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Section 812 Benzene Case Study:
Status Update for EPA SAB Advisory Council on Clean Air Act Compliance Analysis

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Outline

- Background/Purpose
- Scenario Development
- Emissions Estimation
- Air Quality Modeling
- Exposure Assessment
- Health Effects Estimation
- Benefit Valuation
- Next Steps

Background

- Section 812 of Clean Air Act requires EPA to evaluate costs and benefits of federal air programs
- Two previous 812 studies included limited analysis of air toxics
  - Retrospective: benefits from three Hazardous Air Pollutants (HAPs) criticized by Science Advisory Board (SAB) for overestimation
  - First Prospective: looked at costs only
- SAB recommended in June 2001 that report should include case study of benefits of control of a single, non-reactive, data-rich HAP such as benzene

Purpose and Scope

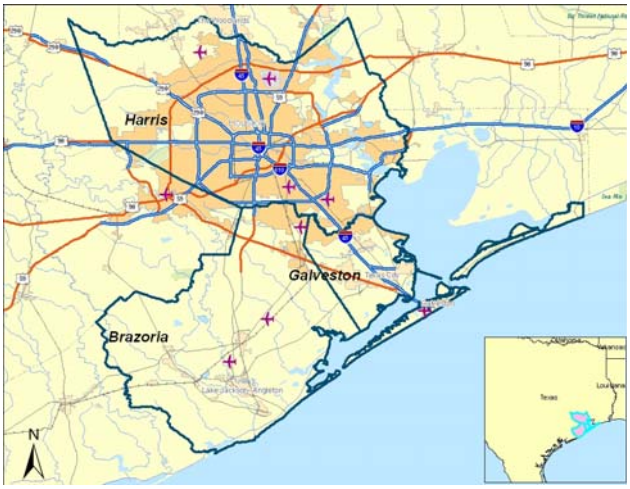
Purposes:

- To generate example Clean Air Act Amendments (CAAA) benefit results for a HAP in an urban setting
- To consider the value of this exercise more broadly for HAP benefits characterization

Scope:

- Conducted a local-scale study of benzene in Houston, focusing on three counties:
  - Harris
  - Brazoria
  - Galveston
- Estimated benefits of reductions in benzene resulting from multiple CAA Titles from 1990 to 2020
- Results reported for three target years (2000, 2010, 2020)

Study Area



Source: "Section 812 Clean Air Act Cost-Benefit Study Air Toxics Case Study: Benzene Emissions Reduction in Houston – Draft Report." E.H. Pechan & Associates, February 2006.

Scenario Development

- Without-CAAA Scenario: Freeze regulations at 1990 levels
- With-CAAA Scenario: Include all current and anticipated regulations affecting benzene emissions
  - Title I (through SIP requirements, e.g., vehicle I/M programs)
  - Title II
    - Tailpipe Standards (Tier 1 & 2, Heavy Duty Engine/Diesel rule)
    - Evaporative Emissions Standards (Stage II and Onboard Vapor Recovery, Evaporative Test Procedure)
    - Fuel Regs (RFG Phase II, Summertime Volatility Requirements, Sulfur limits)
  - Title III
    - Identify MACT rules affecting benzene, such as:
      - 7 year MACT - Oil and Natural Gas Production
      - 4 year MACTs - Petroleum Refineries, Gasoline Distribution
      - 2 year MACT – Hazardous Organic NESHAP
  - 2007 Mobile Source Air Toxics (MSAT) rule not included

Emission Estimation

- Point and Non-Point Sources
  - 1990 NEI for HAPs used for base year (1990) emissions estimates
  - Without-CAAA: 1990 NEI for HAPs used as base year file for estimating emissions for 2000, 2010, and 2020
  - With-CAAA: 2002 NEI used for 2000 and as the base year emissions file for 2010 and 2020 emission estimates
  - Non-point sources also includes aircraft, locomotives, commercial marine vessels
- On-Road Sources
  - Generated seasonal hourly link-level (i.e., roadway segment) emissions data
  - VMT estimates from HGAC and TTI for 2005
  - Emissions factors from MOBILE 6.2
- Non-Road Sources (sources in NONROAD model only)
  - Product of benzene speciation factors and VOC emissions estimates
  - Speciation factors and fuel data inputs – EPA's NMIM
  - VOC emissions for EPA's 2004 NONROAD model

Emission Estimation - Results

Table I-1. Houston-Galveston Benzene Emissions Summary (tons per year [tpy])

Sector	1990	2000 *without-CAAA*	2000 *with-CAAA*	2010 *without-CAAA*	2010 *with-CAAA*	2020 *without-CAAA*	2020 *with-CAAA*
Point/Nonpoint	5,409	6,532	1,230	6,699	1,258	7,702	1,440
Nonroad	740	900	567	1,127	354	1,351	360
Onroad vehicles	2,375	1,541	762	1,449	328	1,988	282
Total	8,524	8,973	2,559	9,275	1,940	11,041	2,082

Source: "Section 812 Clean Air Act Cost-Benefit Study Air Toxics Case Study: Benzene Emissions Reduction in Houston – Draft Report." E.H. Pechan & Associates, February 2006.

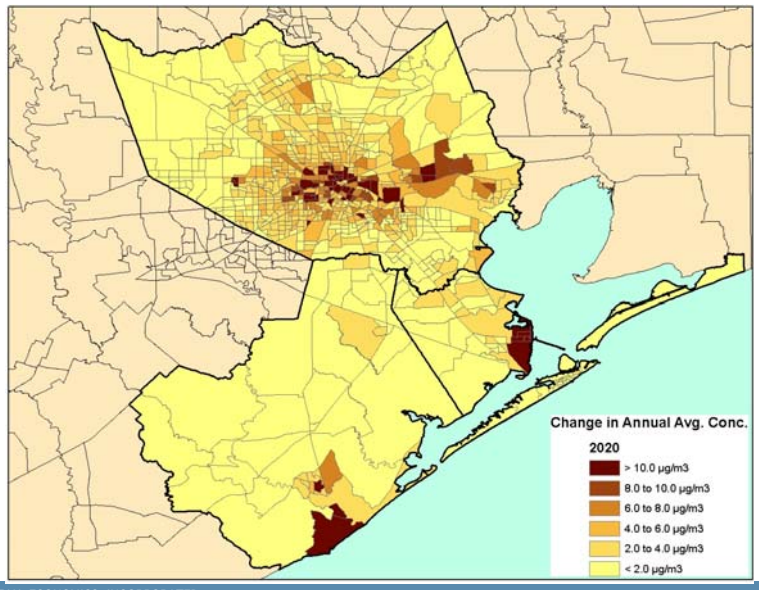
Air Quality and Exposure Modeling

- American Meteorological Society/U.S. EPA Regulatory Model (AERMOD) dispersion model used to estimate the impacts of CAAA benzene controls on ambient concentrations.
  - Modeled at block group level (2000 Census boundaries).
  - Meteorological data for 1990 base year and 2000 (all other years).
  - Emissions data processed using Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP).
  - County level emissions data (nonroad, nonpoint) spatially allocated to census tracts.
  - Used county-specific 1999 NATA background levels to account for mid-range to long-range transport.
  - Calculated annual average concentrations. Hourly average concentrations were also calculated for use in HAPEM6.

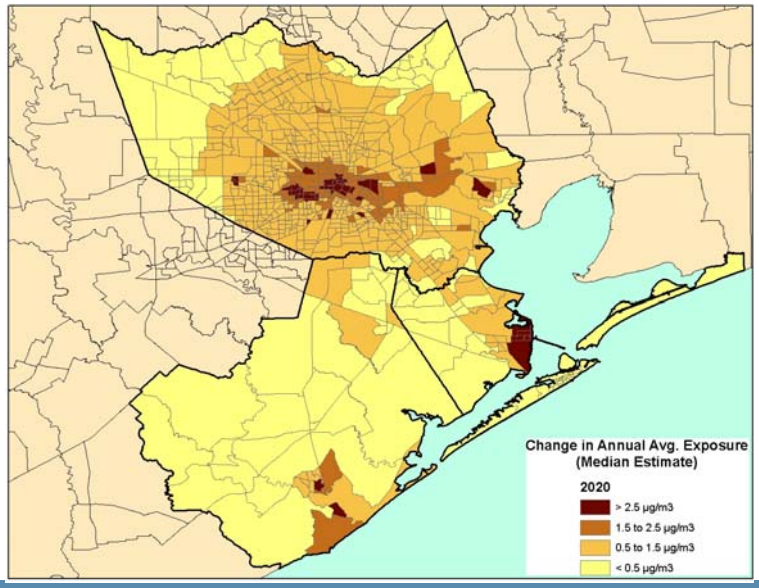
Air Quality and Exposure Modeling (Cont'd)

- Exposure modeling based on the Hazardous Air Pollutant Exposure Model (HAPEM6) model.
  - Includes 14 different microenvironment (ME) exposures (e.g., residential, school, office, public transit, service station).
  - Uses time-activity data from EPA's Consolidated Human Activity Database (CHAD) and commuting data from 2000 Census.
  - Yields distribution based on variability in time activity patterns and uncertainty in ME factors.
  - Separate distributions by age (0-1; 2-4; 5-15; 16-17; 18-64; >=65).
  - Accounts for exposure gradients near major roadways.
  - Exposure concentrations at the census tract level.

Estimated Reductions in Ambient Benzene Levels (AQM) (Year 2020, Without-CAAA Minus With-CAAA Scenario)



Estimated Reductions in Benzene Exposure (HAPEM) (Year 2020, Without-CAAA Minus With-CAAA Scenario)



Health Effects Estimation – Key Endpoints

- Benzene literature review completed in July 2005
- Key benzene health endpoints identified
  - Cancer
    - All leukemias – most data rich endpoint
    - Leukemia subtypes – AML has some epidemiologic evidence, others are inconclusive
    - Other cancers include Hodgkin's and Non-Hodgkin's Lymphoma, but data is limited
  - Non-Cancer
    - Subclinical (e.g., changes in white blood cell counts) effects found at occupational levels. Limited data for ambient levels.

Health Effects Estimation – Approach to Estimating Avoided Cancer Cases

- Goal is to calculate the expected number of fatal and non-fatal cases of benzene-induced leukemia avoided as a result of the CAAA in the Houston area
- Lifetable approach
  - Patterned after NRC's BEIR IV report on radon exposure (1988)
  - Allows for estimation of benefits to age-specific cohorts
  - Allows us to model "cessation lag" effects on benefits directly by using cumulative weighted exposure estimates
  - Generates estimate of benefits expected in each year, not a rolled-up estimate to be spread across future years (as in criteria pollutant analysis)
  - Model will be run with both leukemia mortality and incidence data. The difference between leukemia incidence and leukemia mortality results will provide estimate of non-fatal cases.

Health Effects Estimation – Model Selection

After reviewing the available literature, a main model was selected for estimating avoided cancer cases:

- Epidemiologic Data – Pliofilm cohort study (Crump et al., 1994), which informs the unit risk range in EPA's Integrated Risk Information System (IRIS)
- Cancer Endpoint – all leukemias
- Shape of the Dose-Response (D-R) Relationship – linear
- Exposure Weighting – D-R relationship weights exposures in the past differentially. The peak weight occurs at 5.3 years prior to current year (Crump et al., 1994).

$$w(t) = (t/K^2) \exp(-t/K)$$

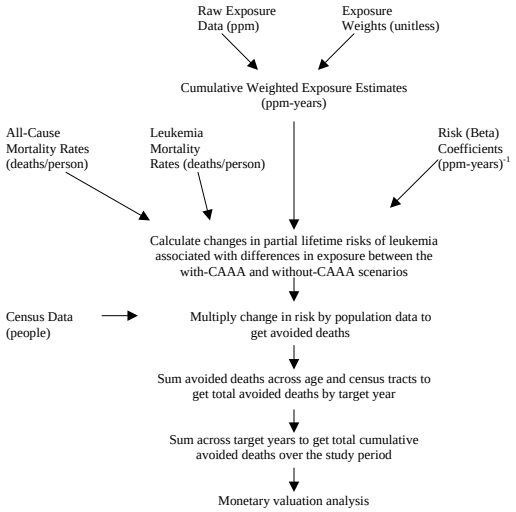
Where: t = number of years before current year; and

K = number of years before current year where weight is maximum

Weighting consistent with review of peer-reviewed literature on latency/cessation lag (e.g., Silver et al., 2002; Hayes et al., 1997).

Health Effects Estimation – Risk Calculations

BENZENE CASE STUDY LIFETABLE MODEL



Health Effects Estimation – Risk Calculations

- Goal is to estimate the differences in risk of dying of leukemia in a given year between the with-CAAA and without-CAAA scenarios.
- Basic risk equation:

$$R = h/h^* \times S \times (1-q)$$

Where:

R = risk of dying from leukemia in the current year, given survival up to that year;

h = leukemia mortality rate;

h* = all-cause mortality rate;

S = probability of surviving up to the current year;

q = probability of surviving through the current year; and

1-q = probability of dying during the current year.

Health Effects Estimation – Additional Planned Analyses

Sensitive Subpopulations

- Service station workers
- Homes with attached garages
- People living near major roadways

Sensitivity Analyses

- Chinese worker cohort data
- Alternate lag assumptions (e.g., 0-year, 5-year)
- High end and low end exposures (individual risk only)
- Comparison of all leukemia and AML

Health Effects Estimation – Non-Cancer

- EPA developed a reference concentration (RfC) of 0.03 mg/m^3, based on a critical effect of decreased lymphocyte count
- No differences found in the number of individuals experiencing benzene concentrations above the RfC under the with-CAAA and without-CAAA scenarios (proposed approach in the original analytic plan)
- Even if individuals move below the RfC, the likely benefit is difficult to value in economic terms
  - Outcome uncertain
  - Critical effect is of uncertain clinical significance

Benefits Valuation

- Benefits estimates for fatal cancers
- Dollar value of fatal cancers estimated using value of statistical life (VSL) (starting with a value of $5.5 million for 1990) plus a $110,000 pre-mortality morbidity estimate on a per case basis from EPA's Cost of Illness Handbook (All values in 1999 $)
- Non-fatal cancers also valued using the pre-mortality morbidity estimate ($110,000 per case)
- Income growth incorporated for VSL, assuming an elasticity value of 0.4
- Benefits discounted using 5% rate (3% and 7% used as a sensitivity analysis) per current guidance

Next Steps

- Welcome feedback or insights on the analytical methods
- Working to finalize the analysis
  - Q/C of main results
  - Continue with sensitivity analyses runs
  - Continue with sensitive subpopulation analyses
- Possible consultation with SAB Subcommittees in Spring 2007

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