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Fracking Fumes: Air Pollution Impacts on Health and Well-Being

Health and Shale Gas Development: State of the Science Conference

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Hell on Wheels: Port Authority's Broken Promise Is Choking Newark's Kids

BY MAX RIVLIN-NADLER

May 3, 2016

Seaport and UNGD Communities? What's the Connection?

- Similarities in chemical hazards and exposures
- Disproportionate distribution of risks and benefits
- Environmental justice (EJ) usually focused on urban areas, poor communities, and people of color…
- But similar principles apply to unconventional natural gas development (UNGD)

Health Effects of Air Pollution on Local Communities

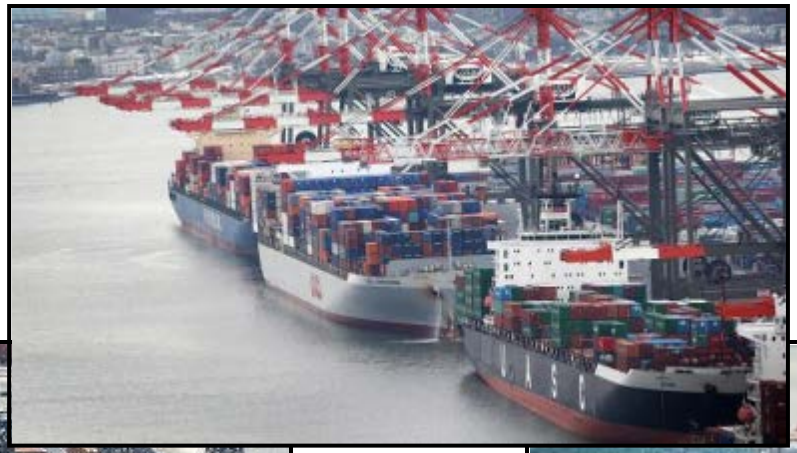
No UNGD sites in New Jersey

…but we do have air pollution

Most air emissions from fracking are not new

…but 'hyperlocal' impacts are a big knowledge gap

Ports-impacted Environmental Justice (EJ) communities : Newark/Elizabeth Seaport and Airport



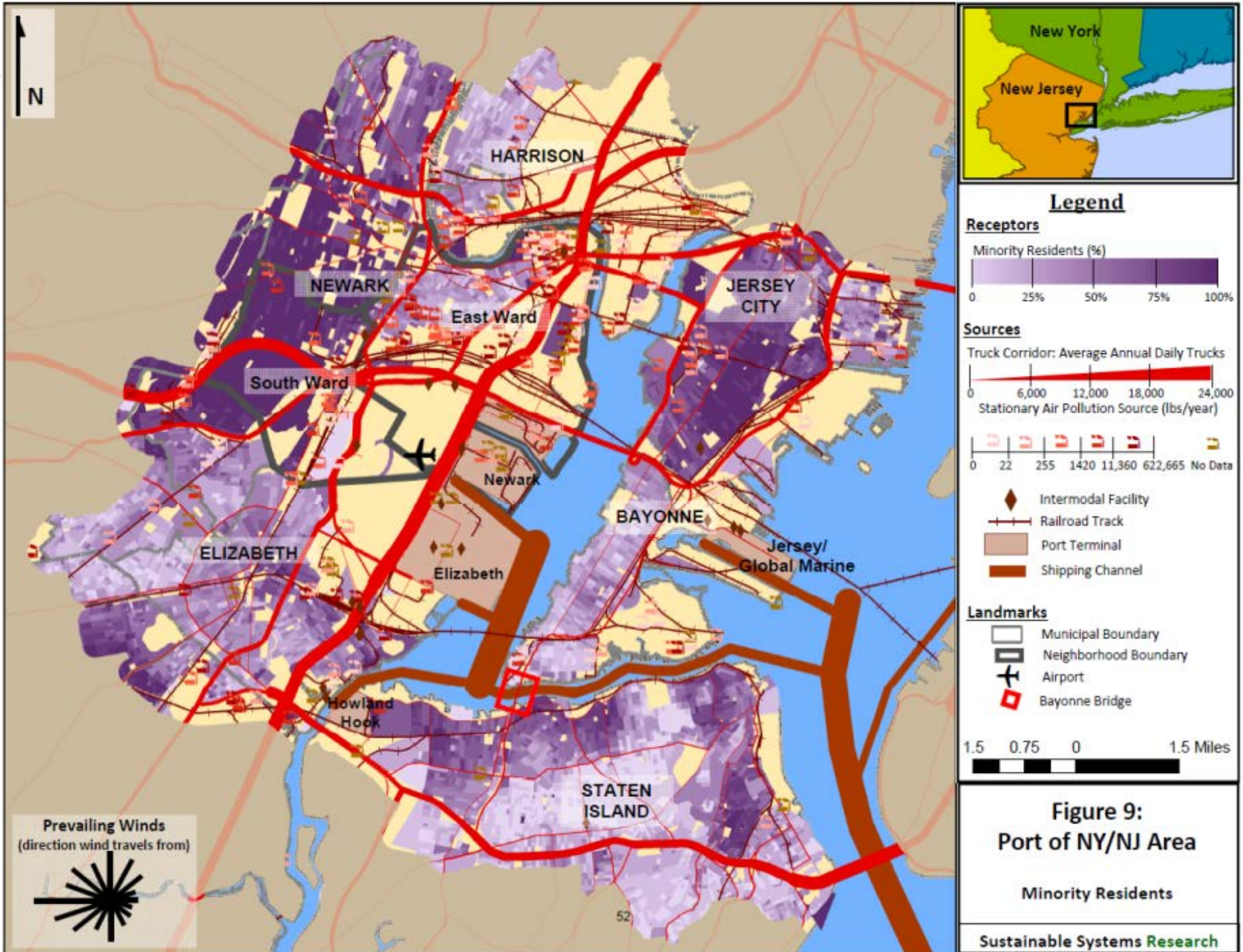


Figure 9:
Port of NY/NJ Area

Minority Residents

Sustainable Systems Research

Location of Ambient Air Monitors around Ironbound, Newark, NJ

Liberty Airport

Diesel Trucks in Newark

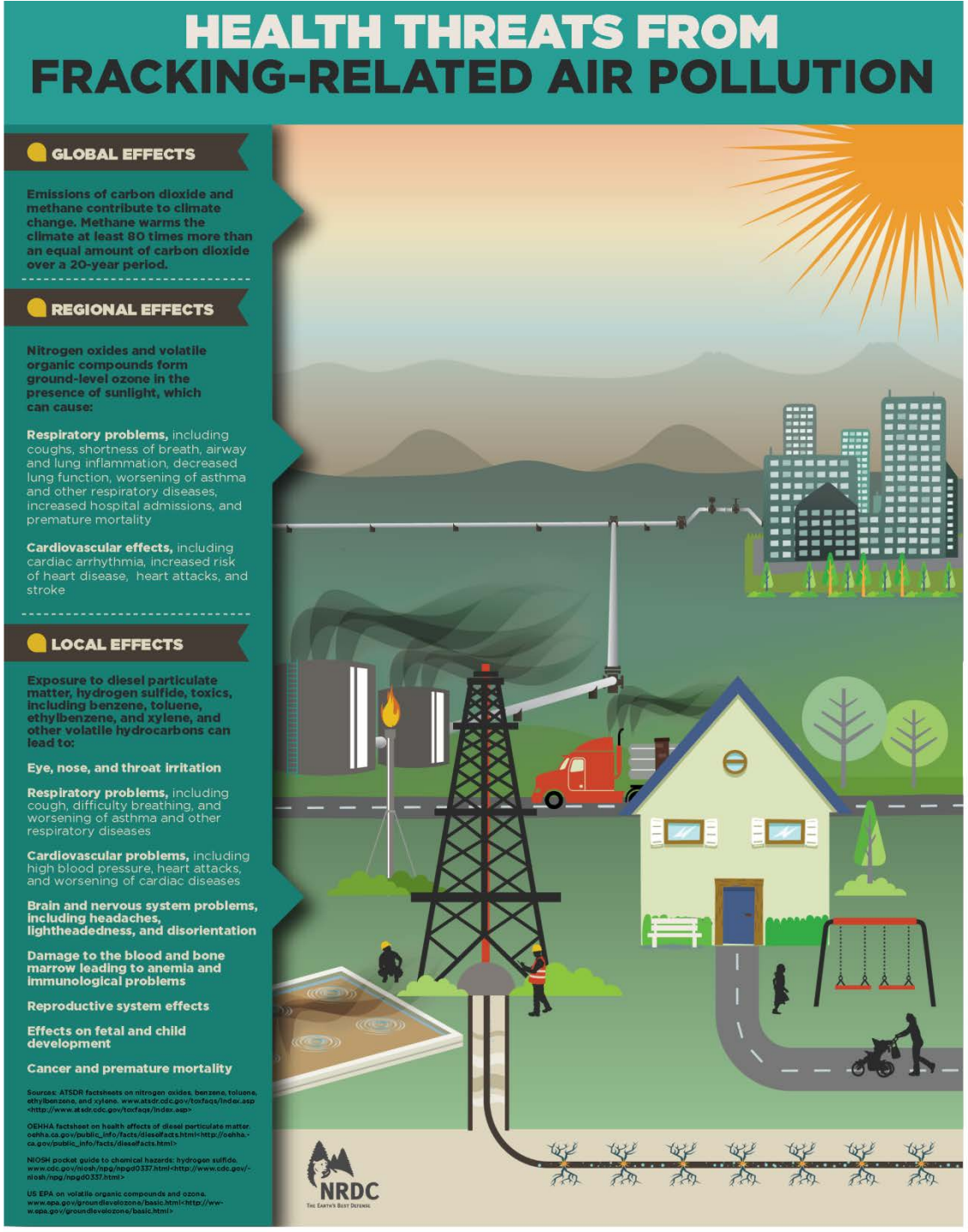



Community members counted 144 diesel trucks passing by Hawkins Street K-8 School in the Ironbound from 7:30 to 8:30 AM on Dec 11, 2009.

UNGD: Potential Environmental Hazards

- Water pollutants
- **Air pollutants**
- Noise
- Other stressors
  - Light
  - Anxiety
  - Psychological stress

NRDC (2014)
Fracking Fumes: Air Pollution from Hydraulic Fracturing Threatens Public Health and Communities



Community-Centered Concerns

- **UNGD communities**
  - Disease
  - Illness
  - Symptoms
  - Exposures
  - Uncertainty
  - Distrust
  - Global Energy Industry
- **“Traditional” urban EJ communities**
  - Disease
  - Illness
  - Symptoms
  - Exposures
  - Uncertainty
  - Distrust
  - Global Goods Movement Industry

Current Challenges

- Characterizing exposure: What? How much? Where? When? How long?
- Multiple exposures and stressors
- How do we take a more holistic approach?
  - Empirical evidence of symptoms, illness, disease
  - Learning more about ‘hyperlocal’ impacts
  - In what ways can we generalize about local conditions?

Air Pollutants from UNGD

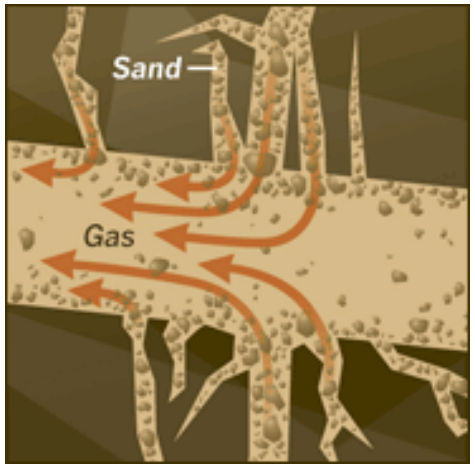
1. Non-methane hydrocarbons and other consituents of raw natural gas
2. Fracking fluid compounds
   - Many and ??
3. Combustion products
   - Particles
   - Gases and vapors
4. Road “dust”
5. Secondary air pollutants
   - Ozone

Air Pollutants from UNGD

- Natural gas constituents
  - Average raw nature gas composition:
    - 78% benzene, 18% Non-Methane Hydrocarbons (NMHCs), less than 2% nitrogen, carbon dioxide, hydrogen sulfide, and water
  - NMHCs
    - Ethane, propane
    - Benzene, ethyl benzene, toluene, xylene (BTEX), etc.
- Released during drilling, from “produced water,” condensation tanks

Air Pollutants from UNGD

- Fracking fluid compounds
  - Silica
  - Propietary formulations
    - Solvents
    - Acids
    - Surfactants
    - Lubricants
    - Biocides, etc.



NIOSH

Air Pollutants from UNGD

- Combustion products
  - Diesel exhaust (drill rigs, trucks, compressors)
    - Particles – “diesel particulate matter” (DPM)
    - Vapors and gases
      - VOCs (Benzene, formaldehyde, etc)
      - Polycyclic aromatic hydrocarbons (PAHs)

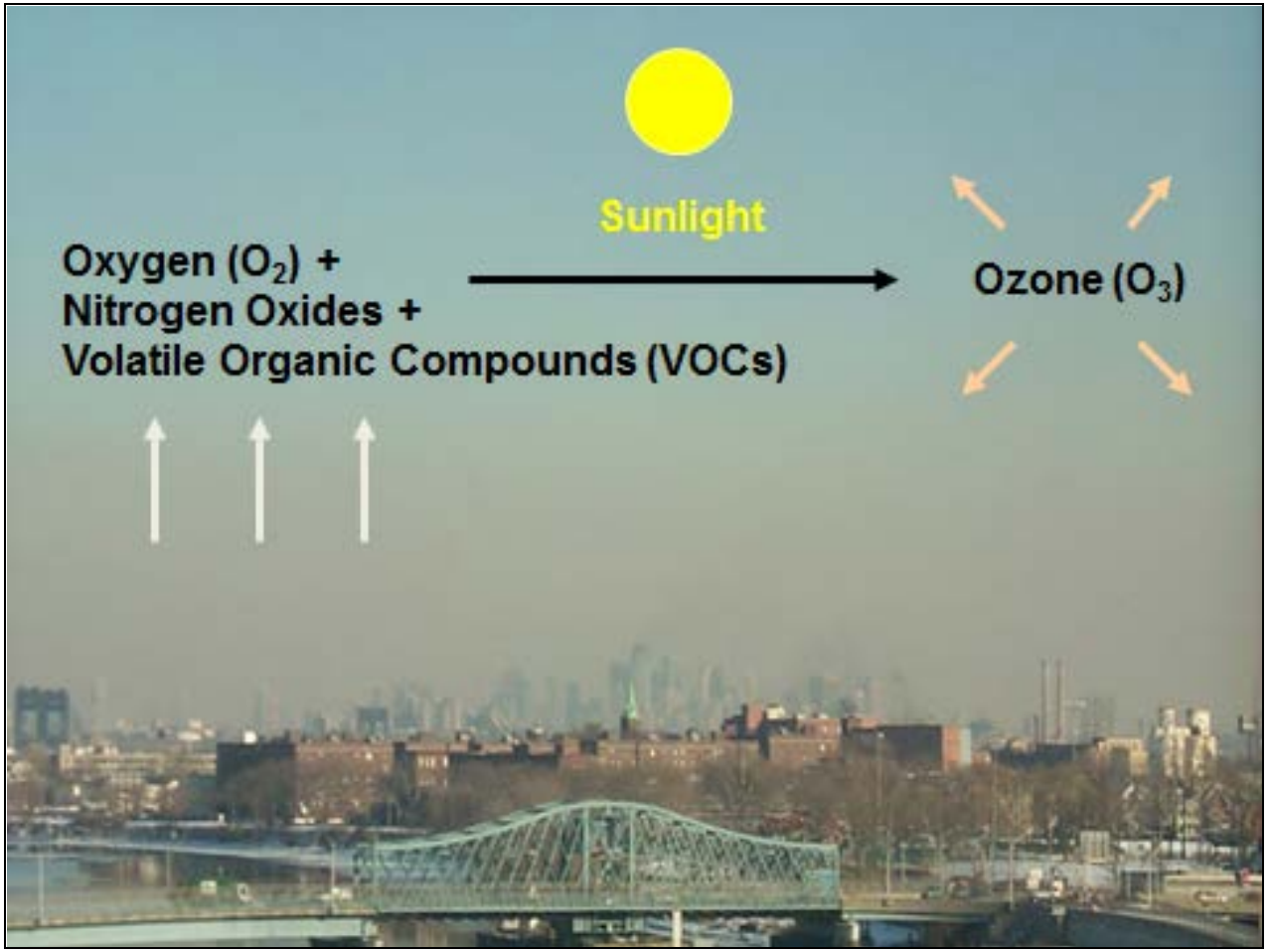
US Geological Survey

Air Pollutants from UNGD

- "Dust" – onsite and roadway
  - "Crustal material"
  - Re-suspended contaminants

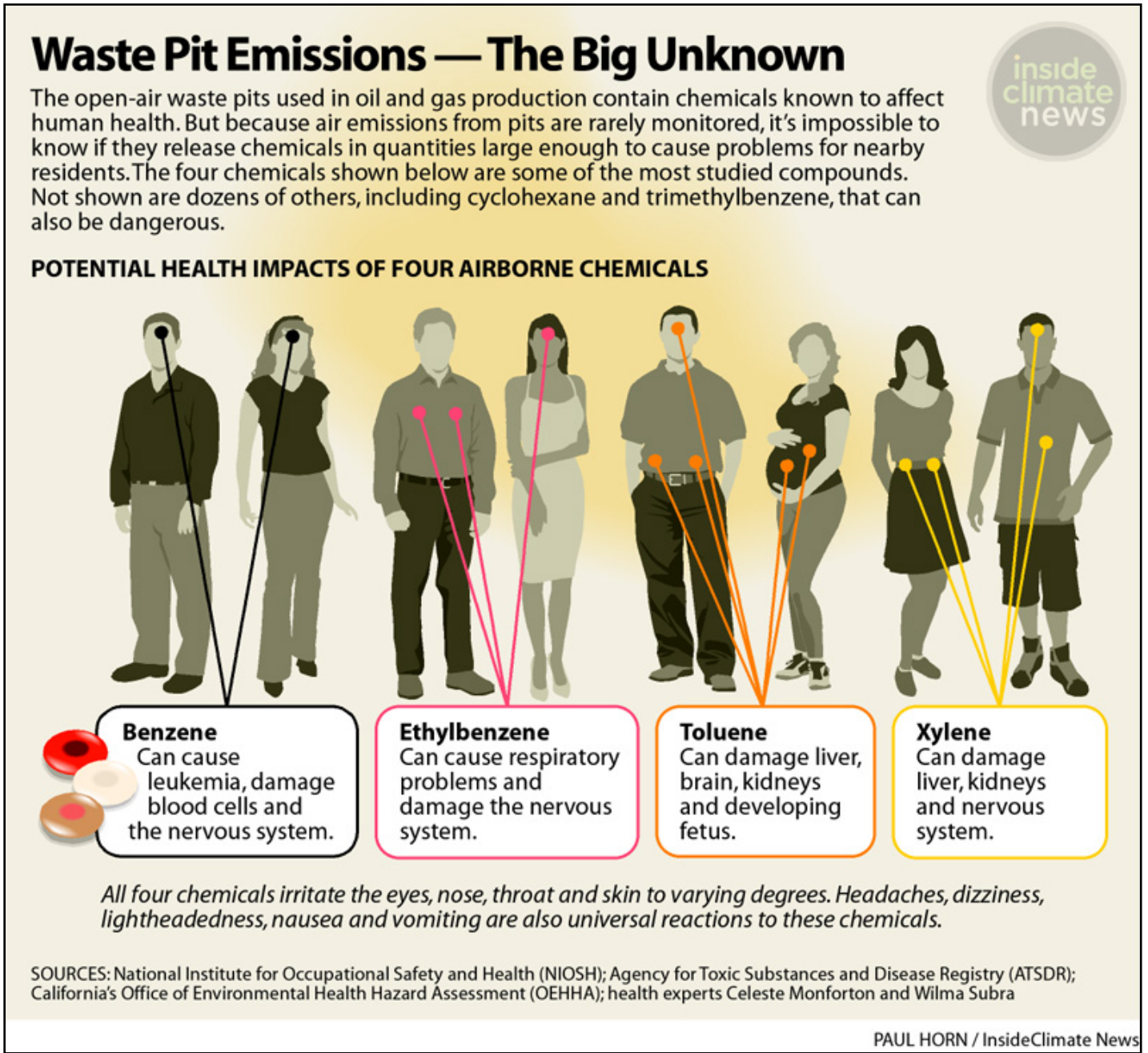
Air Pollutants from UNGD

- Secondary air pollutants - Ozone



What can these pollutants do to health?

Example Open-Air Waste Pit Emissions:



What is the Goal?

"**Health** is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

World Health Organization

Health Outcomes that Matter

- **Five D's**
  - Death
  - Disease
  - Disability
  - Discomfort
  - Dissatisfaction

Health Outcomes are Rarely Ever Certain

- **Risk = Hazard x Exposure**
- Hazard: Intrinsic toxicity of the agent
- Exposure: Determines the dose
- “The dose makes the poison” –Paracelsus

Risk in the “Real-World”

- But risk occurs in a context
  - Places/locations
  - Time
  - People
    - Susceptibility
    - Individual values
- How complicated is that!?

Risk = Hazard x Exposure:

Assessing Hazard

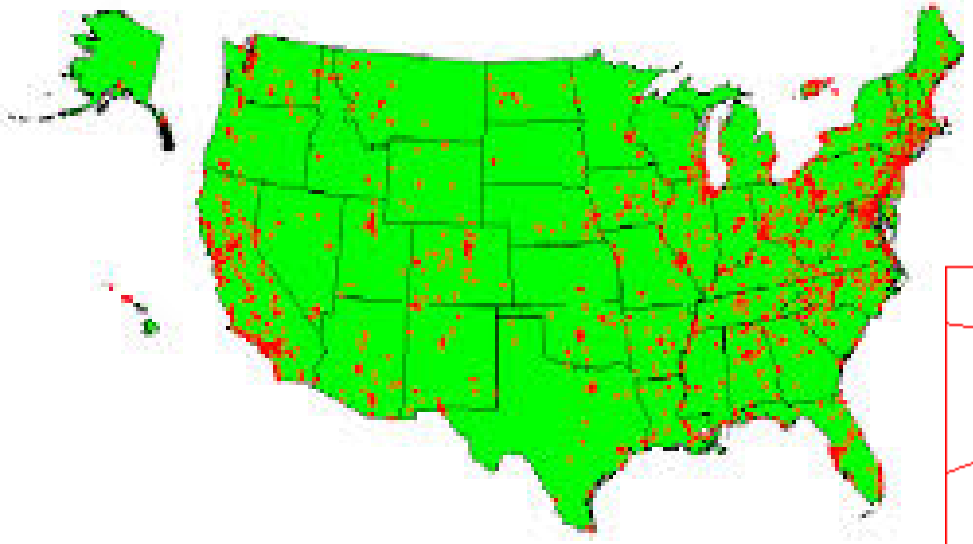
- Animal models
- Controlled exposure (chamber) studies with human volunteers
- Studies of workers: compare the experience of exposed workers to unexposed workers

Risk = Hazard x Exposure: Assessing Hazard

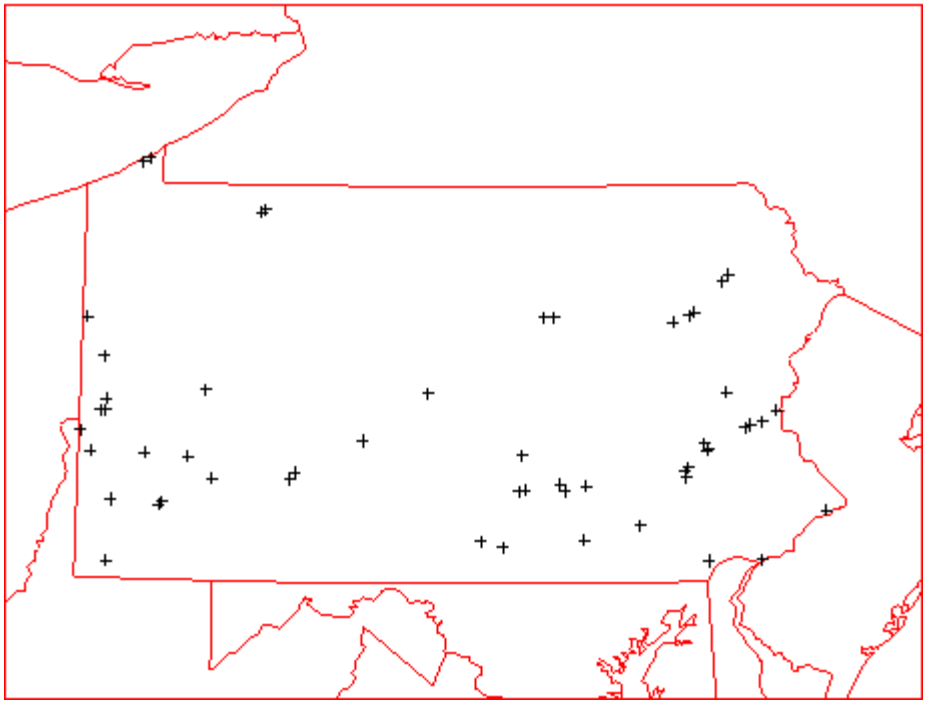
- Population studies
  - Cohort studies: Compare people living in cities with different air pollution levels
  - Time-series studies: Examine deaths and hospitalizations from day-to-day in the same population
  - Panel studies: Follow smaller groups of people over time with monitoring of exposure

Standards: National Ambient Air Quality Standards (NAAQS)

State and Local Monitoring (SLAMS) Network



Pennsylvania Air Monitoring Network



NAAQS Relevant to UNGD

- Particulate Matter ($PM_{2.5}$ and PM_{10})
  - Includes diesel particulate matter, other combustion products, road dust
- Inorganic gases
  - Nitrogen oxides (NOx)
  - Carbon monoxide (CO)
- Secondary pollutants
  - Ozone (O_3), formed from NOx and VOCs

EPA Hazardous Air Pollutants (HAPS)

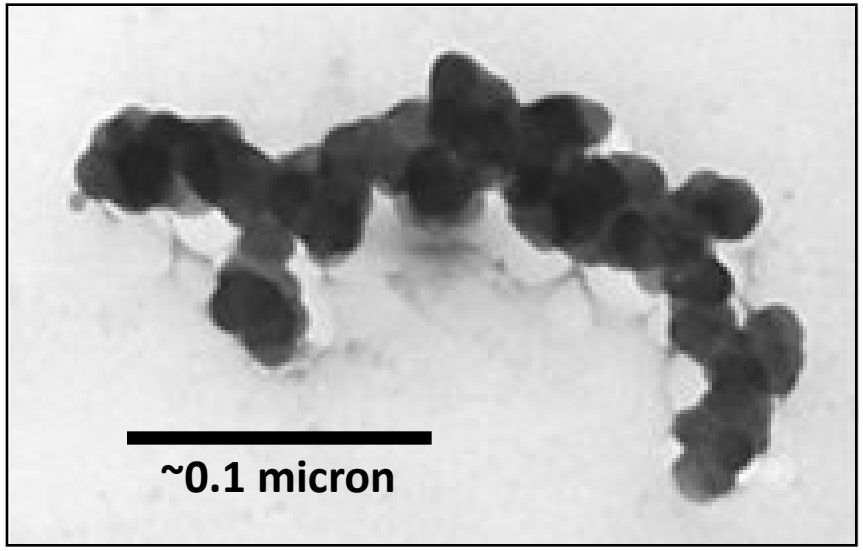
- a.k.a Air Toxics
- HAPs have no concentration standards
  - Reference concentrations: noncancer and cancer
- Performance standards for controls on emissions

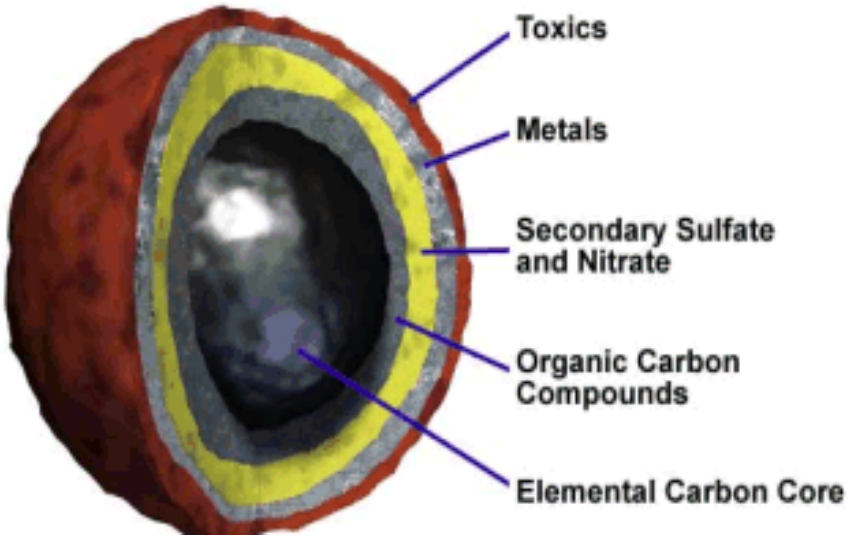
HAPs and other VOCs Relevant to UNGD

- VOCs
  - Non-methane hydrocarbons, eg. BTEX
  - Fracking fluid components
  - Vehicle and equipment emissions
- Some can cause cancer, birth defects, nervous system effects, etc.
- Some implicated in asthma, developmental disorders

Diesel Exhaust: A Mixture of Particles, HAPs, and other VOCs

- Particles less than 2.5 microns (PM 2.5)
- Mostly less than 0.1 micron (“ultrafine”)
- 40 known toxic chemicals
- Black carbon measured as a “marker”
- Air levels not regulated, per se.





Particulate Matter Air Pollution

- Health effects
  - Respiratory disease and death
  - Cardiovascular disease and death
  - Developmental?
  - Neurodegenerative?

Diesel Exhaust and Cancer Risk

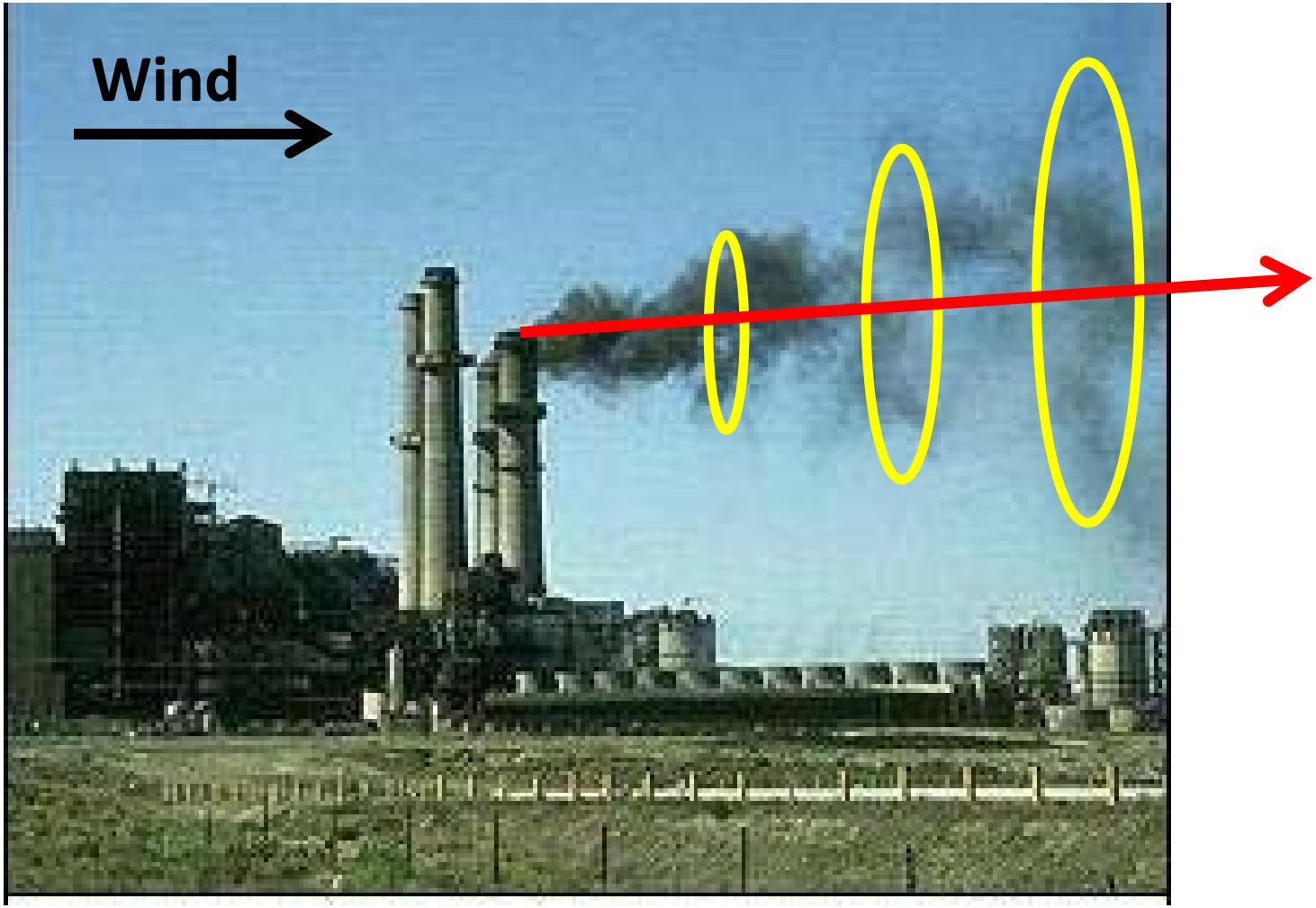
- Miner studies: Increased lung cancer
- IARC 2012– Diesel exhaust causes lung cancer
- Exposure assessment
  - Relatively high levels in confined spaces
  - Long periods of exposure
- Is intermittent exposure a cause of cancer?

Risk = Hazard x Exposure:

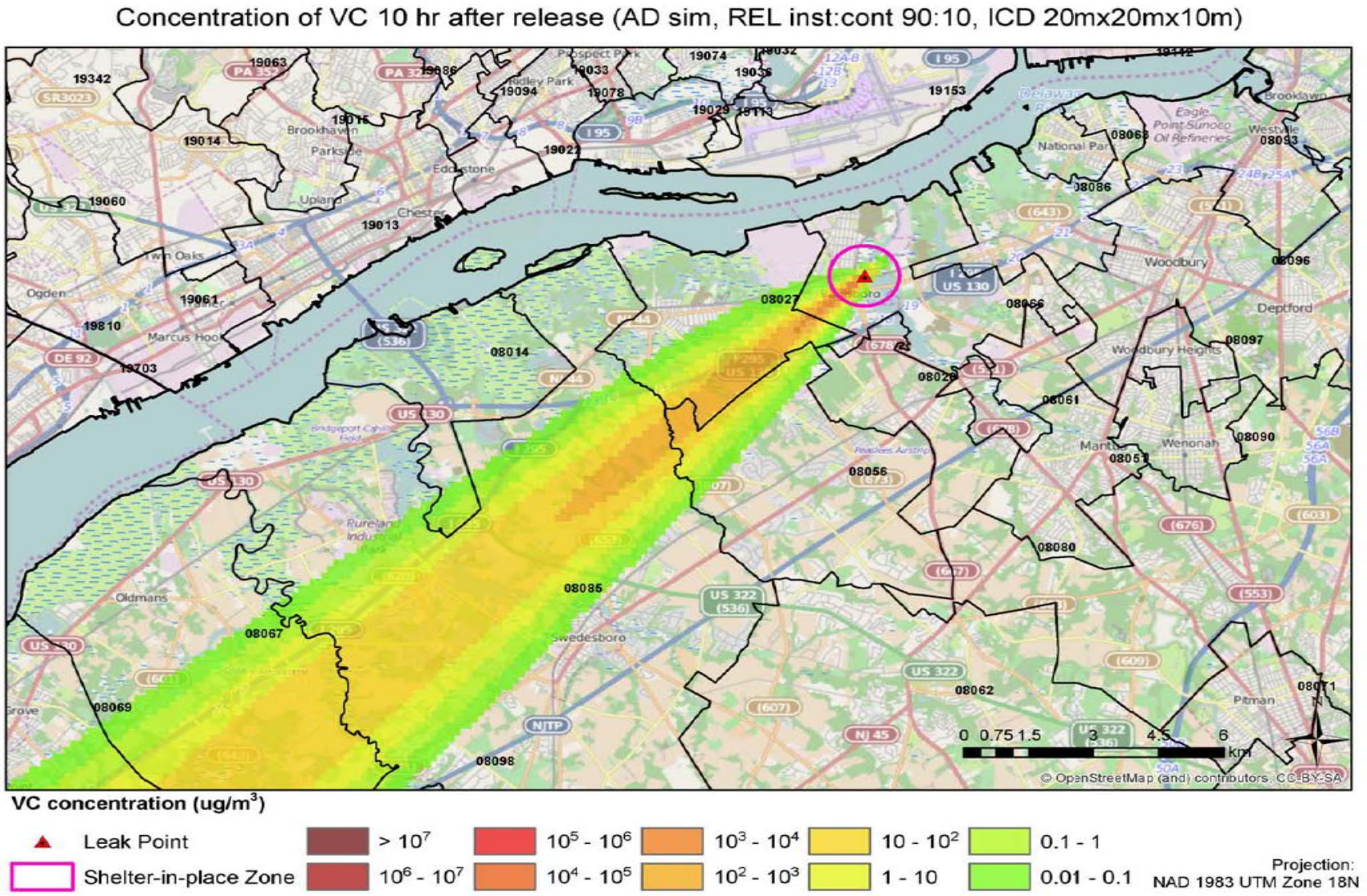
Assessing Exposure

- Exposure pathways
  - Source, transport, route of exposure, exposure
- Transport: Air that moves
- Route of exposure: Primarily inhalation
- Dispersion
  - “Source strength”
  - Wind direction and speed
  - Topography
  - Vertical mixing

Dispersion of air pollutants



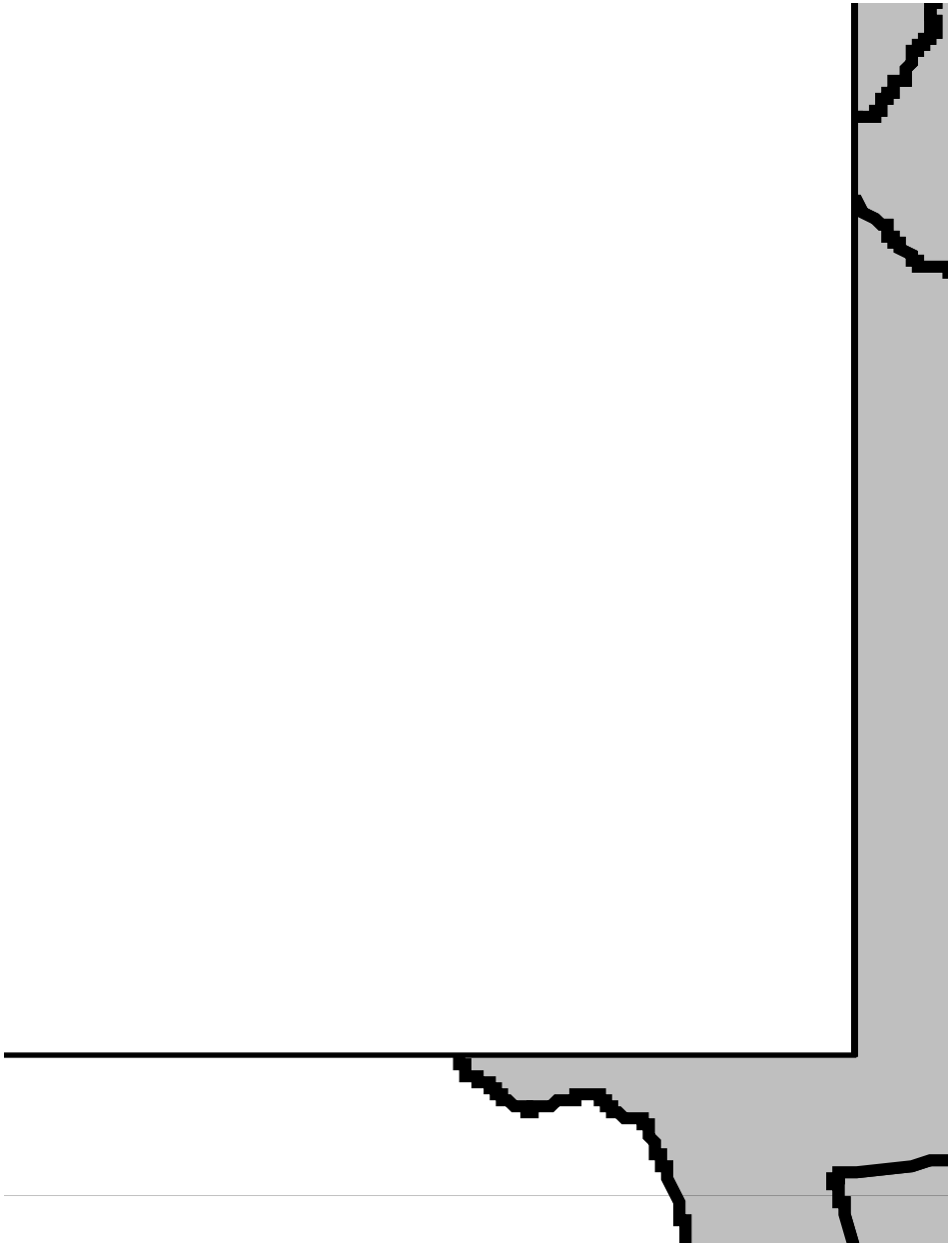
For illustration purposes:
Modeling the plume of a vinyl chloride spill in New Jersey



Local effects of air pollution: Diesel exhaust cancer risk in NJ

- Risk of lung cancer may be as high as about 1 in 1,000 from lifetime exposure to diesel particulate matter in some urban communities in NJ

Diesel Particulate Matter Lung Cancer Risk 2020



Benchmark = 1 in 1 million risk level

Health Effects of Short-Term Exposures to Diesel Exhaust

Some of our research approaches:

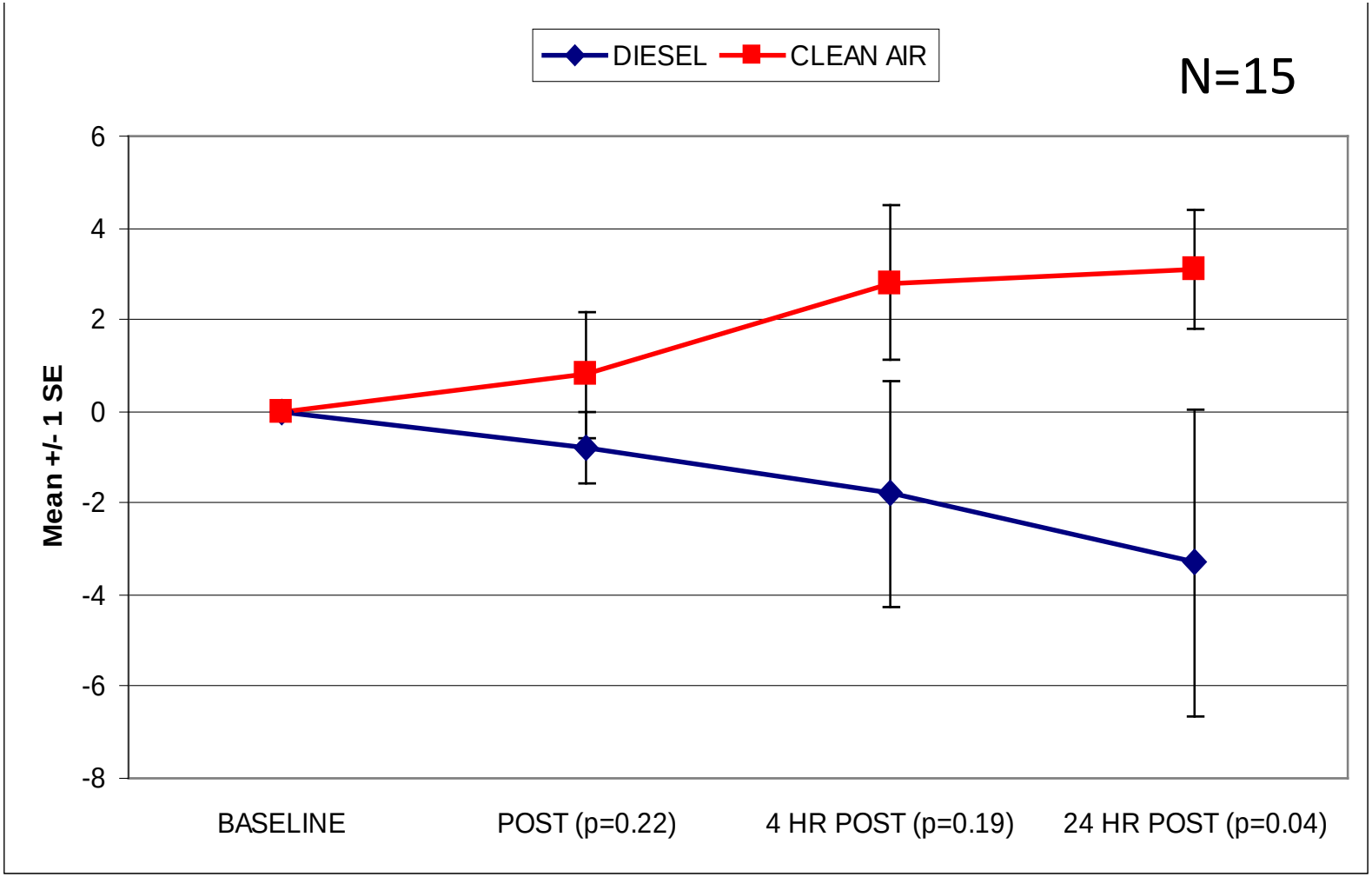
1. Controlled environment facility
2. On highways during commuting
3. In affected communities

A Controlled Exposure Study

- Isolate the effect of the air pollutant
- 15 adults with asthma
- Exposure to diluted diesel exhaust (300 ug/m3) for 1 hour
- Compared to clean air
- Lung function, airway hyperreactivity, measures of oxidative stress

FEV1 before and after diesel vs clean air exposure among adults with asthma

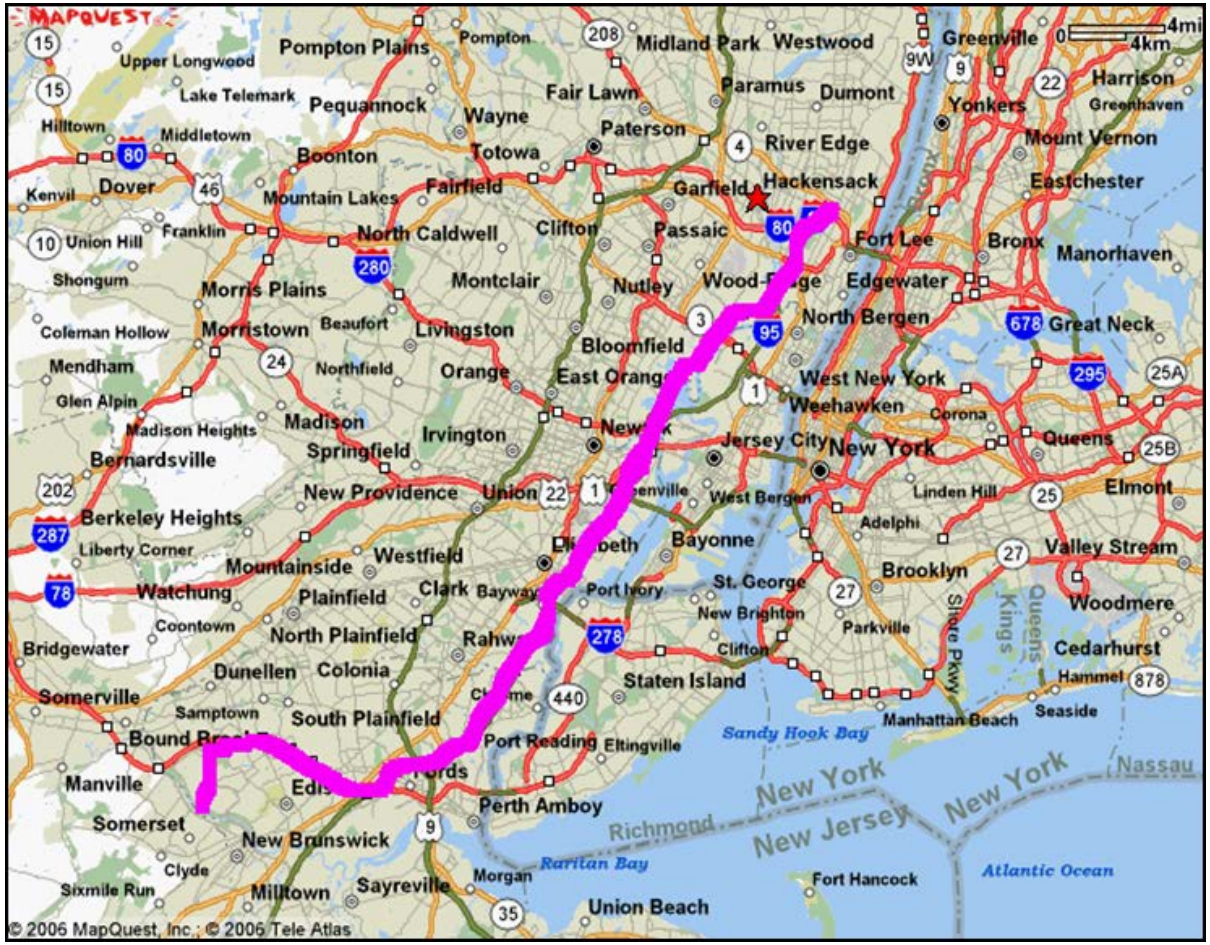
(FEV1 as % predicted)



Hussain, S. et al. (2012) JOEM 54(10): 1186-191.

Commuter Exposure to Diesel Exhaust

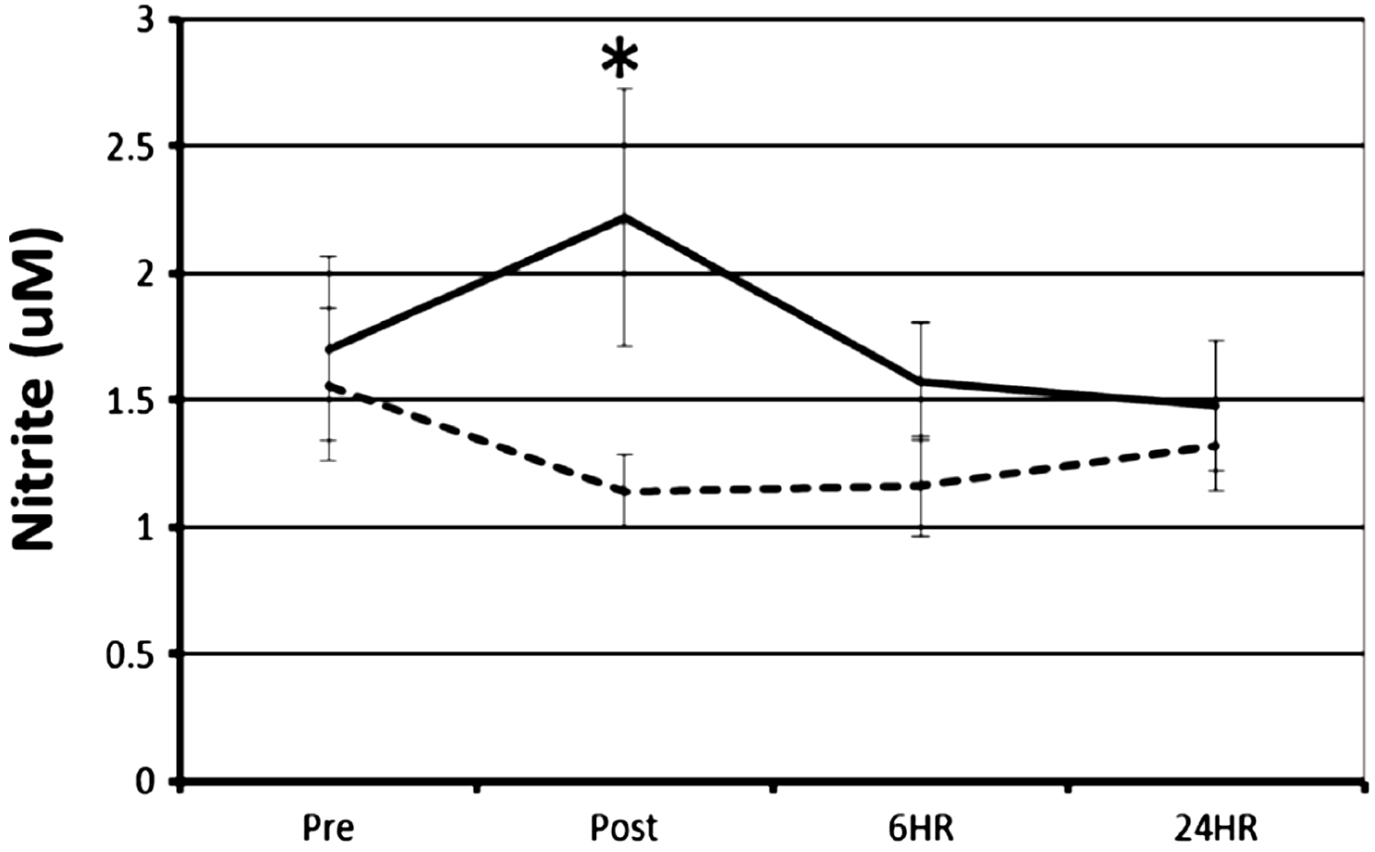
90-minute rides from campus to Exit 18 and back, mostly on NJ Turnpike in the truck lanes



One recent study: 21 healthy adult volunteers on 2 rides at least 1 week apart:

- One ride breathing clean air with particles filtered out
- One ride breathing regular “highway air”

Nitrite levels in exhaled breath condensate before and after traffic particle (solid line) vs. filtered air exposure (dotted line)



Laumbach RJ et al. (2014) Particle and Fiber Toxicology. 11:45.

Community Study: Impacts of Exposure to Diesel Exhaust on Asthma

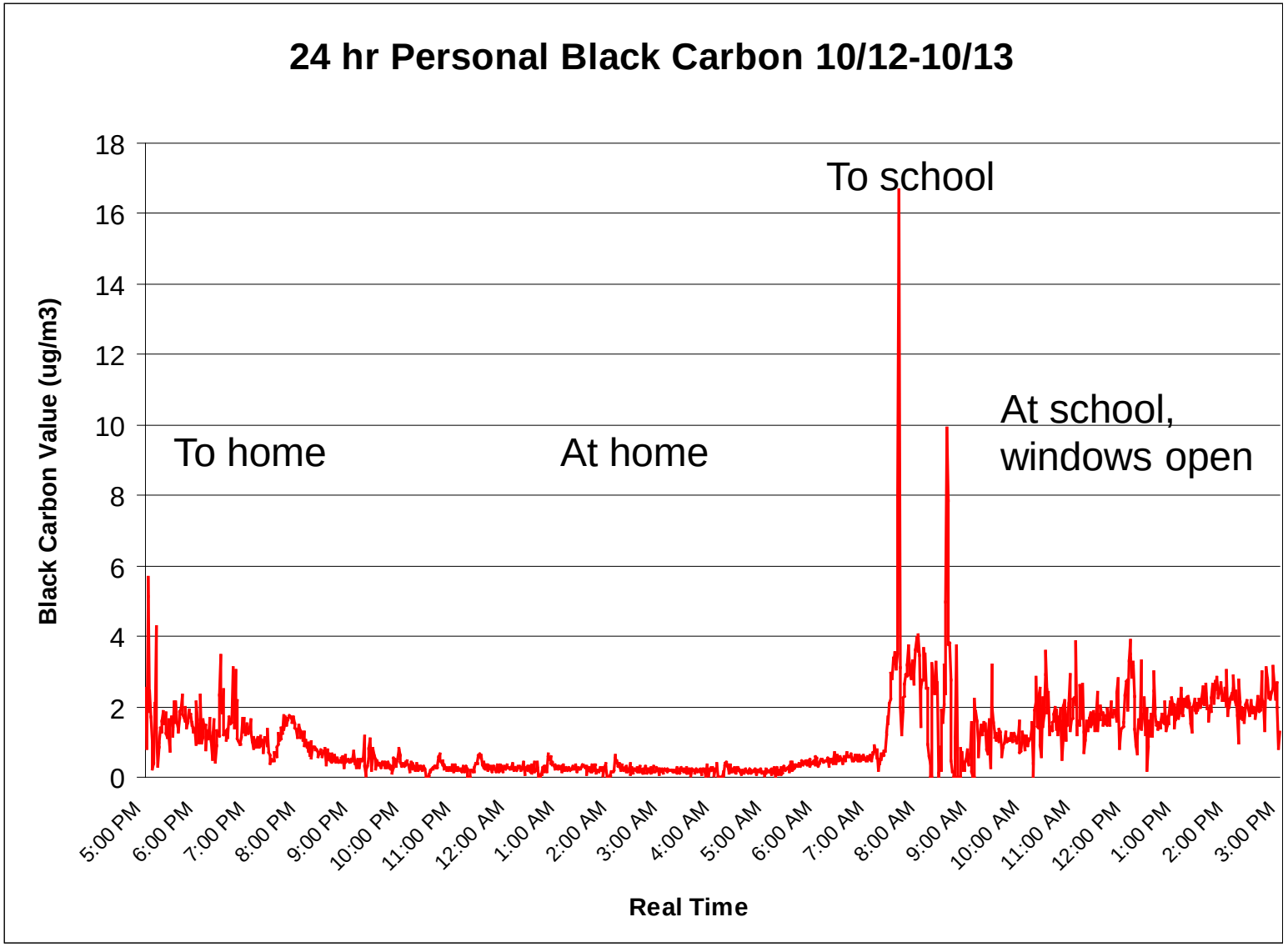
- "Effects of Traffic Air Pollution and Stress on Childhood Asthma in an Urban Community," funded by US EPA
- A community-based participatory research project with the Ironbound Community Corporation
- 40 children aged 9-14
- Wearing personal monitors for black carbon and NO_2
- Stress levels measured by interviews and stress hormone levels
- Does stress makes kids more susceptible to the effects of air pollution on asthma?

Monitoring personal exposure to traffic-related air pollution in Newark NJ

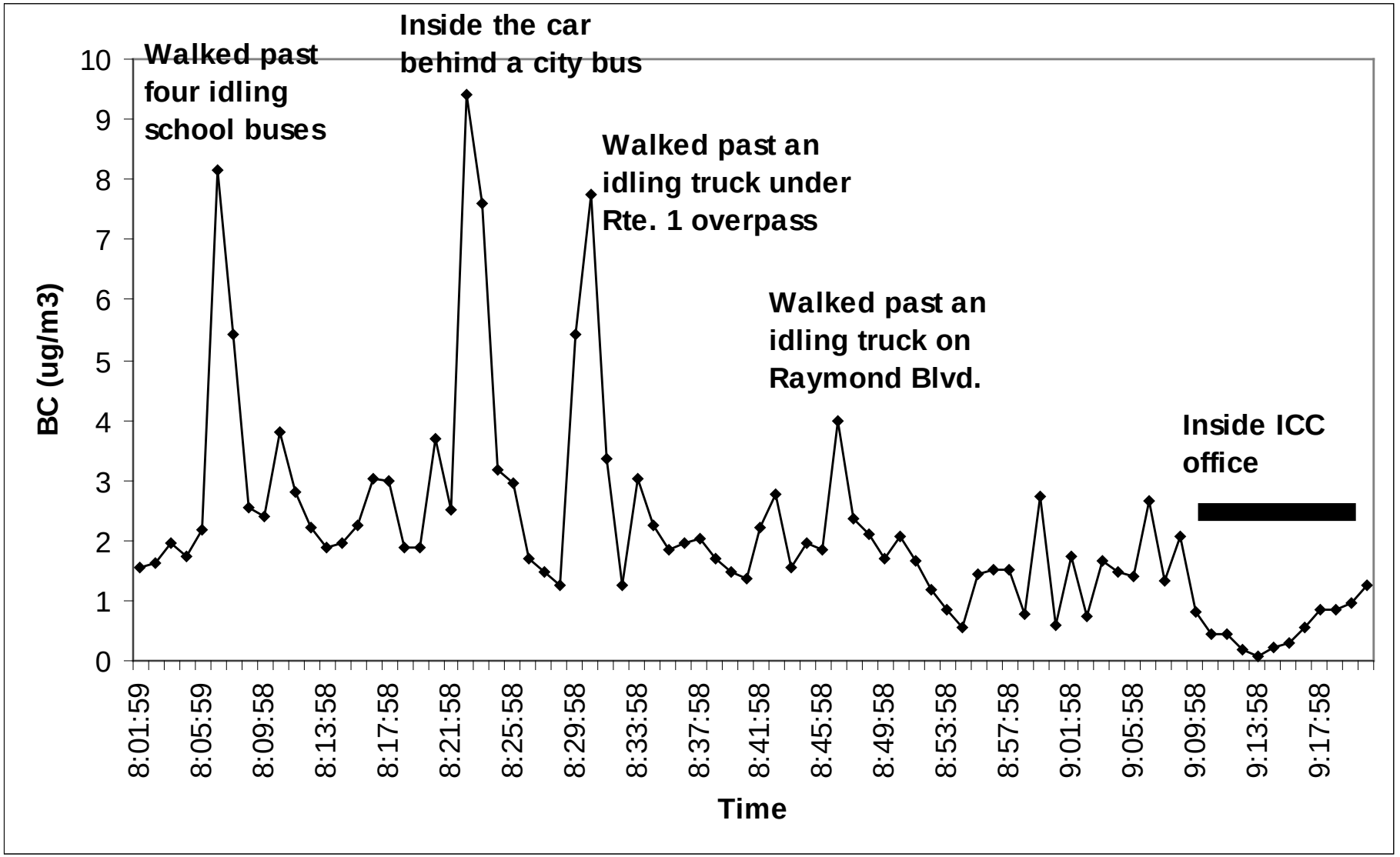
Personal black carbon monitor:
24-hr continuous 1-min. ave. with GPS location

Ogawa Passive Sampler
for NO_2, daily 24-hr average

Black carbon levels during one day for one participant



Personal BC data Elizabeth-Newark



Controlling Hazards

- Engineering controls
  - Product substitution
  - Closed systems
  - Filtration/capture of emissions
  - Dust suppression
- Set-back distance: How far?

Location of Ambient Air Monitors around Ironbound, Newark, NJ

Liberty Airport

Is Citizen Science Part of the Answer?

- New, low-cost monitors
  - Particulate matter
  - Nitrogen dioxide
  - Ozone
- Can be deployed widely
- Measure in several locations simultaneously
- Measure personal exposures
- Multiple monitors
- GPS and mapping

Air Sensor Citizen Science Toolbox EPA Measure • Learn • Share

Conclusions

- We know a lot about the *potential* health effects of “fracking fumes.”
- Risk = Hazard X Exposure
- We need to know more about hazard
  - What’s in fracking fluids?
  - Who is susceptible to air pollutants, and when?
- We need to know more about exposure
  - Variability in time and space
  - The important factors in exposure pathways
  - Co-exposures to other chemicals and stressors
- Precautionary approach and more studies needed

Questions?