



## **We live in a multi-pollutant world:**

Estimating cumulative health risk from air pollution in Toronto neighbourhoods

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I do not have any conflicts of interest to disclose related to this presentation

# Learning Objectives

1. Describe an approach for assessing cumulative health risk from mixtures of air pollutants
2. Discuss the study findings and their application to local public health policy
3. Discuss the benefits of using spatial techniques in communicating about health risk with the community



History of contamination in the neighbourhoods

## Ashbridges Bay Treatment Plant

- Largest point source in Toronto (by mass of release)

## 2005 Studies

- ABTP air emission study
- Health status study





Image: Google earth

## Community concern about

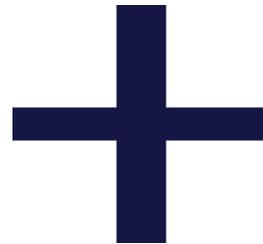
- Impact of local sources
- Cumulative impacts
- Air toxics

Led to first in a series of  
local air quality studies

## Air Quality Modellers

Model ambient concentrations

Estimate sector contributions to pollution



## Public Health Staff

Substance selection

Cumulative health impacts calculations



# Substances included in the studies

1. Acetaldehyde
2. Acrolein
3. Benzene
4. 1,3-Butadiene
5. Cadmium
6. Carbon tetrachloride
7. Chloroform
8. Chloromethane
9. Chromium
10. 1,4-Dichlorobenzene
11. 1,2-Dichloroethane
12. Dichloromethane
13. Ethylene dibromide
14. Formaldehyde
15. Lead
16. Manganese
17. Mercury
18. Nickel compounds
19. Nitrogen Oxides
20. PAHs (as B[a]Ps)
21. PM2.5
22. Tetrachloroethylene
23. Toluene
24. Trichloroethylene
25. Vinyl Chloride
26. Carbon Monoxide
27. PM10
28. Sulfur Dioxide
29. VOC (anthropogenic/Biogenic)
30. Ozone

Based on Substances in Toronto's Chemtrac Program

# Modelling Domains

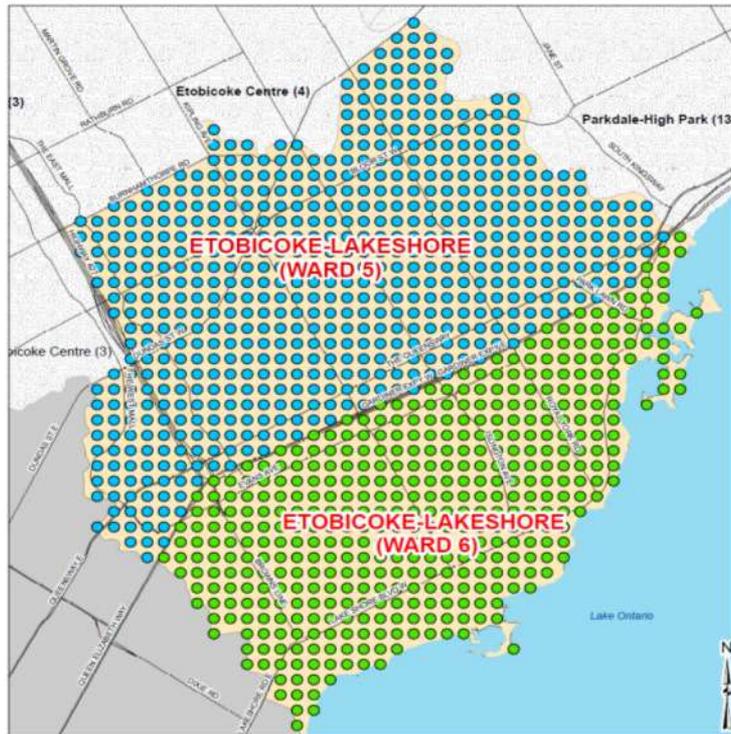


# Two Toronto Neighbourhoods (So far...)



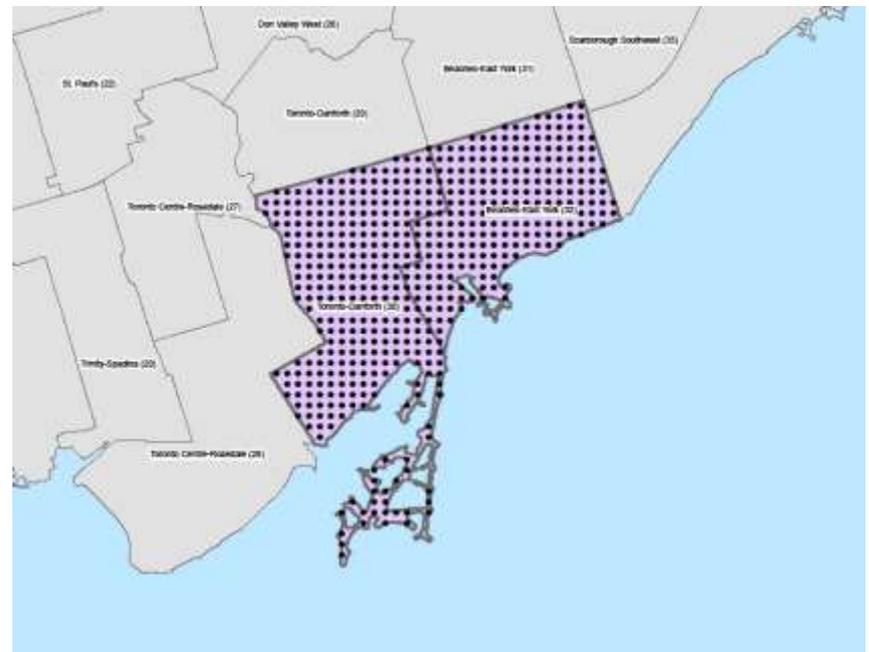
# Two Toronto neighbourhoods

## South Etobicoke/Lakeshore



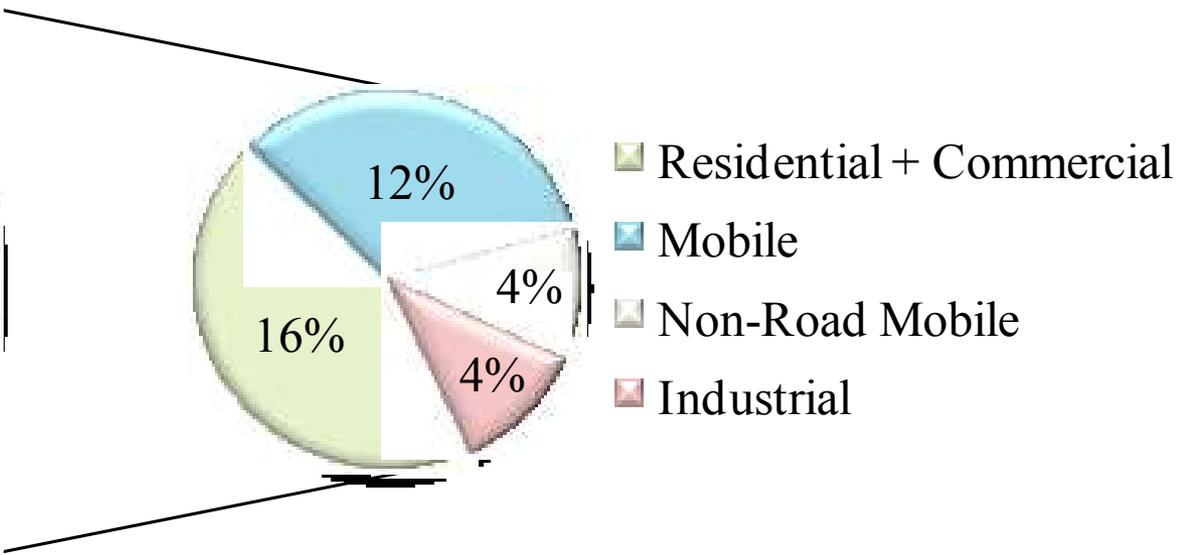
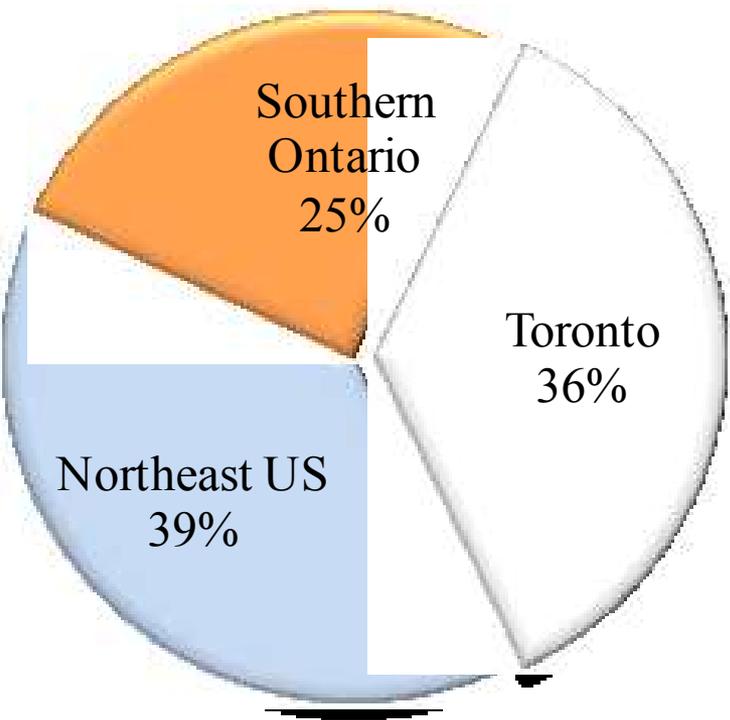
1049 Receptor Points

## South Riverdale and the Beach

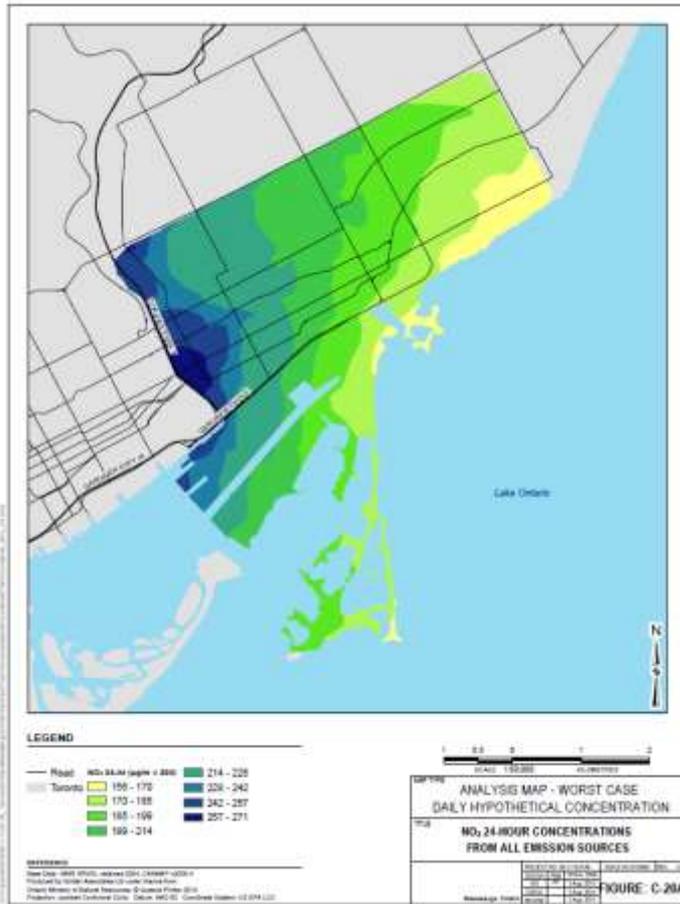


551 Receptor Points

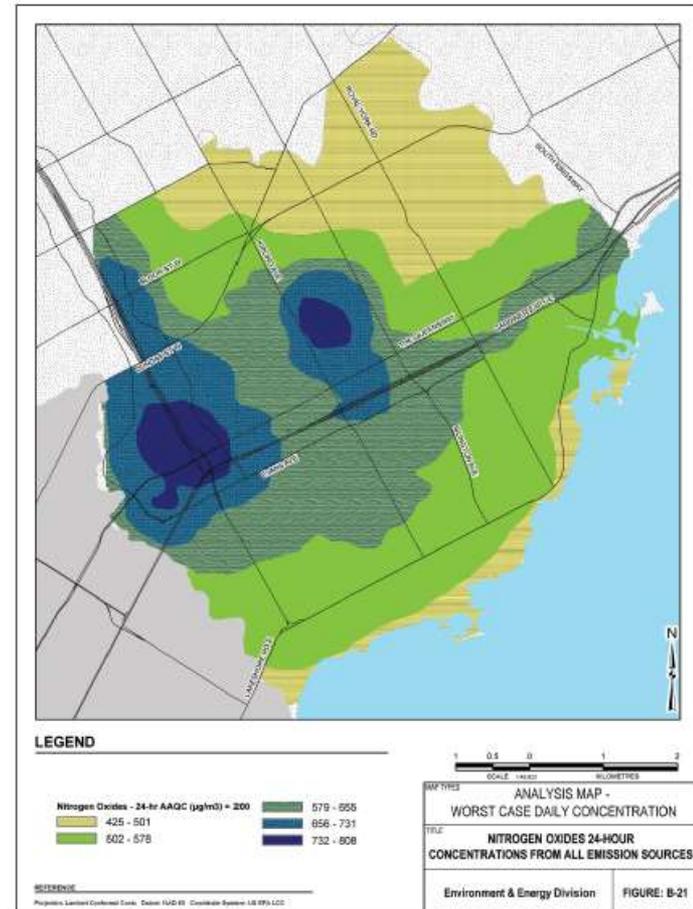
# Findings: Sources of air pollution in Toronto



# Findings: NO<sub>2</sub> as an example



South Riverdale and Beaches



Etobicoke-Lakeshore

# Findings: Ambient Concentrations

Most substances met Ontario's ambient air quality criteria (AAQCs)



Image: Google earth

Five substances are present at levels that exceed air quality standards or guidelines:

- Nitrogen Oxides
- Benzene
- Benzo[a]pyrene\*
- Particulate Matter < 10 microns (PM<sub>10</sub>)
- Particulate Matter < 2.5 microns (PM<sub>2.5</sub>)

\*Results for benzo[a]pyrene require further validation

Estimating cumulative health impacts means considering the health risks of exposure to multiple pollutants at one time. But...

Different chemicals have different kinds of health impacts

- Eg, neurological, cancer, respiratory impacts

Different chemicals have different levels of *toxicity*

- Some can be harmful at low levels of exposure, while others are a concern at higher levels of exposure

Toronto Public Health assessed cumulative health impacts for three types of substances:

- Non-carcinogens
- Carcinogens
- Criteria air pollutants

## Key references:

Department of Environmental Quality (DEQ). 2006. Portland Air Toxics Assessment. Portland, OR. <http://www.deq.state.or.us/aq/toxics/pata.htm>.

Morello-Frosch, Rachel A., Tracey J. Woodruff, Daniel A. Axelrad, and Jane C. Caldwell. 2000. Air Toxics and Health Risks in California: The Public Health Implications of Outdoor Concentrations. *Risk Analysis* 20, no. 2: 273-292. doi:10.1111/0272-4332.202026.

## Non-carcinogens

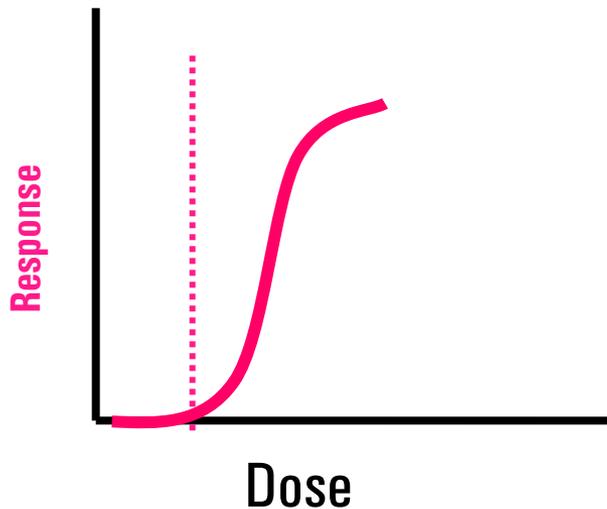
1,2-Dichloroethane  
1,3-Butadiene  
1,4-Dichlorobenzene  
Acetaldehyde  
Acrolein  
Benzene  
Cadmium  
Carbon Tetrachloride  
Chloroform  
Chloromethane  
Chromium (III)  
Chromium (IV)  
Dichloromethane  
Ethylene Dibromide  
Formaldehyde  
Lead  
Manganese  
Mercury  
Nickel  
Tetrachloroethylene  
Toluene  
Trichloroethylene

Non-carcinogens are toxic substances that may be associated with health effects such as

- Developmental
- Neurological
- Reproductive

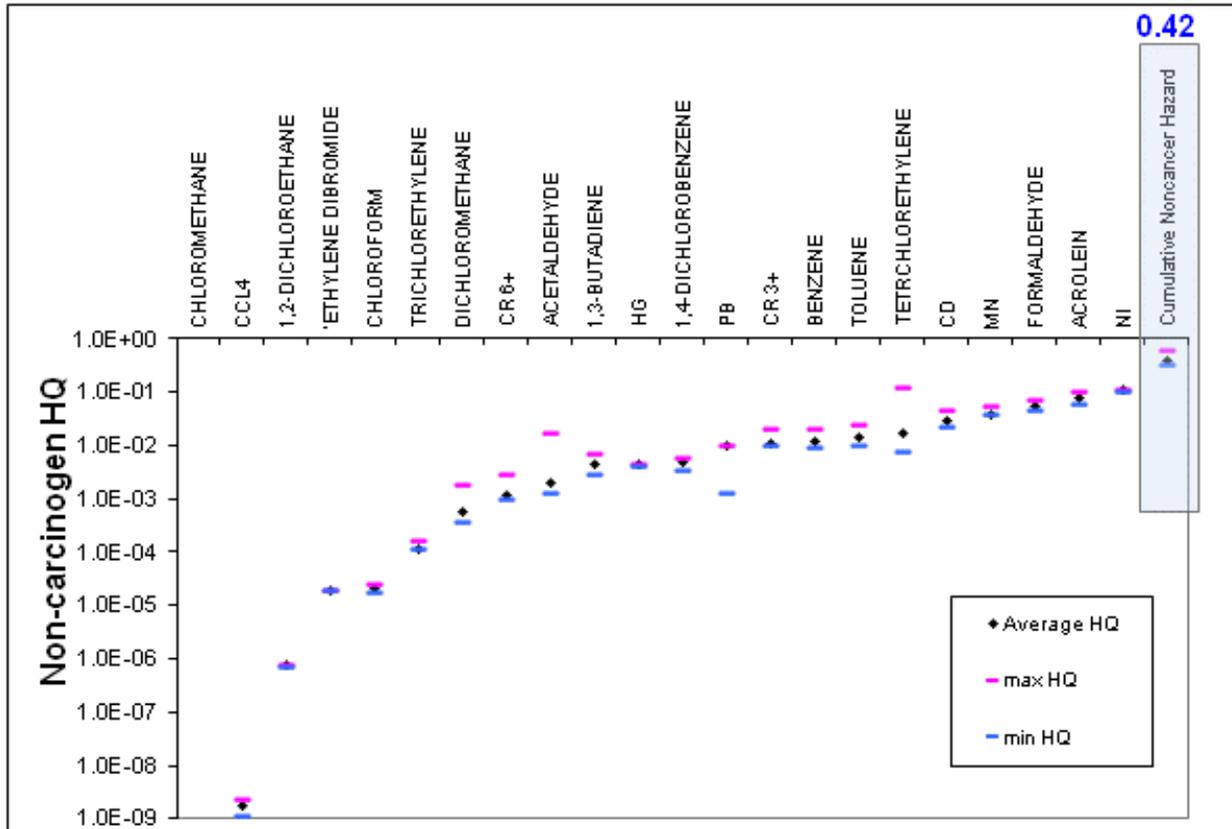
Non-carcinogens are assumed to have a *threshold* for effects

# Risk Characterization: Threshold



- There is a dose rate below which harmful effects are not expected
- Generally easy to interpret if actual dose is above or below the exposure benchmark

# Cumulative Assessment: Non-cancer effects (South Etobicoke/Lakeshore)



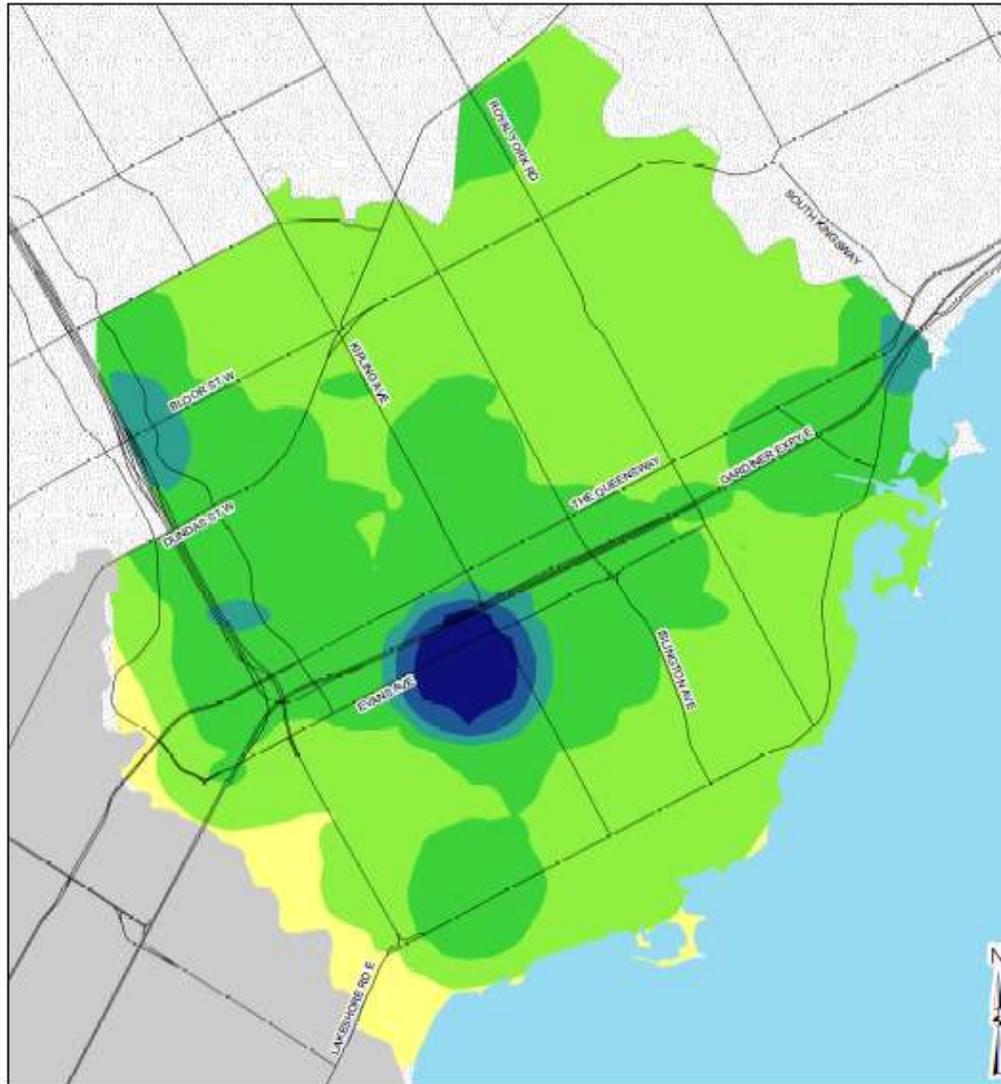
Cumulative Hazard ratio is 0.42

Below the threshold for concern

**Average, maximum and minimum non-cancer risk values estimated for each carcinogenic substance based on average annual concentrations from the 1049 receptor sites.**

**Hazard ratios below 1 are considered acceptable**

# Non-carcinogens



**Cumulative Hazard Ratio**

Considered together, the 22 non-carcinogens included in the study are not expected to be present at levels that pose a health concern

## Carcinogens above level of concern

1,3-Butadiene  
1,4-Dichlorobenzene  
Acetaldehyde  
Benzene  
Benzo[a]pyrene  
Chromium (VI)  
Formaldehyde  
Tetrachloroethylene

## Carcinogens below level of concern

1,2-Dichloroethane  
Cadmium  
Carbon tetrachloride  
Chloroform  
Chloromethane  
Dichloromethane  
Ethylene Dibromide  
Lead  
Nickel  
Trichloroethylene  
Vinyl Chloride

- Carcinogens are toxic substances that are associated with a risk of cancer
- There is some level of risk even at low levels of exposure
- Carcinogens are often considered not to have a threshold

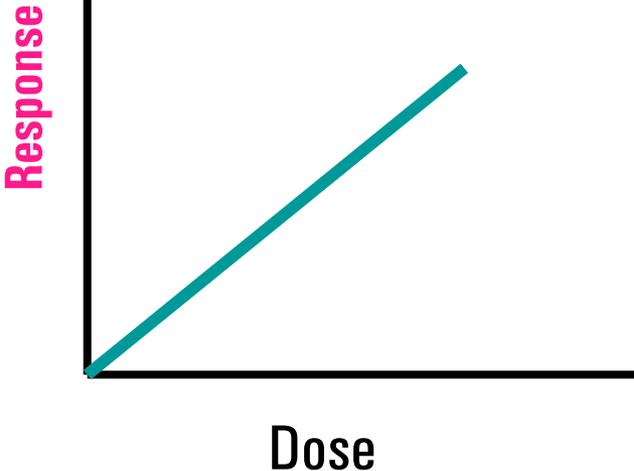
# Exposure-Response: no threshold

Slope of dose-response curve  
= “cancer slope factor”

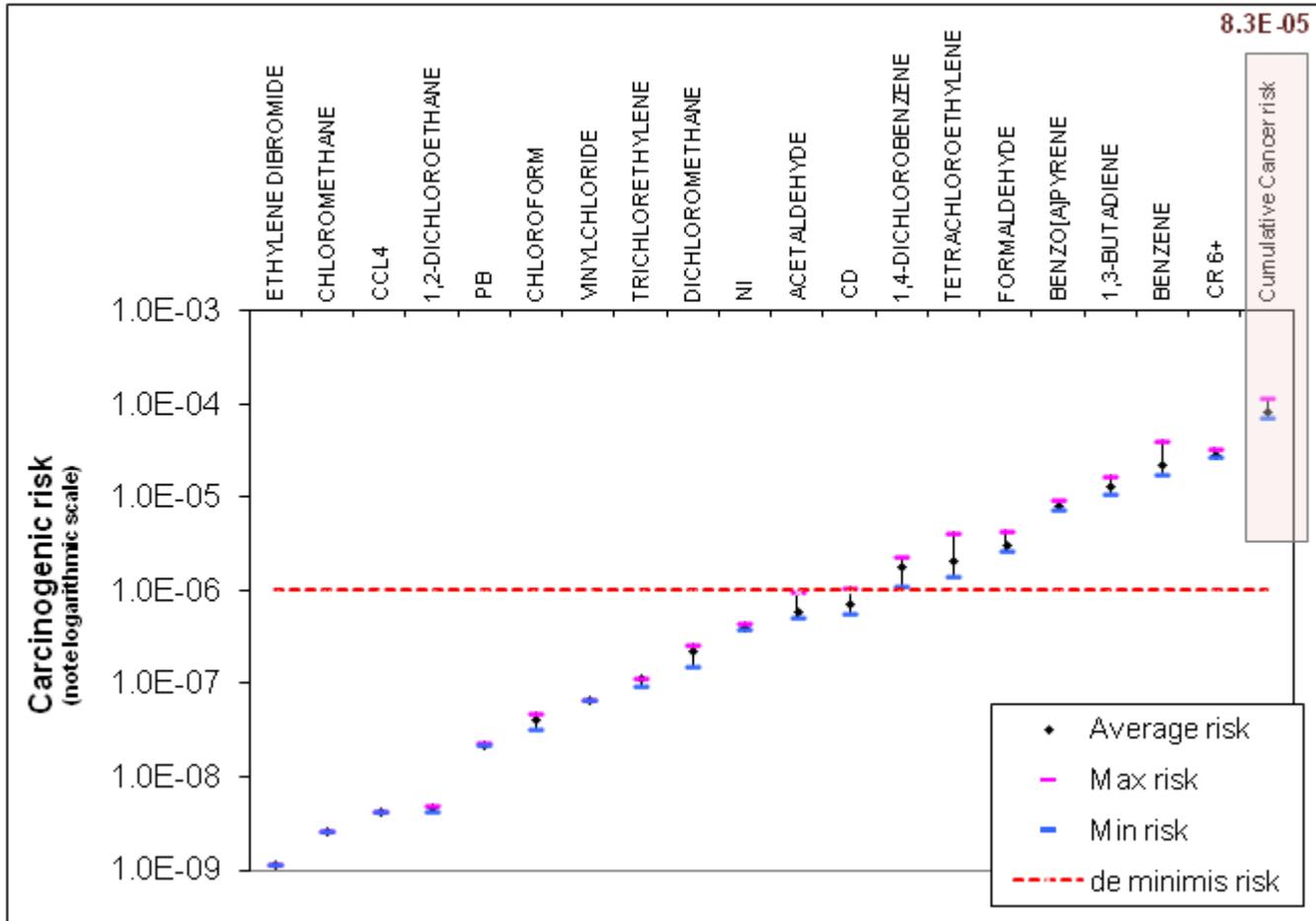
NO THRESHOLD for effect

provides information to  
calculate the *incremental  
lifetime cancer risk*

For example, for an airborne substance, the slope factor represents the increase in the lifetime risk of an individual who is exposed for a lifetime to  $1 \mu\text{g}/\text{m}^3$  of the chemical in air.



# Cumulative Assessment: Cancer risk (South Riverdale/The Beach)



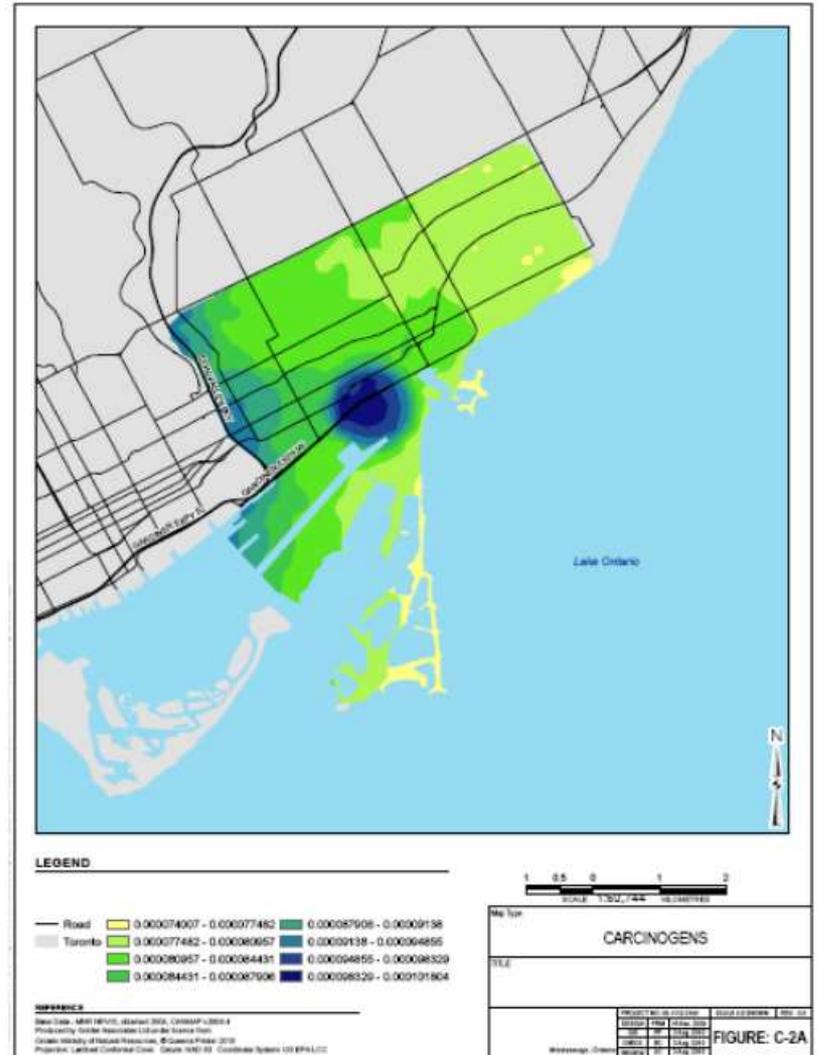
Cumulative cancer risk is 83 in 1 million

This is about 2 percent of the total cancer incidence rate in Toronto

Average, maximum and minimum cancer risk values estimated based on average annual concentrations from the 551 receptor sites.

1 in 1 million excess lifetime cancer risk is the *de minimis* risk level

- Considered together, the carcinogens included in the study may be present at levels that pose a health concern

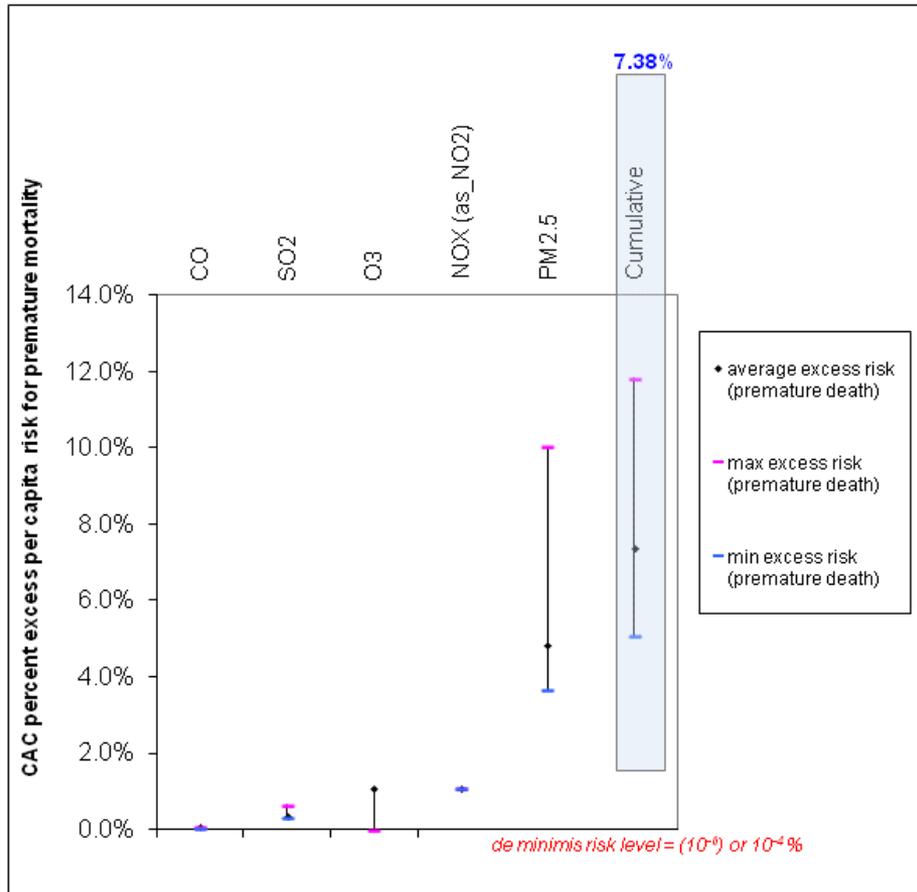


**Cumulative Lifetime Cancer Risk**

Criteria Air Contaminants (CACs)
Carbon monoxide
Nitrogen oxides
Ozone
Particulate matter
Sulphur oxides

- Criteria Air Contaminants are pollutants that are associated mainly with higher risks of heart and lung diseases
- These effects can occur at any level of exposure

# Cumulative Assessment: Criteria Air Contaminants (South Etobicoke/Lakeshore)

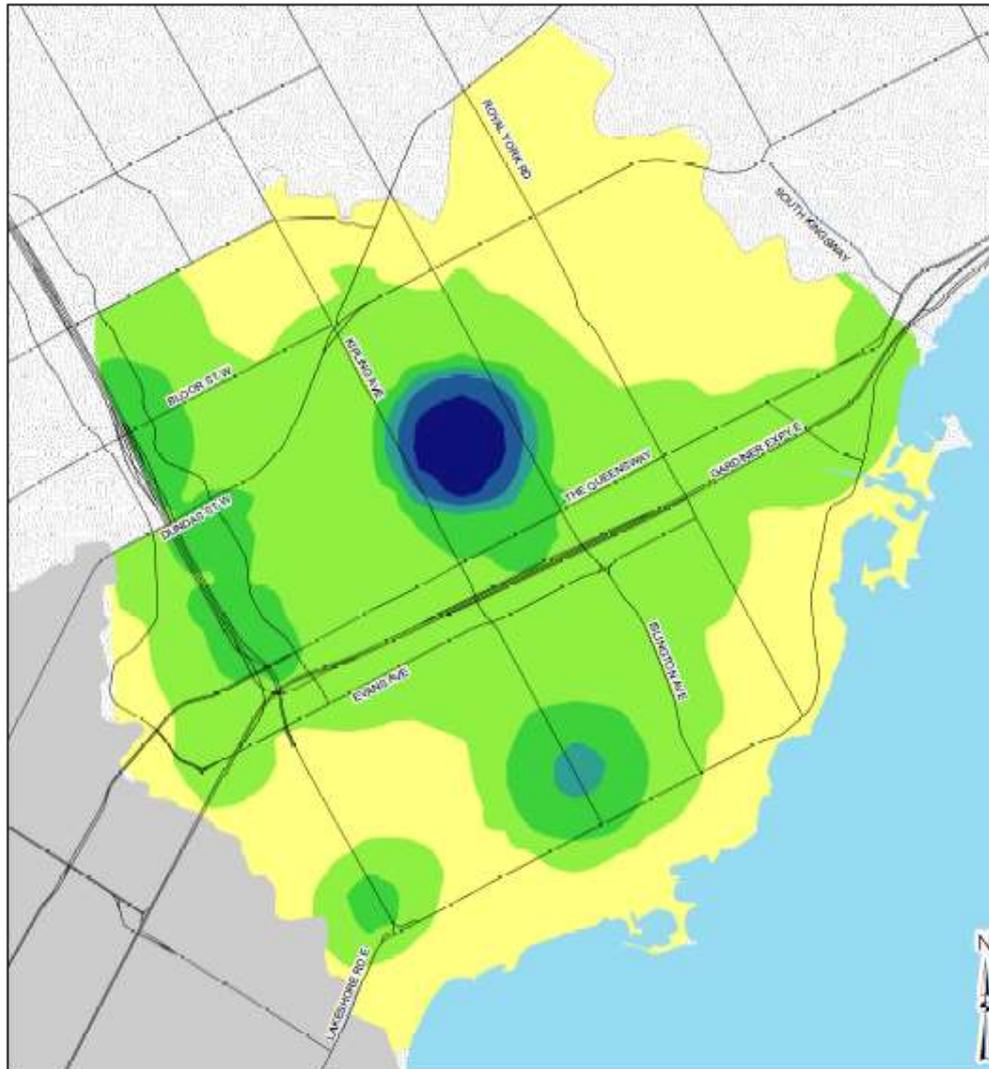


Cumulative increased risk of premature death is 7.4 percent

**Average, max and min risk of acute premature death estimated for each CAC based on average annual concentrations at the 1049 receptor sites.**

**Any risk <10<sup>-6</sup> (10<sup>-4</sup> %) is considered tolerable**

# Criteria Air Contaminants



**Cumulative excess risk of premature death**

- Considered together, the criteria air contaminants may increase the risk of premature mortality by 7.4 per cent.
- This risk is consistent with Toronto Public Health's estimate that air pollution is associated with about 1,300 premature deaths a year in Toronto.
- Transportation and industry are main sources of risk

The same five substances exceed ambient air quality criteria or standards

Health risks are of similar magnitude in both areas

<b>Type of Health outcome</b>	<b>South Riverdale and Beach</b>	<b>Etobicoke-Lakeshore</b>
Noncancer (immune, neurological, development etc.)	No risk	No risk
Cancer	83 in one million	44 in one million*
Respiratory and Cardiovascular	8.9% increase	7.4% increase

In both, transportation is an important source of local pollution and related health risk

# Conclusions (1)



The non-carcinogenic contaminants occur below levels of concern to health, even when the combined exposure is taken into account

Most carcinogens are below the one in one million excess cancer risk benchmark

The cumulative risk from carcinogens is very low when compared to the total incidence rate of cancer in Toronto

Criteria air contaminants such as ozone, nitrogen dioxides, and particulate matter contribute to the burden of illness

## Conclusions (2)



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Secretariat, Ministry of Infrastructure



Source: <http://worldneighborhoods.com>

Levels of risk are consistent across the first two studies

For many substances of greatest concern, locally generated emissions are mainly from transportation sources

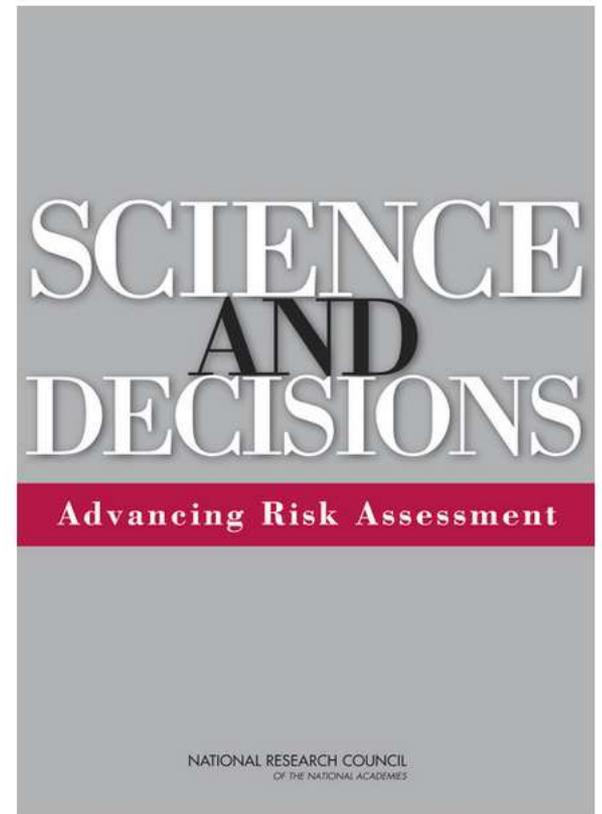
Increased energy efficiency at home and in businesses will also help improve local air quality

Reductions in emissions outside Toronto will also help improve air quality in the city

Communications: naming and explaining the categories of health risk

Input data quality: eg., concerns about background levels of B[a]P

Classic risk assessment approach vs. emerging evidence for nonthreshold mechanisms in noncarcinogens

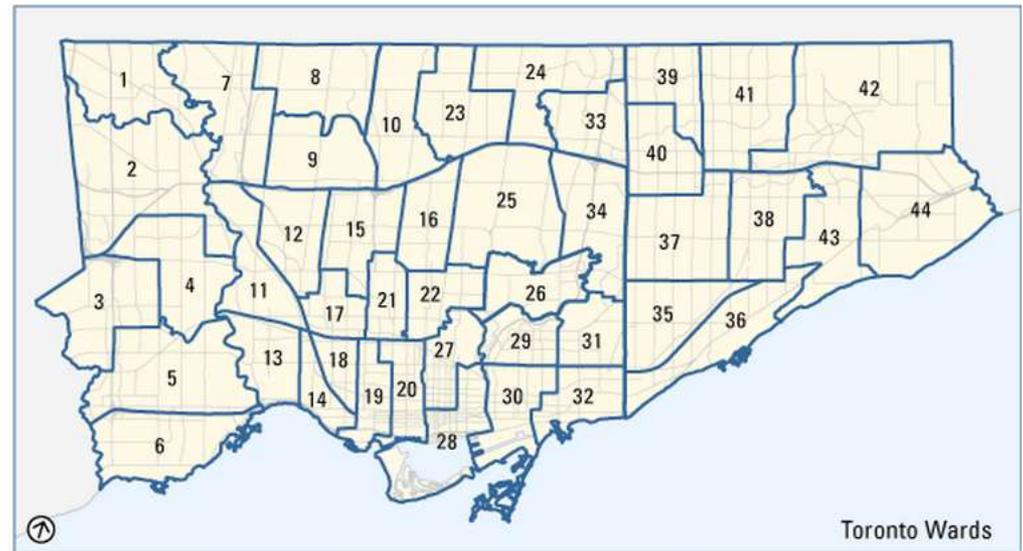


## Benefits

- Community Engagement
- Communication tool
- Prioritize sectors of interest for pollution prevention
- Can spur action from facilities

## Next Steps

- Community Animators
- More neighbourhoods



- City Staff to investigate ways of reducing emissions from heavy trucks
- City Staff to conduct additional local air quality studies and report on ways the city is supporting residents in improving local air quality
- Request the OMOE to help with verifying findings and roadside air quality monitoring

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