# Risk Characterization for the NATA National-Scale Assessment

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**Science Advisory Board Review**

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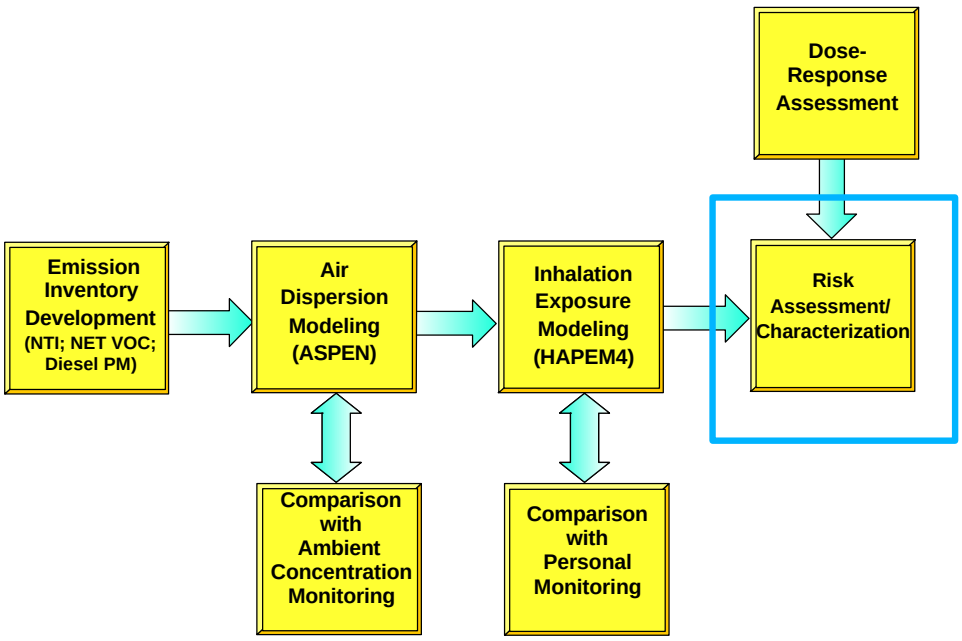
## How Does the Risk Assessment/Characterization Fit into the National Scale Assessment?



## Uncertainty Analysis: Introduction

- Analysis of uncertainty is integral part of risk characterization
  - Uncertainty: imperfect knowledge
  - Variability: real differences

## Quantitative estimates of variability and uncertainty

- "Bottom-up" approach
  - State-of-the-art for this analysis
  - For this assessment, data are not adequate to support approach
    - Inventory
    - ASPEN inputs
    - Exposure factors
    - Dose-response information
  - Subject of current planning
- "Top-down" approach
  - Use ratios as estimate of combined U&V at three mileposts
  - Combine ratios probabilistically to illustrate total propagated U&V

## "Top-Down" Approach

- Illustration of approach
  - Purpose:
    - serve as example, solicit input on whether to pursue approach
    - provide a some approximate sense of precision of risk estimates for risk communication
  - Mileposts
    - Modeled concentrations
    - Modeled exposures
    - Dose-response

## "Top-Down" Approach

- Limitations of illustration
  - Variability and uncertainty not separated
  - Important sources of variability and uncertainty fell outside analysis
  - Based on relatively little monitoring and dose-response data

## Modeled Ambient Concentrations

- Monitor-to-model ratio
  - 7 substances, 3 classes
  - Represents both bias and range of uncertainty
  - Inverted from earlier output for clarity -- multipliers for modeled estimates

Table 5-2. *Illustration*: Calculated percentiles for monitor:model ratio distribution.

| Monitor:Model Ratio for: | 2.5% | 5% | 50% | 95% | 97.5% |
|---|---|---|---|---|---|
| Stable gas | 0.69 | 0.78 | 1.4 | 2.6 | 2.9 |
| Reactive gas | 0.76 | 0.88 | 2.0 | 4.3 | 5.0 |
| Particulate | 1.2 | 1.4 | 4.9 | 16 | 20 |

## Modeled Exposures

- Personal-to-ambient ratio
  - From correlation coeffs. for PM and O3
    - Raw data not available
  - Represents:
    - Uncertainty in ME factors
    - Variation among individual activity
    - No bias

Table 5-3. *Illustration*: Percentiles for uncertainty and variability in the personal: ambient ratio distribution.

| Personal:ambient ratio for: | 2.5% | 5% | 50% | 95% | 97.5% |
|---|---|---|---|---|---|
| Gas | 0.09 | 0.14 | 1.0 | 7.6 | 13 |
| Particulate | 0.13 | 0.21 | 1.0 | 4.5 | 7.1 |

## Dose-Response

- **Carcinogens**
  - **Ratio of "true" potency for dataset to estimated potency**
  - **Represents statistical uncertainty**

Table 5-4. *Illustration*: Percentiles for variability in the benzene URE.

| Ratio of "true" URE to the estimated URE | 2.5% | 5% | 50% | 95% | 97.5% |
|---|---|---|---|---|---|
| Benzene | 0.14 | 0.19 | 1.0 | 5.3 | 7.2 |

- **Non-carcinogens**
  - **Uniform distribution from 0.3 to 3 (from order-of-magnitude uncertainty in def.)**

## Propagated Uncertainty and Variability

- **Propagation via Monte Carlo simulation**
  - **Ratios assumed independent**

$$(Mon2Mod)(Pers2Amb)(DR) = RR$$

Table 5-5. *Illustration*: Combined uncertainty and variability, in terms of the risk ratio (i.e., the ratio of "true" risk to estimated risk).

| Risk Ratio for: | 2.5% | 5% | 50% | 95% | 97.5% |
|---|---|---|---|---|---|
| Cancer: stable gas | 0.06 | 0.11 | 1.4 | 20 | 36 |
| Cancer: reactive gas | 0.08 | 0.14 | 2.0 | 29 | 51 |
| Cancer: particulate | 0.23 | 0.41 | 4.7 | 61 | 100 |
| Noncancer: stable gas | 0.13 | 0.22 | 2.1 | 19 | 33 |
| Noncancer: reactive gas | 0.16 | 0.27 | 2.9 | 29 | 48 |
| Noncancer: particulate | 0.48 | 0.76 | 7.0 | 57 | 92 |

## Propagated Uncertainty and Variability -- Reasonable Range of Risks

- Caveats
  - Major uncertainties outside analysis
  - Results for a few substances applied generally
- Results
  - Stable gases: Individual risks within a tract may "reasonably" range from ca. 1 order of magnitude lower to 1.5 OM higher
    - "reasonable" = 95% confidence limits
  - Reactive gases: ca. 1 OM lower to 1.7 OM higher
  - Particulate: ca. 0.5 OM lower to 2 OM higher
- Important sources of variability & uncertainty
  - Gases: personal-to-ambient ratio
  - Particulate: monitor-to-model ratio

## Future Uncertainty Analysis

- Table 5-6 provides framework for a more complete analysis (under consideration)
  - Full "bottom-up" under consideration
    - Components described by frequency distributions, aggregated by Monte Carlo
    - Need shape, bias, separation of variability from uncertainty for each component
    - Need to determine where to treat inputs individually and where to aggregate
  - Use of expert panels for each area
  - Possible data collection

## Risk Characterization: Key Limitations

- Based on 1996 data
- Quantitative risk estimates for only 32 substances
  - Qualitative discussion for diesel emissions
- Inhalation exposures only
- Inventoried emissions only
- Low resolution -- local risks not reliably captured
- Population averages rather than individual extremes

## Risk Characterization

- Cancer
  - URE = risk per ug/m3, for lifetime
  - Risk = URE for each substance x median exposure for each tract
  - Result: ca. 61K risk estimates x 29 substances

## Risk Characterization *(continued)*

- Combining cancer risks
  - Selected substances exceeding 1e-6 risk in the 99th %ile tract
  - Separated into proposed guidelines categories of "known" (i.e., Group A) and "likely" (i.e., Groups B and C) carcinogens
  - Risks summed for each group at tract level

## Risk Characterization *(continued)*

- Non-cancer
  - RfC = level believed safe
  - HQ = median exposure for each tract / RfC
    - Ratio between "safe" level and exposure
  - Result: ca. 61K HQs x 27 substances

## Risk Characterization *(continued)*

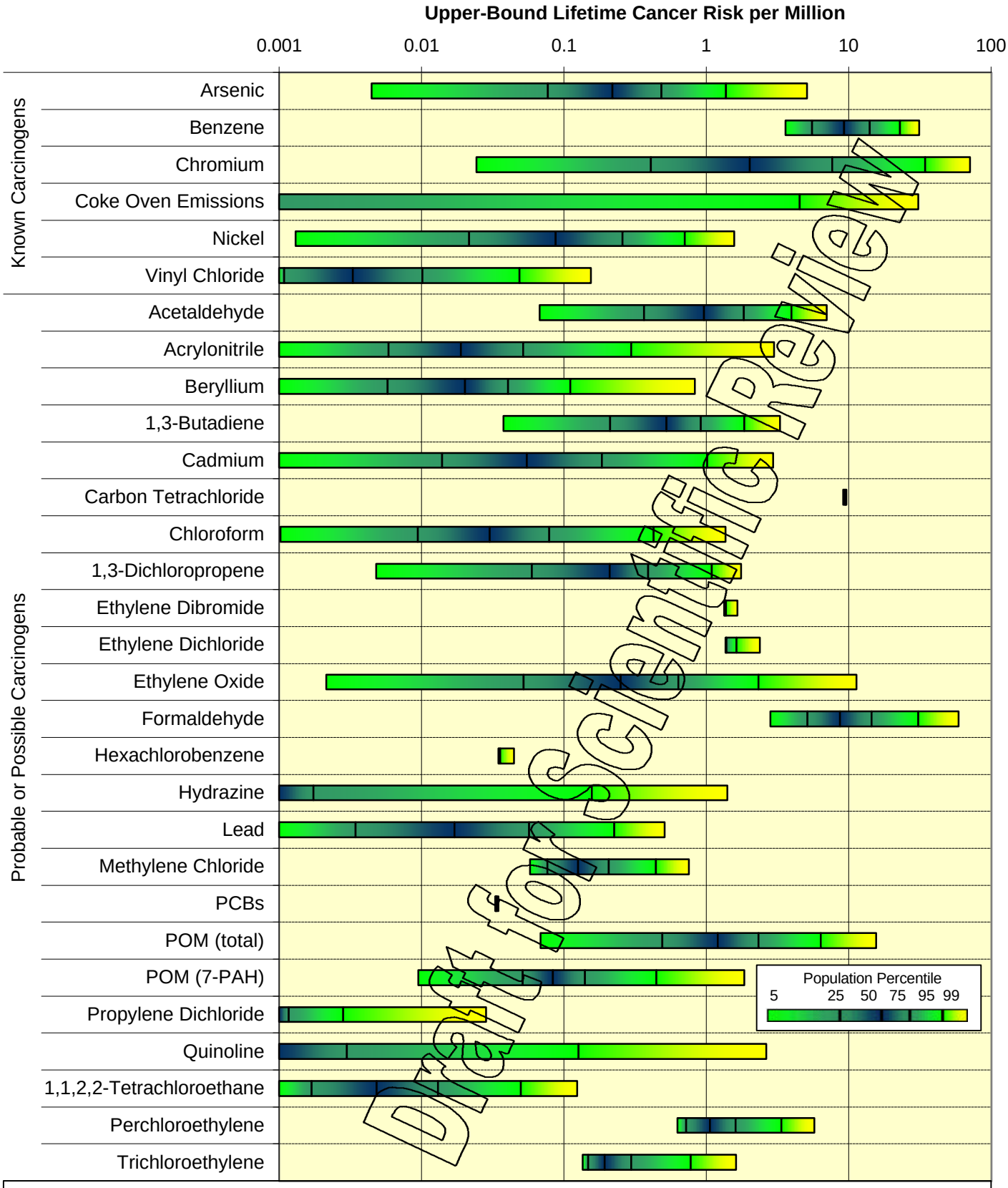
- Combining non-cancer hazards
  - HAPs that affect different organs may be independent
    - Adding all HQs not defensible (other than screening)
  - Hazard index = sum of HQs for similar modes of action
    - If MOA data not available, EPA guidelines suggest combining by target organ
  - Selected HAPs exceeding HQ=0.01 in 99th %ile tract

## Risk Characterization *(continued)*

- Separated into six target organs or systems
  - respiratory
  - cardiovascular
  - blood
  - liver / kidney
  - nervous
  - immune
- Separated into "high" and "low" uncertainty by UF range
- Sum of HQs (within 12 categories) = target organ specific hazard index (TOSHI)

# 1996 Risk Characterization

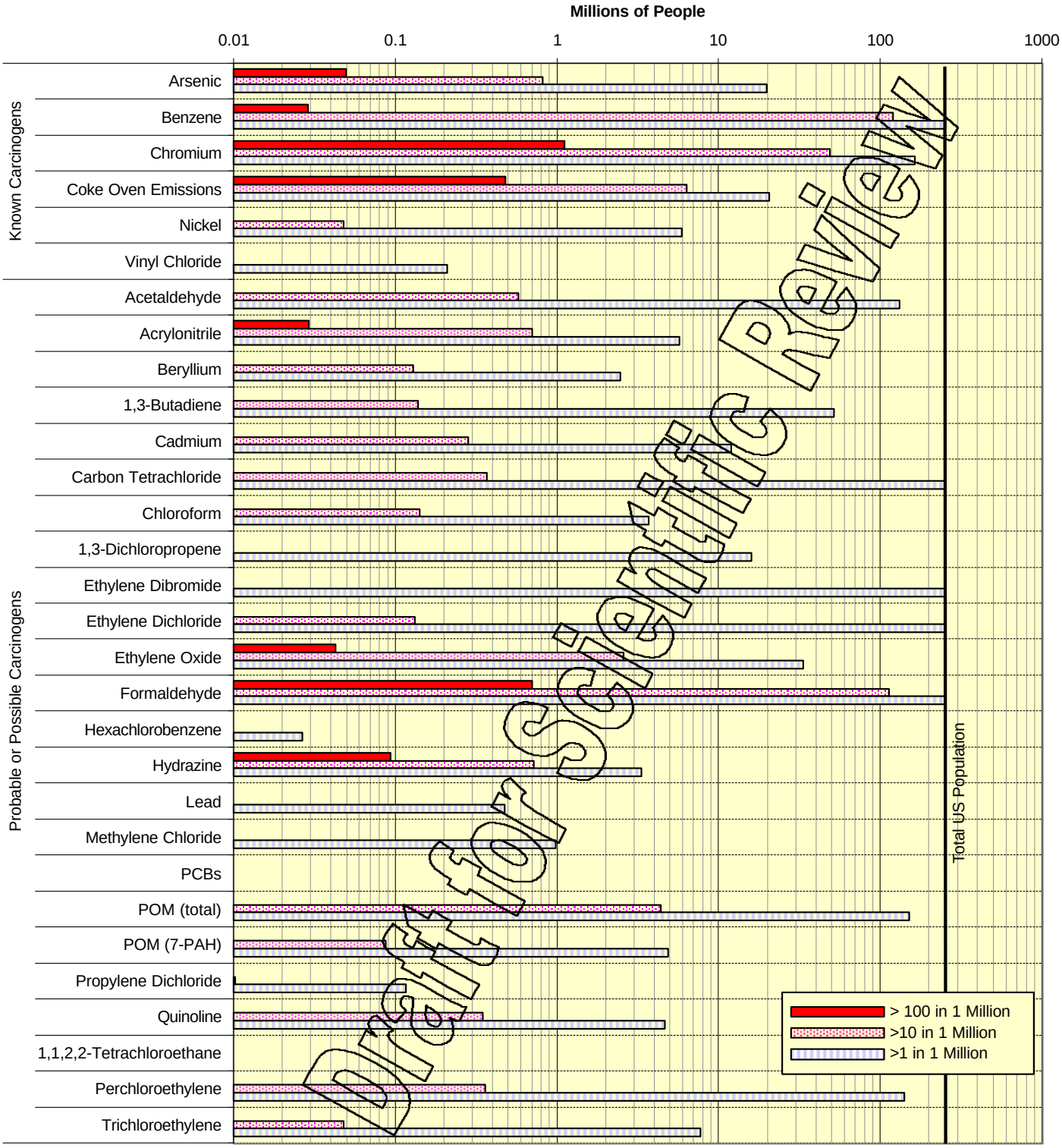
**Distribution of lifetime cancer risk for the US population, based on 1996 exposure* to all source sectors and background combined.**




* Results are based on inhalation exposure to outdoor sources only. Although these results assume continuous exposure to 1996 levels of air toxics over a lifetime, current and planned control programs are expected to substantially reduce these exposures and associated cancer risk for some pollutants. See additional information on the following page.

# 1996 Risk Characterization

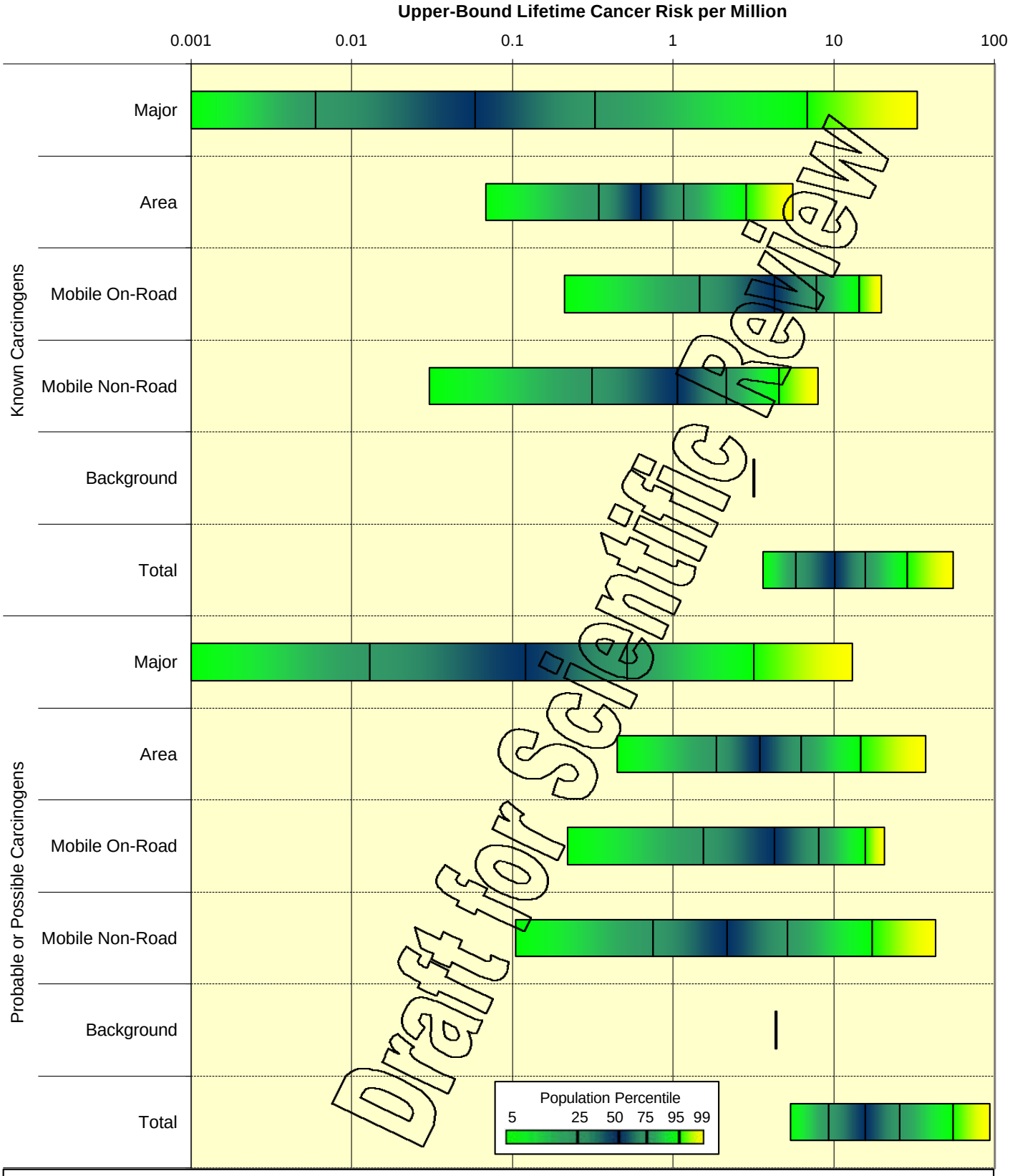
## Population whose 1996 exposure* exceeded set cancer risk levels based on all source sectors and background.




* Results are based on inhalation exposure to outdoor sources only. Although these results assume continuous exposure to 1996 levels of air toxics over a lifetime, current and planned control programs are expected to substantially reduce these exposures and associated cancer risk for some pollutants. See additional information on the following page.

# 1996 Risk Characterization

**Distribution of lifetime cancer risk for the US population, based on 1996 exposure* to multiple carcinogens.**

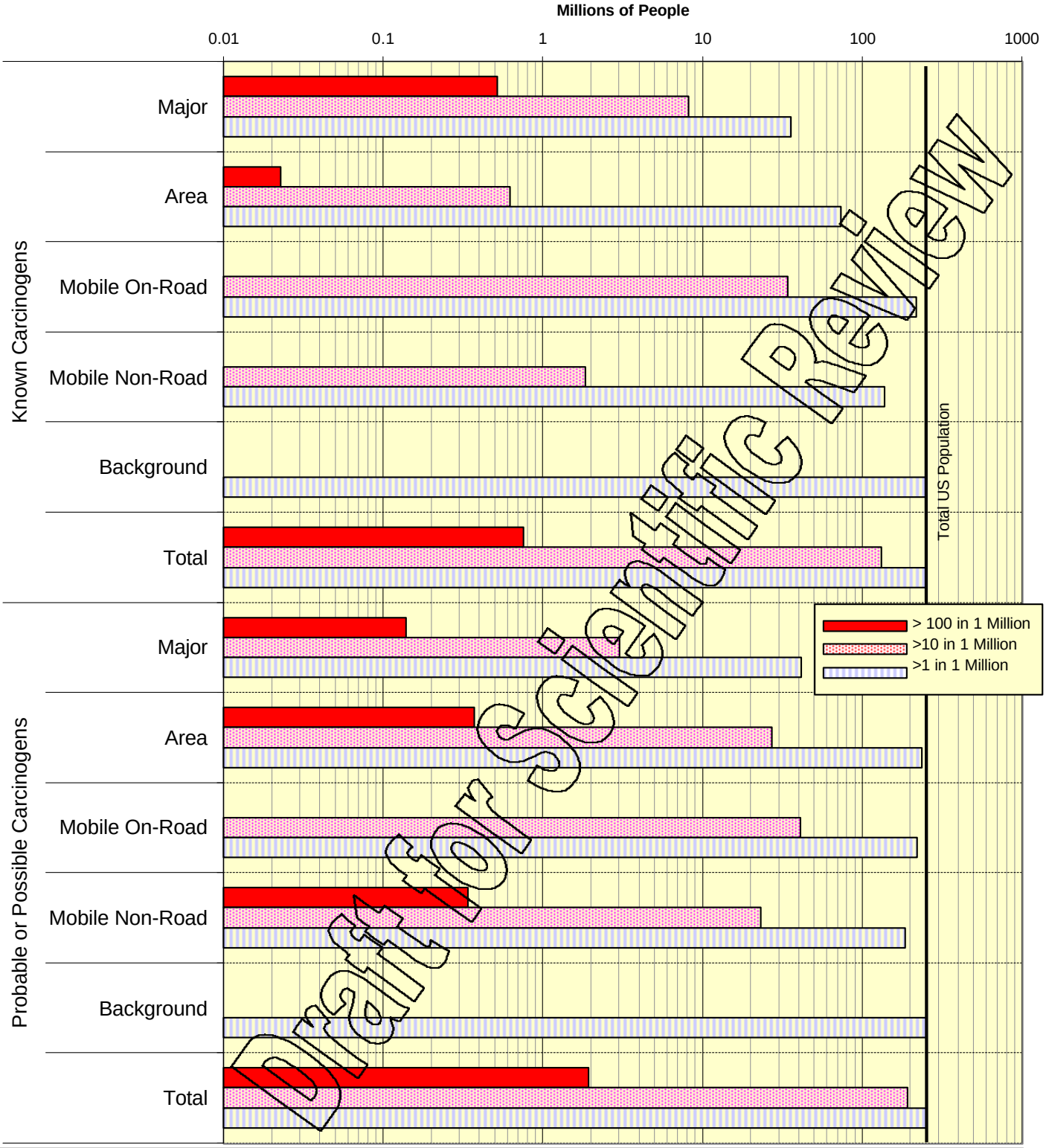



Draft for Scientific Review

* Results are based on inhalation exposure to outdoor sources only. Although these results assume continuous exposure to 1996 levels of air toxics over a lifetime, current and planned control programs are expected to substantially reduce these exposures and associated cancer risk for some pollutants. See additional information on the following page.

# 1996 Risk Characterization

**Population whose 1996 exposure* exceeded set risk levels of risk for carcinogens combined.**




* Results are based on inhalation exposure to outdoor sources only. Although these results assume continuous exposure to 1996 levels of air toxics over a lifetime, current and planned control programs are expected to substantially reduce these exposures and associated cancer risk for some pollutants. See additional information on the following page.

## Risk Characterization: Summary of Quantitative Risk Estimates

- National driver
  - Risk > 1e-5 for 10 million
  - HQ > 1.0 for 10 million
- Regional driver
  - Risk > 1e-5 to 2.5 million or risk > 1e-4 for 10,000
  - HQ > 1 for 10,000
- Important national contributor
  - Risk > 1e-6 for 10 million
- Important regional contributor
  - Risk > 1e-6 for 2.5 million
  - HQ > 1 for 10,000

## Diesel Risk Characterization

- National-scale assessment characterizes potential diesel risk in terms of:
  - Carcinogenic effects
  - Non-cancer effects
  - Contribution to PM mortality

## Diesel Exhaust Carcinogenicity

- Assessment of potential cancer risk for diesel exhaust guided by EPA's draft HAD and CASAC's comments. The conclusions:
  - Diesel exhaust is likely to be a human carcinogen at environmental exposure levels.
  - Ubiquity of exposure – particularly in highly populated areas.
    - Low end of occupational exposure overlaps with or within 10-fold of environmental exposures.
  - While EPA did not believe that a potency factor could be derived at this time, CASAC concurred with EPA's attempt to present perspective on potential risk (i.e., a risk range was provided with careful description of limitations and assumptions)

## Comparison to Other National-Scale Assessment Air Toxics

- In comparative terms, EPA concluded that diesel exhaust ranked with the other 11 substances that the assessment suggests pose the greater risk (of the 33 substances evaluated). This view is based on a qualitative analysis of:
  - The conclusions of the draft HAD as modified by CASAC (previous slide)
  - The national-scale assessment itself (which confirms the exposure conclusions in the HAD)
  - The fact that the diesel hazard assessment is based on 22 epidemiology studies:
    - many of which show increased lung cancer associated with diesel exhaust
    - in contrast, most of the other HAPs evaluated for NATA have carcinogenic risk estimates based on animal studies

## Risk Characterization: Summary of Draft Quantitative Risk Estimates

- National drivers
  - Acrolein
  - Benzene
  - Carbon tet.
  - Chromium
  - Formaldehyde
- Regional drivers
  - Arsenic
  - Coke oven emissions
  - Ethylene oxide
  - Manganese
  - POM
  - Hydrazine
- National contributors
  - Acetaldehyde
  - 1,3-Butadiene
  - Ethylene dibromide
  - Ethylene dichloride
  - Perc.
  - POM
- Regional contributors
  - Acrylonitrile
  - Cadmium
  - Chloroform
  - 1,3-Dichloropropene
  - Hydrazine
  - Nickel
  - Quinoline
  - Trichloroethylene

## Risk Characterization: Summary of Draft Quantitative Risk Estimates

- Not found to be drivers or contributors
  - Beryllium
  - Hexachlorobenzene
  - Lead compounds
  - Mercury compounds
  - Methylene chloride
  - PCBs
  - Propylene dichloride
  - 1,1,2,2-Tetrachloroethane
  - Vinyl chloride
- But --
  - Inhalation exposure only
  - Low resolution
  - No individual extremes