United States Environmental Protection Agency

Risk and Exposure Assessment for the Review of the Primary National Ambient Air Quality Standard (NAAQS) for Sulfur Oxides, External Review Draft

Staff from the
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency

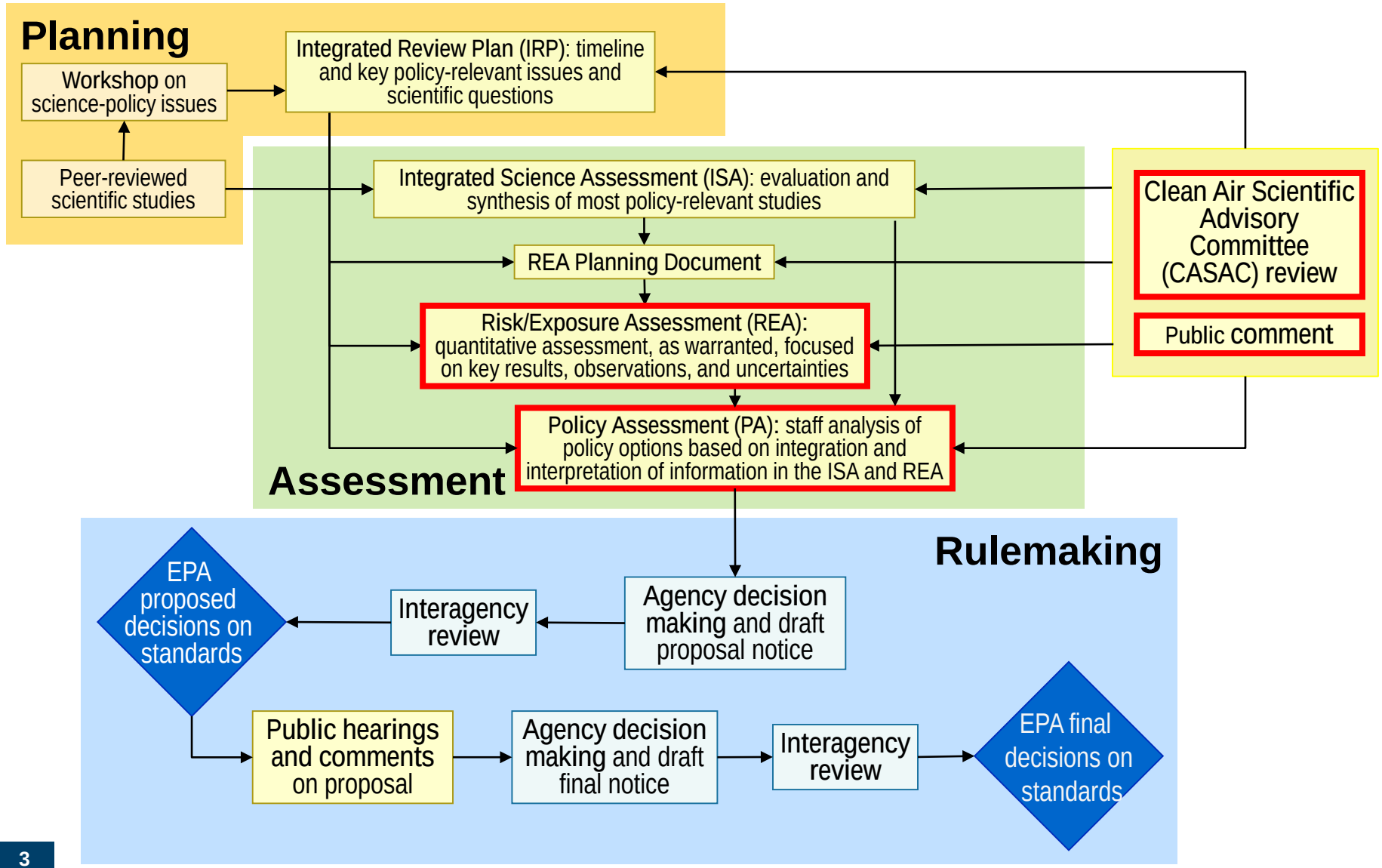
September 18-19, 2017
Meeting of Sulfur Oxides Panel
Clean Air Scientific Advisory Committee

EPA Speakers

Office of Air Quality Planning and Standards (OAQPS)
- Health and Environmental Impacts Division (HEID)
  - Ambient Standards Group (ASG)
  - Risk and Benefits Group (RBG)
- Air Quality Assessment Division (AQAD)
  - Ambient Quality Modeling Group (AQMG)

- Introduction/Background
  - Erika Sasser, Director, HEID
  - Karen Wesson, Group Leader, ASG
  - Robert Wayland, Group Leader, RBG
- Overview of the Risk and Exposure Assessment
  - Stephen Graham (OAQPS/HEID/RBG)
- Overview of the Policy Assessment
  - Nicole Hagan, SO_2 NAAQS Review Staff Lead (OAQPS/HEID/ASG)
- Additional EPA OAQPS Staff
  - Deirdre Murphy (OAQPS/HEID/ASG)
  - James Thurman (OAQPS/AQAD/AQMG)

NAAQS Review Process



Roles of REA and PA in the NAAQS Review Process

- Risk and Exposure Assessment (REA)
  - Presents quantitative assessments of exposures and risks under specified air quality scenario(s), drawing on information in ISA, prior assessments and CASAC advice on REA planning document
  - Does not present conclusions with regard to standard

- Policy Assessment (PA)
  - Presents transparent staff evaluation of policy implications of key scientific and technical information in ISA and REA for consideration by Agency
  - Review of draft PA facilitates CASAC advice to the Agency on adequacy of current standard, and on revisions, as appropriate

Schedule for Current Review of Primary SO_2 NAAQS

Schedule

- In March 2017, we met with the CASAC to discuss the 2nd draft ISA and the REA Planning Document
- The final ISA is to be released by December 2017*
- The final REA and PA will reflect consideration of the CASAC's advice and public comment
- The notice of proposed rulemaking is to be signed by May 25, 2018*
- The notice of final rulemaking is to be signed by January 28, 2019*

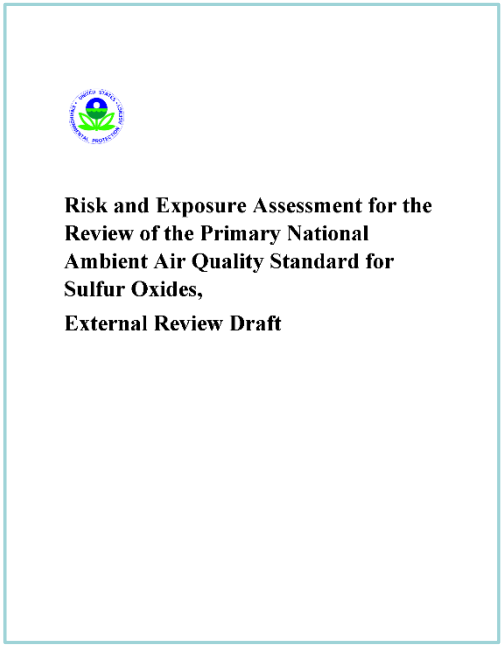
* These dates are specified by a court-ordered schedule.

REA: Overall Purpose and SO_2 Specific Goals

- Overall Purpose
  - The REA provides a quantitative analysis of estimated population exposure and risk, focused on:
    - Magnitude of population exposure and risk estimated in different types of study areas under conditions just meeting the current standard and the portion of the at-risk populations estimated to be affected
    - Identification and evaluation of key uncertainties associated with exposure/risk estimates
- Specific Goals
  - Assess exposure and risk in study areas having varied geographic, population, and source related attributes
  - Develop hypothetical air quality scenarios that reasonably reflect spatial and temporal variability in ambient 5-minute SO_2 concentrations that may occur in areas of U.S. when air quality just meets the current standard
  - Based on health effects observed in controlled human exposure studies of people with asthma
    - Estimate frequency of 5-minute SO_2 exposures at or above benchmarks
    - Estimate risk of SO_2 exposure-related lung function decrements

REA Document Organization

- **Organization of the draft REA:**
  - **Chapter 1:** Introduction
  - **Chapter 2:** Overview of assessment approach
  - **Chapter 3:** Ambient air concentrations
  - **Chapter 4:** Population exposure and risk
  - **Chapter 5:** Results
  - **Chapter 6:** Variability analysis and uncertainty characterization


Risk and Exposure Assessment for the Review of the Primary National Ambient Air Quality Standard for Sulfur Oxides,

External Review Draft

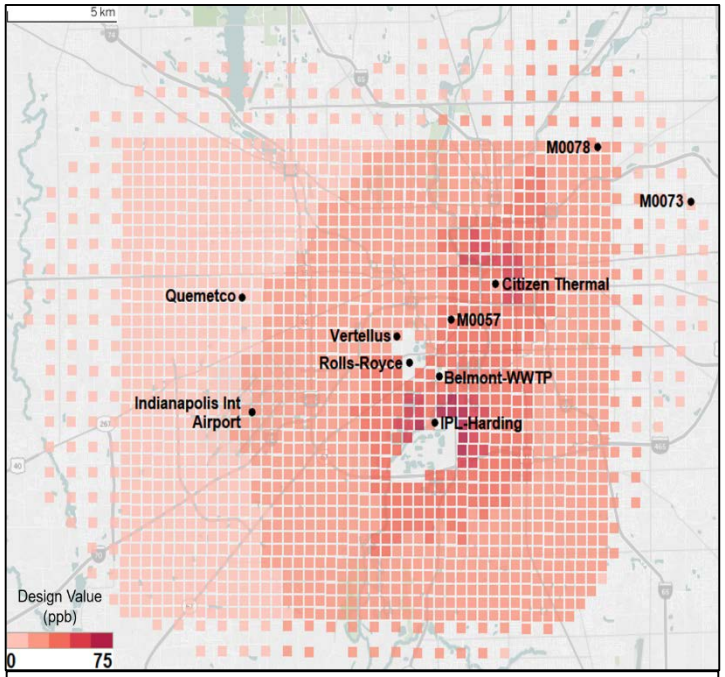
Features of REA Study Areas

Features of study areas included in the exposure and risk assessment
(based on draft REA, Tables 3-1 and 4-1).

Geographic Attributes		Monitoring Attributes		Study Population Attributes		Source Attributes	
Study Area	Region	2011-2013 Design Values (ppb)	Monitors Reporting 5-Minute Data (n) (Continuous data n)	Population	Asthma Prevalence	Number Emitting >100 tons	Types
Fall River, MA	New England	64	1 (1)	183,874	Child: 5.7% - 21.5% Adult: 5.1% - 17.6%	1	EGU
Indianapolis, IN	Ohio River Valley	78	3 (0)	538,020	Child: 5.8% - 19.4% Adult: 2.5% – 17.6%	4	EGUs, secondary lead smelter, airport
Tulsa, OK	Midwest	55	4 (4)	230,471	Child: 7.3% - 16.1% Adult: 4.0% - 14.4%	3	EGU, petroleum refineries

Ambient Concentrations: Hourly

- Air quality modeling used to represent spatial variability in hourly ambient concentrations
  - AERMOD Modeling System used to estimate hourly concentrations across a 3-year period, 2011-2013, in each study area
  - Fine spatial grid used, yielding about 1,400 – 1,900 air quality receptor points within each study area
- Adjustment of hourly concentrations to just meet the current standard
  - Air quality receptor with highest concentration used to calculate adjustment factor
  - Concentrations contributed by the primary source in a study area were adjusted proportionally
    - Concentrations contributed by other sources (and background) were left unadjusted



Draft REA Figure 3-2. Air quality receptors in the Indianapolis exposure modeling domain and design values calculated from modeled hourly concentrations adjusted to just meet the current standard.

Ambient Concentrations: 5-Minute

- Local 5-minute monitoring data used to estimate the continuous 5-minute concentrations for each air quality (AQ) receptor in each exposure modeling domain
- Prepared monitoring datasets
  - Filled gaps in the hourly, maximum 5-minute and continuous 5-minute datasets
    - Interpolation used, appropriate for data having fewer than 5-10% missing values
  - For monitors reporting only 5-minute maximum and hourly, the continuous 5-minute concentrations were estimated
    - Random sampling of lognormal distributions used
    - Lognormal distributions informed by local continuous 5-minute measurement data that were stratified and linked by peak-to-mean ratios
- Used monitoring datasets to estimate continuous 5-minute concentrations for hourly AQ receptor concentrations via a rank order approach
  - Each year's hourly concentrations – at each monitor and AQ receptor – were ranked from low to high (i.e., values of 1 to 8760, or 8784), then linked via rank number
  - Each AQ receptor was assigned the monitor's 5-minute continuous concentrations after a proportional adjustment using the hourly concentration ratio
  - Where there are multiple monitors for a study area (Indianapolis, Tulsa), a 5-10 km radius used to link source-related monitors with local air quality receptors

Exposure and Risk: Approach

- Exposure
  - APEX, EPA's population-based human exposure model was used to link fine spatial and temporal scale ambient concentrations with study area population demographics, human activity data, and physiological attributes
    - At-risk study populations included children and adults with asthma
    - Use of APEX is key to both the exposure and risk estimation because the adverse health effect depends on the exposed individuals having an elevated ventilation rate
- Risk
  - Comparison to Benchmarks
    - 5-minute exposures occurring at elevated ventilation were compared to benchmark concentrations based on consideration of controlled human exposure studies (100, 200, 300, 400 ppb)
  - Lung Function Risk
    - A continuous exposure-response (E-R) function developed from the controlled study data was used to estimate the probability of response associated with any 5-minute exposure while at elevated exertion
    - Exposures occurring while at elevated ventilation were linked to the E-R function and used to estimate the percent of the study population in each area expected to experience a lung function decrement (i.e., sRaw of 100%, 200%)

Exposure and Risk: Findings (Main Analysis)

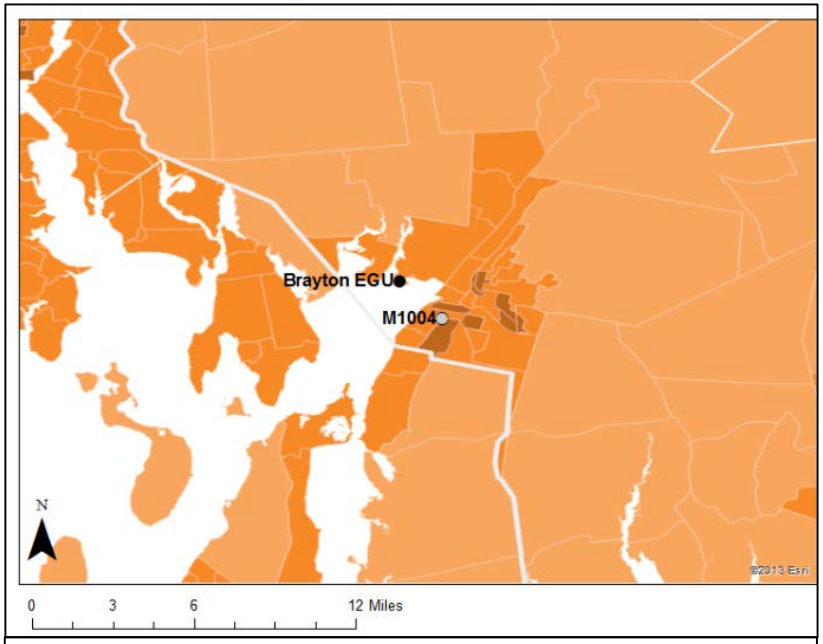
- Exposures and both types of risk estimates, in terms of percentages of each population, are higher for children with asthma than adults with asthma
  - Greater frequency and amount of time spent outdoors is key factor

- Comparison to Benchmarks
  - No children with asthma experienced a day with a 5-minute exposure at or above 300 ppb
  - Less than 1% of children with asthma experienced a day with exposure at or above 200 ppb in any of three years in any study area
    - No individuals experienced multiple days above 200 ppb

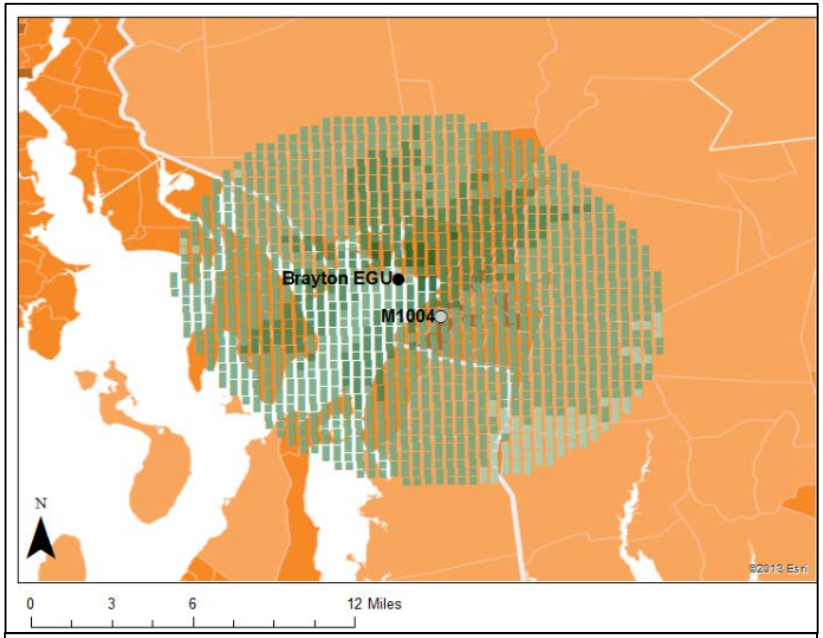
- Lung Function Risk
  - Less than 1% of children with asthma experienced a day with sRaw estimated to increase by at least 200% in any of three years in any study area
  - Less than 2% of children with asthma experienced a day with sRaw estimated to increase by at least 100%, in any of three years in any study area

Exposure and Risk: Findings (Main Analysis)

- Study area estimates influenced by extent to which highest ambient air concentration locations coincided with higher population density
  - Higher exposure and risk estimates in study area with this pattern (Fall River)



Draft REA Figure 5-1. Fall River population density, 2012 U.S. Census tracts.



Draft REA Figure 5-4. Overlay of population density with modeled air quality receptor design values (2011-2013) adjusted to just meet the current standard.

Sensitivity Analyses to Characterize Important Uncertainties

- Air Quality Adjustment
  - Compared main analysis results with those based on adjustment approach that used receptor having 99th percentile highest design value (rather than the maximum) to adjust concentrations to just meet the current standard
- Estimation of Continuous 5-minute Concentrations at Monitors
  - Compared simulated exposures using
    - Measured continuous 5-minute monitor concentrations
    - Estimated continuous 5-minute monitor concentrations
- Combining Continuous 5-minute Monitor Data with AERMOD Hourly Data
  - Compared simulated exposures using two alternative approaches with the rank order approach used for main analysis
    - Calendar based: directly link hourly (and hence associated 5-minute) monitor concentrations with hourly receptor concentrations based on matched date/hour of day
    - Binned: assign hourly (and hence associated 5-minute) monitor and hourly receptor concentrations to bins by 5 ppb increments, randomly link two data sets by bin.
- Exposure-Response Function
  - Exposures also estimated using the lower (5th percentile) and upper (95th percentile) prediction intervals of the mean E-R regression estimate, for both the 100% and 200% increase in sRaw