



# AERMOD v. 12345 Beta Options: A Step Backwards?

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Sierra Club

# Overview

- AERMOD underwent a very thorough evaluation and development process
- Model evaluation was based on 17 field studies, as presented in AERMOD: Latest Features and Evaluation Results. (EPA-454/R-03-003)
- Based on the 17 field studies, EPA showed that AERMOD closely predicted monitored impacts where it matters most (robust highest concentrations)
- The field studies used to develop the beta options are low-level releases (Prairie Grass, Idaho Falls, Oak Ridge)
- Major NOx and SOx sources are usually released from elevated stacks
- What effect do these beta options tend to have on regulatory design calculations for EGUs?
- Do the beta options improve model performance for EGUs?

## Summary of Non-Default Beta Options

- LOWWIND1:
  - Min  $\sigma_v$  can be set from 0.01 to 1.0 m/s
  - Min WS can be set from 0.01 to 1.0 m/s
  - No horizontal meander component
- LOWWIND2:
  - Min  $\sigma_v$  can be set from 0.01 to 1.0 m/s
  - Min WS can be set from 0.01 to 1.0 m/s
  - Maximum meander component can be set from 0.5 to 1.0 (FRANmax)
- AERMET ADJ\_U\* adjusts friction velocity under low wind/stable conditions
- Various combinations of the above

## Evaluating EGU Impacts with AERMOD Beta Options

- This analysis uses four of the field studies included in the AERMOD evaluation process:
- Baldwin (1-hr SO<sub>2</sub>):      Rural, flat terrain, 3 stacks, HS = 184.4 m
- Kincaid (1-hr SO<sub>2</sub>):      Rural, flat terrain, 1 stack, HS = 187 m
- Lovett (1-hr SO<sub>2</sub>):      Rural, complex terrain, 1 stack, HS = 145 m
- Tracy (1-hr SF<sub>6</sub>):      Rural, complex terrain, 1 stack, HS = 90.95 m

## How do Beta Options Affect EGU Impacts?

- The beta options have the following effects:
- Baldwin (1-hr SO<sub>2</sub>):      Higher impacts; lower model performance
- Kincaid (1-hr SO<sub>2</sub>):      Increased variability in modeled impacts; no improvement in model performance
- Lovett (1-hr SO<sub>2</sub>):      Increased variability in modeled impacts; no improvement in model performance
- Tracy (1-hr SF<sub>6</sub>):      Lower impacts; lower model performance
- In general, beta options decrease model performance and increase variability of impacts from EGUs

## Modeling Scenarios

- AERMOD v. 02222
- AERMOD v. 12345 (no beta options)
- AERMOD v. 12345, beta LOWWIND1, SVmin = 0.5 m/s; WSmin = 0.5 m/s
- AERMOD v. 12345, beta LOWWIND2, SVmin = 0.3 m/s; WSmin = 0.5 m/s; FRANmax = 0.95
- AERMOD v. 12345, beta ADJ\_U\*
- AERMOD v. 12345, beta ADJ\_U\*, with LOWWIND1, SVmin = 0.5 m/s; WSmin = 0.5 m/s
- AERMOD v. 12345, beta ADJ\_U\*, with LOWWIND2, SVmin = 0.3 m/s; WSmin = 0.5 m/s; FRANmax = 0.95

# USEPA used Robust Highest Concentration in AERMOD Evaluation

- Robust highest concentrations (RHC) are useful in evaluating modeled impacts likely to be used for compliance verification
- “Represents a smoothed estimate of the highest concentrations, based on a tail exponential fit to the upper end of the concentration distribution” (EPA-454/R-03-003)
- $RHC = \chi(n) + (\chi_{ave} - \chi(n)) * \ln((3n-1)/2)$
- $n = \min(m_o, m)$ ;  $m_o$  is the number of values used to characterize the upper end of the concentration distribution,  $m$  is the number of values exceeding a specified threshold value
- $n = 26$  for AERMOD evaluation
- $\chi(n) = n^{\text{th}}$  largest value
- $\chi_{ave} = \text{average of the } n-1 \text{ largest values}$

# Modeled RHC/Observed RHC Values

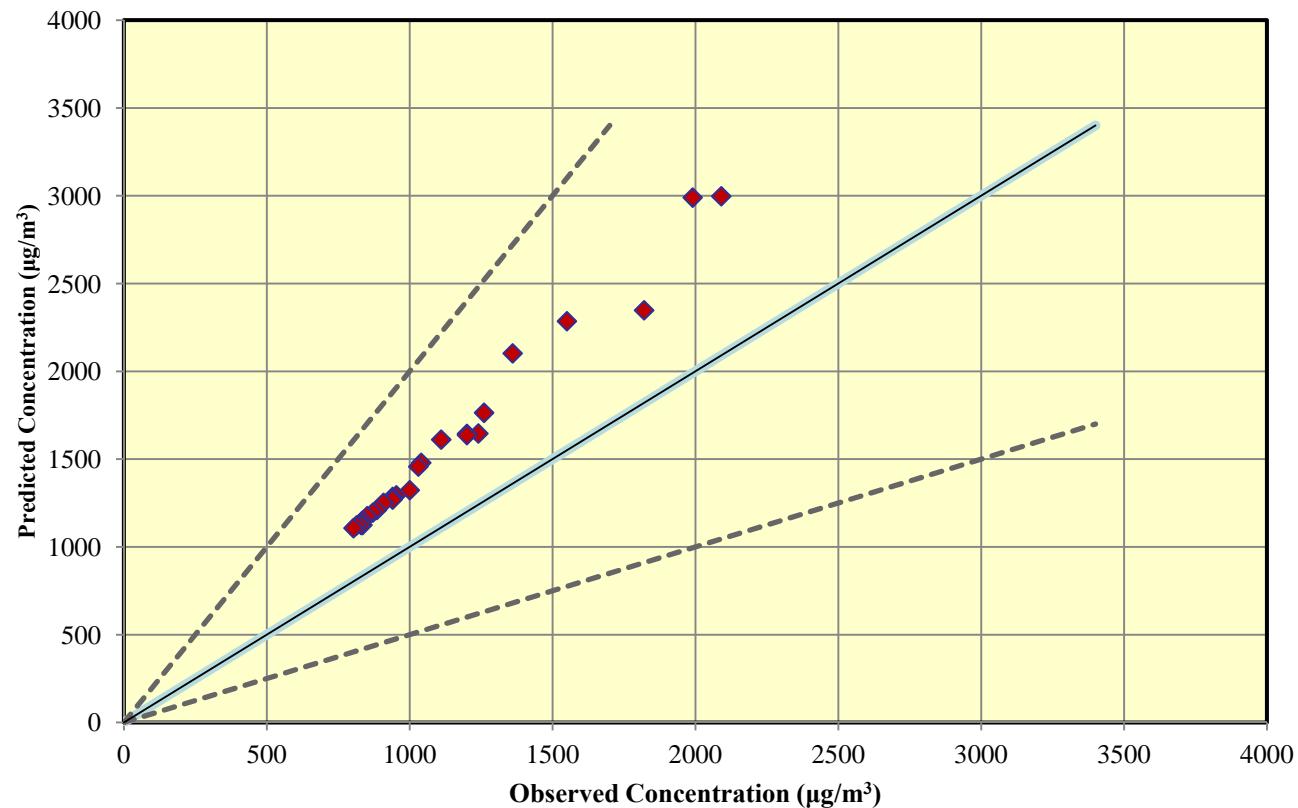
Scenario	Baldwin (1-hr SO <sub>2</sub> )	Kincaid (1-hr SO <sub>2</sub> )	Lovett (1-hr SO <sub>2</sub> )	Tracy (1-hr SF <sub>6</sub> )
v. 02222	1.42	0.84	0.90	1.05
v. 12345	1.56	0.83	0.78	1.12
v. 12345, LOWWIND1, 0.5, 0.5	1.71	0.87	0.77	0.84
v. 12345, LOWWIND2, 0.3, 0.5, 0.95	1.58	0.76	0.69	0.90
v. 12345, ADJ_U*	1.56	0.83	0.85	0.74
v. 12345, ADJ_U*, LOWWIND1, 0.5, 0.5	1.71	0.87	0.77	0.53
v. 12345, ADJ_U*, LOWWIND2, 0.3, 0.5, 0.95	1.58	0.76	0.78	0.61

## Quantile-Quantile Plots

- Examined 26 highest modeled and monitored concentrations (applicable for regulatory design concentrations)
- Concentrations are unpaired in space and time
- Predicted concentrations represent highest modeled impact across all receptors (monitor locations) for each data period – same as RANKFILE
- Observed concentrations represent highest impact across all monitors for each data period
- Model performance decreases as values move away from middle 1:1 line

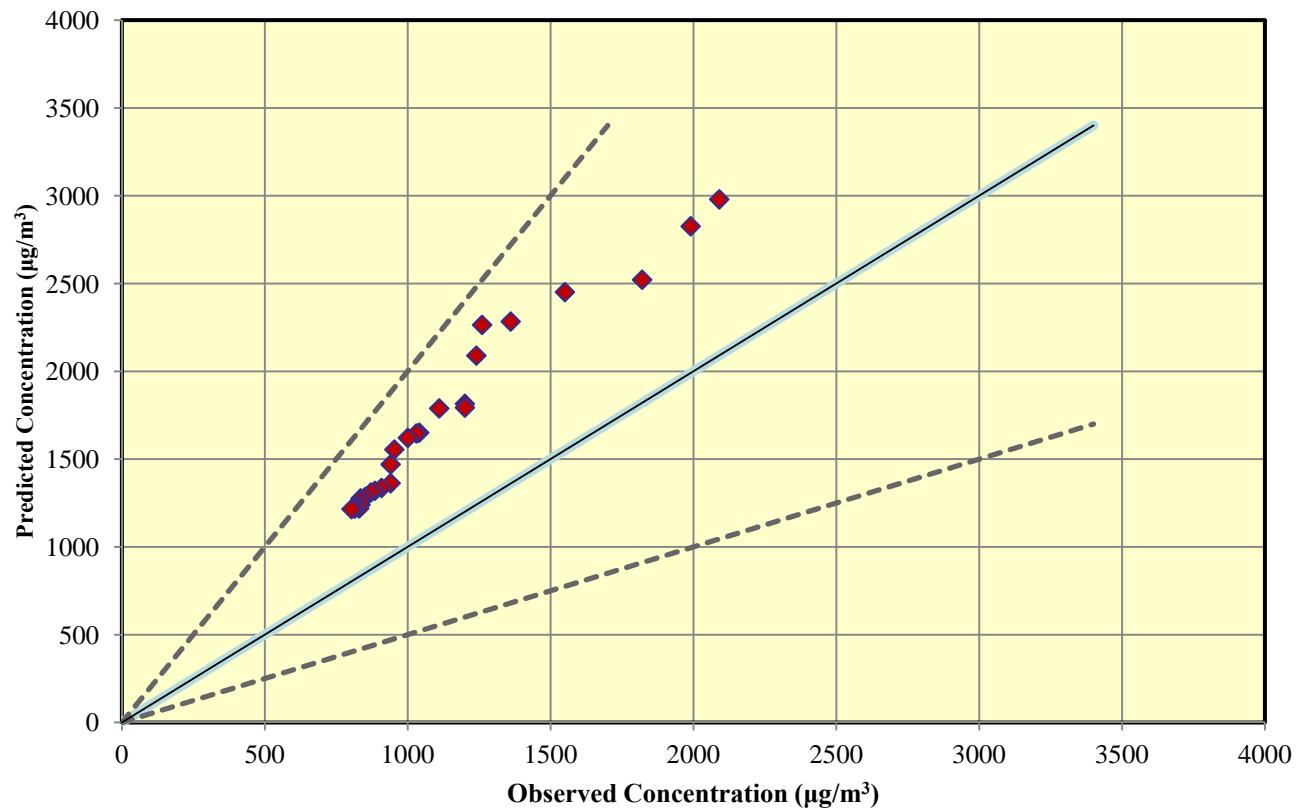
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 02222

**Baldwin 1-hour SO<sub>2</sub> (Mod/Obs RHC = 1.42 (n=11), 1.42 (n=26))**



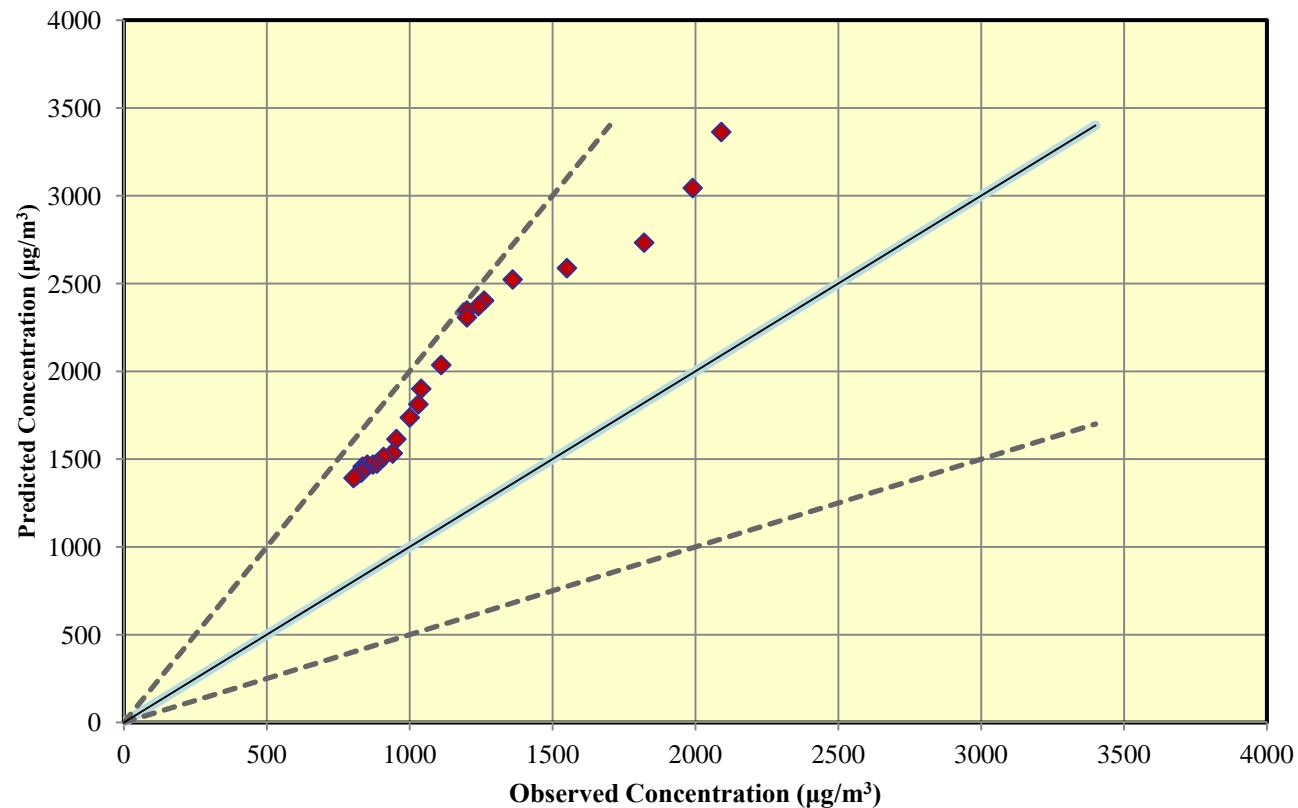
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345

**Baldwin 1-hour SO<sub>2</sub> (Mod/Obs RHC = 1.50 (n=11), 1.56 (n=26))**



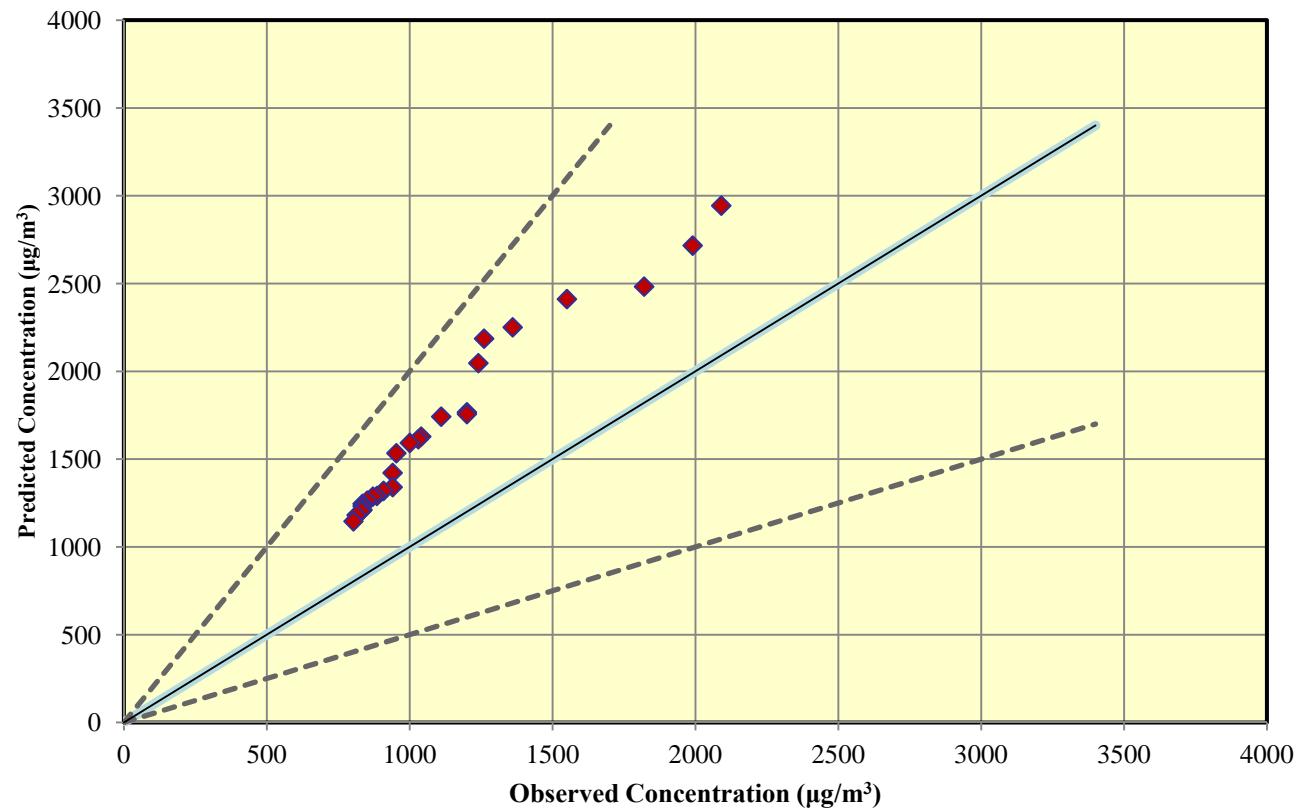
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND1 (0.5 0.5)

**Baldwin 1-hour SO<sub>2</sub> (Mod/Obs RHC = 1.66 (n=11), 1.71 (n=26))**



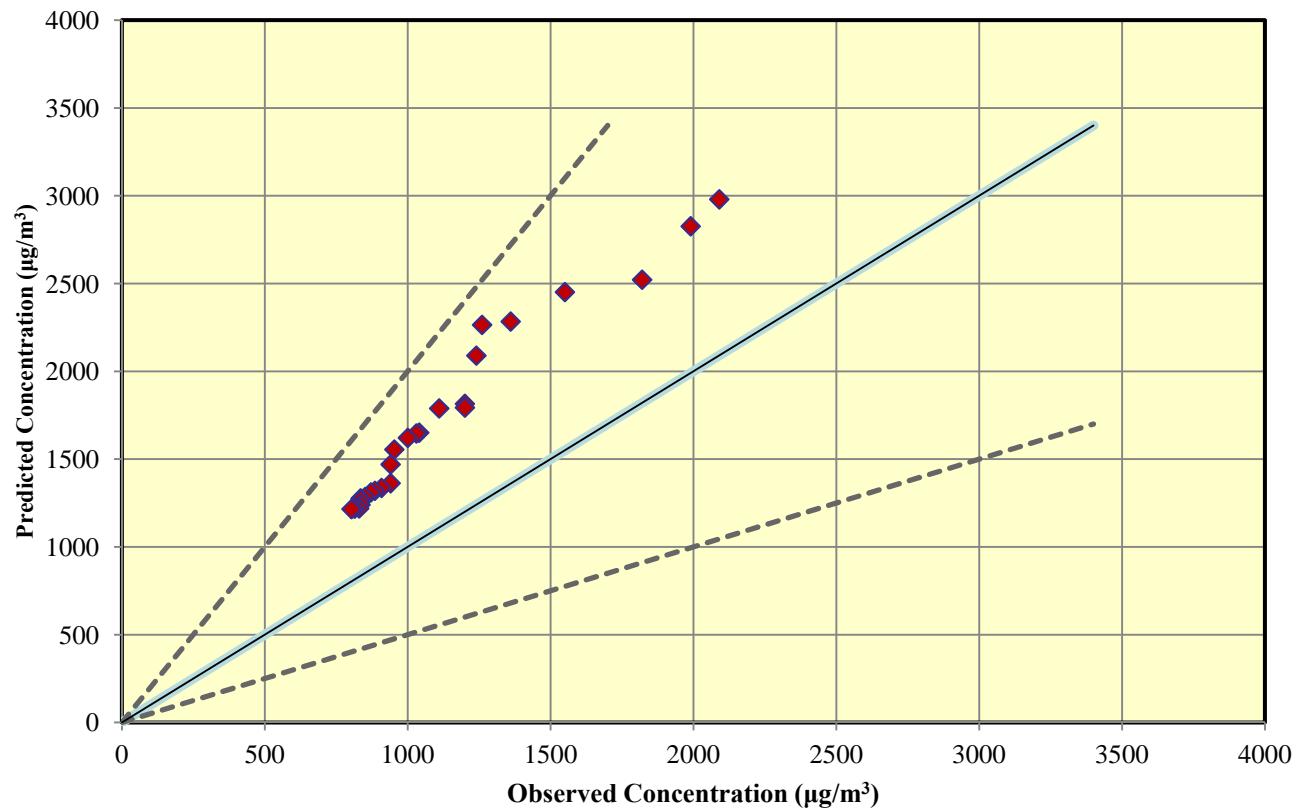
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND2 (0.3 0.5 0.95)

Baldwin 1-hour SO<sub>2</sub> (Mod/Obs RHC = 1.46 (n=11), 1.58 (n=26))



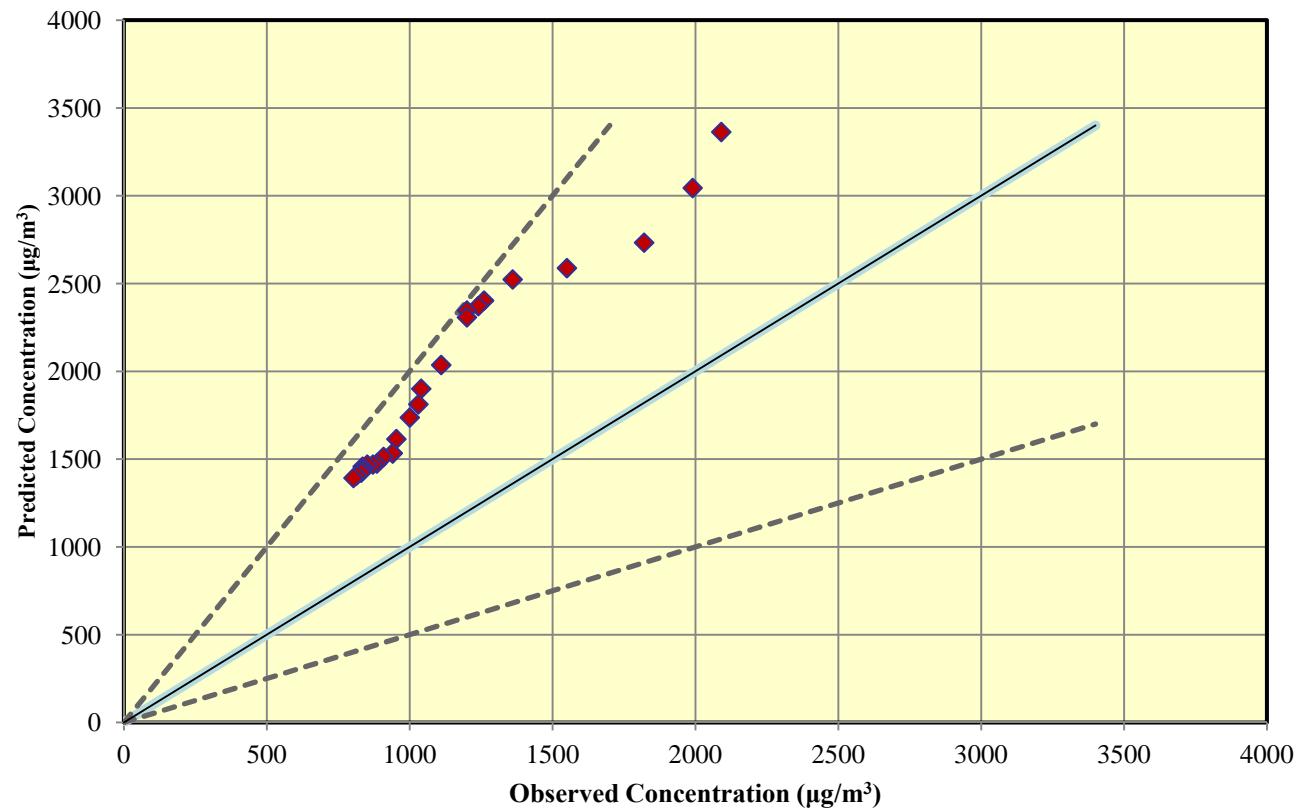
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Baldwin 1-hour SO<sub>2</sub> (Mod/Obs RHC = 1.50 (n=11), 1.56 (n=26))



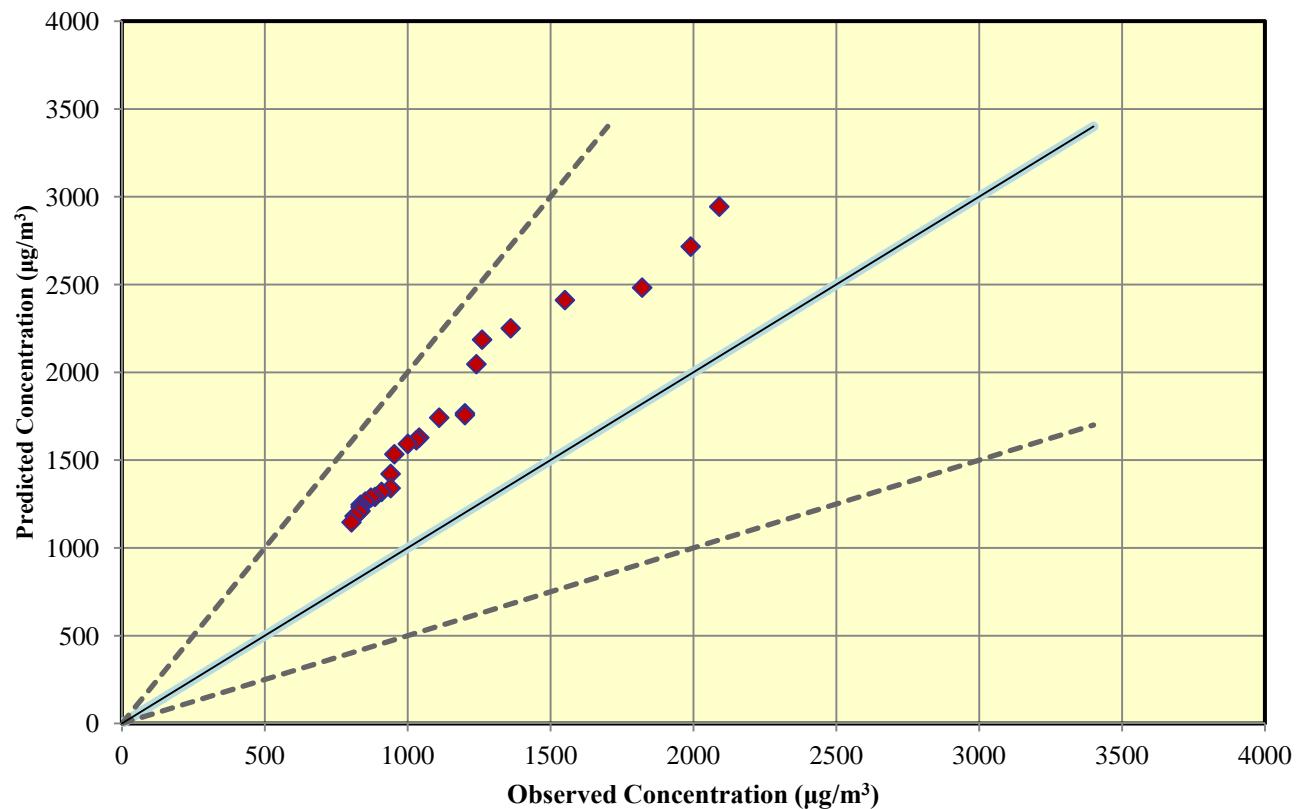
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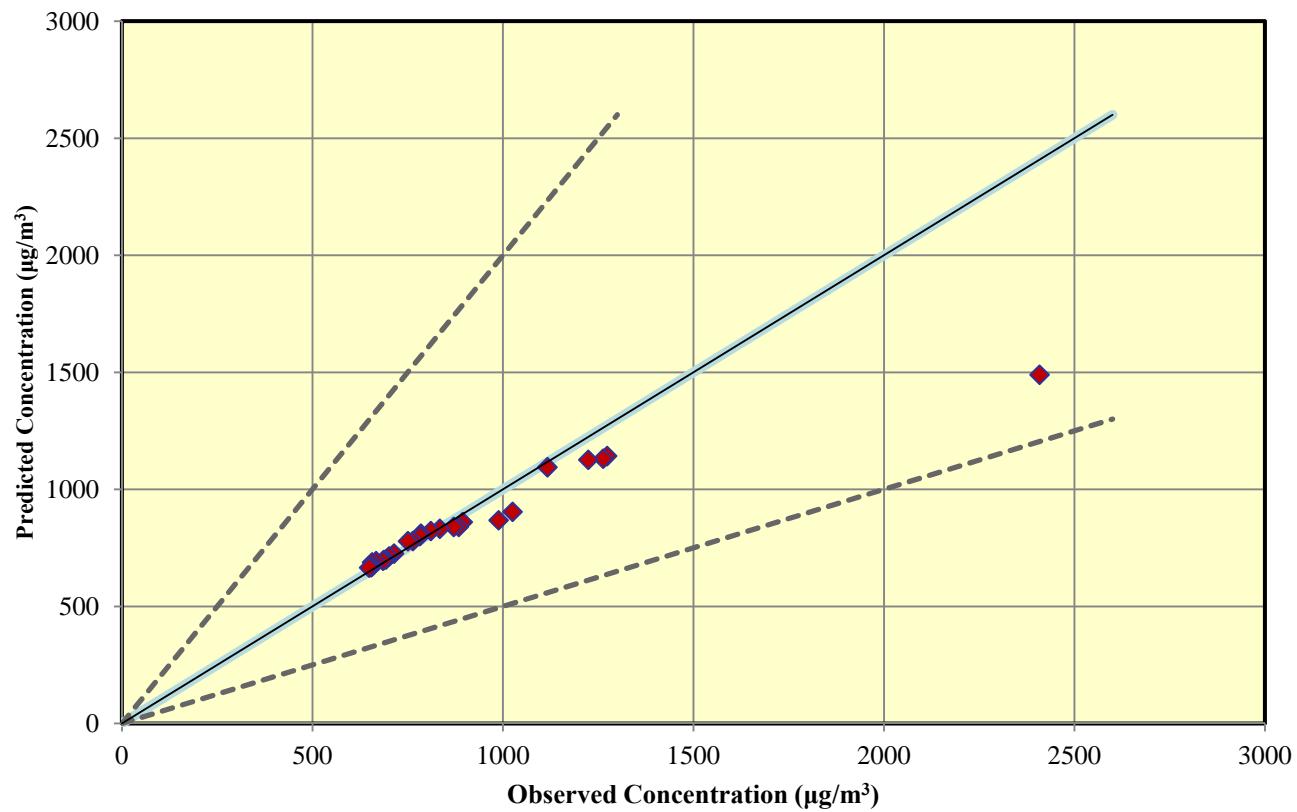
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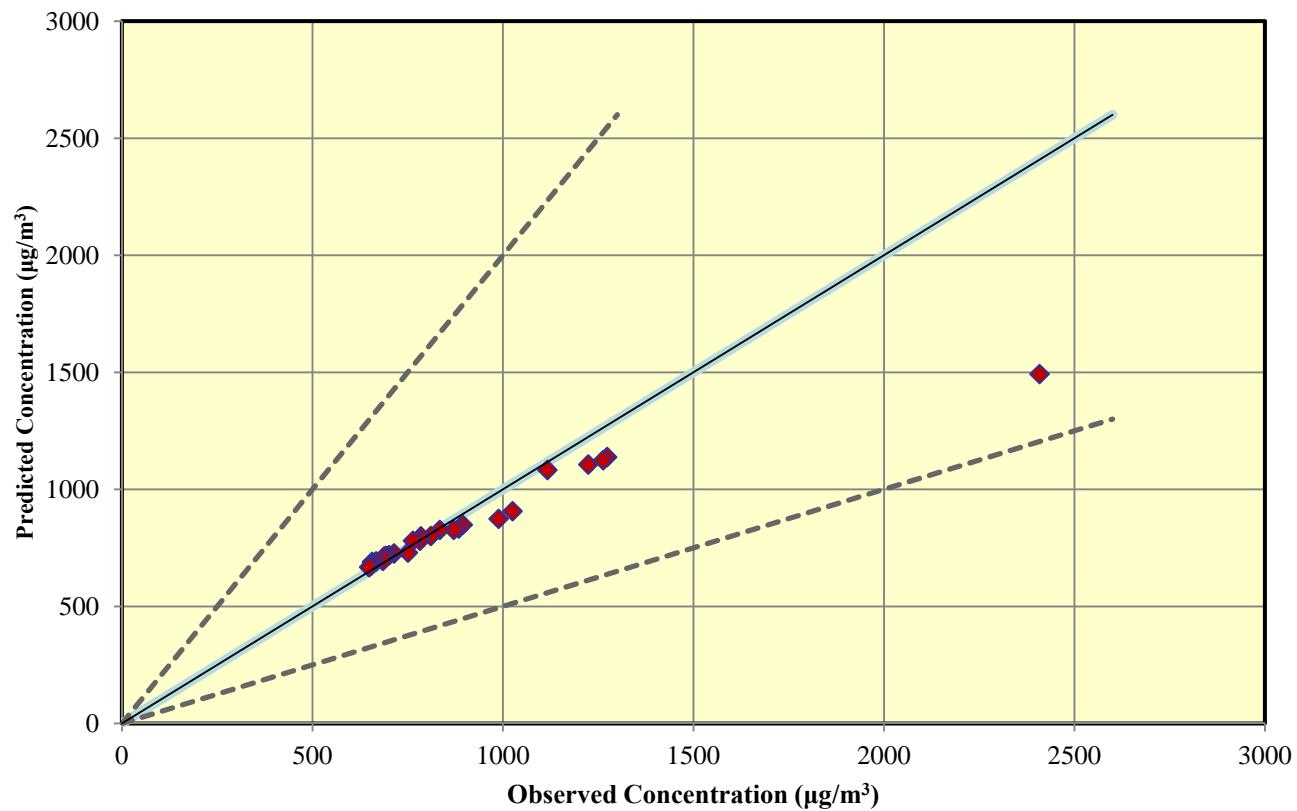
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 02222

**Kincaid 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.75 (n=11), 0.84 (n=26))**



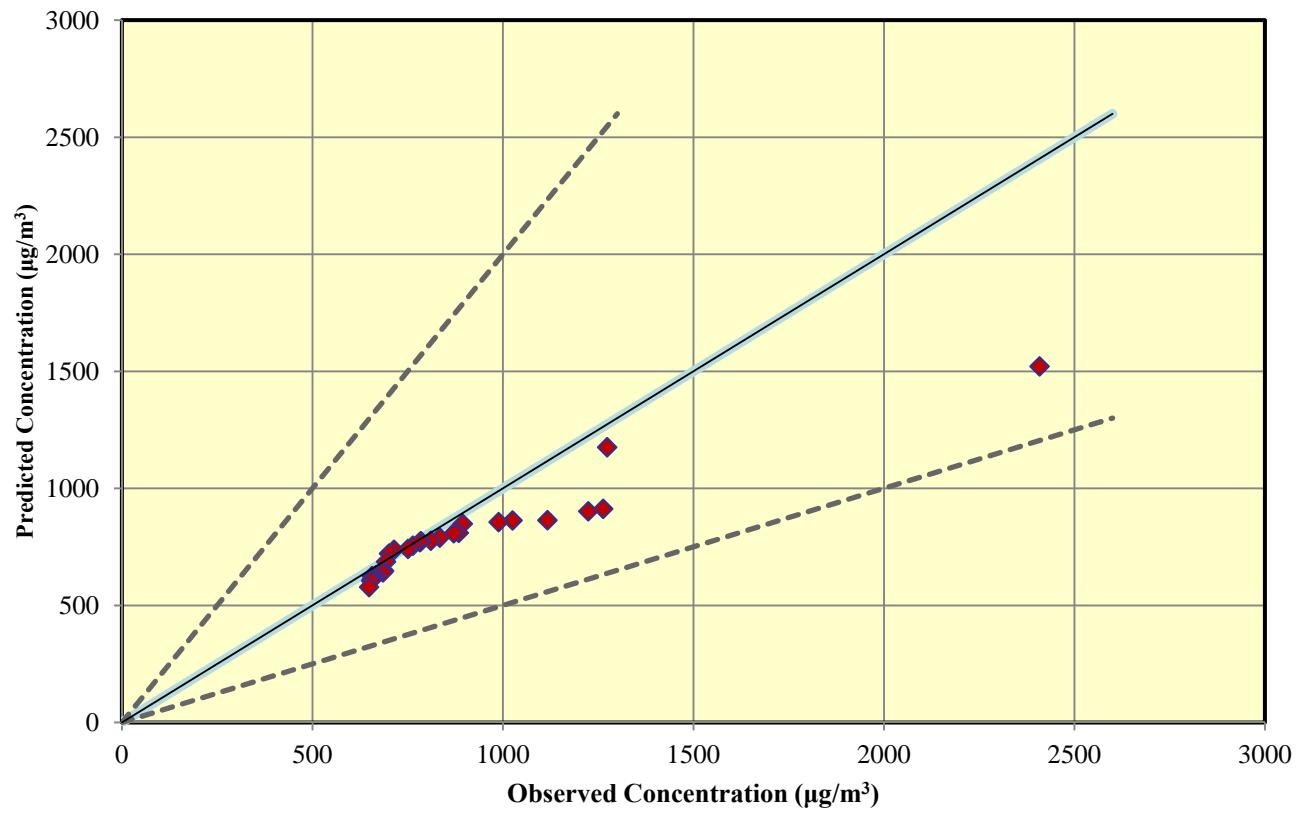
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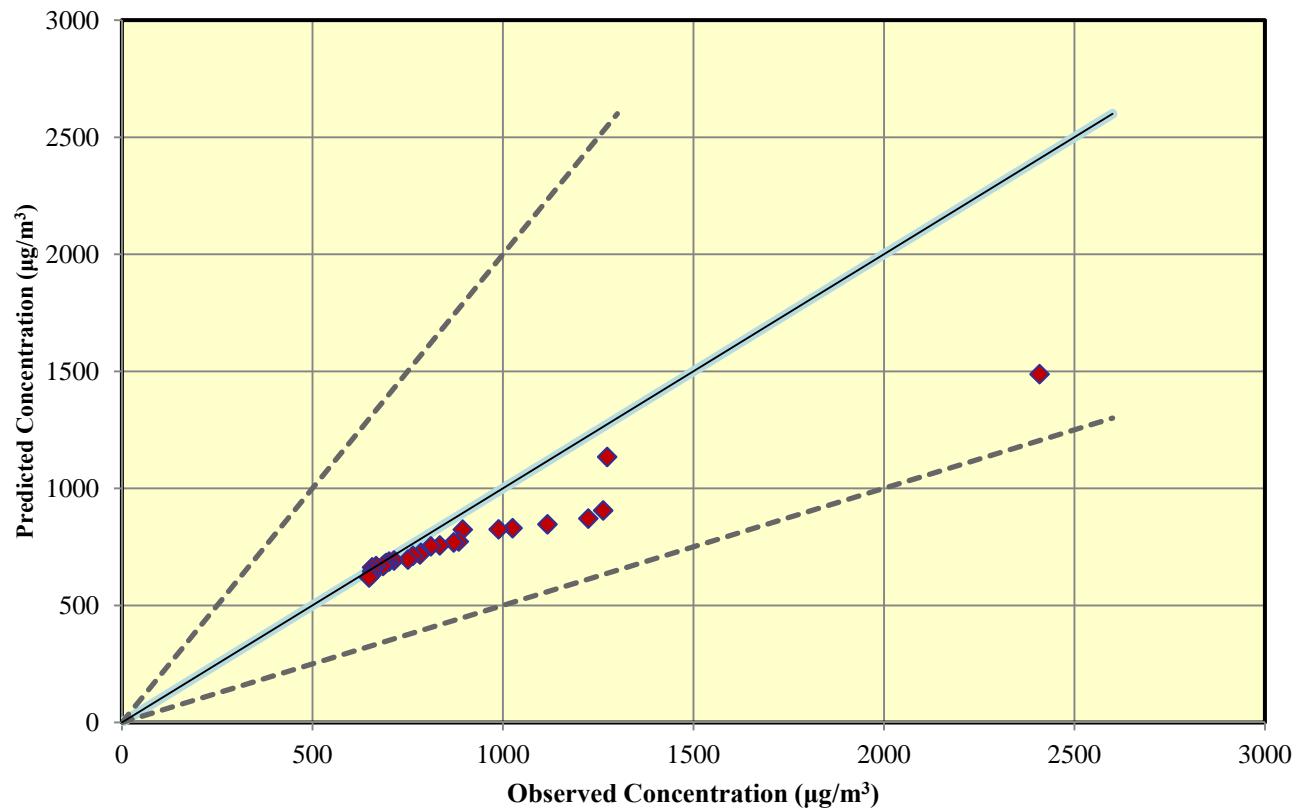
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND1 (0.5 0.5)

**Kincaid 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.68 (n=11), 0.87 (n=26))**



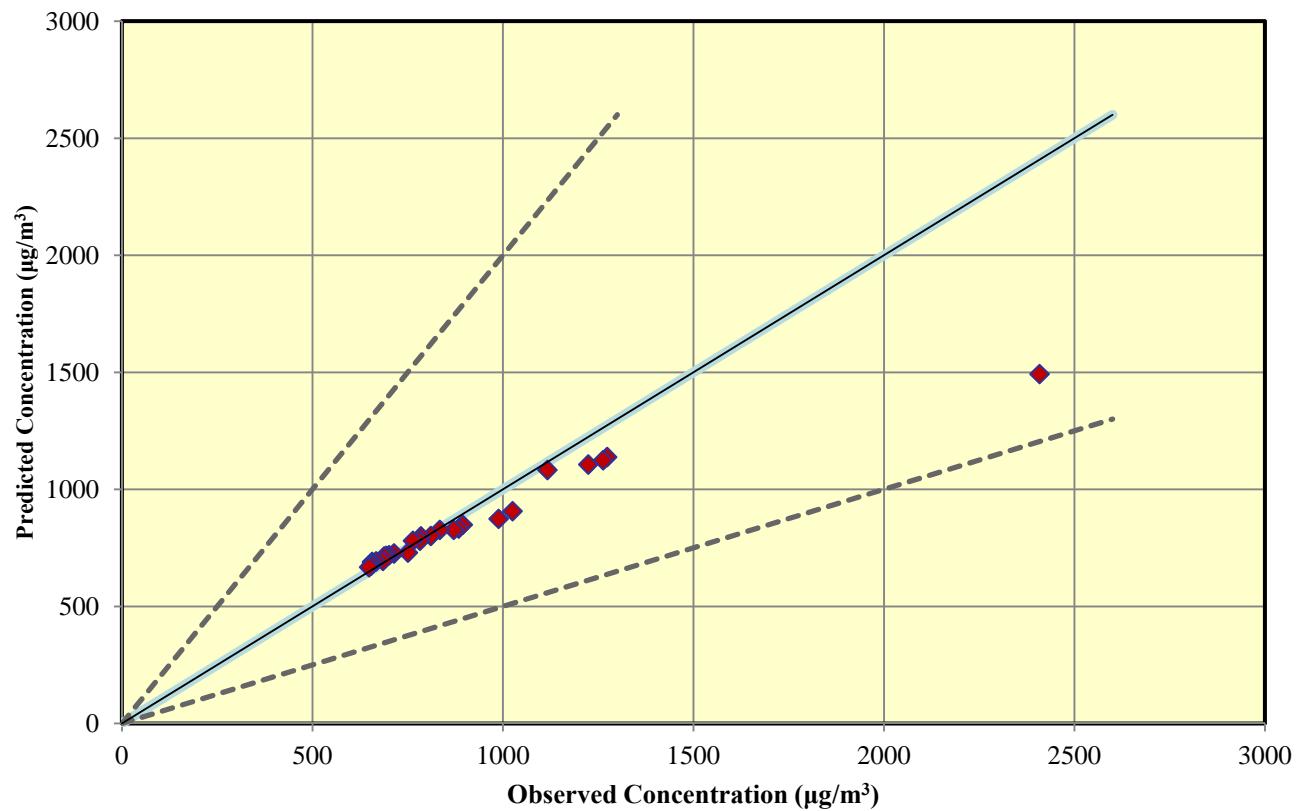
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND2 (0.3 0.5 0.95)

**Kincaid 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.67 (n=11), 0.76 (n=26))**



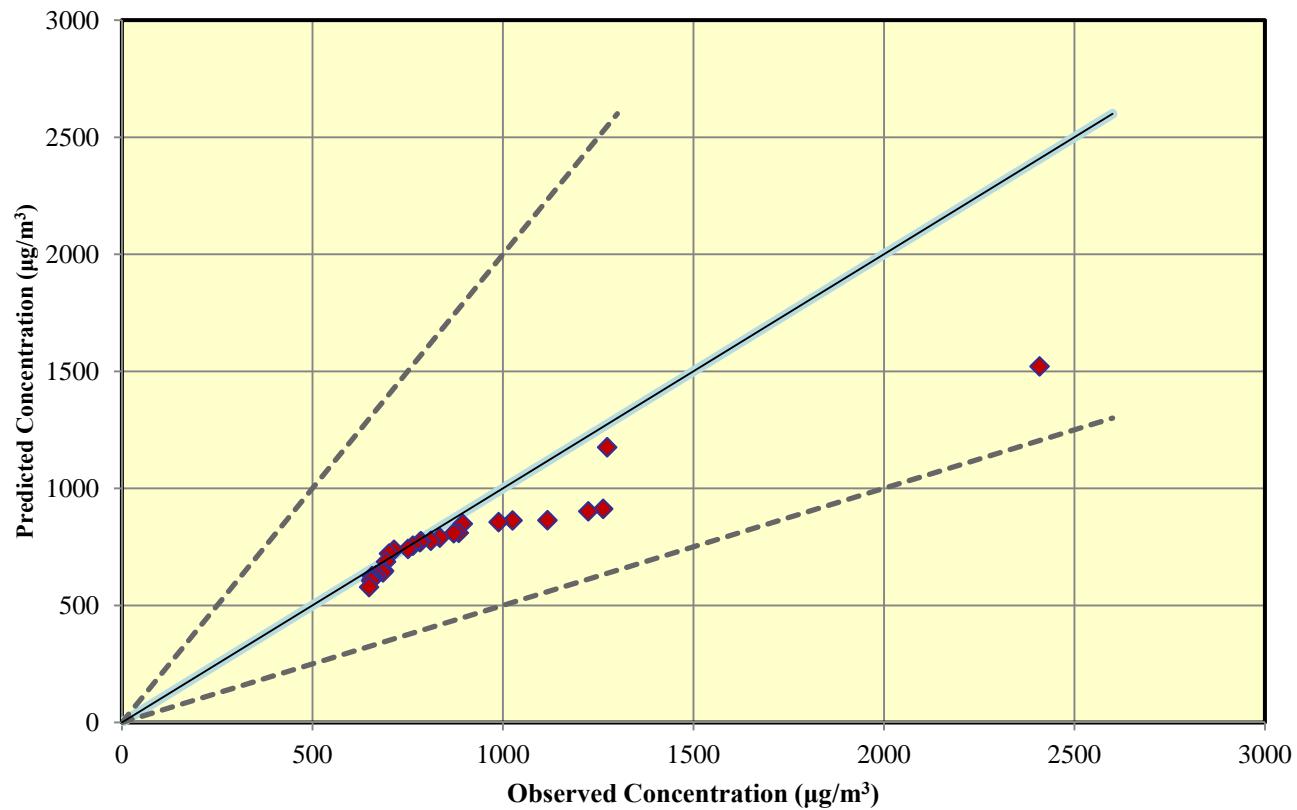
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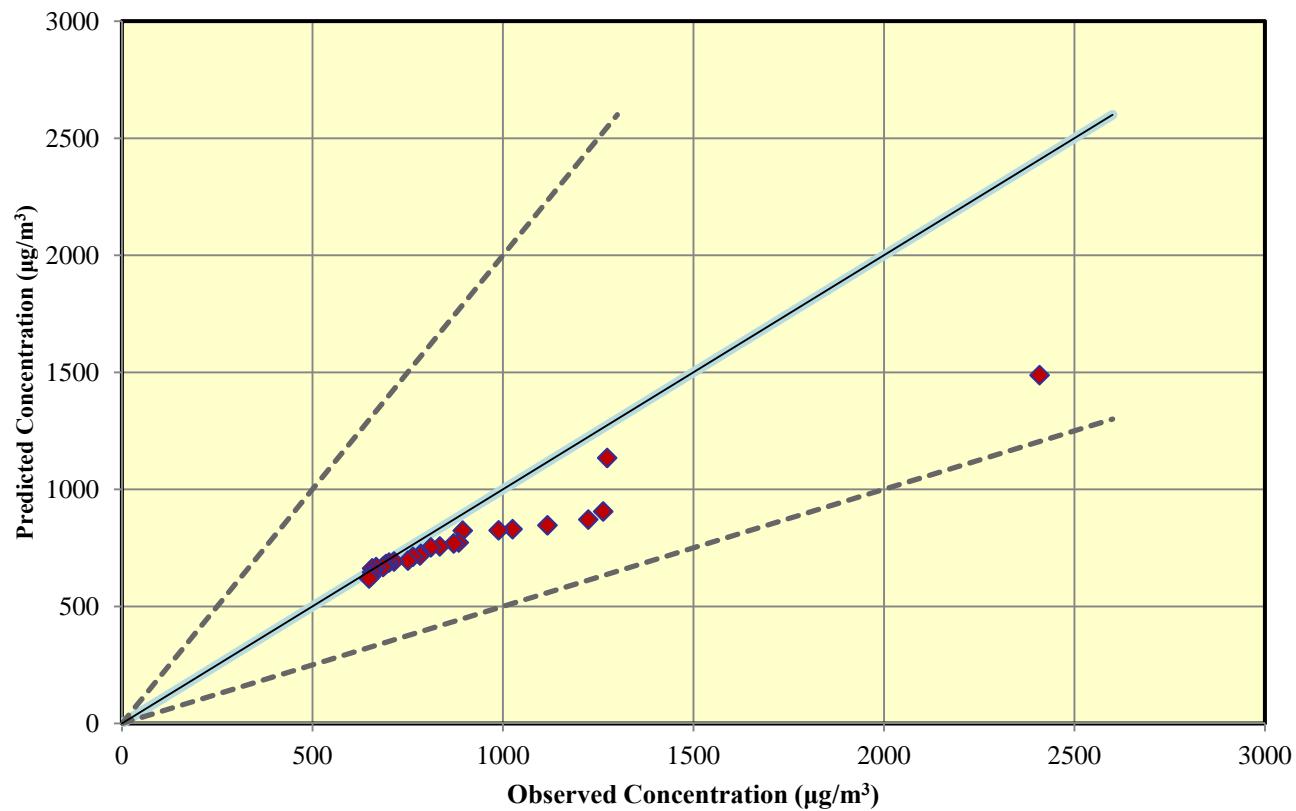
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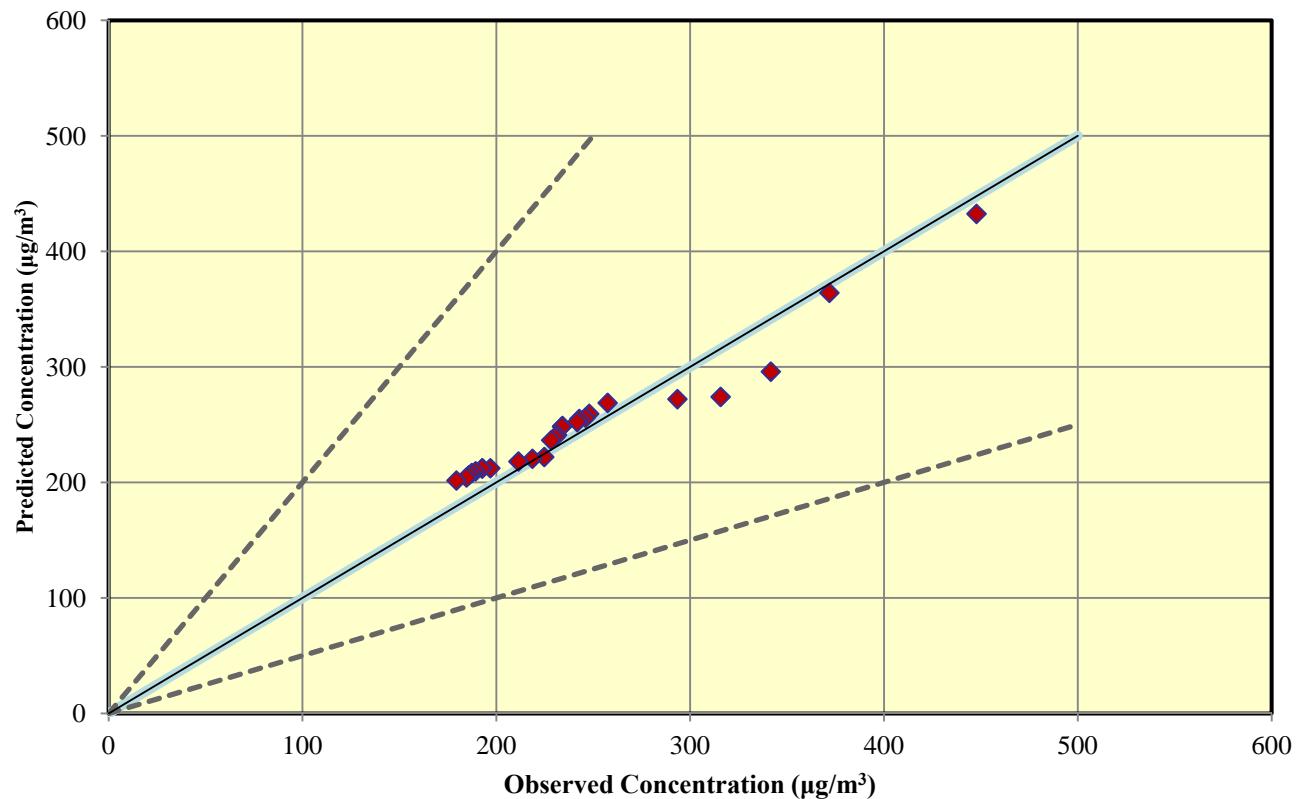
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*, LOWWIND2 (0.3 0.5 0.95)

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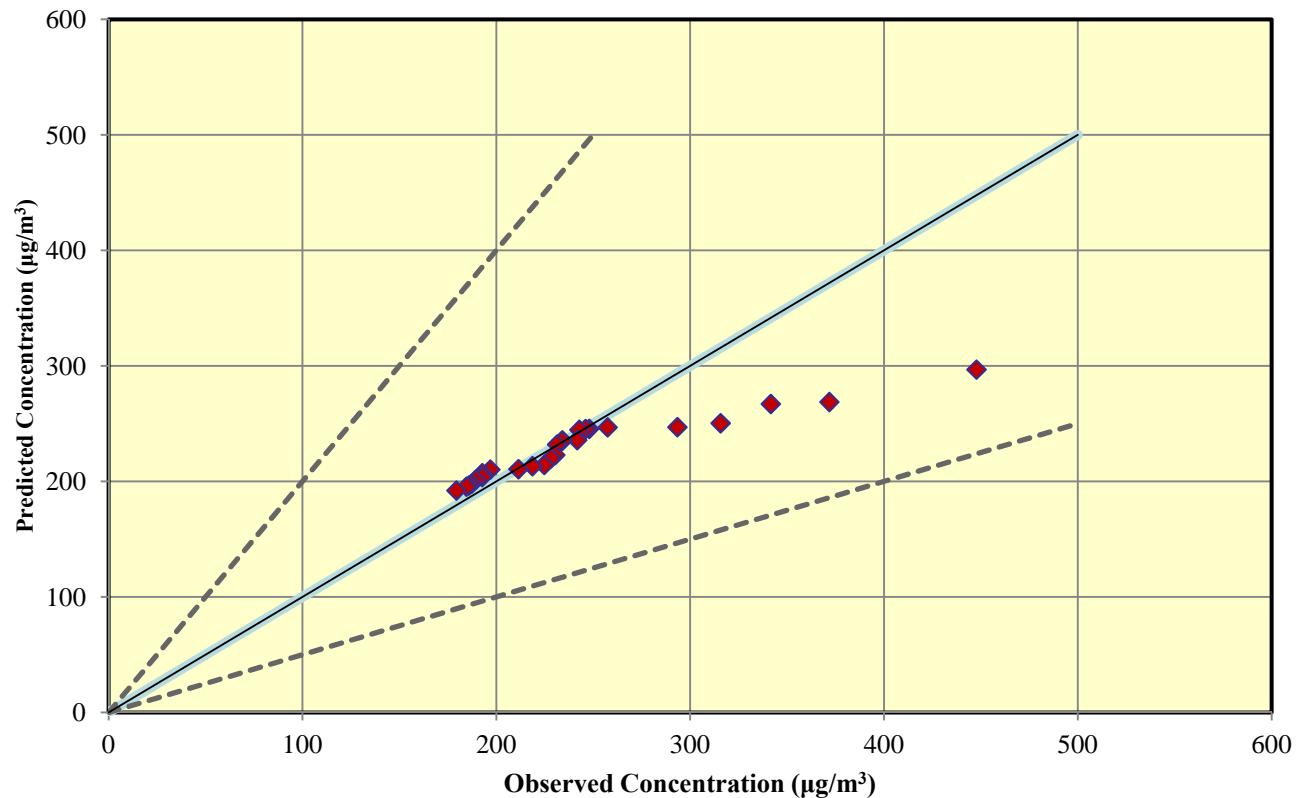
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 02222

**Lovett 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.89 (n=11), 0.90 (n=26))**



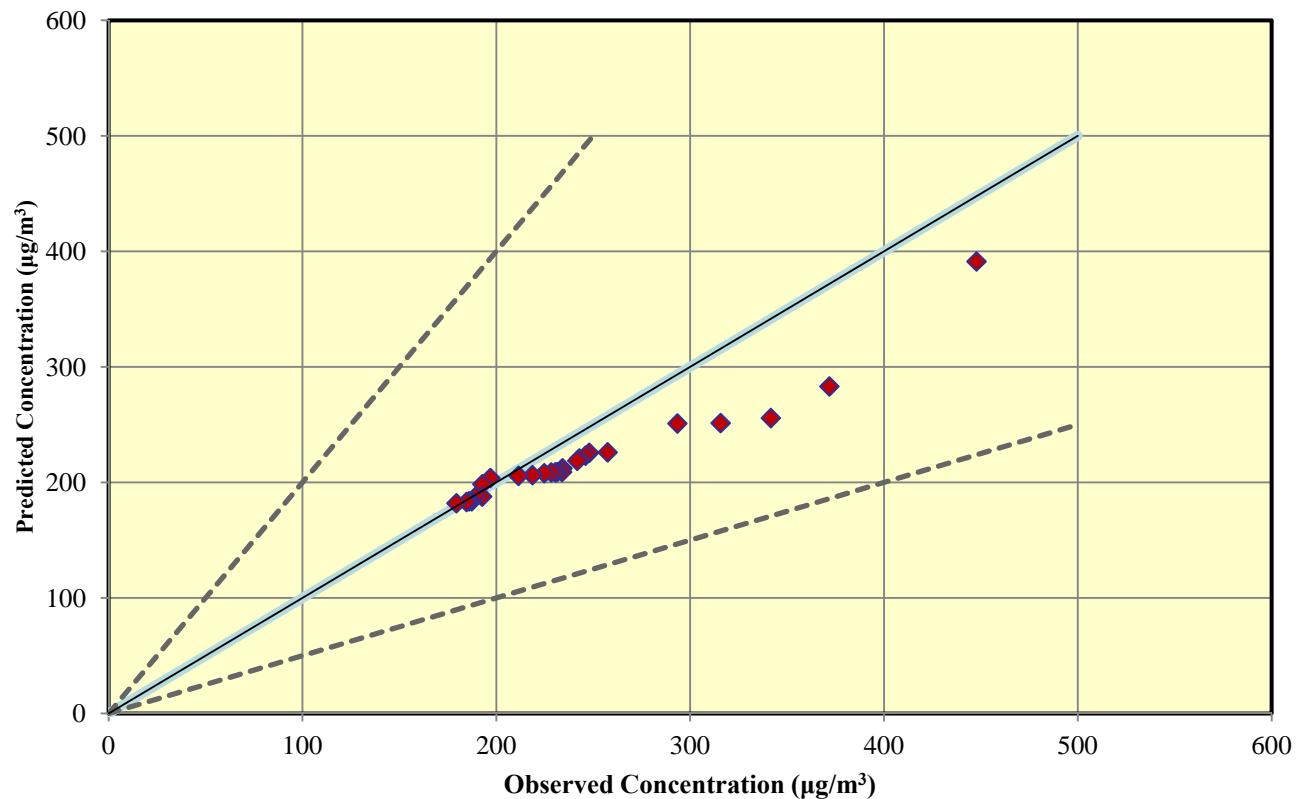
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345

**Lovett 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.69 (n=11), 0.78 (n=26))**



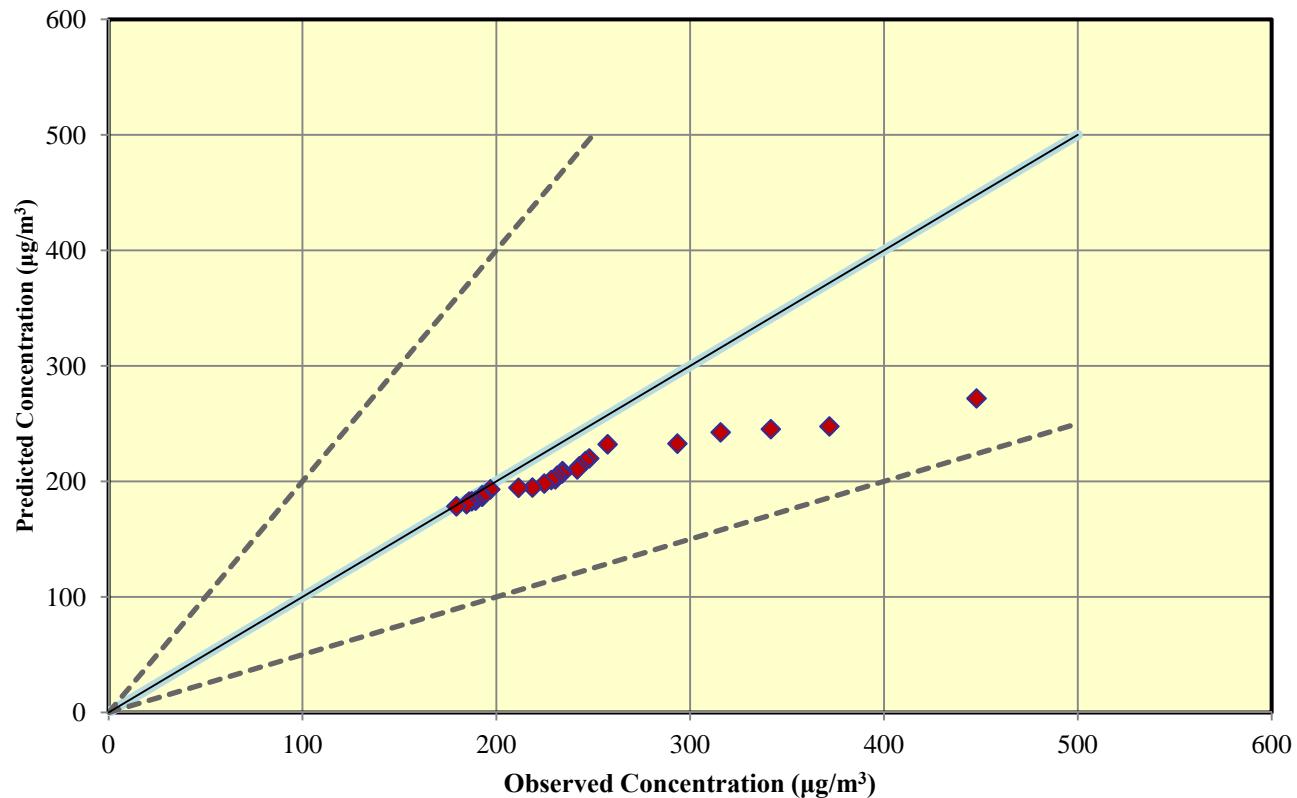
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND1 (0.5 0.5)

**Lovett 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.79 (n=11), 0.77 (n=26))**



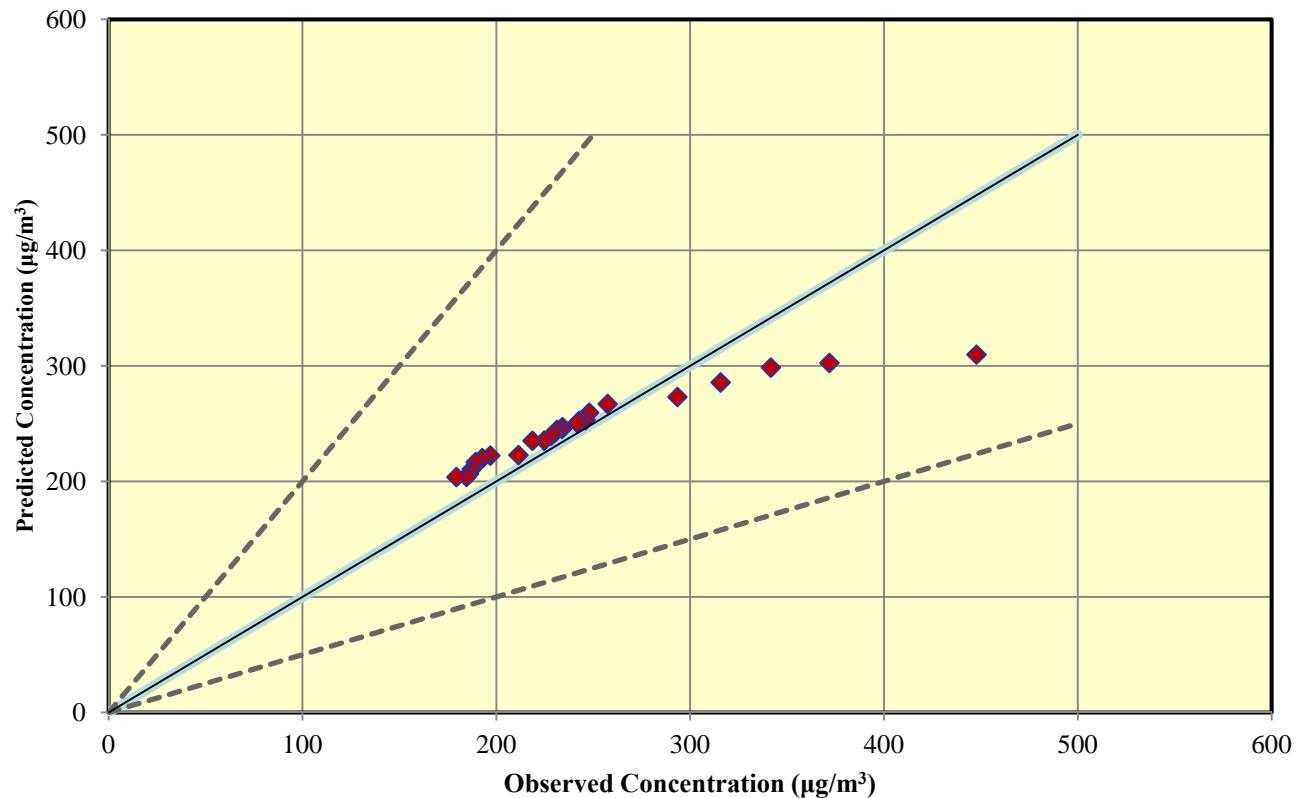
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND2 (0.3 0.5 0.95)

**Lovett 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.66 (n=11), 0.69 (n=26))**



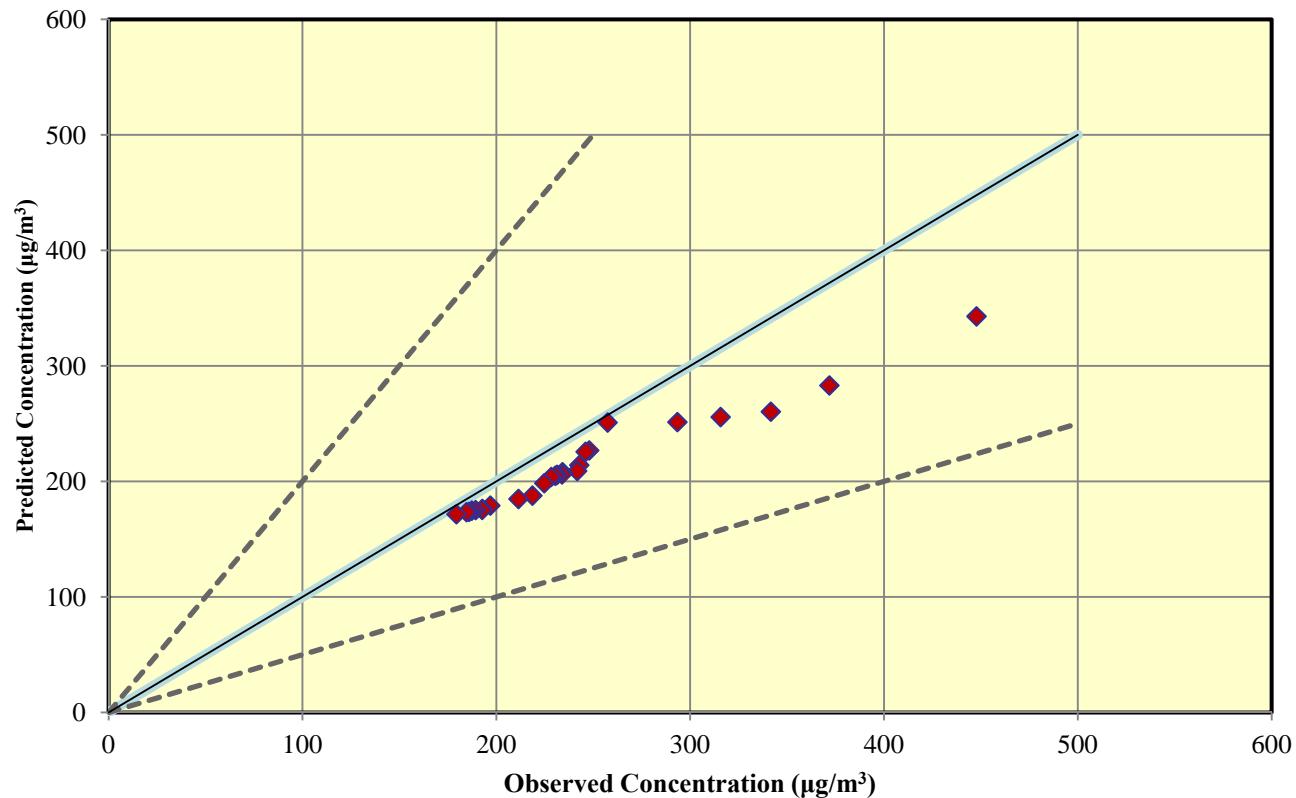
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*

**Lovett 1-hour SO<sub>2</sub> (Mod/Obs RHC = 0.78 (n=11), 0.85 (n=26))**



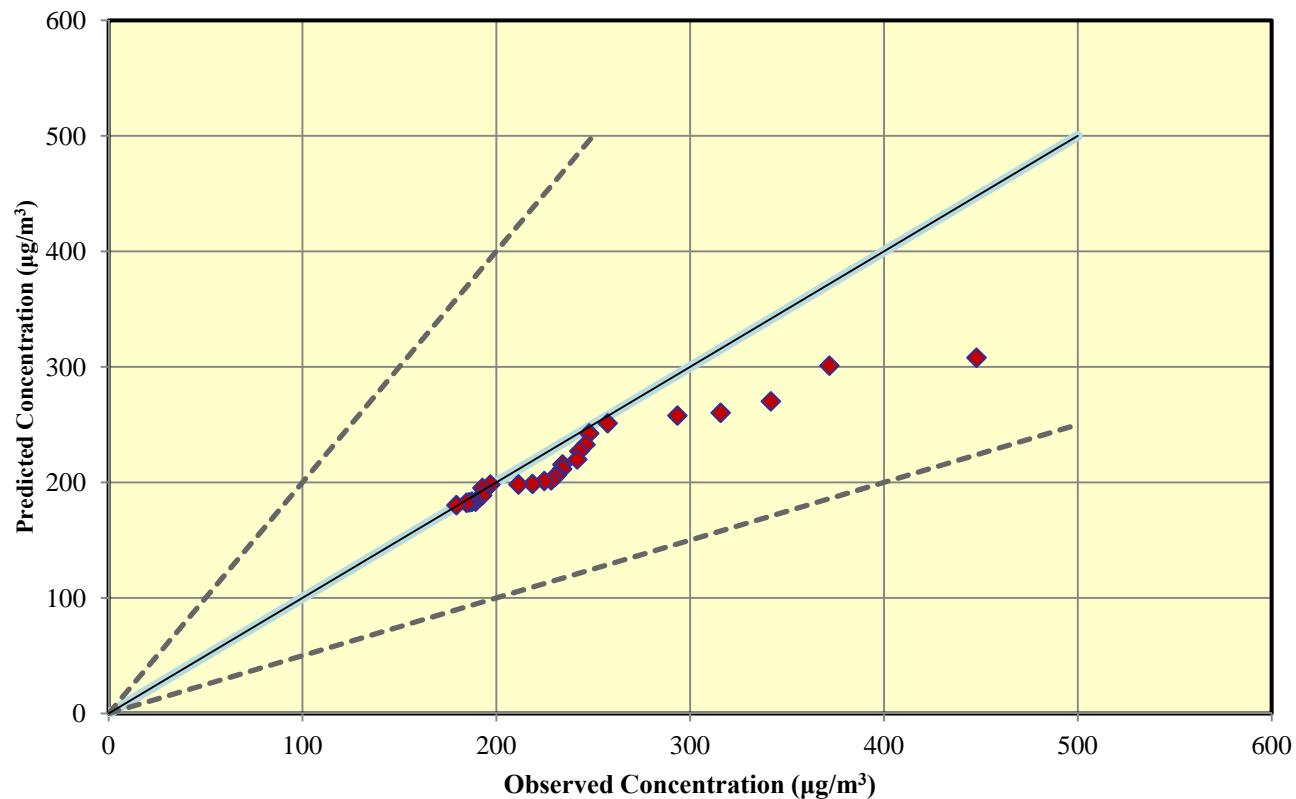
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*, LOWWIND1 (0.5 0.5)

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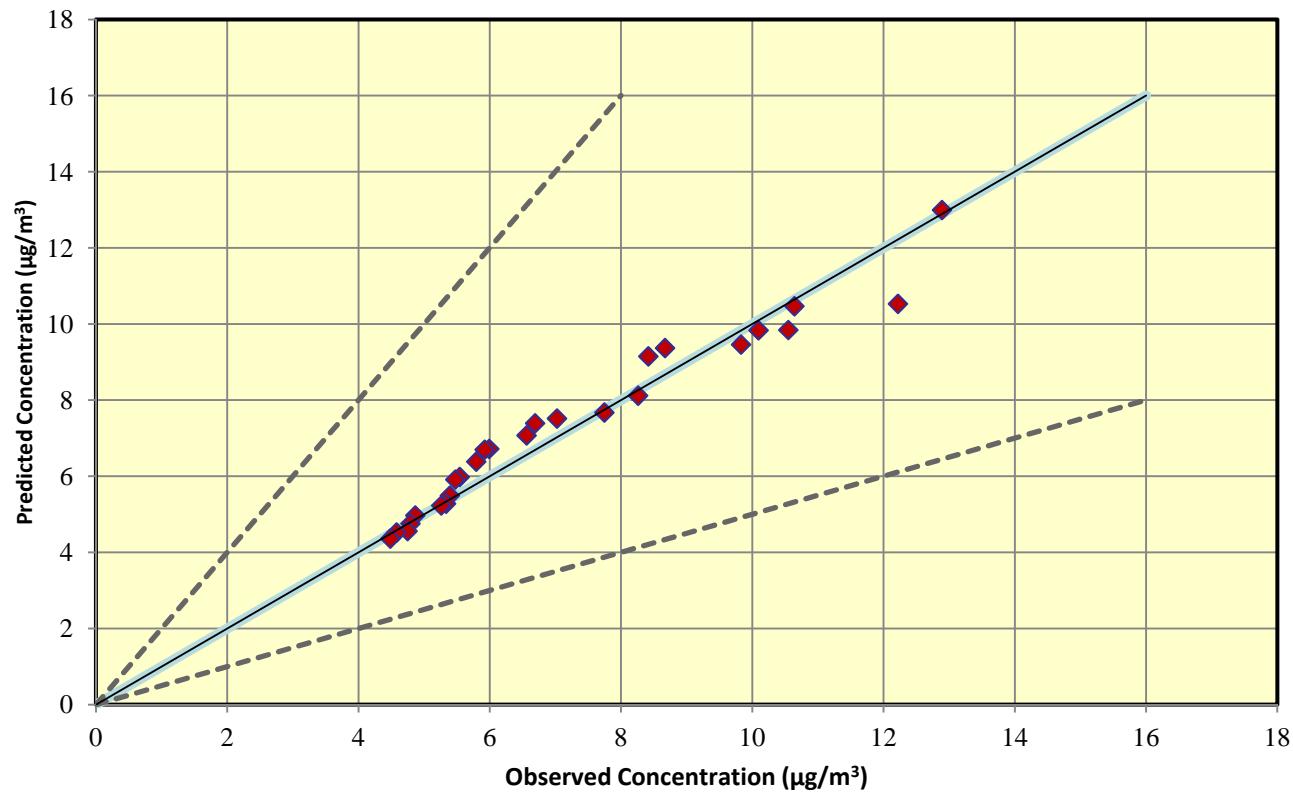
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*, LOWWIND2 (0.3 0.5 0.95)

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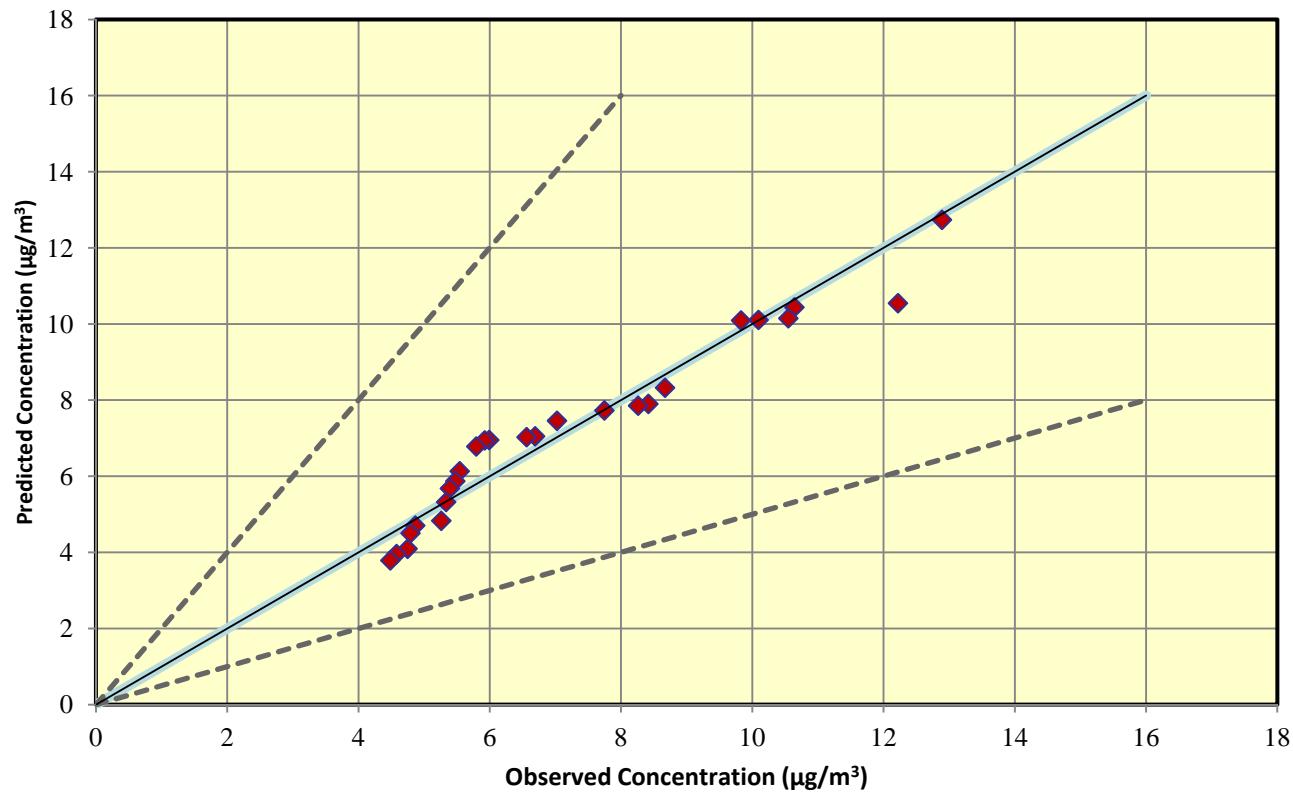
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 02222

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.91 (n=11), 1.05 (n=26))



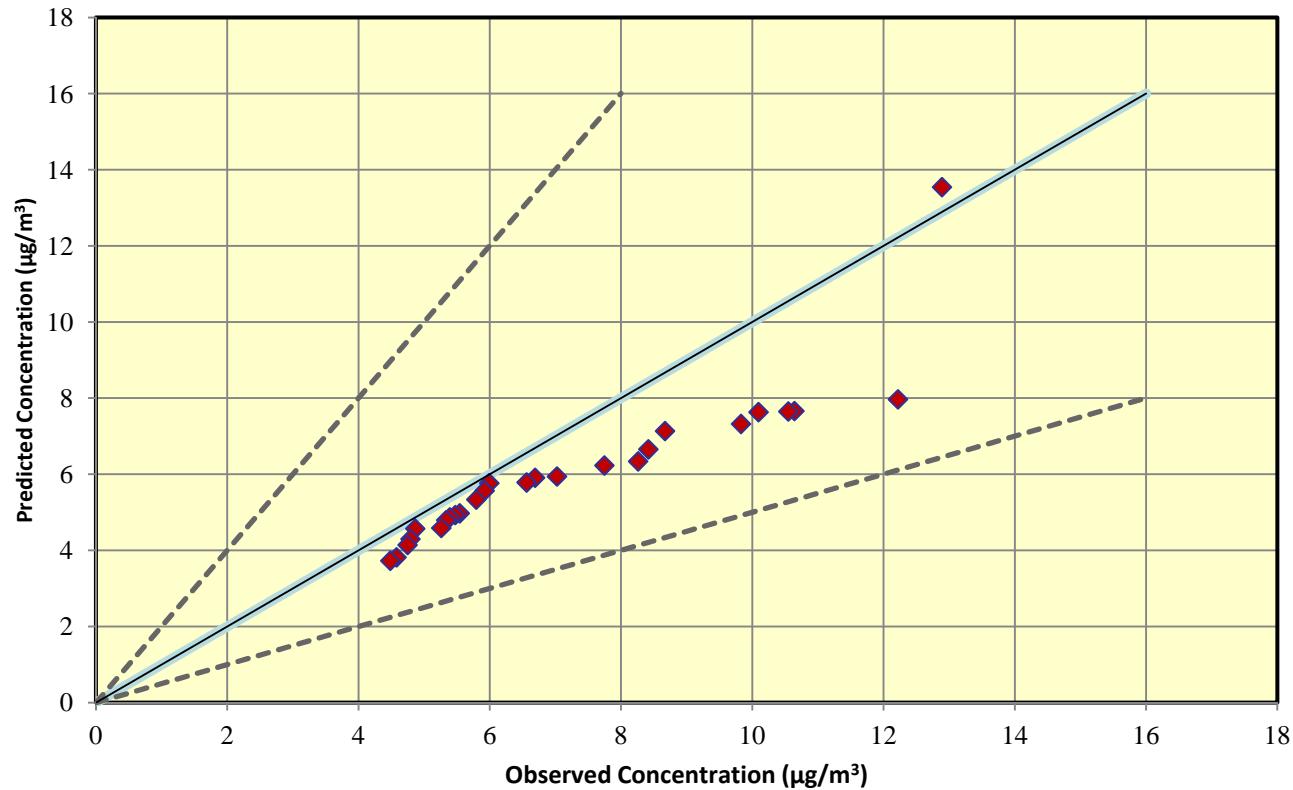
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.89 (n=11), 1.12 (n=26))



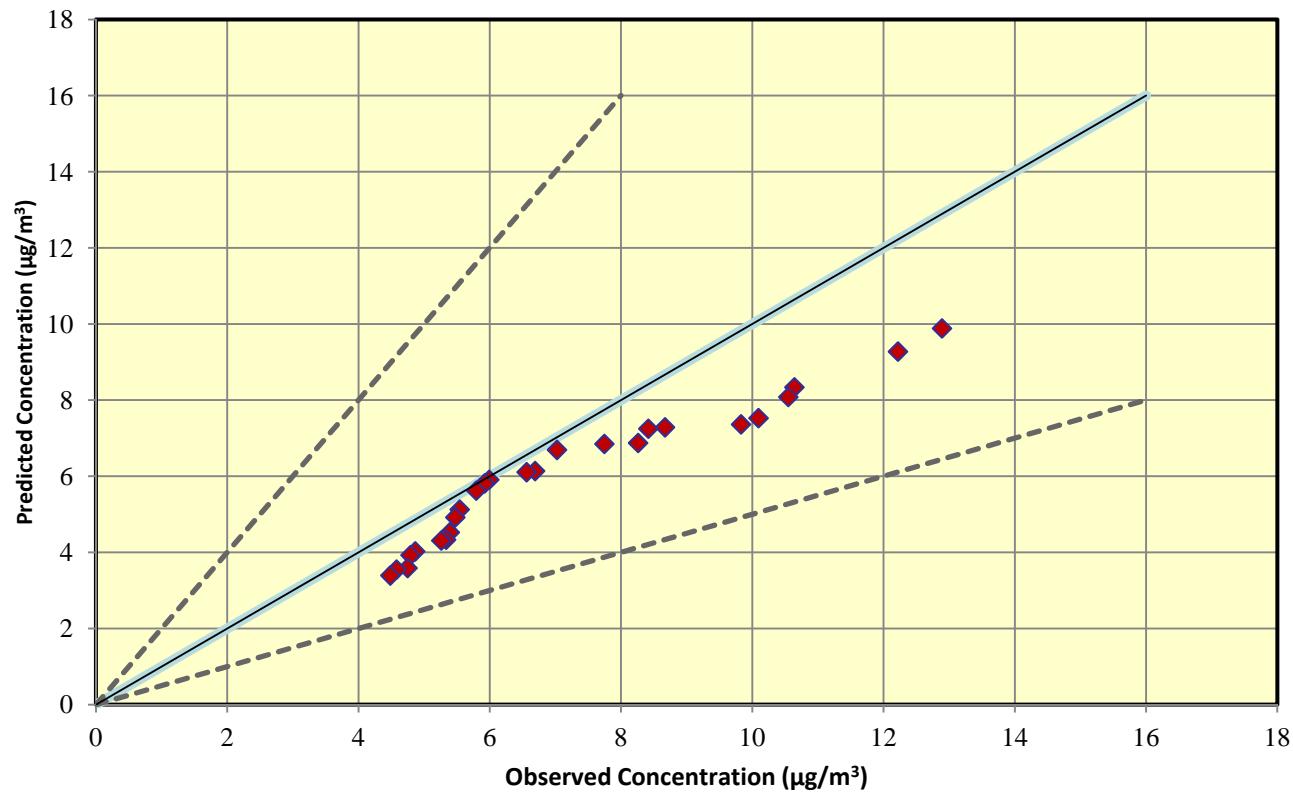
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND1 (0.5 0.5)

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.74 (n=11), 0.84 (n=26))



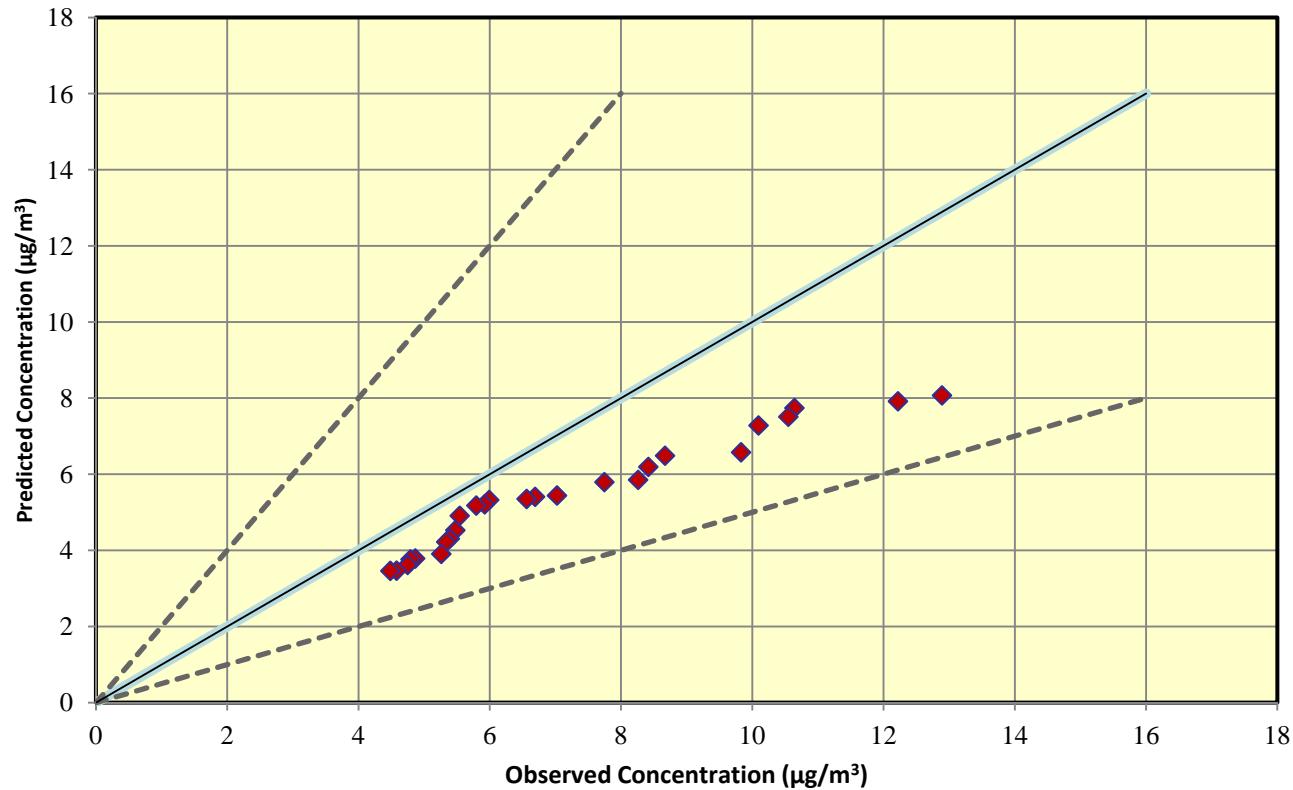
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta LOWWIND2 (0.3 0.5 0.95)

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.66 (n=11), 0.90 (n=26))



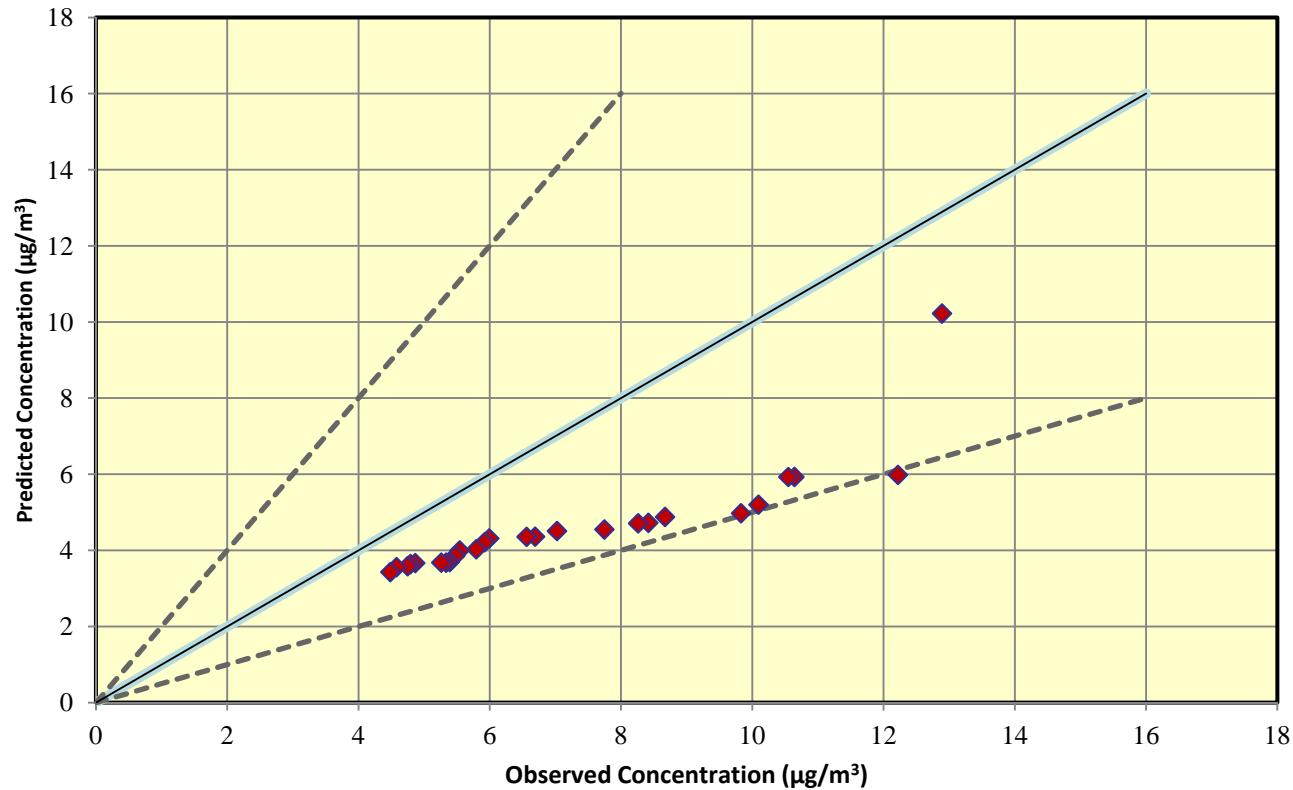
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.64 (n=11), 0.74 (n=26))



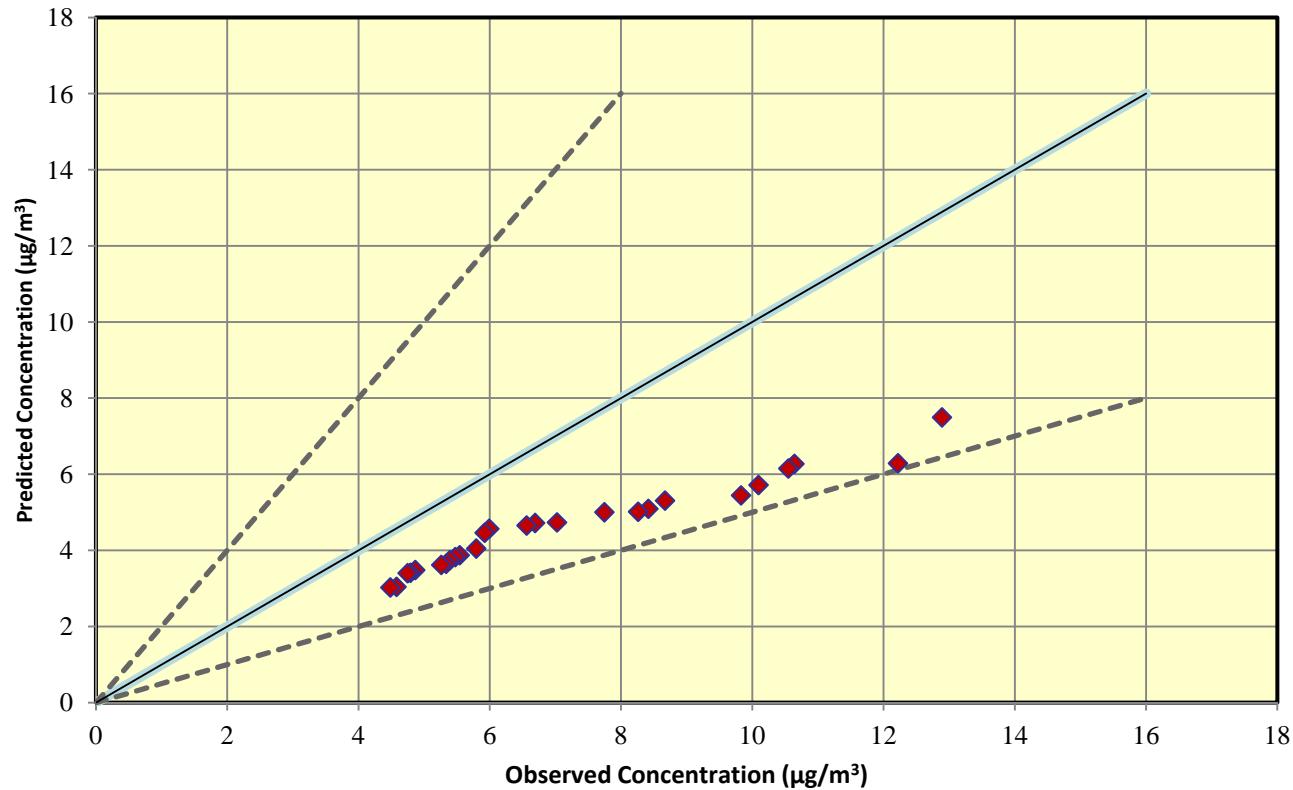
## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*, LOWWIND1 (0.5 0.5)

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.52 (n=11), 0.53 (n=26))



## Evaluation of 26 highest Modeled and Monitored Concentrations: AERMOD v. 12345, Beta ADJ\_U\*, LOWWIND2 (0.3 0.5 0.95)

Tracy 1-Hour SF<sub>6</sub> (Mod/Obs RHC = 0.51 (n=11), 0.61 (n=26))



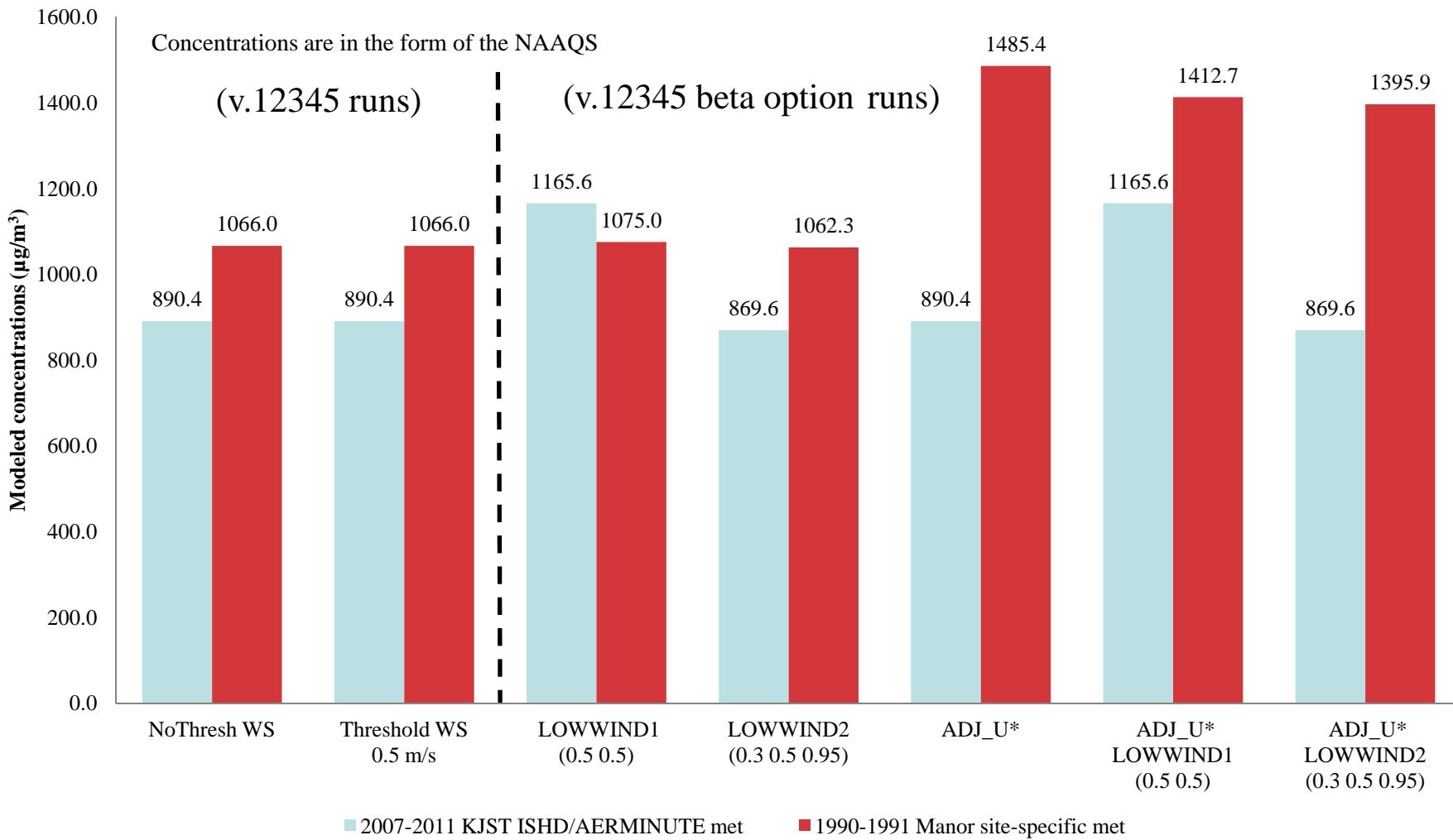
## Homer City, PA EGU Analysis

- Homer City is one of the largest SO<sub>2</sub> sources in the country
- 3 tall stacks (HS = 244 to 260 m)
- Facility is 3.8 km from Homer Center High School
- Modeled with two met data sets:
  - 2007 – 2011 KJST/KPIT (ISHD/FSL, with one-minute ASOS winds)
  - 1990 – 1991 Manor site-specific met
- Examined AERMOD v. 12345 and beta options
- Beta options tend to increase modeled impacts compared to AERMOD v. 12345 regulatory default options
- Beta options introduce wide variability of modeled impacts

## Homer City Modeling Scenarios

- AERMOD v. 12345 (no beta options)
- AERMOD v. 12345 (no beta options), THRESH\_1MIN = 0.5 m/s
- AERMOD v. 12345, beta LOWWIND1, SVmin = 0.5 m/s; WSmin = 0.5 m/s
- AERMOD v. 12345, beta LOWWIND2, SVmin = 0.3 m/s; WSmin = 0.5 m/s; FRANmax = 0.95
- AERMOD v. 12345, beta ADJ\_U\*
- AERMOD v. 12345, beta ADJ\_U\*, with LOWWIND1, SVmin = 0.5 m/s; WSmin = 0.5 m/s
- AERMOD v. 12345, beta ADJ\_U\*, with LOWWIND2, SVmin = 0.3 m/s; WSmin = 0.5 m/s; FRANmax = 0.95

# Homer City 1-hour SO<sub>2</sub> impacts at Homer Center High School using Allowable Emissions



## Summary of Conclusions

- For the four AERMOD EGU evaluation studies analyzed here, v. 12345 beta options decrease model performance and increase variability of impacts
- The beta options are not bug fixes
- The beta options introduce new performance problems
- Efforts will be better spent collecting multi-level site-specific met data (with turbulence parameters)
- Site-specific met and AQ data are always useful, but rarely exist for major SO<sub>2</sub> sources (pre-construction monitoring requirements often waived)
- Major emission sources should routinely collect post-construction ambient AQ data, to augment modeled impacts and to ensure compliance
- AERMOD has been rigorously evaluated – the revised model formulations are not necessary and are a step backwards for EGUs