Single-Source Impacts on Secondary $PM_{2.5}$ Formation – A Case Study

Midwest Environmental Compliance Conference

Joe Stolle, PE, Senior Environmental Engineer
Wendy Vit, PE, Senior Environmental Engineer

GeoEngineers

May 2017

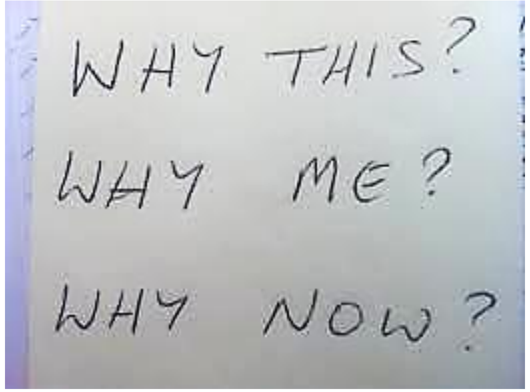
Appendix W Revisions

- On December 20, 2016, the U.S. Environmental Protection Agency (EPA) finalized revisions to Appendix W, *Guideline on Air Quality Models*
- In response to the President's "Regulatory Freeze Pending Review" memorandum (January 20, 2017), EPA extended effective date to March 21, 2017 and then to May 22, 2017
- Changes must be integrated into regulatory processes by January 17, 2018 (one year following *Federal Register* publication date)

GeoEngineers

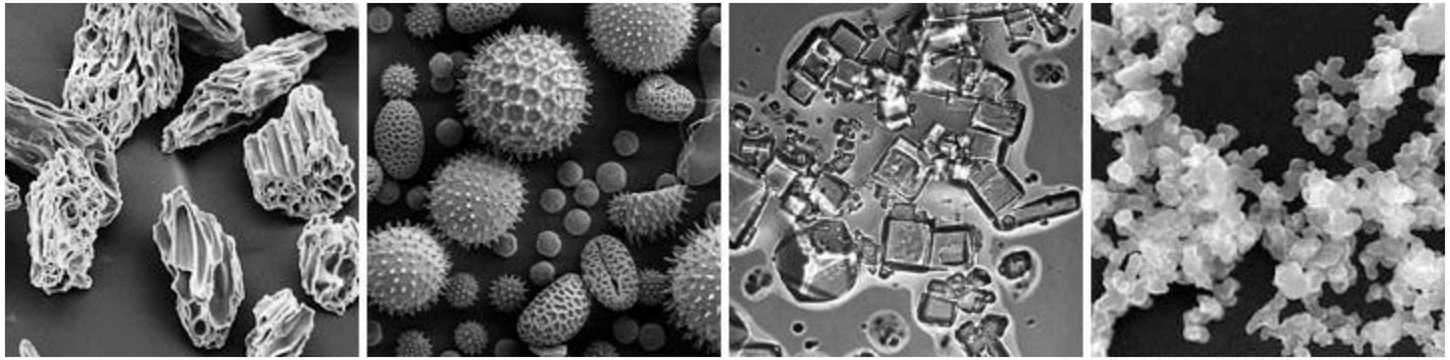
Single-Source Contribution to $PM_{2.5}$

- EPA granted a petition from Sierra Club to establish models for ozone and $PM_{2.5}$ for use in Prevention of Significant Deterioration (PSD) permitting
- Primary $PM_{2.5}$ has historically been addressed in PSD permits, but secondary formation has become more important as NAAQS have become more stringent
- Advances in chemical transport modeling science make it possible to evaluate single-source contributions to secondary formation
- EPA issued separate guidance on single-source modeling



Ambient $PM_{2.5}$ Composition

- Ambient $PM_{2.5}$ generally consists of 2 components
  - Primary component: emitted directly from a source
  - Secondary component: formed in the atmosphere from other pollutants
- Secondary $PM_{2.5}$ formation is primarily driven by emissions of NO_x and SO_2
  - NO_x and SO_2 emissions are oxidized and react with ammonia to form ammonium sulfate and ammonium nitrate
  - Fraction of primary vs. secondary $PM_{2.5}$ varies by location, season, background conditions



Simplified PSD Process Overview

- Is source located in attainment/unclassifiable area?
- Is emissions increase for new source or modification greater than Significant Emission Rate (SER)?
  - Primary $PM_{2.5}$: 10 tons/year
  - NO_x: 40 tons/year
  - SO_2: 40 tons/year
- PSD review must consist of the following for each pollutant > SER
  - Best Available Control Technology (BACT)
  - Air quality impact analysis: *$PM_{2.5}$ air quality impact analysis must consider impacts from primary and secondary formation where applicable (SO_2 and/or NO_x)*
  - Visibility, soils and vegetation analysis
  - Impact analysis for nearby Class I areas

Appendix W (as Revised) Recommends 2-Tiered Approach for Estimating Single-source Contribution to Secondary Formation

- Tier 1 – Existing technical information is available
  - Worst-case regional Modeled Emission Rate for Precursors (MERP)
  - Existing comparable chemical transport model data for a similar source
- Tier 2 – Chemical transport model used to address single-source impacts

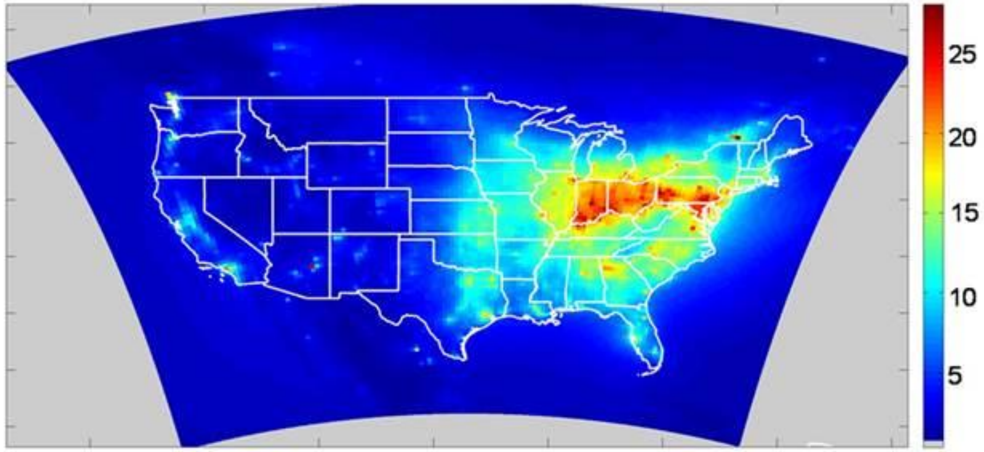
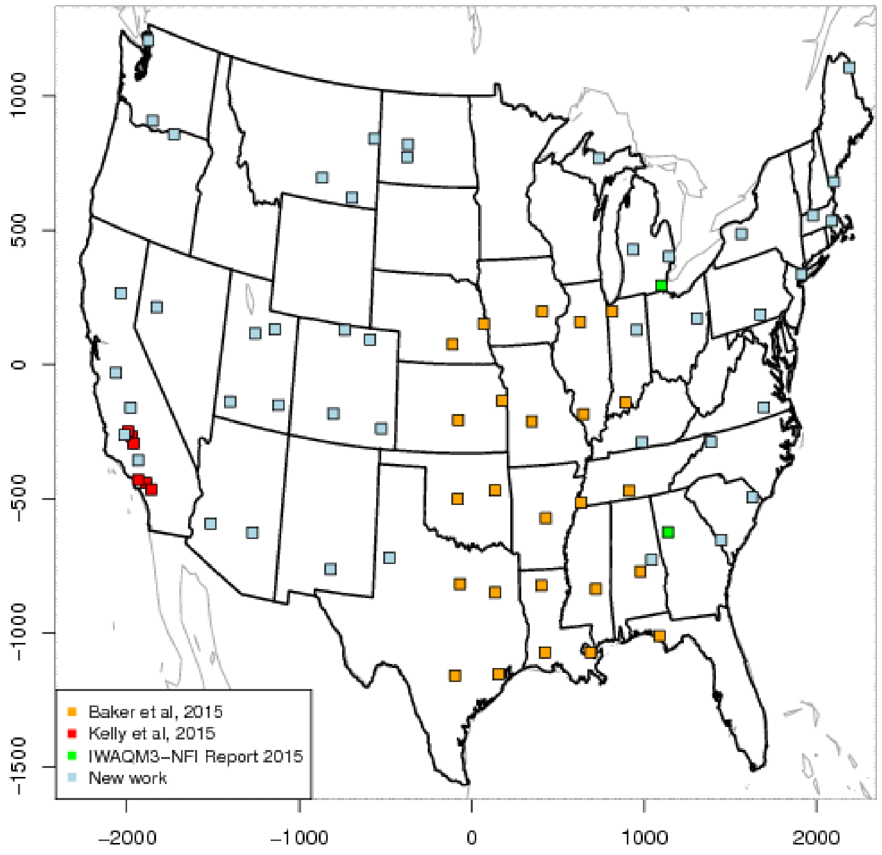


Figure 2. $PM_{2.5}$ simulation result, annual average $PM_{2.5}$ for 2002. Color scale is $PM_{2.5}$ in $\mu g\ m^{-3}$.

GeoEngineers

What Is a MERP?

- Defined as the emission rate of NO_x or SO_2 (in tons per year) that would result in a worst-case modeled impact equal to a Critical Air Quality Threshold (generally 1-3% of the corresponding NAAQS)
- New source/modifications with a potential impact (primary + secondary formation) less than the Critical Air Quality Threshold are assumed to have an insignificant impact on the NAAQS



GeoEngineers

What Is a MERP? (Continued)

- EPA used a photochemical grid model to estimate concentrations from elevated and ground-level releases for multiple emission scenarios
- Emission/release scenario with highest impact for each region used to develop the MERP
- SO_2 has greatest impact on secondary PM formation
- Central and Western US have greater potential for secondary PM formation than Eastern US

$PM_{2.5}$ Precursor Pollutant	Region	MERP for 24-hr $PM_{2.5}$ NAAQS (ton/yr)	MERP for Annual $PM_{2.5}$ NAAQS (ton/yr)
NO_x	Central US	1,693	5,496
NO_x	Eastern US	2,295	10,144
NO_x	Western US	1,075	3,184
SO_2	Central US	238	839
SO_2	Eastern US	628	4,013
SO_2	Western US	210	2,289

Source: February 23, 2017 Memorandum from Tyler Fox to the Regional Air Program Managers regarding distribution of EPA's modeling data used to develop the MERPs.

Test Case

- A major source wishes to make a physical modification that will result in net emissions increases of:
  - 125 ton/yr in primary $PM_{2.5}$
  - 750 ton/yr in SO_2
  - 500 ton/yr in NO_x
- The emissions are released out of an elevated stack:
  - Stack Height = 350’
  - Stack Diameter = 12’
  - Exit Velocity = 4500 fpm
  - Stack Temperature = 150° F
- Fictitious facility is located in central Missouri (attainment for all pollutants)

GeoEngineers

What Steps Are Involved?

1. Compare proposed emission increases to SERs for direct $PM_{2.5}$, NO_x and SO_2
2. If proposed direct $PM_{2.5}$ emission increase >= SER (10 ton/yr), use air dispersion model (typically Aermod) to estimate highest 24-hour and annual $PM_{2.5}$ concentrations
3. If NO_x and/or SO_2 increases >= SERs (40 ton/yr), conduct Tier 1 analysis to evaluate secondary formation
   - Calculate impacts from using worst-case regional MERPs and compare to Critical Air Quality Thresholds for both 24-hour and annual NAAQS
   - If impacts are above the threshold, calculate impacts using comparable data from a similar source, if available
4. If impacts are still above the Critical Air Quality Threshold, a Tier 2 chemical modeling analysis may be required
5. If Tier 2 analysis results in impacts above Critical Air Quality Threshold, additional analyses may be needed and permit may need to include conditions or limits to address impacts

GeoEngineers

Step 1. Compare Emission Increases to SERs

Pollutant	Emission Increase (ton/yr)	Significant Emission Rate (ton/yr)	Requires PSD Review?
$PM_{2.5}$ (Primary)	125	10	Yes
SO_2	750	40	Yes
NO_x	500	40	Yes

- Proposed emission increases >= SER for primary $PM_{2.5}$ and precursors
- Ambient Air Quality Impact Analyses are required for all 3 pollutants
  - 1-hour SO_2 NAAQS, 1-hour and annual NO_2 NAAQS
  - 24-hour and annual $PM_{2.5}$ NAAQS (must include impacts from both primary $PM_{2.5}$ and secondary formation from SO_2 and NO_x)

Step 2. Model Single-Source Primary $PM_{2.5}$

- For this test case, GeoEngineers estimated $PM_{2.5}$ concentrations using the Aermod modeling system
- Used 5 years of representative NWS meteorological data
- Modeled impacts based on highest 24-hour and annual concentrations

Averaging Period	$PM_{2.5}$ NAAQS (μg/m³)	Critical Air Quality Threshold (μg/m³)	Modeled Impact (μg/m³)	Modeled Impact Fraction of Critical Air Quality Threshold
24-hour	35	1.2	0.733	0.61
Annual	12	0.2	0.069	0.35

GeoEngineers

Step 3. Calculate Additive Impacts Using Worst-Case Regional MERPs for Central US

Pollutant	MERP for 24-hr $PM_{2.5}$ NAAQS (ton/yr)	MERP for Annual $PM_{2.5}$ NAAQS (ton/yr)
NO_x	1,693	5,496
SO_2	238	839

NO_x SO_2 Primary Total $PM_{2.5}$

24-hour = 500/1,693 + 750/238 + 0.61 = 4.06 **(>1 May be significant)**

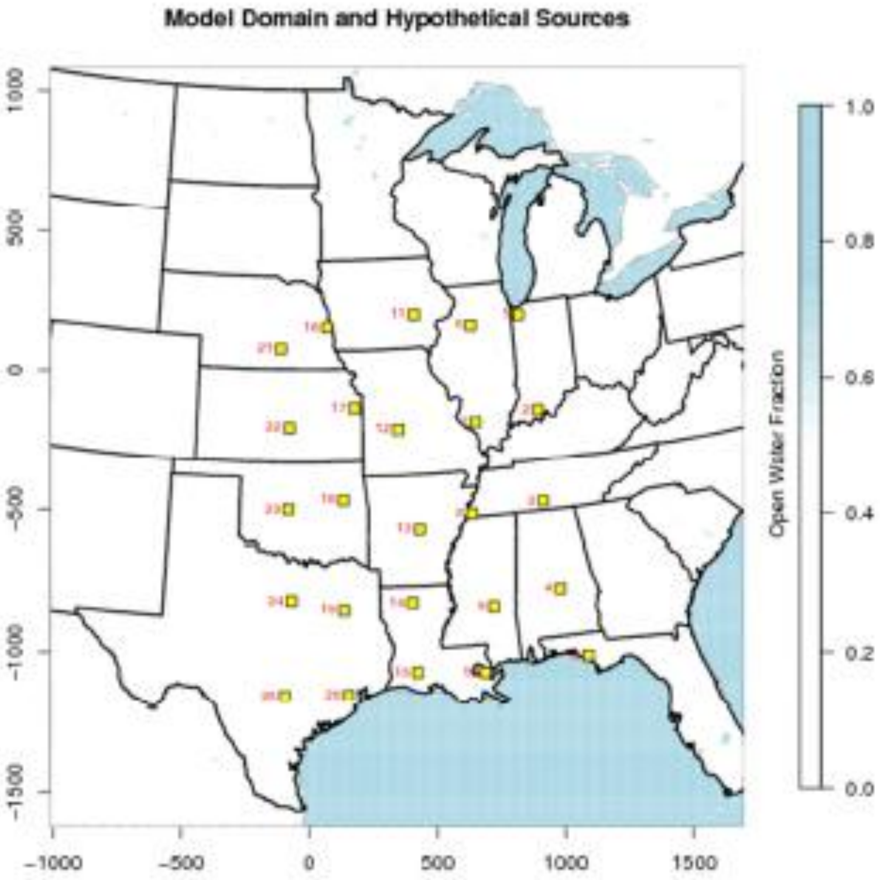
$4.06 * 1.2\ \mu g/m^3 = 4.87\ \mu g/m^3$

Annual = 500/5,496 + 750/839 + 0.35 = 1.33 **(>1 May be significant)**

$1.33 * 0.2\ \mu g/m^3 = 0.27\ \mu g/m^3$

GeoEngineers

Step 4. Are Data from a Comparable Source Available?



EPA Source 12, Central US, Elevated Release

Stack Parameter	Test Case	EPA Source 12
Height (ft)	350	295
Diameter (ft)	12	16.4
Velocity (fpm)	4500	5314
Temperature (F)	150	100

Source: "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM2.5 under the PSD Permitting Program," EPA-454/R-16-006, December 2016.

Step 5. Calculate Additive Impacts Using Comparable Source, 24-hour Average

Pollutant	EPA Source 12 Modeled Emission Rate (ton/yr)	EPA Source 12 Modeled $PM_{2.5}$ Impact (µg/m³)
NO_x	1000	0.09
SO_2	1000	0.65

Source: "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM2.5 under the PSD Permitting Program," EPA-454/R-16-006, December 2016.

NO_x | SO_2 | (Aermod) Primary | Total $PM_{2.5}$

24-hour = (500/1000*0.09) + (750/1000*0.65) + 0.733 = 1.27 µg/m³ (>1.2 µg/m³)

Since the impact is >1.2 µg/m³, the modification could have a significant impact on the 24-hour $PM_{2.5}$ NAAQS

GeoEngineers

Step 5 (Continued). Calculate Additive Impacts Using Comparable Source, Annual Average

Pollutant	EPA Source 12 Modeled Emission Rate (ton/yr)	EPA Source 12 Modeled $PM_{2.5}$ Impact (µg/m^3)
NO_x	1000	0.006
SO_2	1000	0.012

Source: "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM2.5 under the PSD Permitting Program," EPA-454/R-16-006, December 2016.

NO_x SO_2 (Aermod) Primary Total $PM_{2.5}$

Annual = (500/1000*0.006) + (750/1000*0.012) + 0.069 = 0.081 µg/m^3 (<0.2 µg/m^3)

Since the impact is <0.2 µg/m^3, the modification is unlikely to have a significant impact on the annual $PM_{2.5}$ NAAQS

GeoEngineers

What Are the Options?

- Tier 1 results show potential impact is > Critical Air Quality Threshold for 24-hour $PM_{2.5}$ NAAQS
  - Option 1: Use additional data to provide justification that emission increase will not cause a violation of NAAQS
  - Option 2: Take emission limit(s) for $PM_{2.5}$, SO_2 and/or NO_x (*Note this option involves additional air quality impact analyses*)
  - Option 3: Perform Tier 2 modeling analysis utilizing actual location, emissions and release data for source/modification
- For the test case, taking emission limit was not economically feasible. It was determined that a Tier 2 modeling analysis is the best option.

GeoEngineers

Step 6. Tier 2 Photochemical Modeling Analysis for Secondarily Formed $PM_{2.5}$

- For this test case, GeoEngineers applied the CMAQ photochemical grid model
  - Only emissions from the modification were considered – *in addition to the baseline*
  - 1 year of meteorological data (2011) – *may need to be expanded*
  - 12 km horizontal grid (consistent with the modeling study used to develop Tier 1 MERP values) – *may need to be refined*
- Would need to develop a protocol and work closely with the regulatory agency

Component	**24-hour Avg. Modeled Concentration ($\mu g/m^3$)**
Primary $PM_{2.5}$ (Aermod)	0.733
Secondary $PM_{2.5}$ (CMAQ)	0.32
Total	**1.053** **(<1.2 $\mu g/m^3$ - Insignificant)**

GEOENGINEERS

Lessons Learned

- Most projects are expected to be addressed using Tier 1 evaluations. The need for a Tier 2 photochemical modeling analysis will likely be limited to very large increases in SO_2 and NO_x (probably greater than 1,000 ton/yr in most locations).
- Completing Ambient Air Quality Impact Analyses for the SO_2 and NO_2 NAAQS before the $PM_{2.5}$ analysis allows for inclusion of any limits required by those 1-hour NAAQS.
- Our test case was very simple. Analyses are expected to be more problematic for situations such as:
  - significant truck traffic across the ambient boundary,
  - background $PM_{2.5}$ concentrations near the NAAQS,
  - large SO_2 emissions increases.
- Tier 2 analyses will create data that can be used in Tier 1. The need for Tier 2 analyses should decrease over time as information is gained.

GeoEngineers

Conclusions

- Tier 1 and Tier 2 analyses will add time, effort and complexity to the already complex PSD permitting process. Plan accordingly!
- It is strongly advised to meet with MDNR up front and work with the agency closely throughout the project.

Contact Information

- Joe Stolle, PE, Senior Environmental Engineer

  913.898.3000

  jstolle@geoengineers.com

- Wendy Vit, PE, Senior Environmental Engineer

  417.799.2560

  wvit@geoengineers.com