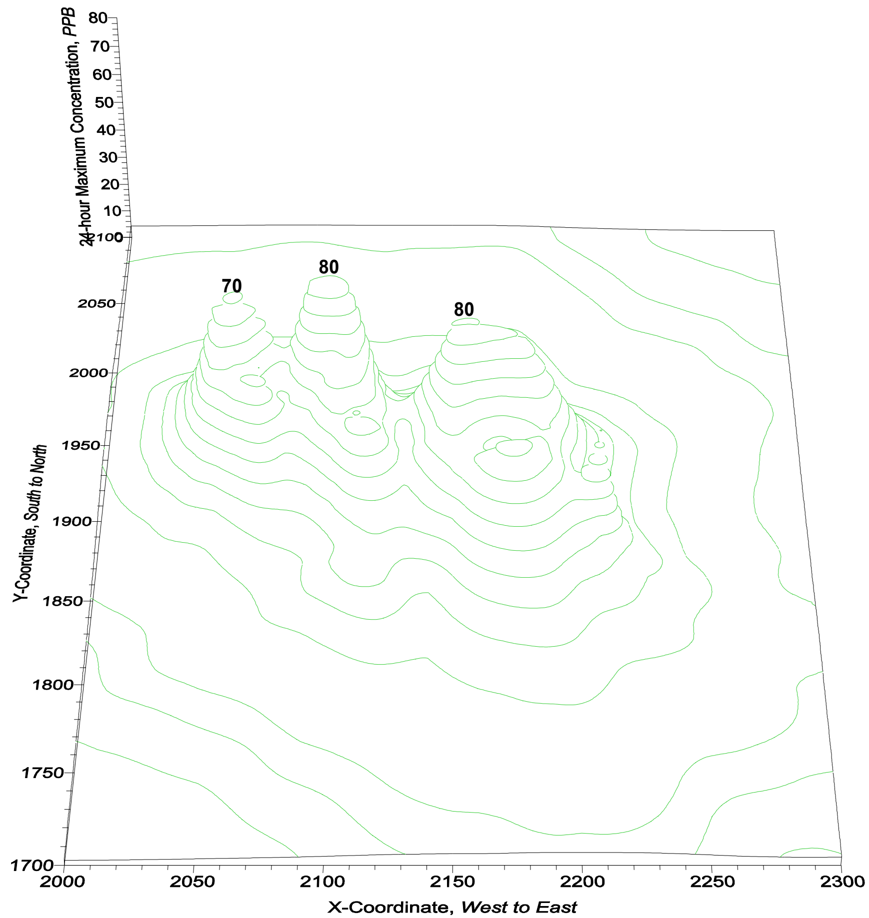




COUPLED MODEL OUTPUT

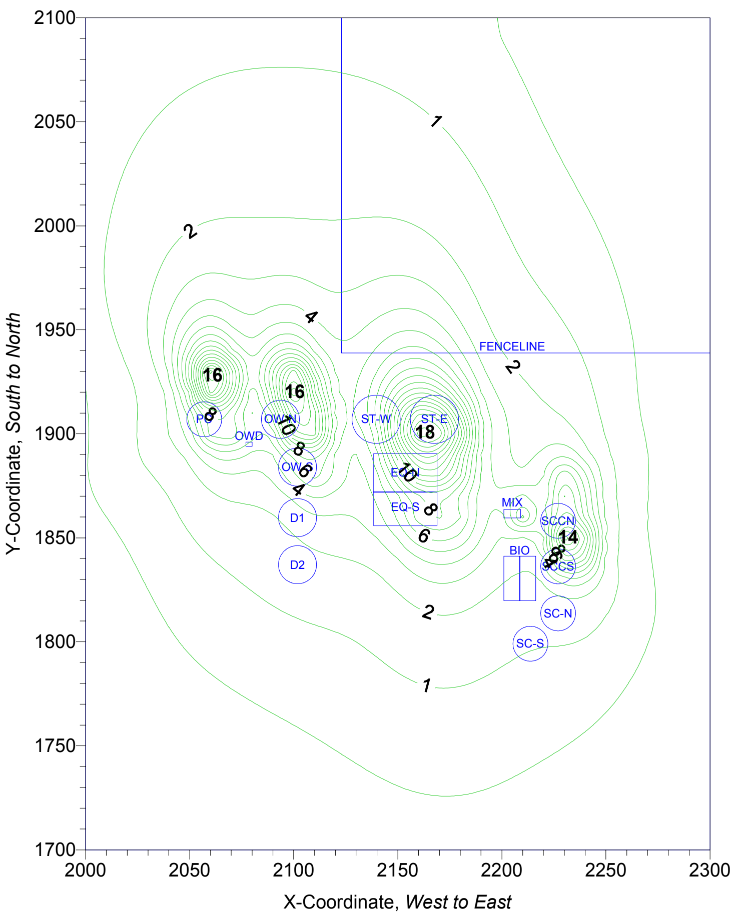
Maximum Methylene Chloride Concentrations, PPB

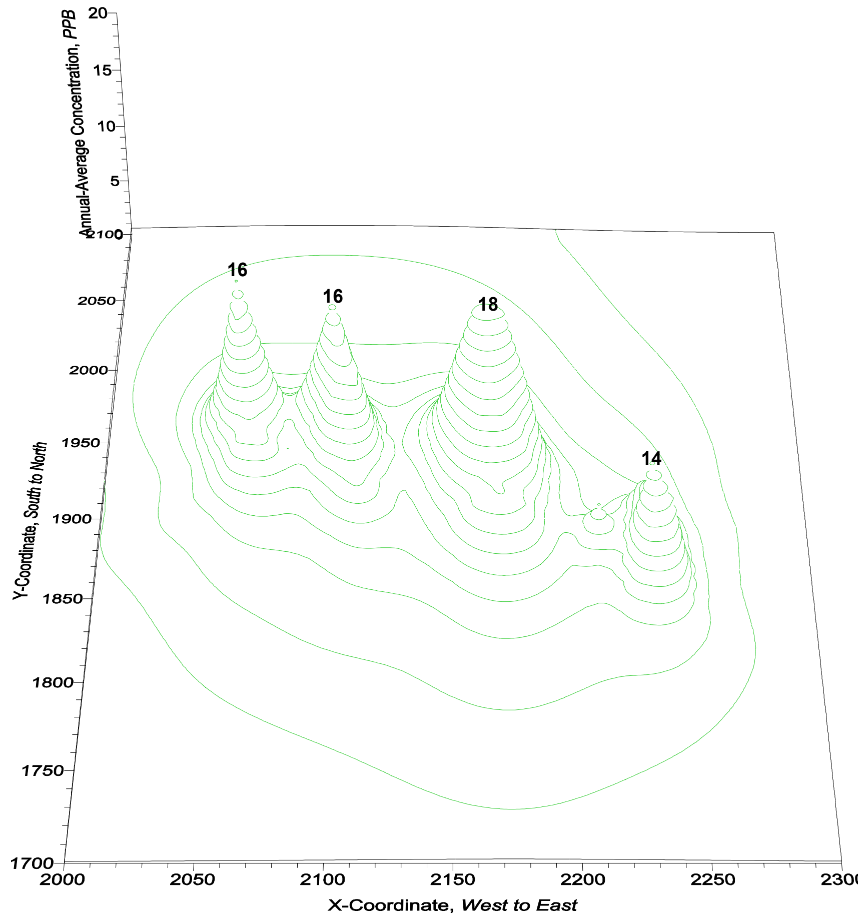




COUPLED MODEL OUTPUT

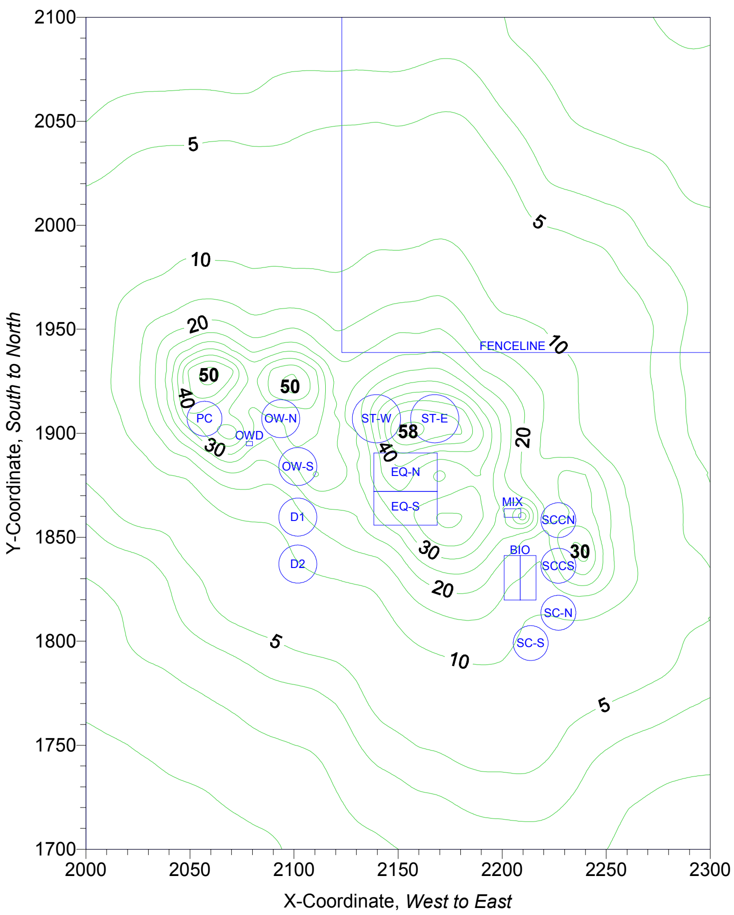
Average Phenol Concentrations, PPB

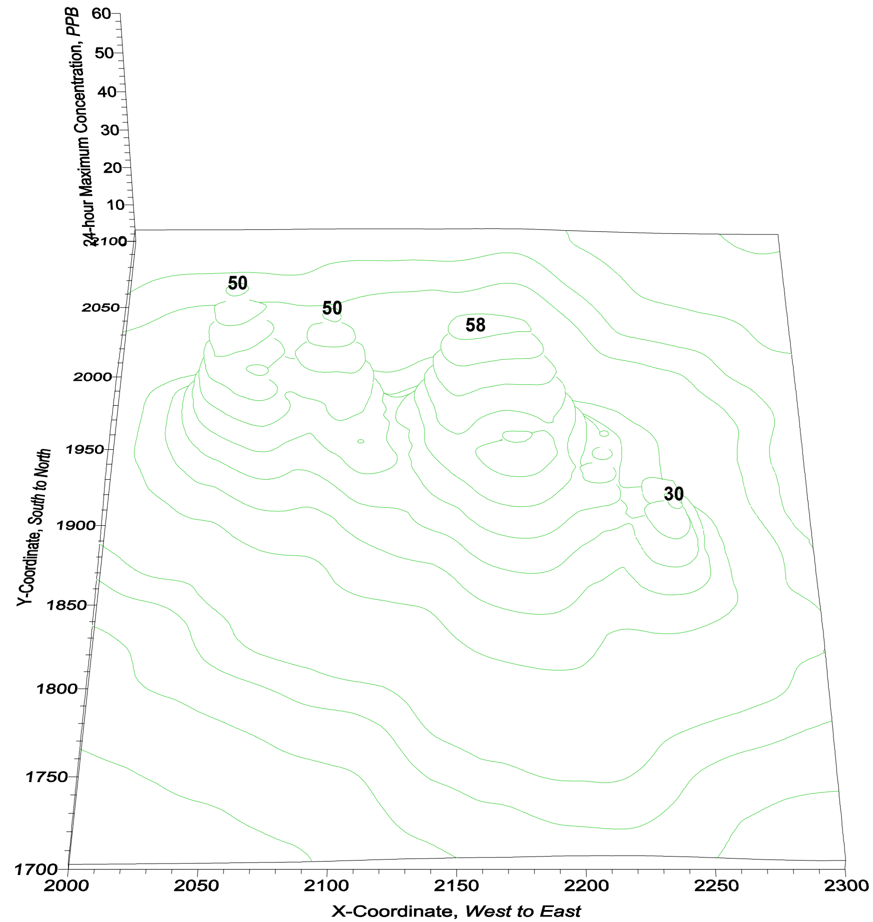




COUPLED MODEL OUTPUT

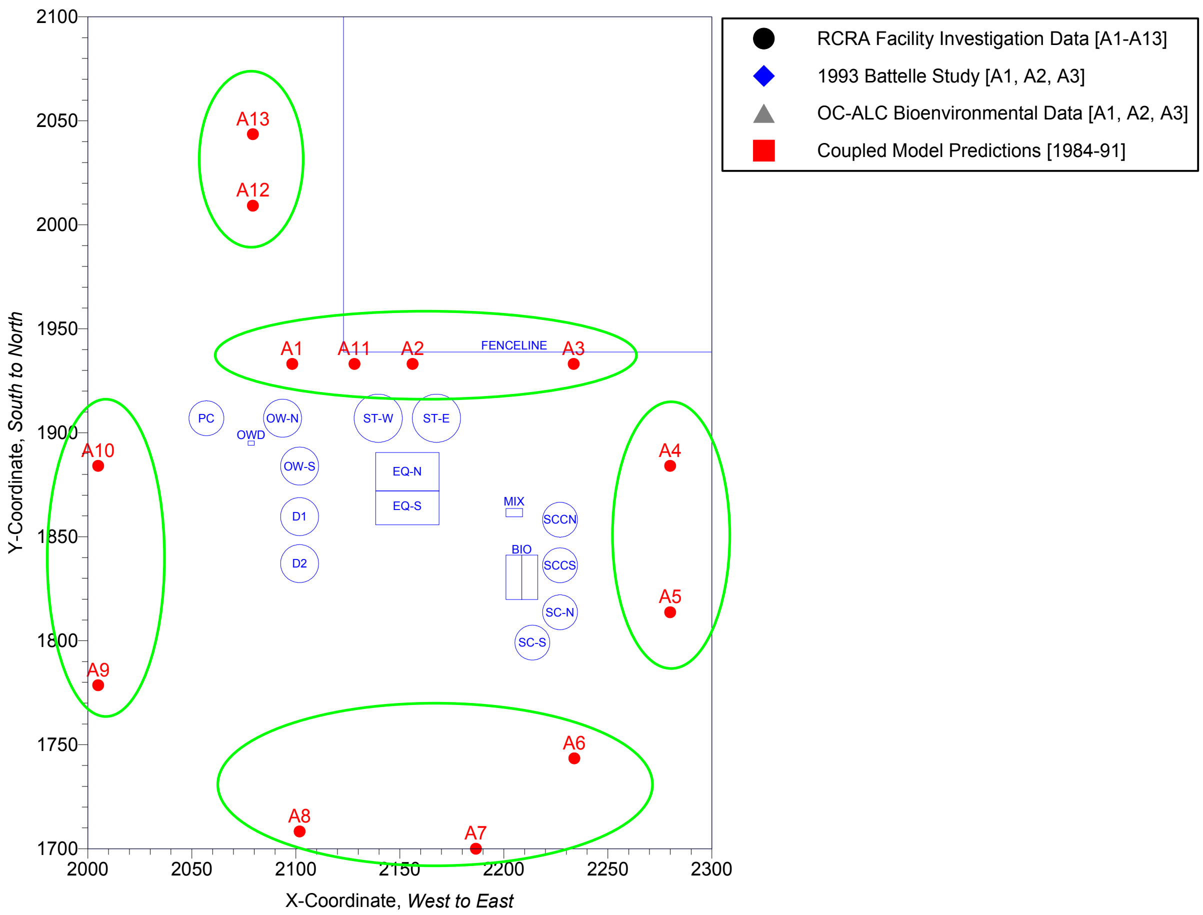
Maximum Phenol Concentrations, PPB





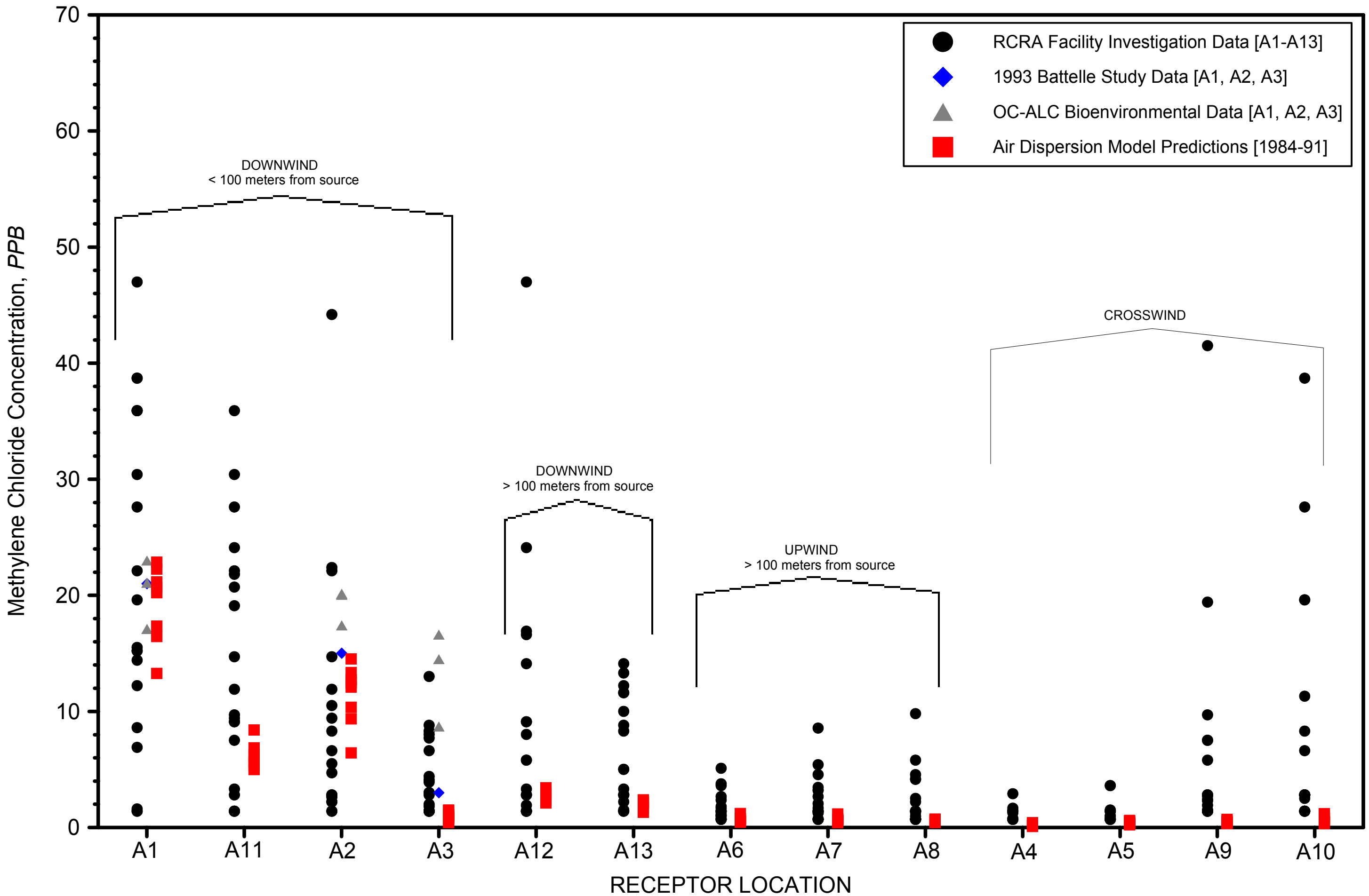
COUPLED MODEL VALIDATION

Location of Periodic Canister Sample Sites



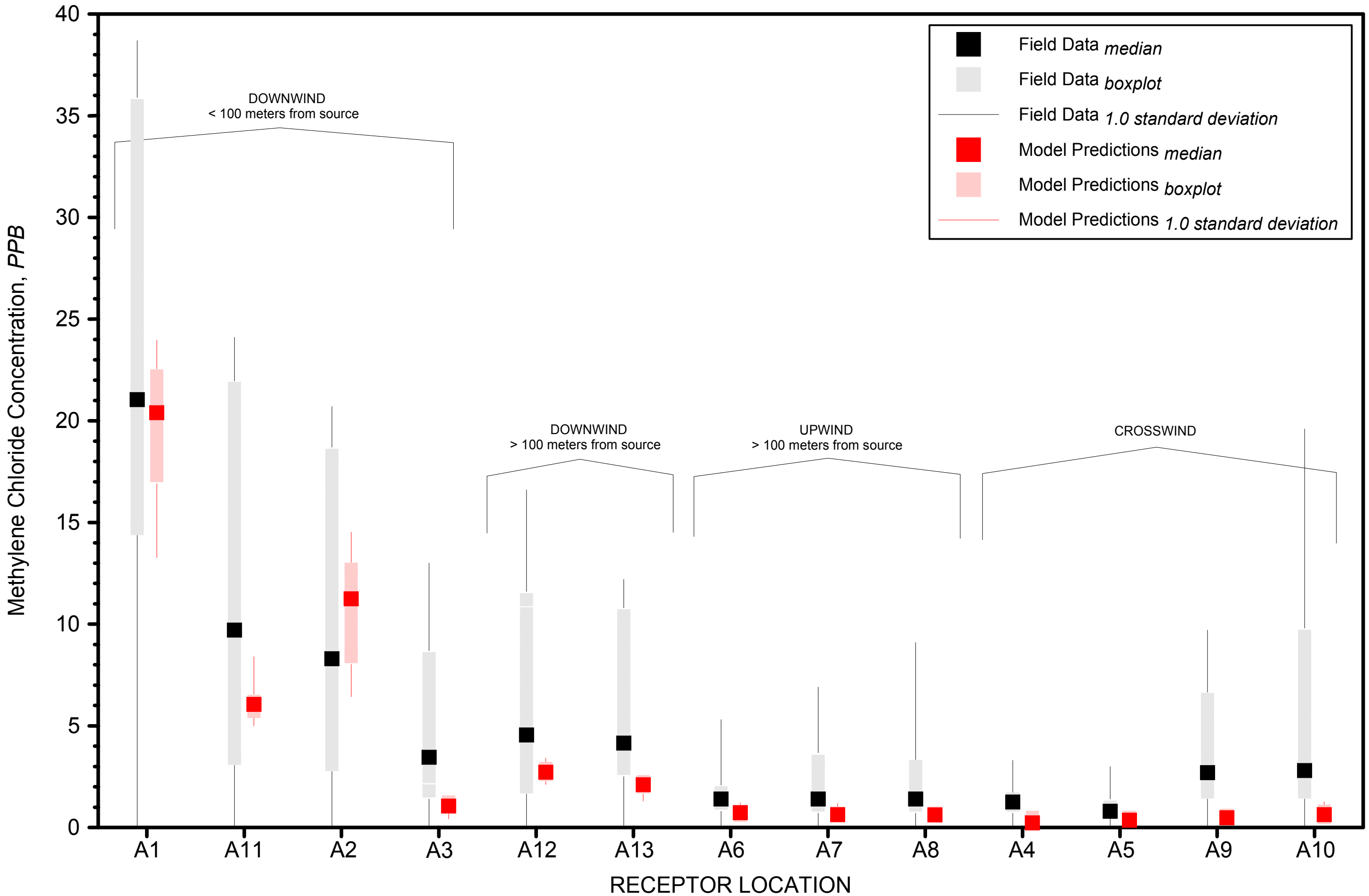
COUPLED MODEL VALIDATION

Methylene Chloride Concentrations, PPB



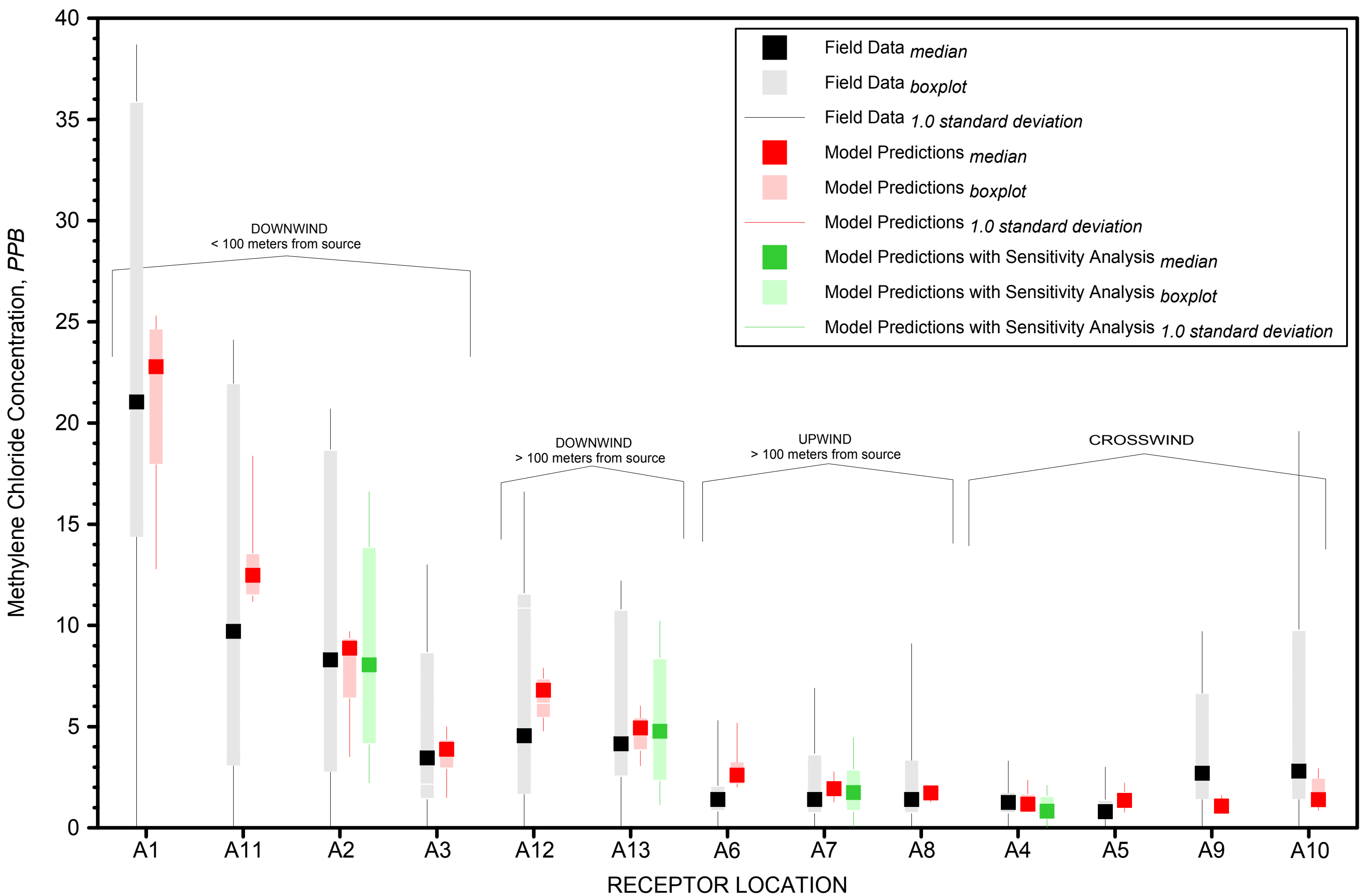
COUPLED MODEL VALIDATION

Methylene Chloride Concentrations, PPB



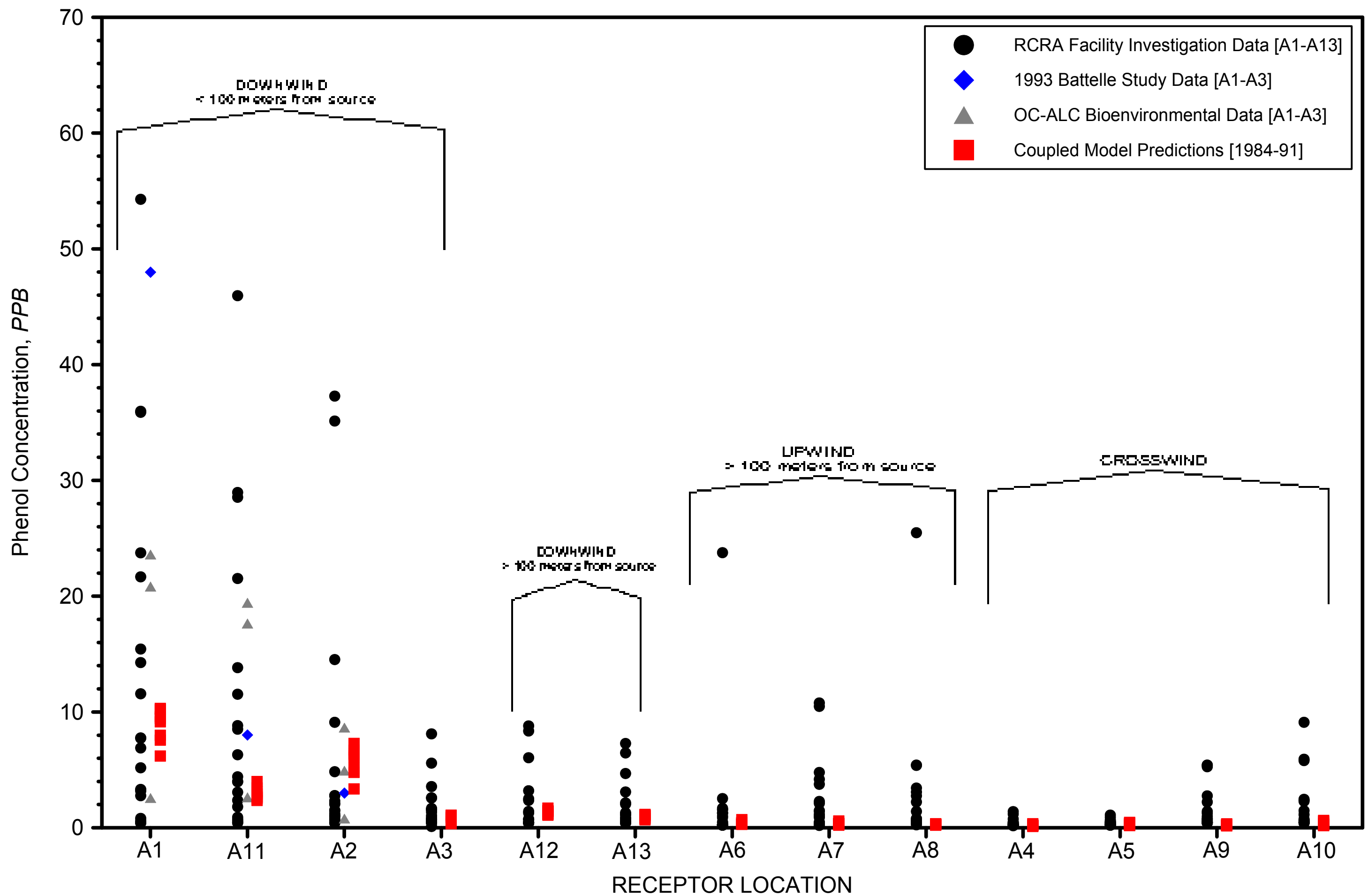
SENSITIVITY ANALYSIS

Methylene Chloride Concentrations, PPB



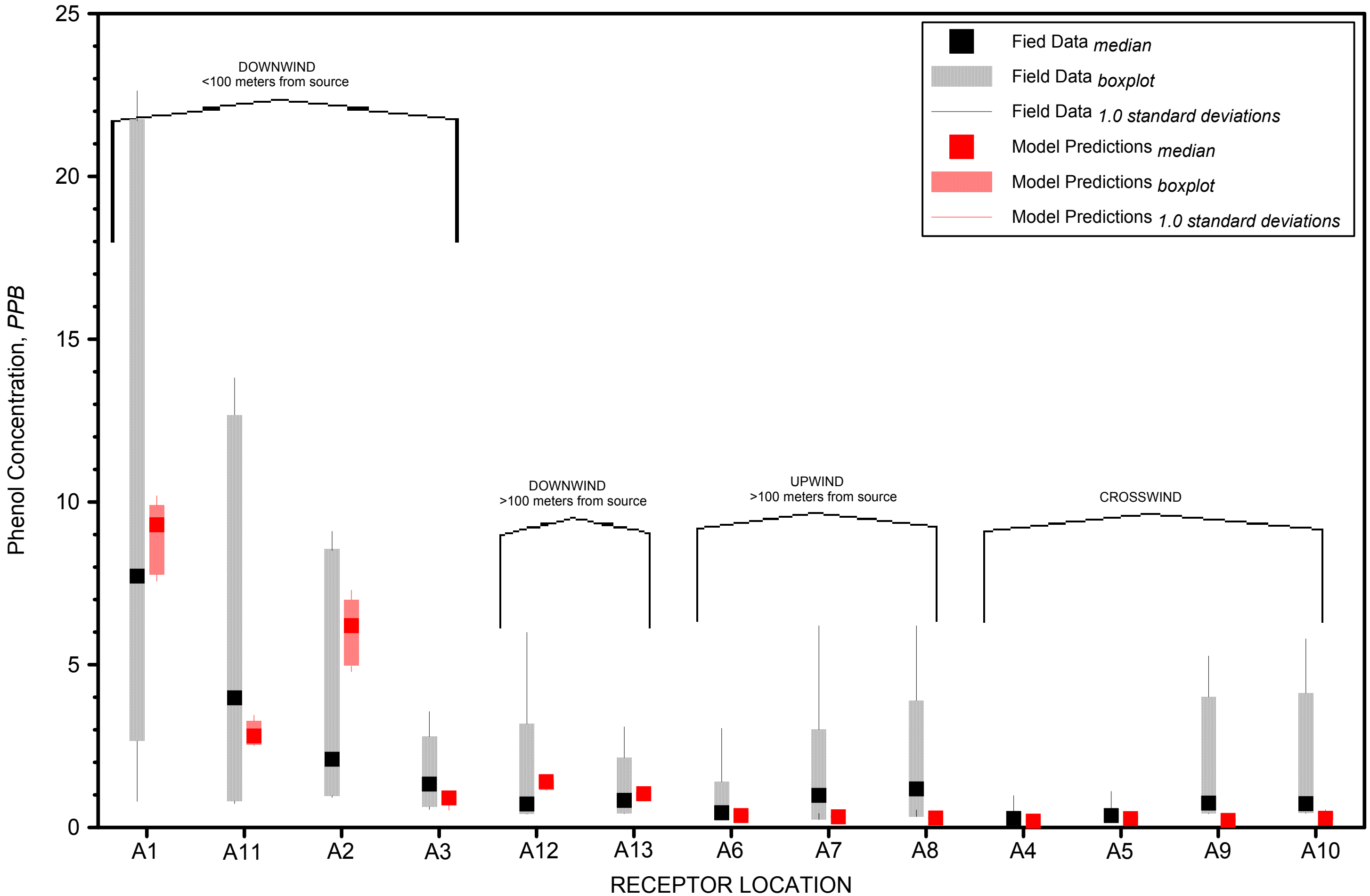
COUPLED MODEL VALIDATION

Phenol Concentrations, PPB

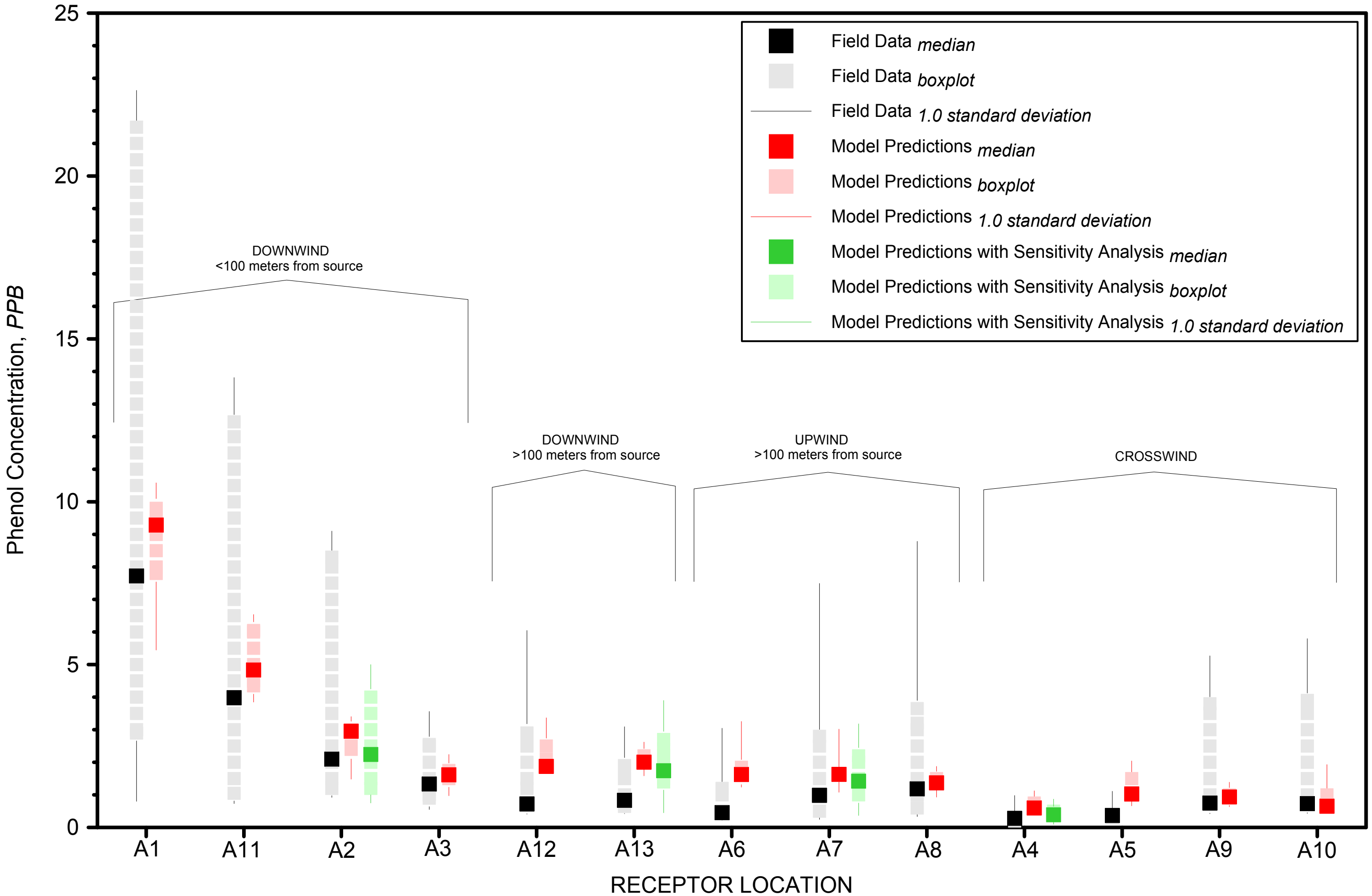


COUPLED MODEL VALIDATION

Phenol Concentrations, PPB

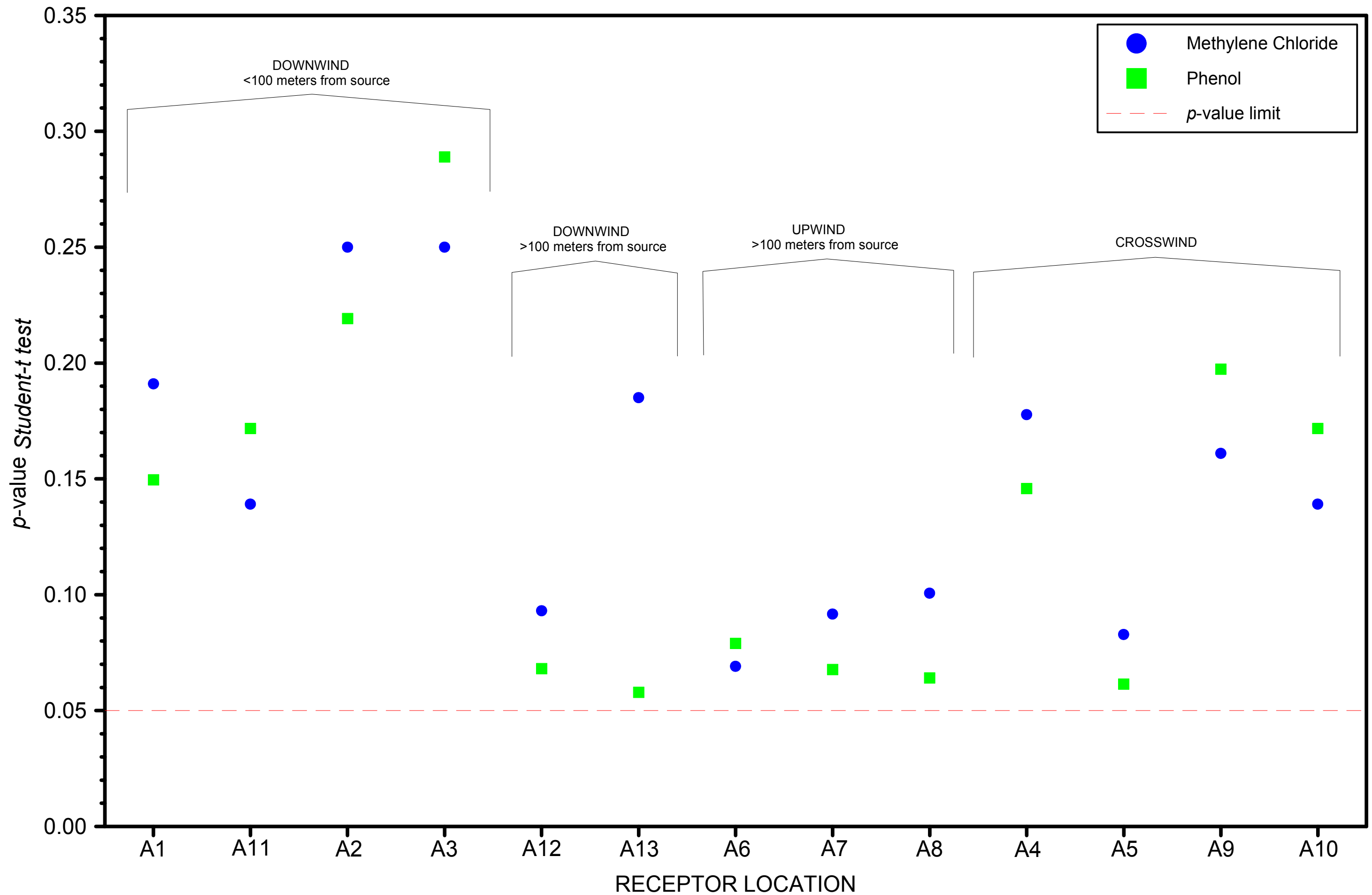


SENSITIVITY ANALYSIS
Phenol Concentrations, PPB



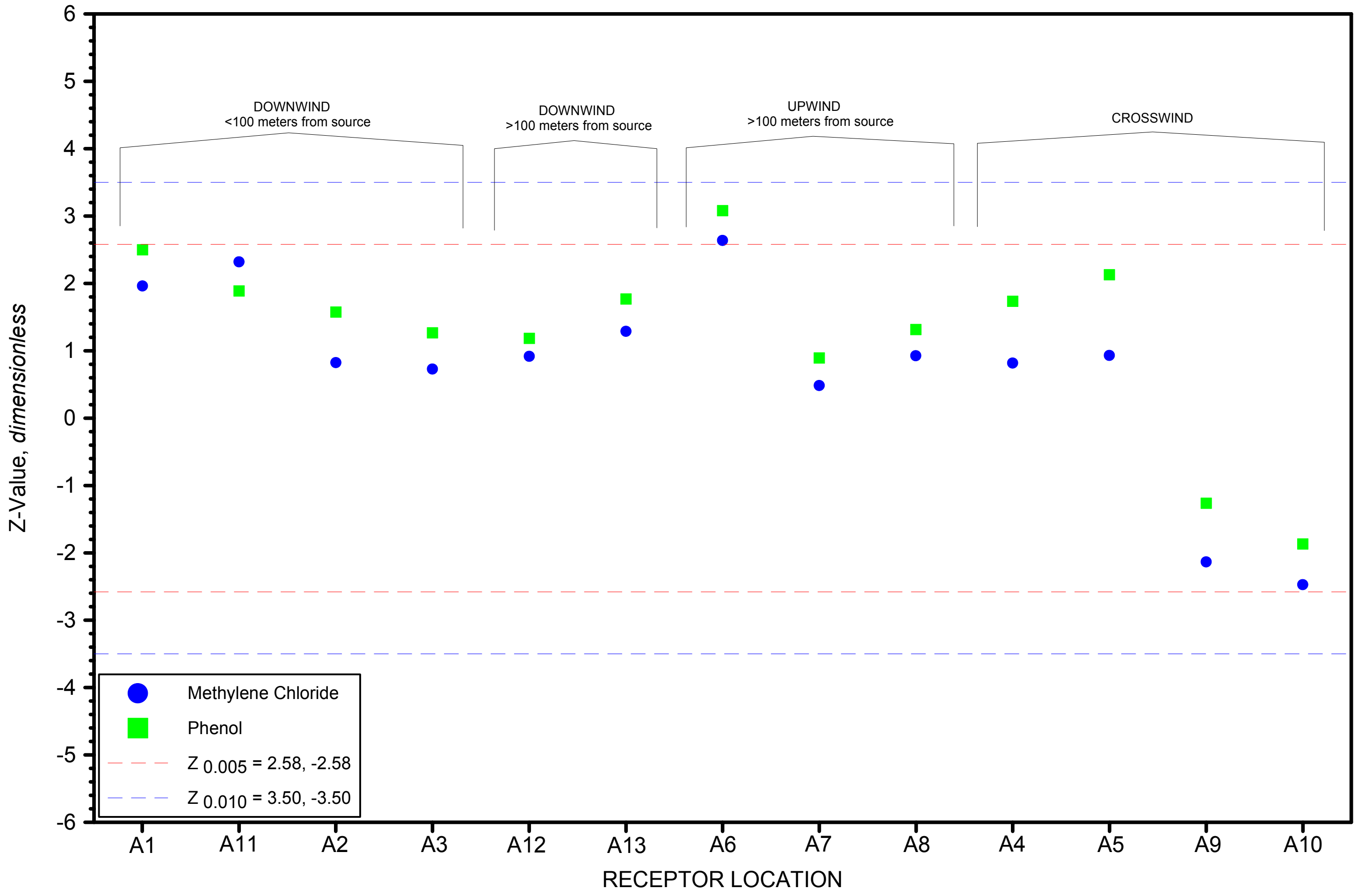
COUPLED MODEL PERFORMANCE

Students t-test Statistical Method



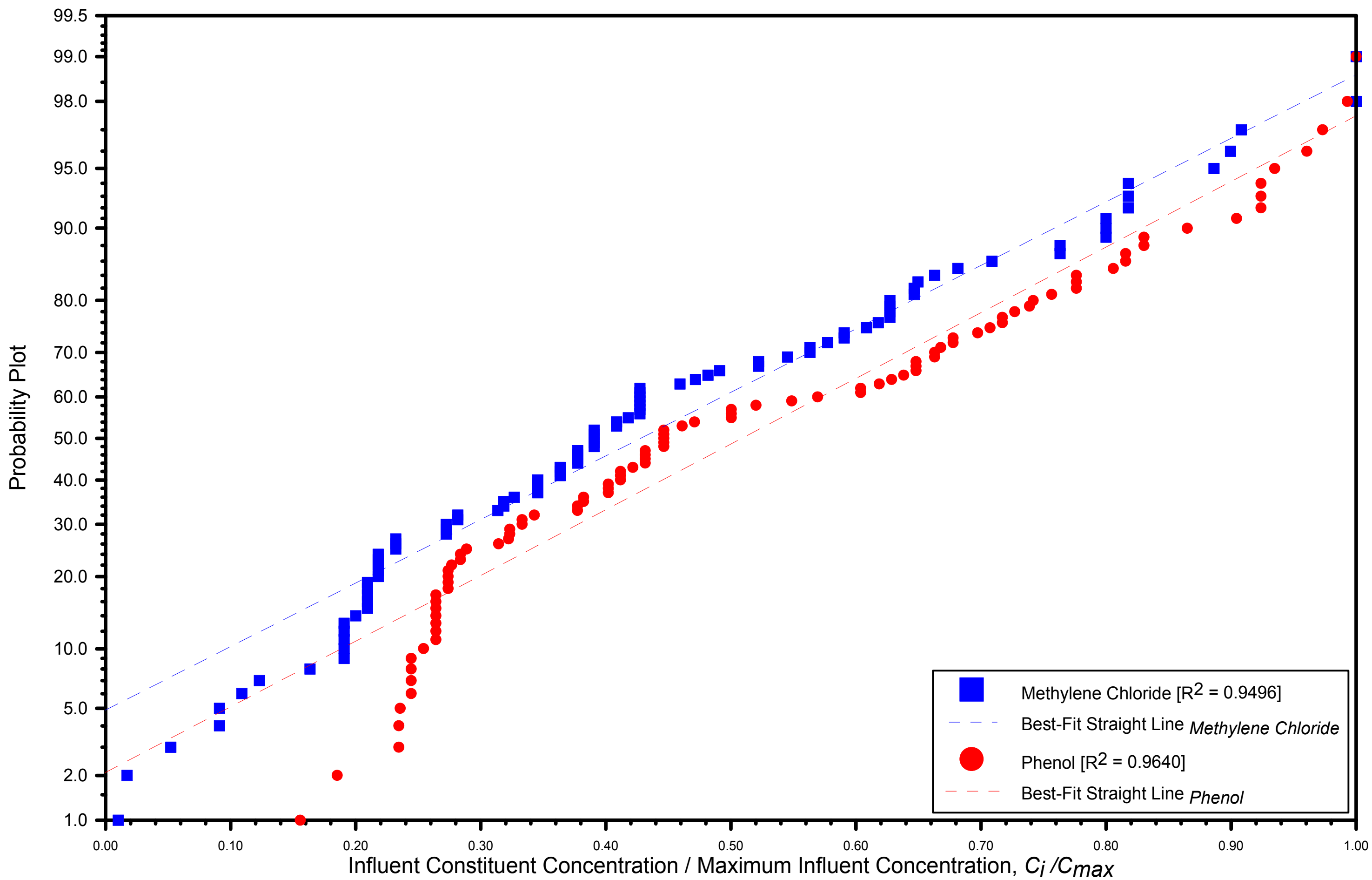
COUPLED MODEL PERFORMANCE

z-test Statistical Method



SENSITIVITY ANALYSIS

Probability versus Influent Constituent Concentration



COUPLED MODELING METHOD

Summary & Conclusions

- Coupling of Emission and Dispersion Models represents a Cost-Effective and Environmentally Responsible Approach
  - *Similar trends between field canister data and coupled model*
- Coupled Model used to develop Chemical Concentration Profiles within the Impact Region of the IWTF
- Coupled Model Effective for Satisfying Emissions Reporting and Regulatory Compliance Requirements
  - *AEI, MAAC standards, POTW NESHAP, etc.*
- Good Agreement between Coupled Model and Field Data
  - *Coupled model appears to slightly under-predict field data*
- Coupled Model Approach Applicable to Other Installations
  - *Model simulates common IWTF collection / treatment processes*
- Coupled Model can be used to conduct Risk Assessment

COMPUTER MODELING OF THE AIR QUALITY IMPACTS RELEASED FROM AN INDUSTRIAL WASTEWATER TREATMENT FACILITY

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