Emission Trends and Monitoring for Benzene and 1,3-Butadiene

Presented by:

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Outline

Emissions

Ambient Monitoring

Technologies for reducing emissions of Benzene and 1,3 Butadiene

Measurement techniques at facilities

Comparison of US and Canadian facilities

Summary and Challenges

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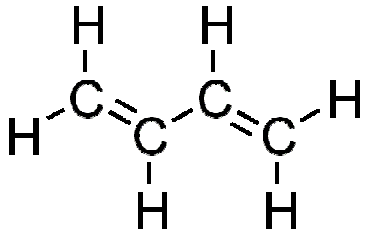
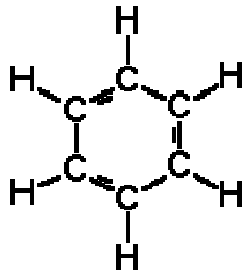
A Tale of Two Chemicals

- Benzene – C6H6, carcinogen, toxic, odour,
- 1,3 Butadiene – C4H6, carcinogen, toxic, odour
- Standards – both currently considered “non-threshold” - target reduce risk of adverse health effects
- Butadiene highly reactive chemical (ozone formation),





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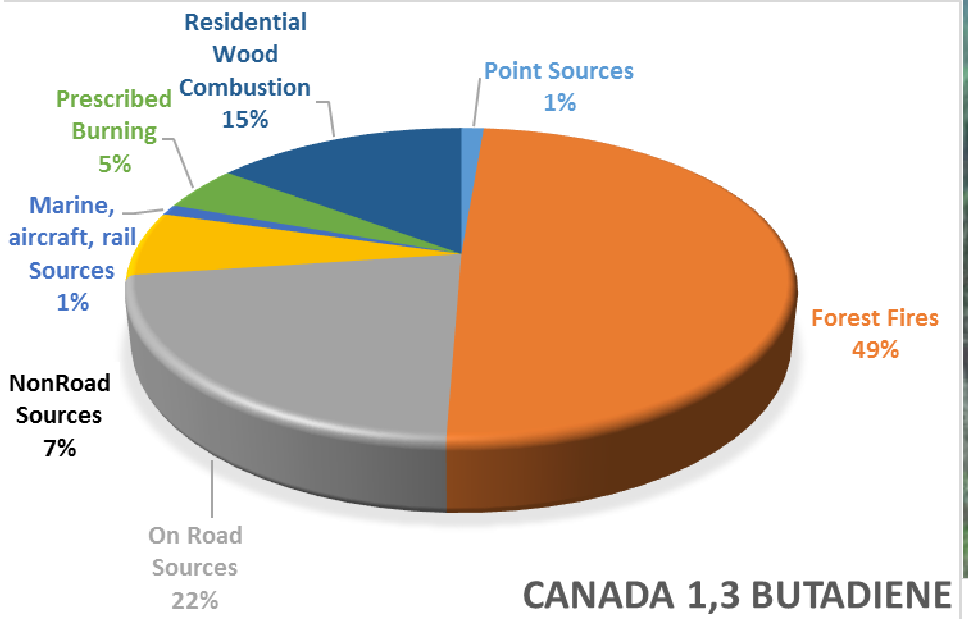
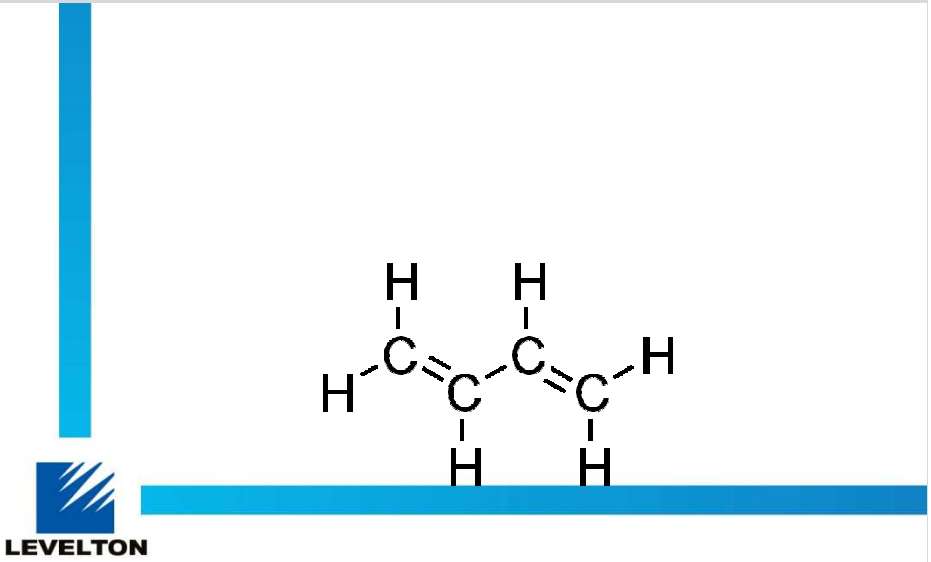
Source Contributions



CANADA 1,3 BUTADIENE
ALL SOURCES



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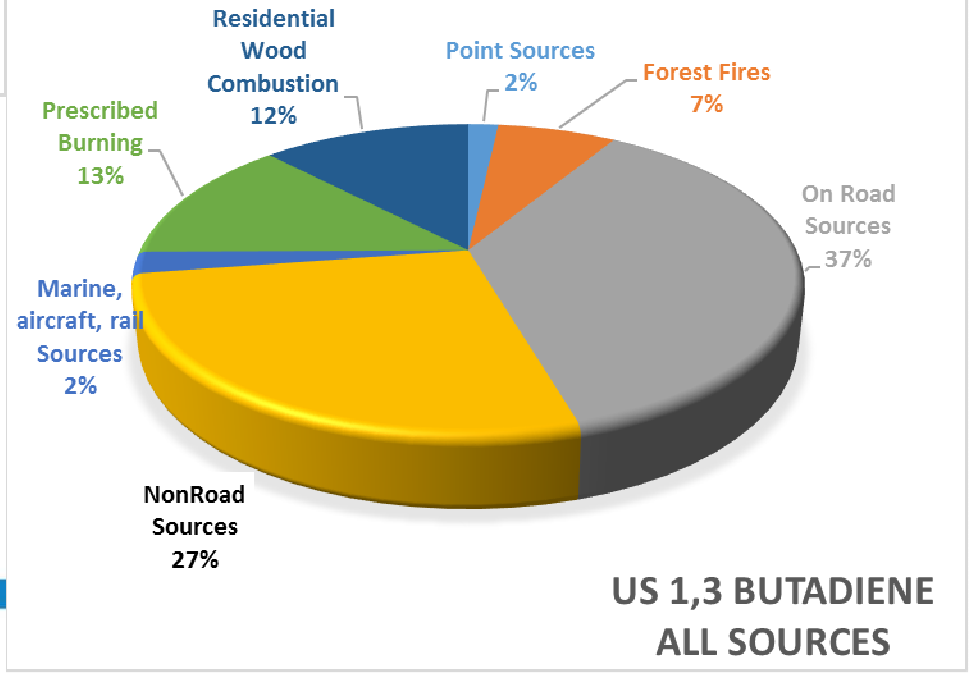
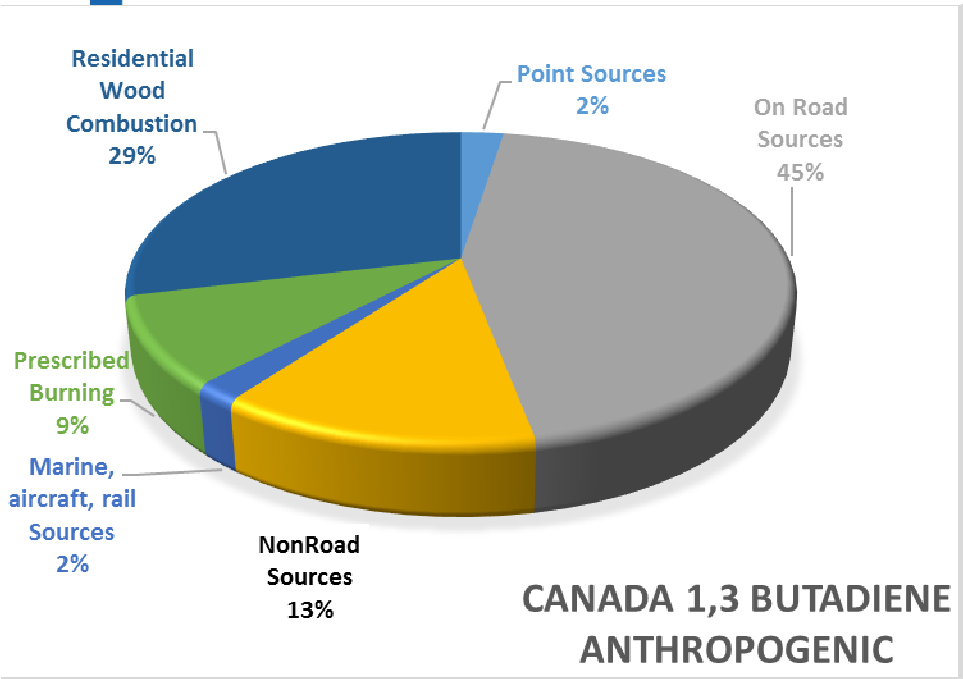
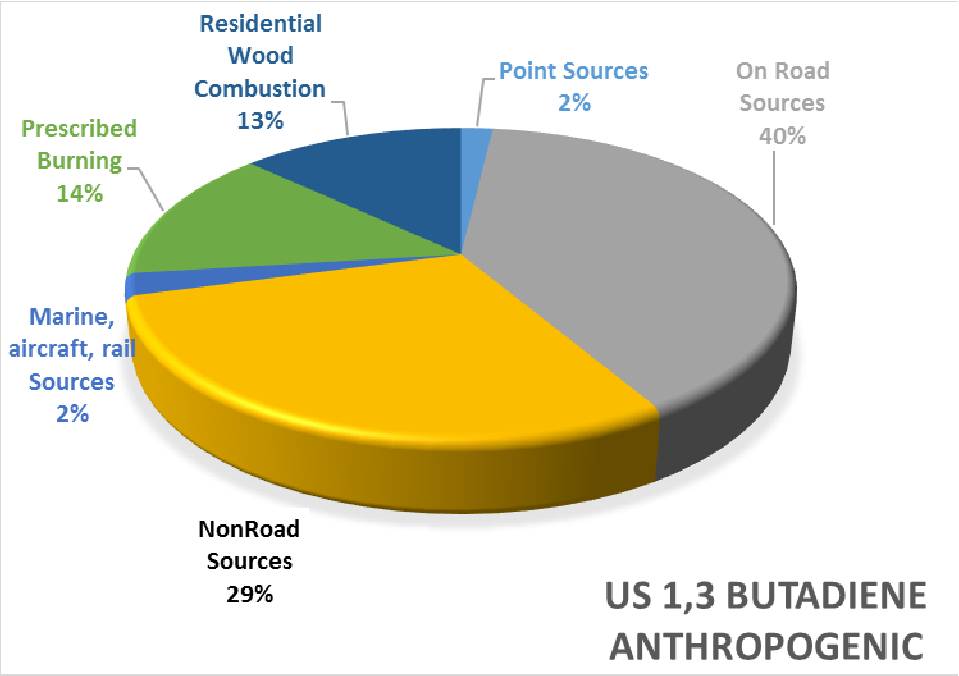


US 1,3 BUTADIENE
ALL SOURCES

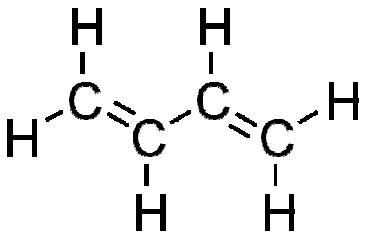
Source Contributions



CANADA 1,3 BUTADIENE ANTHROPOGENIC



US 1,3 BUTADIENE ANTHROPOGENIC



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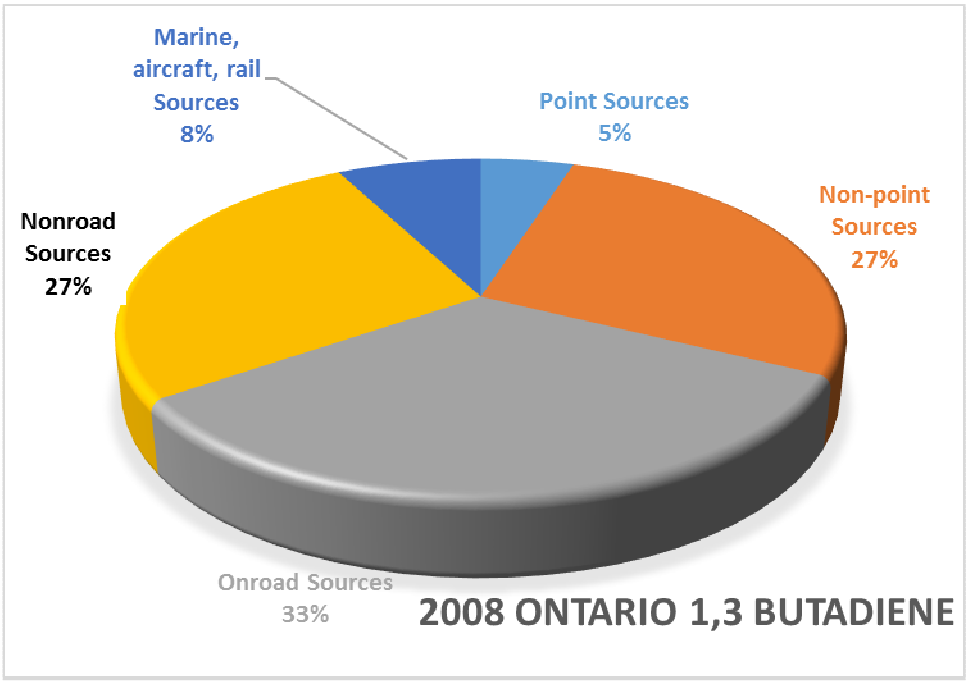
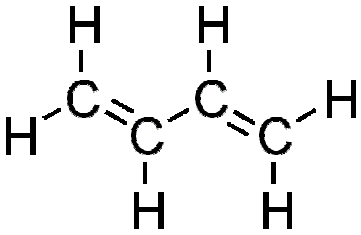
Source Contributions





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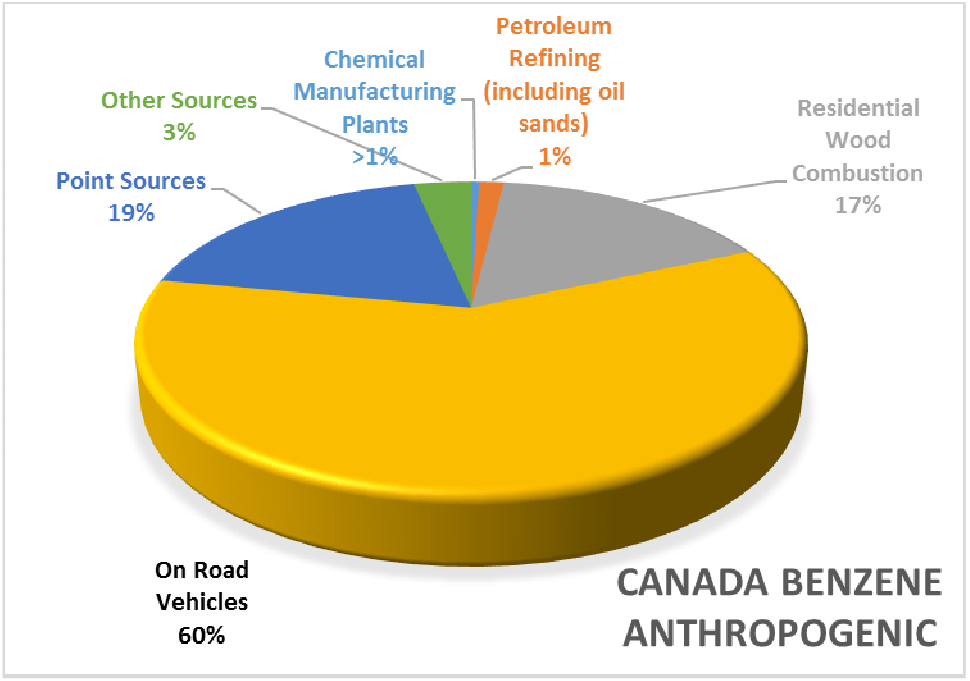
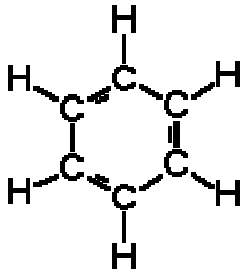
Source Contribtions





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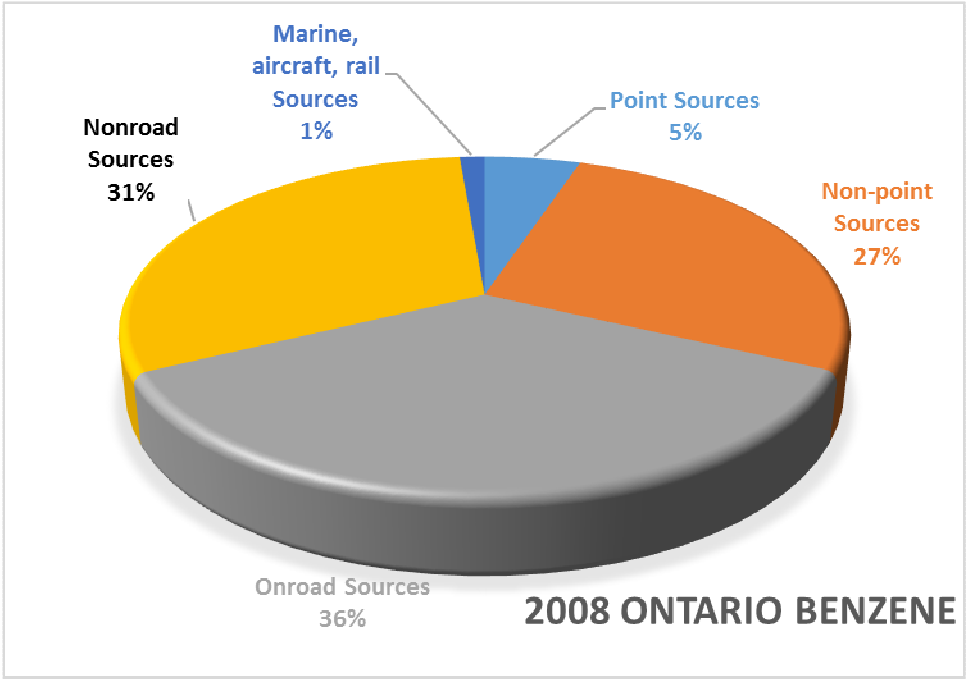

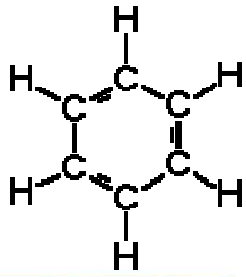

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Emissions

- Trends in Benzene and 1,3 Butadiene emissions in Canada
  - 1993 to 2012
- Trends in:
  - Refining Sector
    - USA
    - Canada
    - Ontario
  - Chemical Sector
    - USA
    - Canada
    - Ontario

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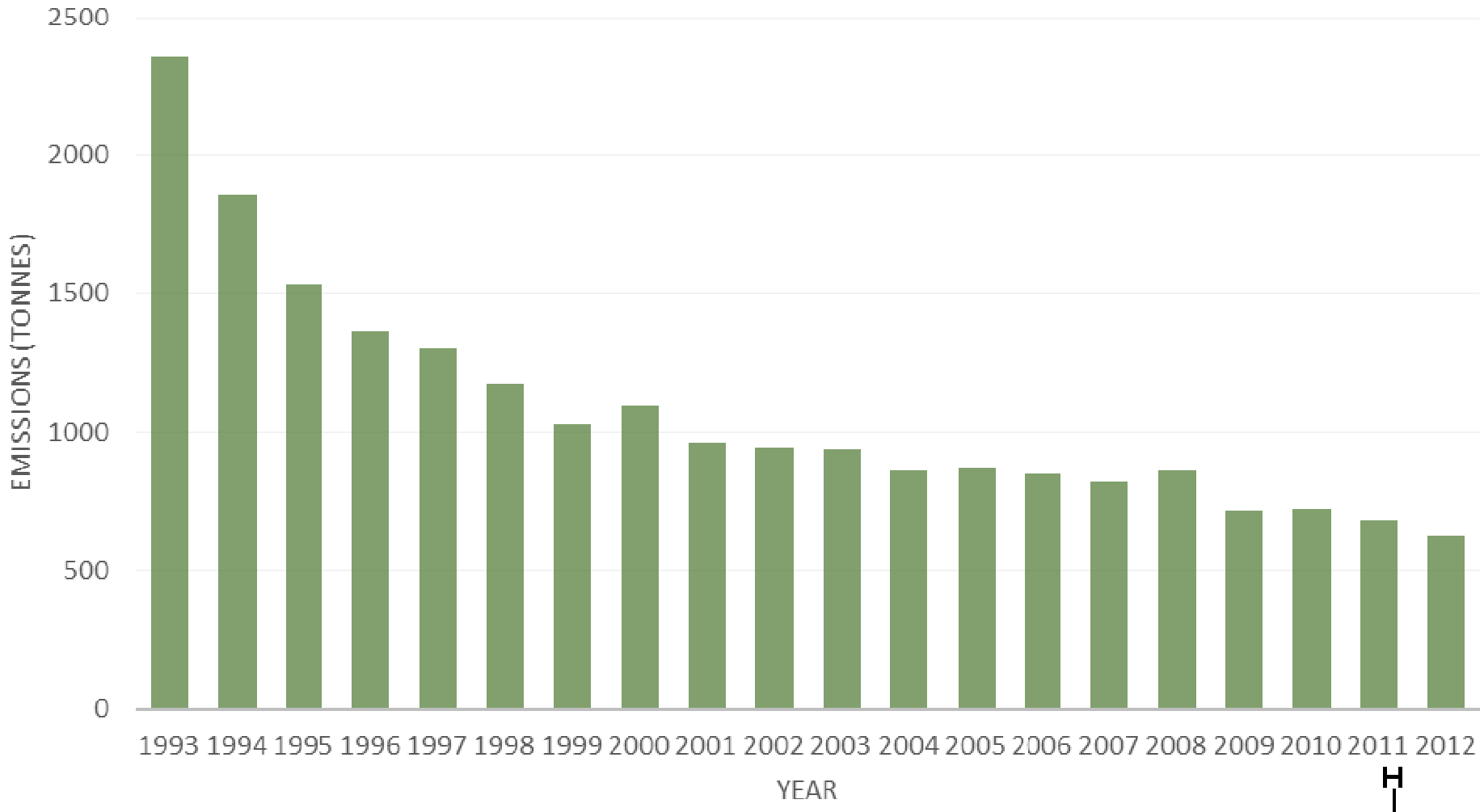
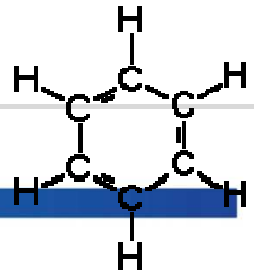
Benzene Emissions in the US Petroleum Refining Sector (1993-2012)





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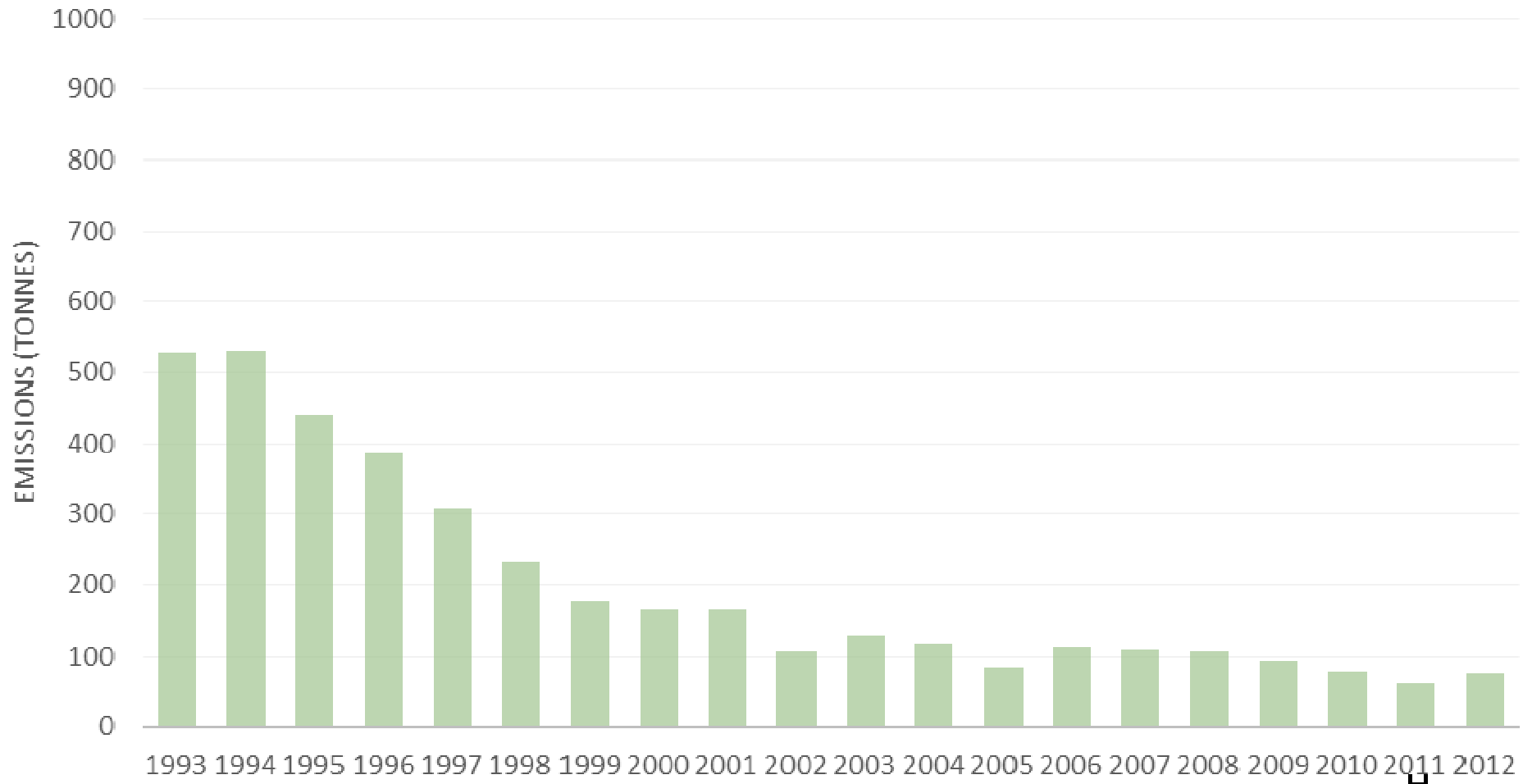
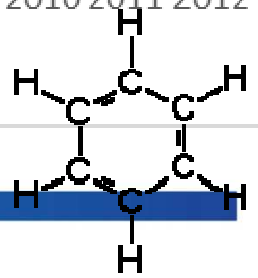
Benzene Emissions in the Canadian Petroleum Refining Sector (1993-2012)





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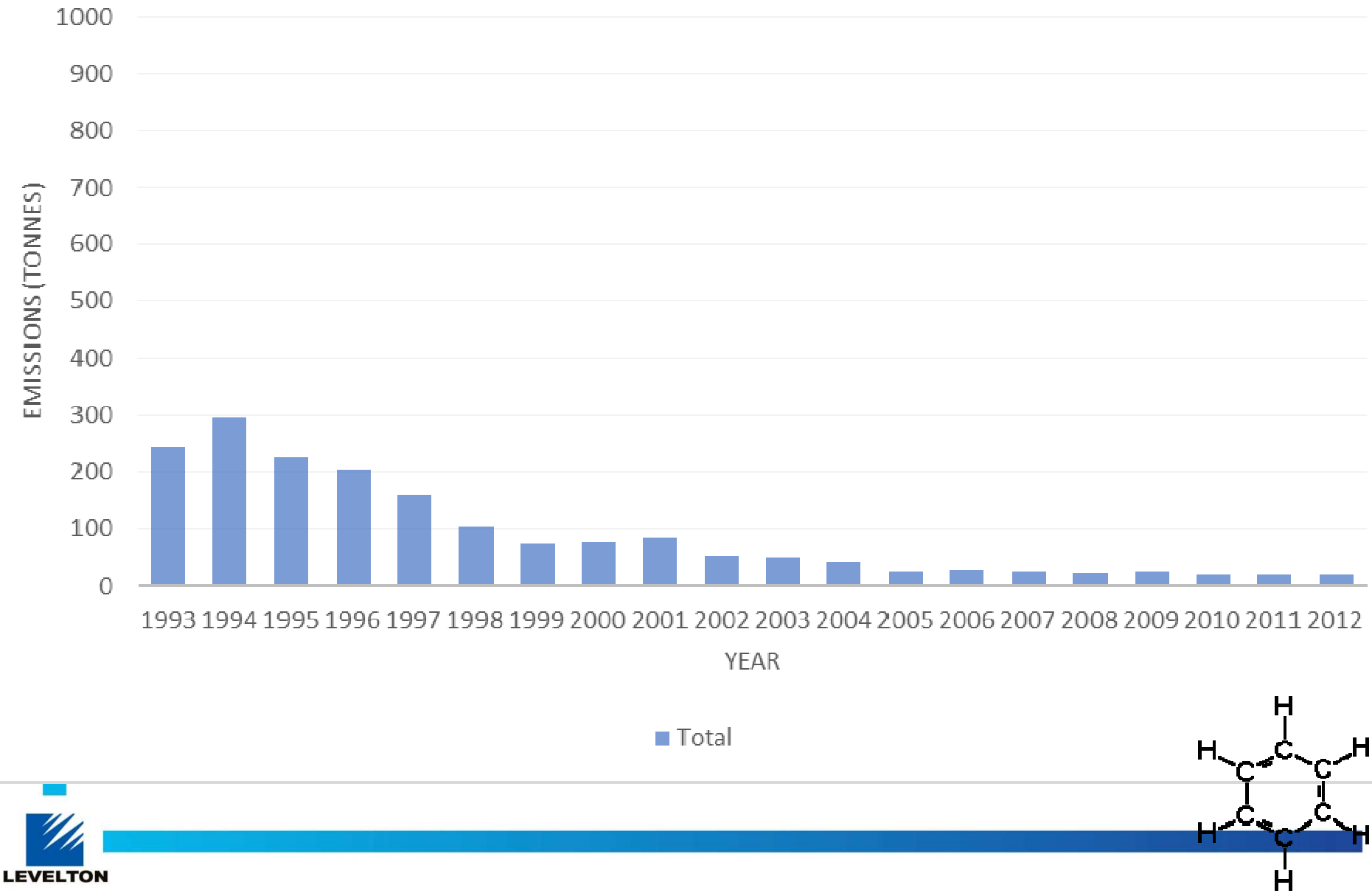
Benzene Emissions in the Ontario Petroleum Refining Sector (1993-2012)



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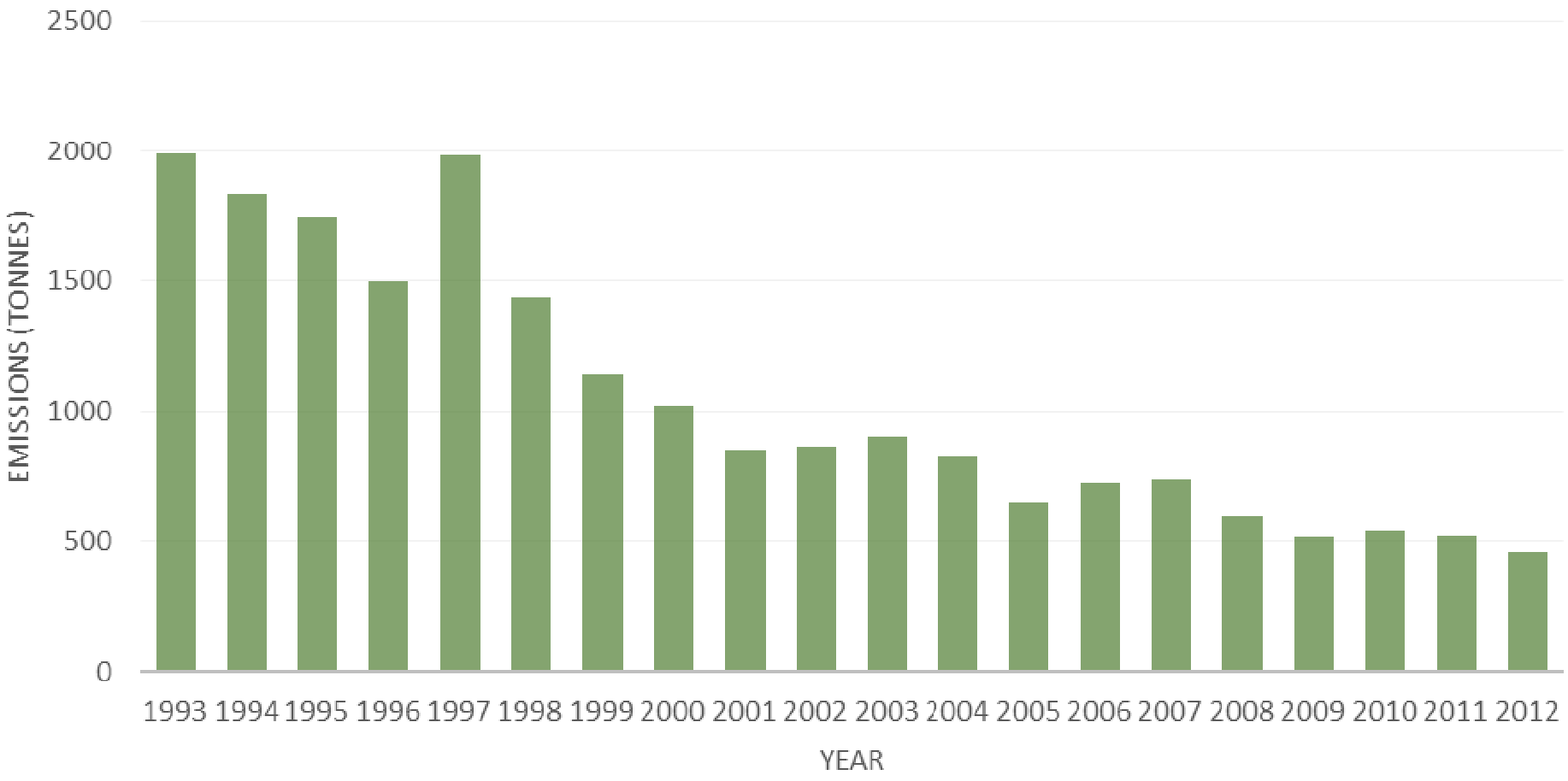
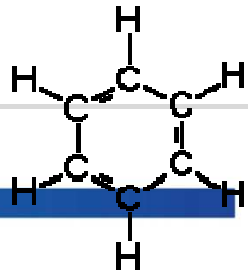
Benzene Emissions in the US Chemical Manufacturing Sector (1993-2012)





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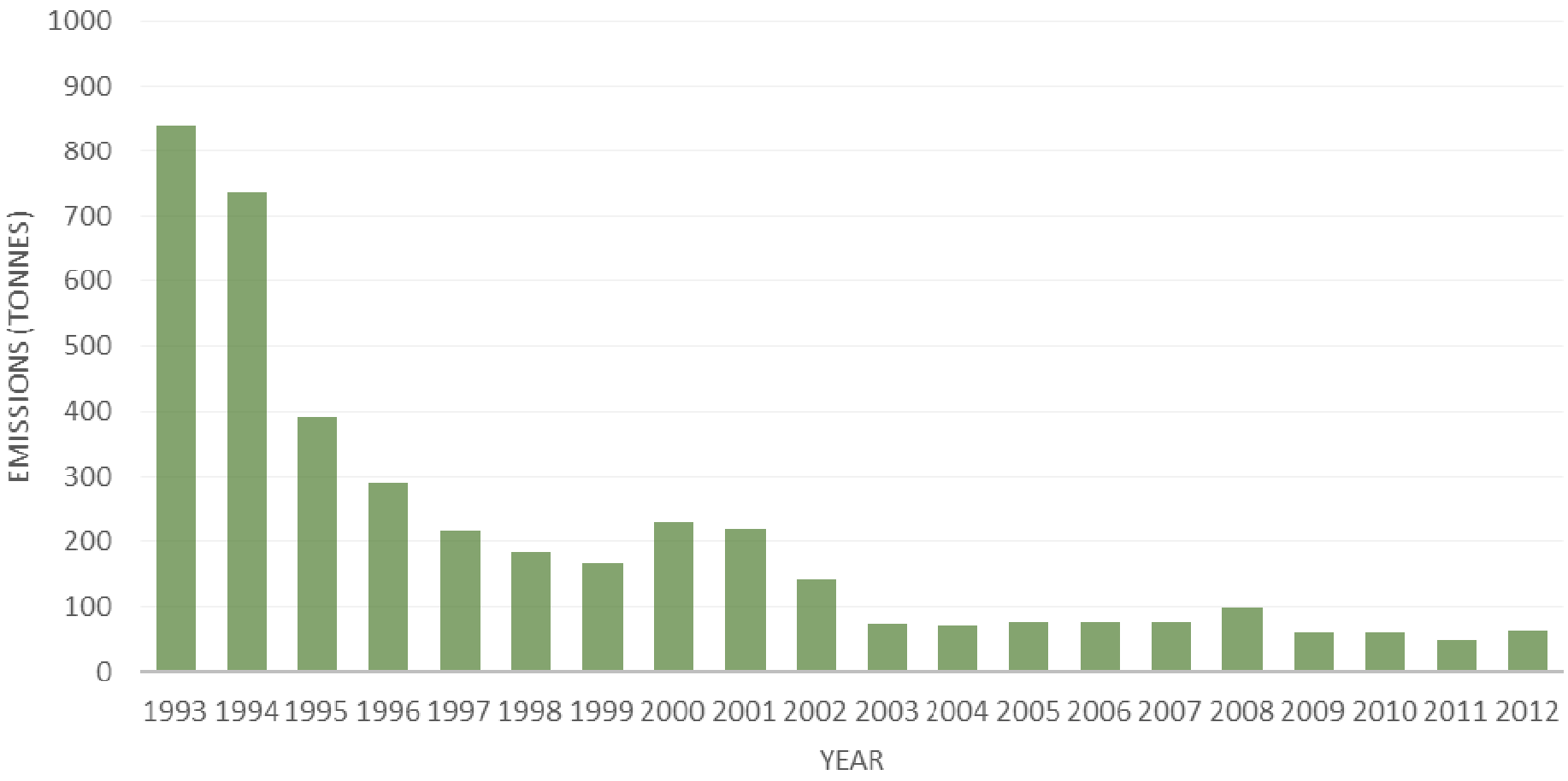
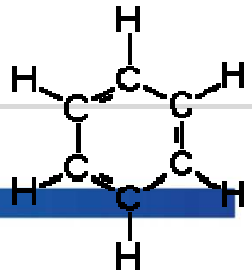
Benzene Emissions in the Canadian Chemical Manufacturing Sector (1993-2012)





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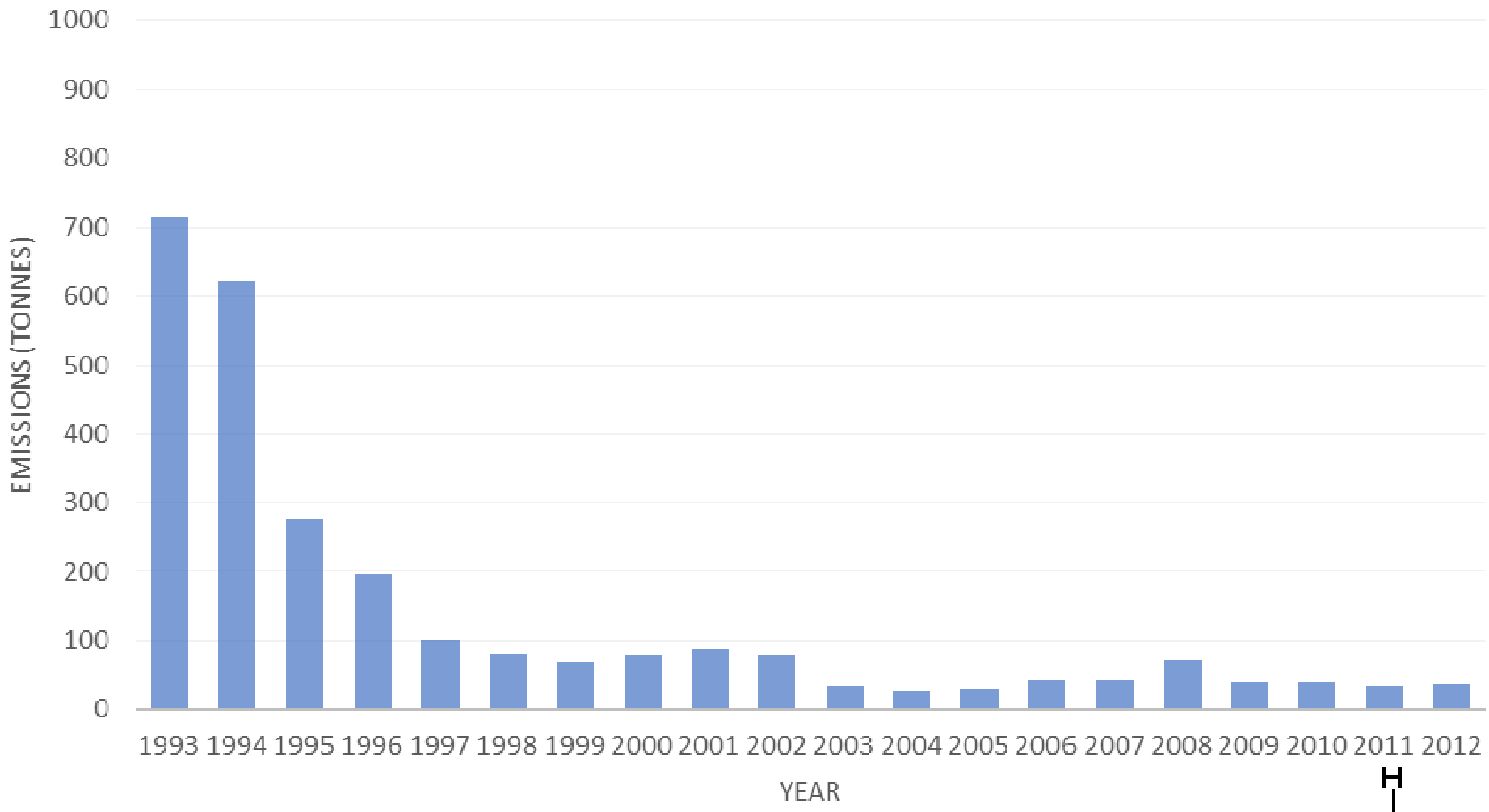
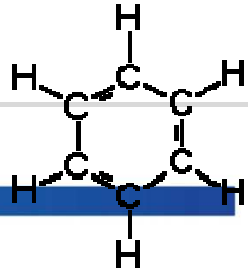
Benzene Emissions in the Ontario Chemical Manufacturing Sector (1993-2012)





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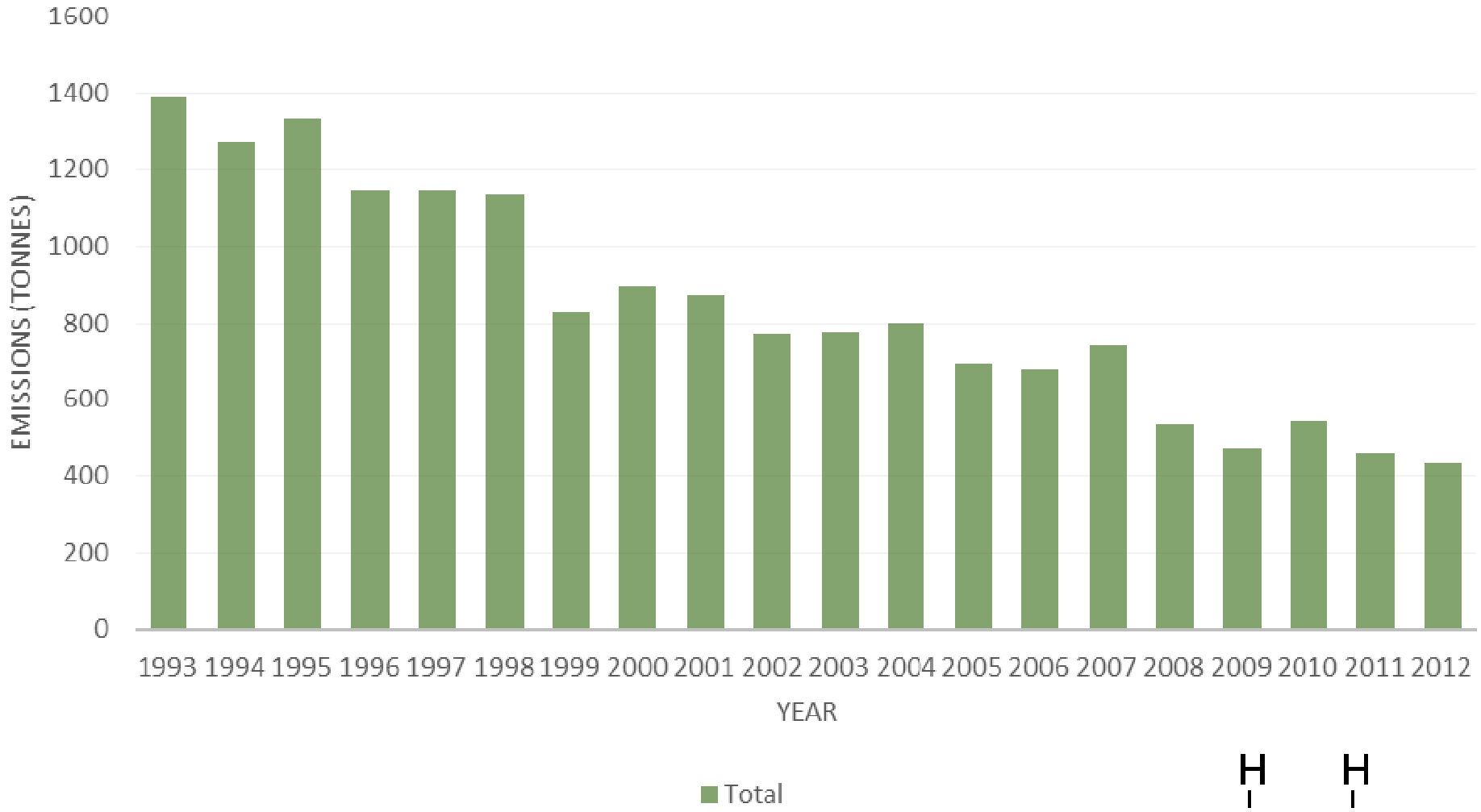
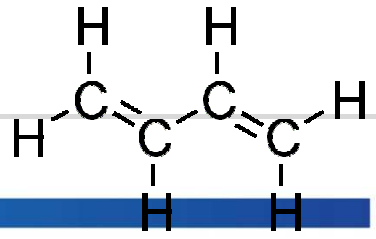
1,3 Butadiene Emission in the US Chemical Manufacturing Sector (1993-2012)





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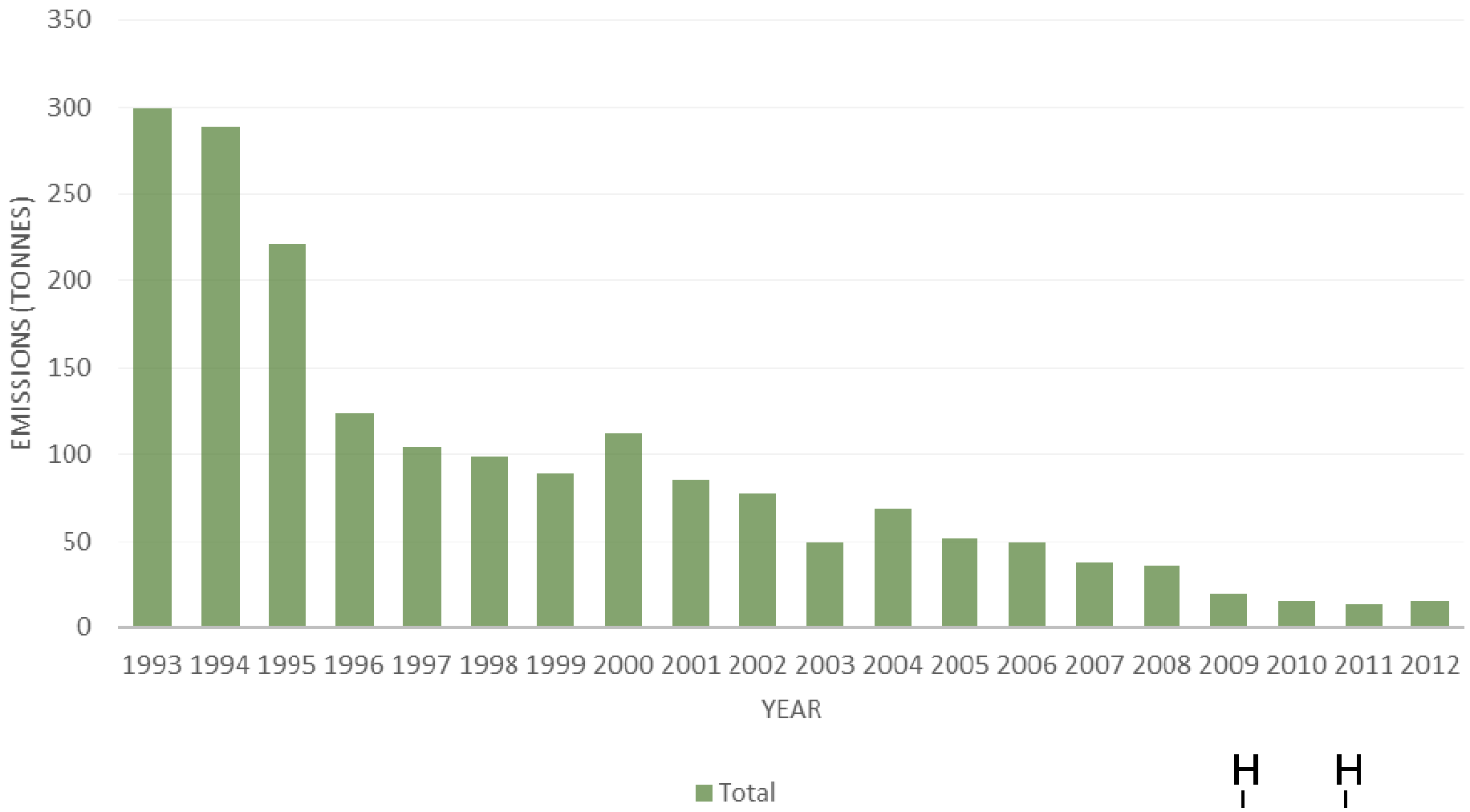
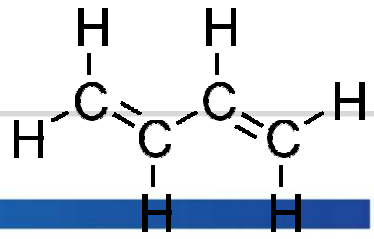
1,3 Butadiene Emission in the Canadian Chemical Manufacturing Sector (1993-2012)





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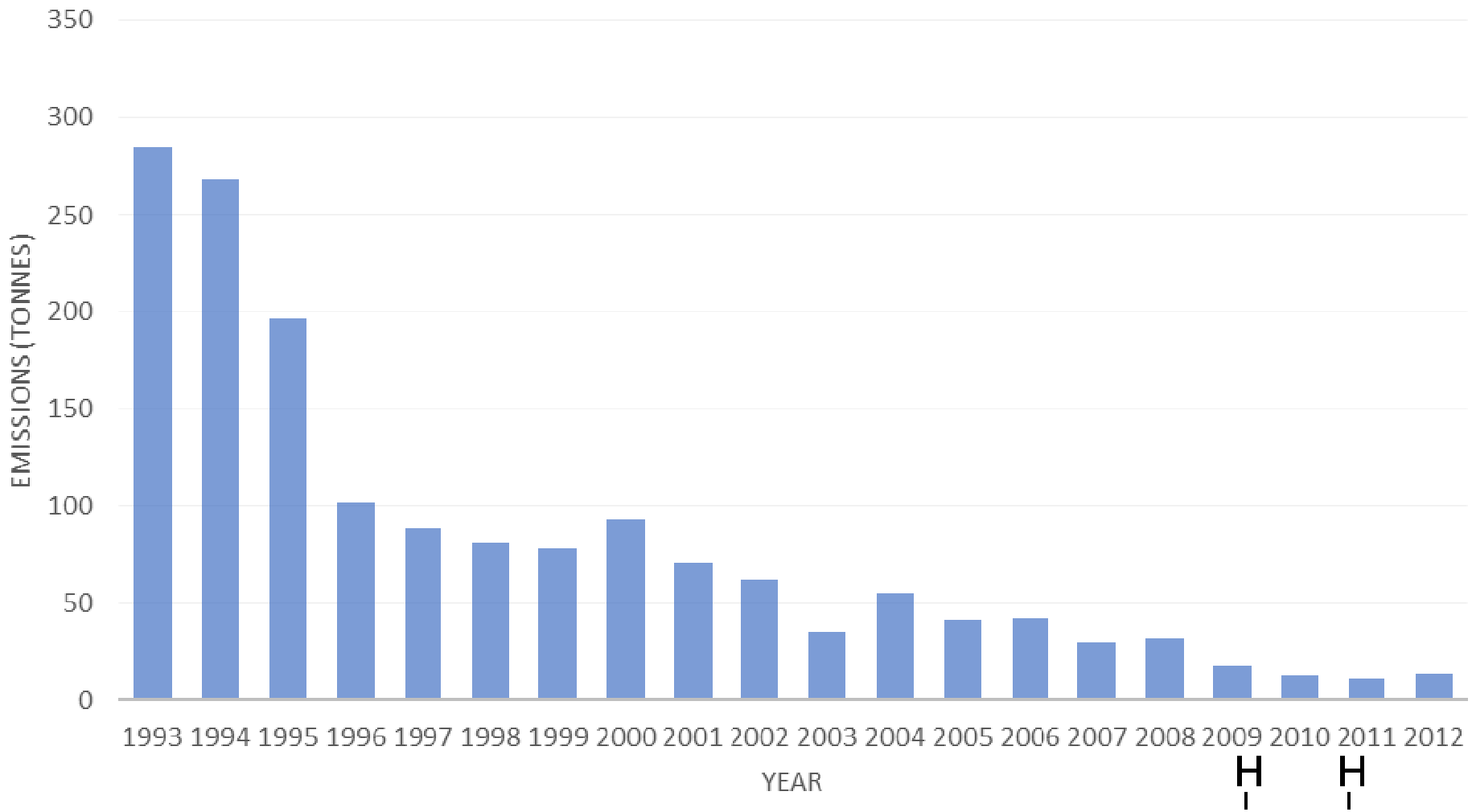
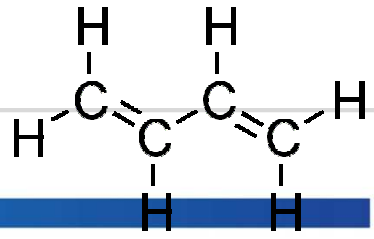
1,3 Butadiene Emissions in the Ontario Chemical Manufacturing Sector (1993-2012)





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Ambient Monitoring

Ambient Monitoring

Trends in Ambient Monitoring data for Benzene and 1,3 Butadiene in:

- Canada
- Ontario
- Sarnia

CCME Reports - reduced ambient concentrations observed in both urban (-76% between 1991 and 2008) and rural (-50% between 1994 and 2008) locations in Canada.

Given the success achieved both in reducing emissions of benzene and in reducing ambient concentrations of benzene, the goals of the Benzene CWS have been achieved.

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Legend
NAPS Monitoring Stations
N
Arctic Ocean
Baffin Bay
Greenland Sea
Greenland
Iceland
Hudson Bay
Bering Sea
United States
North Atlantic
Ireland
Spain
Portugal

Trends in Canada

Location	Annual Average Concentrations Benzene ($\mu g/m^3$) 2000	2012
MetroVancouver	0.4 to 3.2	0.4 to 1.2
Sarnia Lambton Environment Association	2	1.1
Fort Saskatchewan	3	1.1

Location	Annual Average Concentrations 1,3 Butadiene ($\mu g/m^3$) 2000	2012
MetroVancouver	0.07 to 0.5	0.05 to 0.095
Sarnia Lambton Environment Association	0.55	0.09
Fort Saskatchewan	0.29	0.03 to 0.08

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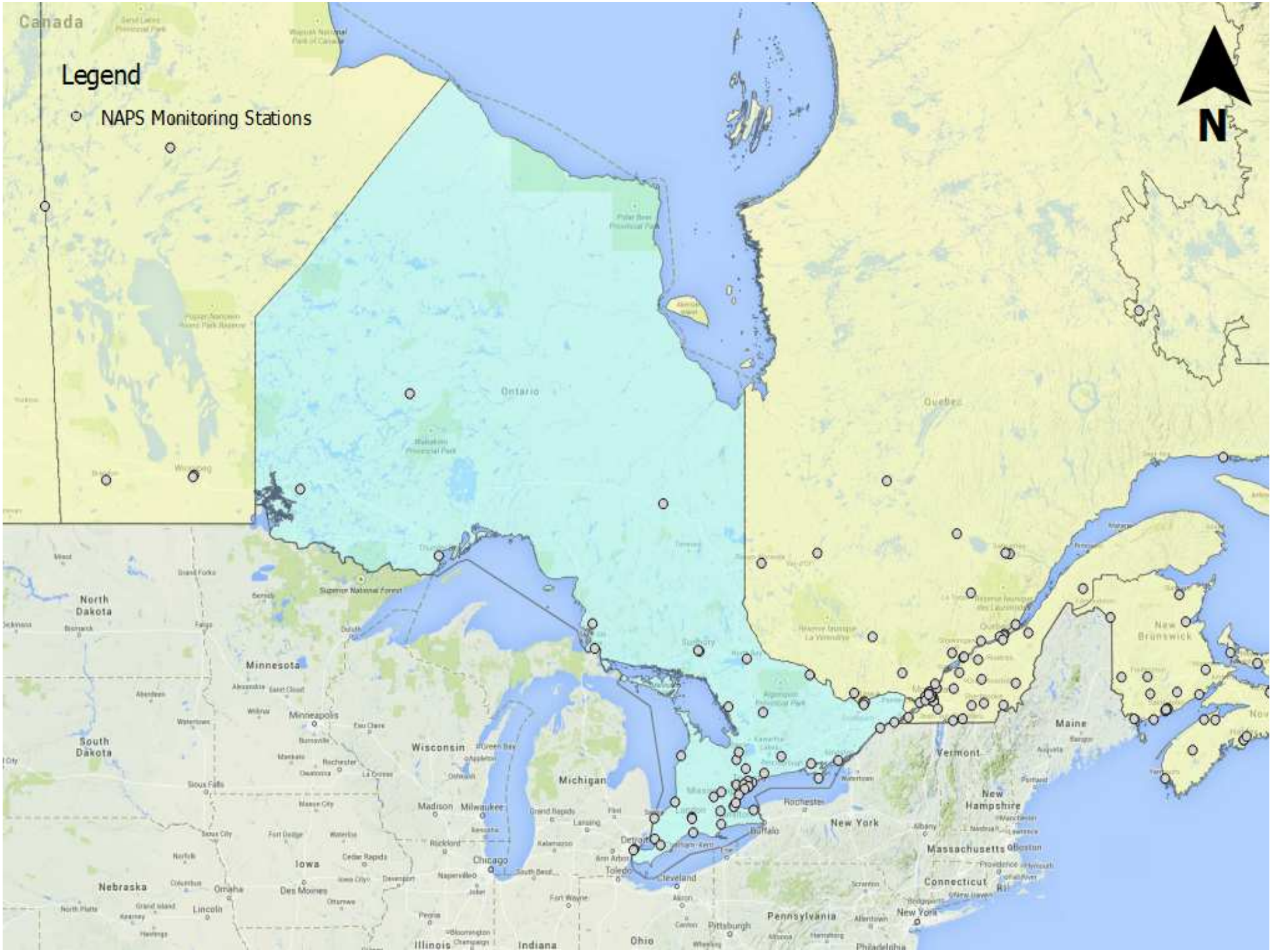
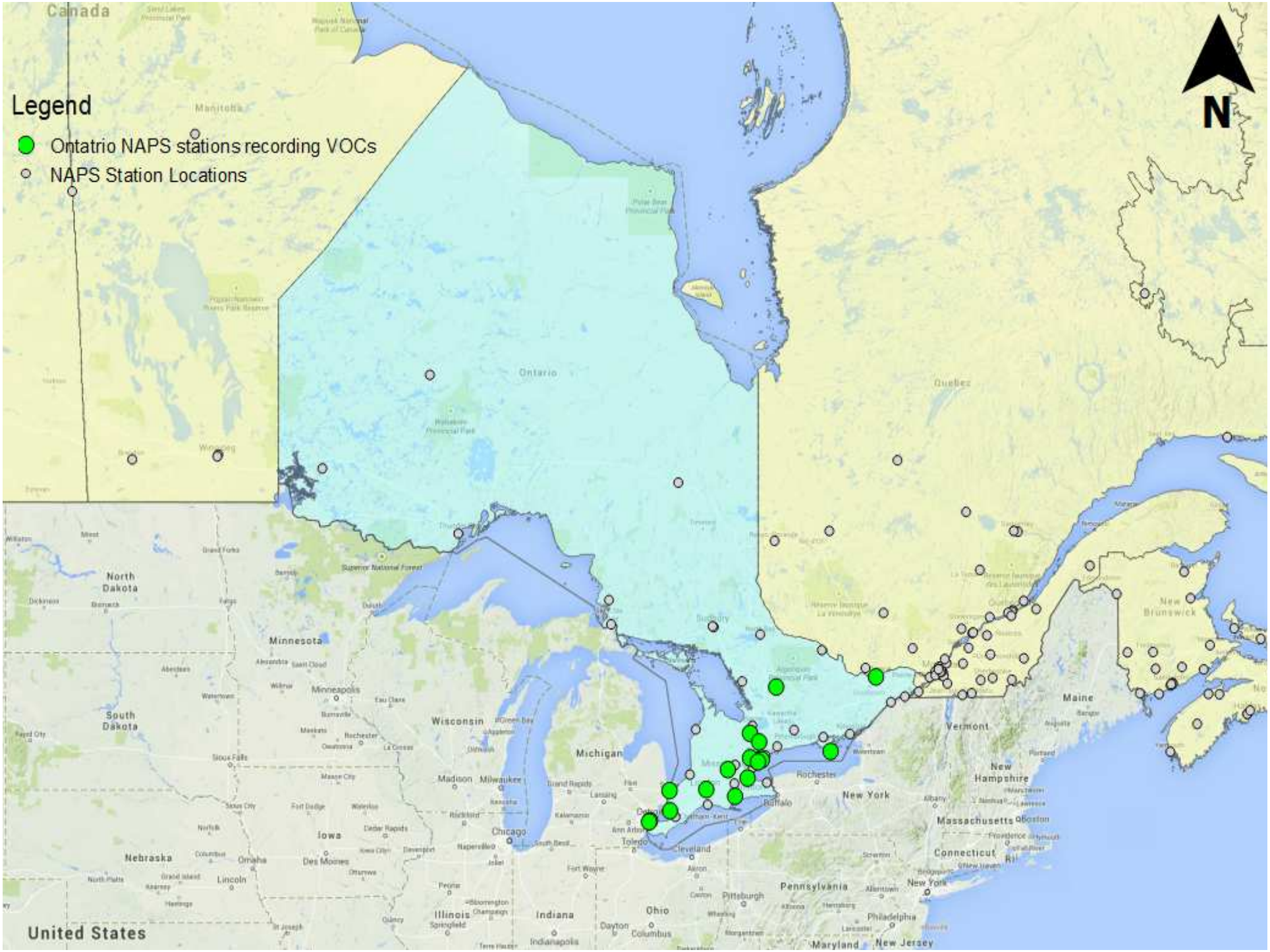
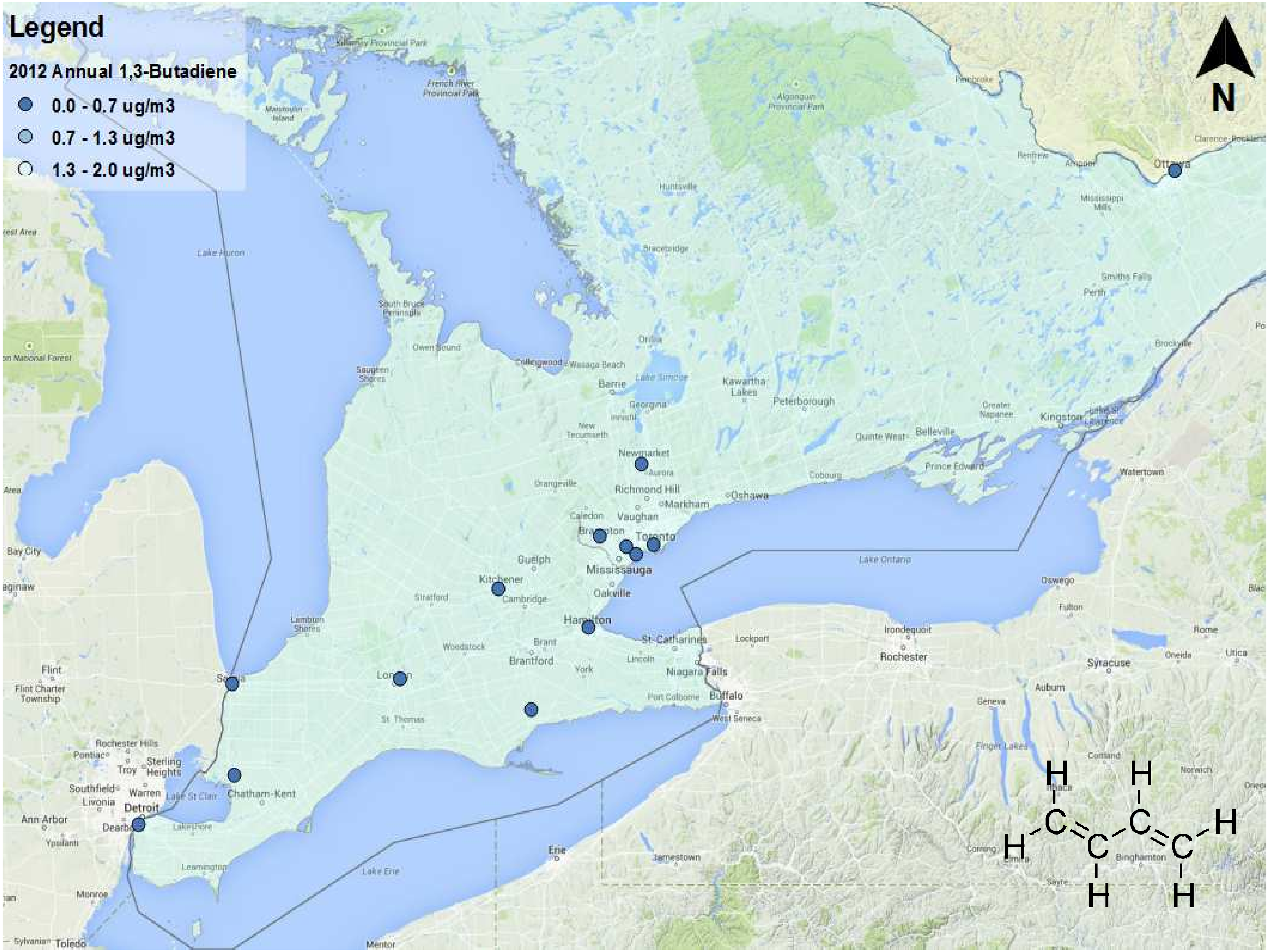
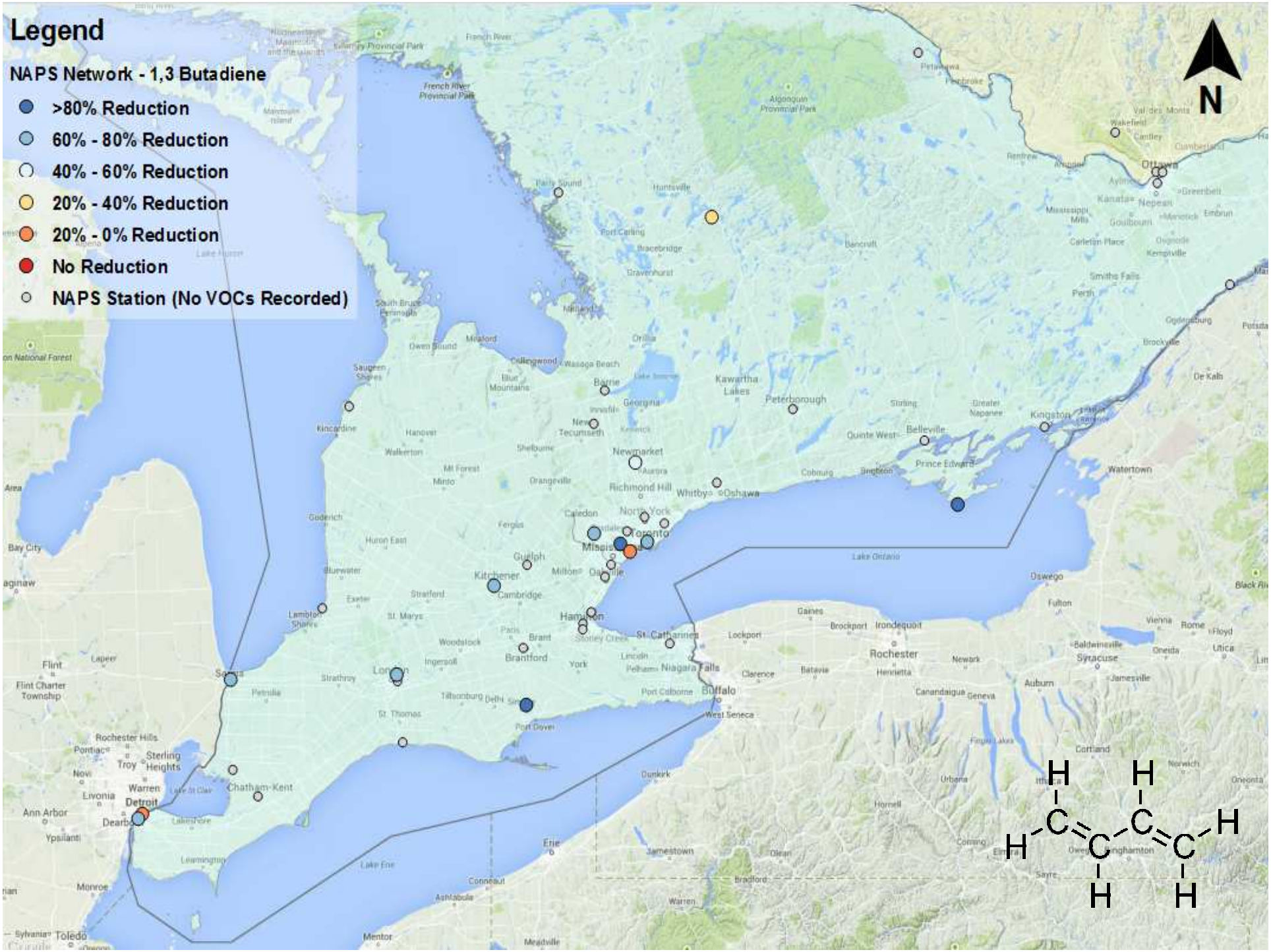
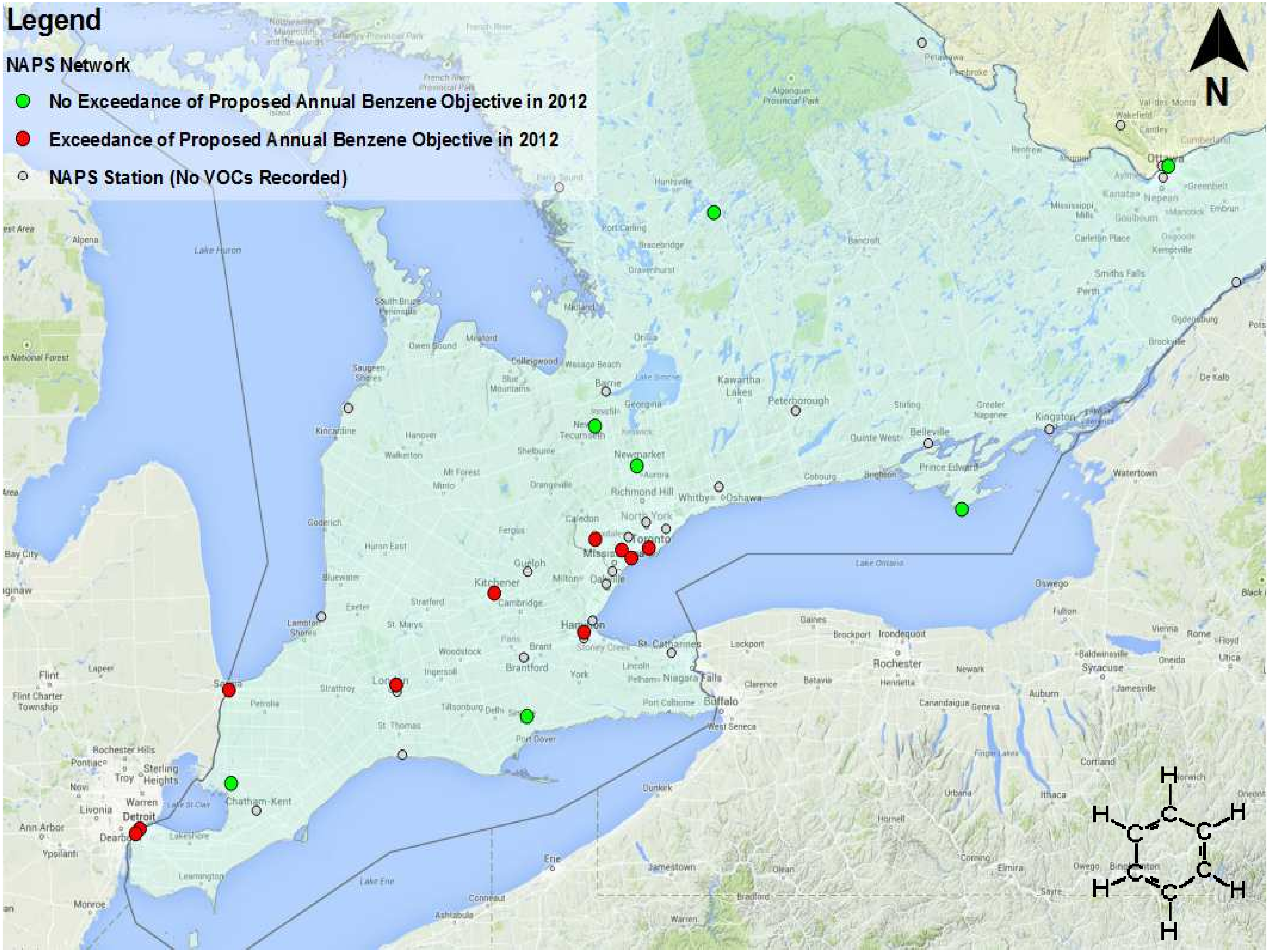

Legend
NAPS Monitoring Stations
N
Canada
Ontario
Quebec
North Dakota
Minnesota
South Dakota
Nebraska
Iowa
Wisconsin
Michigan
Illinois
Indiana
Ohio
Pennsylvania
New York
Vermont
New Hampshire
Maine
Massachusetts
Connecticut
New Brunswick
Minneapolis
Chicago
Detroit
Cleveland
Buffalo
Pittsburgh
Toronto
Ottawa
Montreal

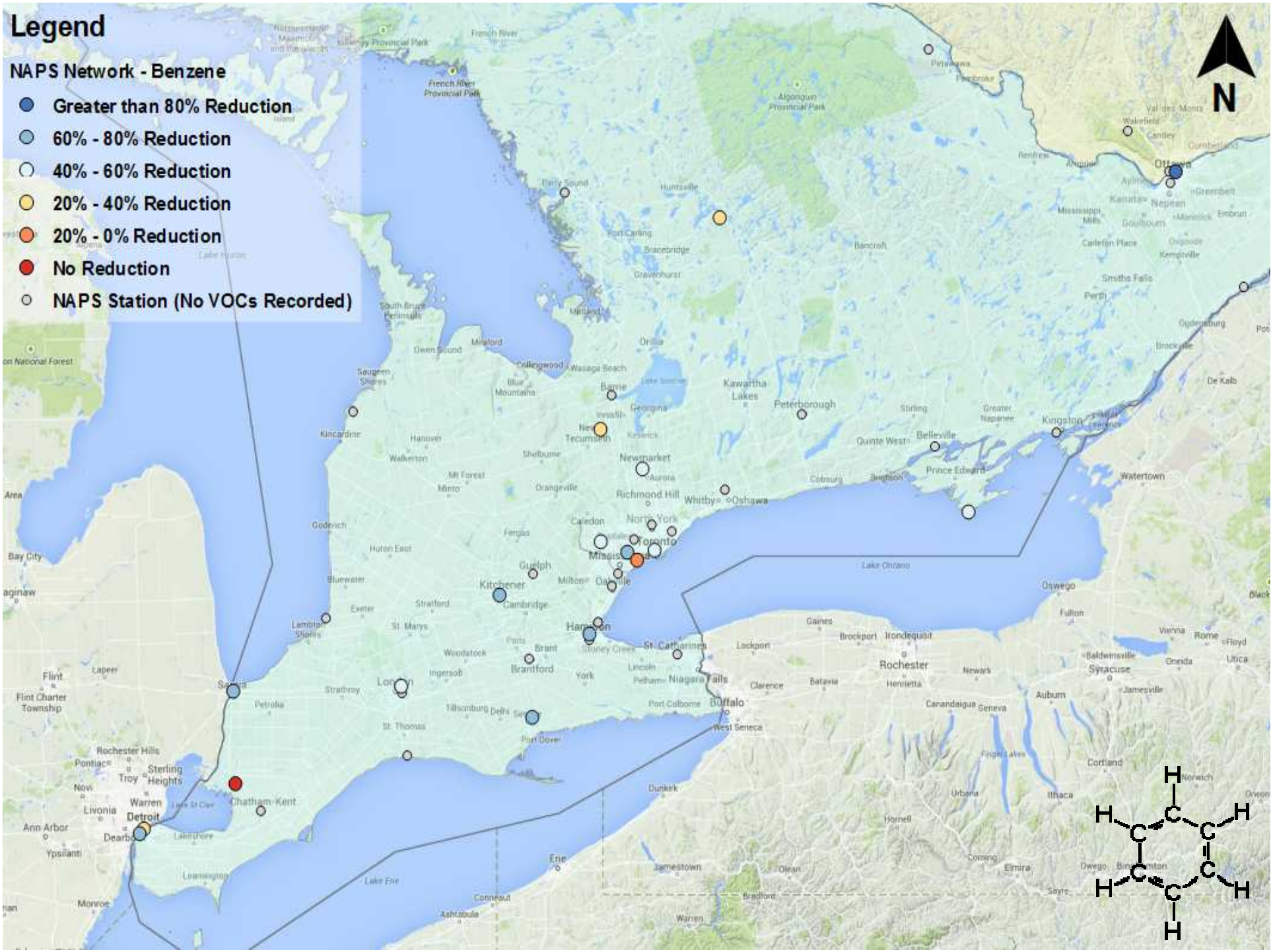

Legend
Ontatrio NAPS stations recording VOCs
NAPS Station Locations
N
Canada
Manitoba
Ontario
Québec
North Dakota
Minnesota
South Dakota
Nebraska
Iowa
Wisconsin
Michigan
Illinois
Indiana
Ohio
Pennsylvania
New York
Vermont
New Hampshire
Maine
Massachusetts
Connecticut
New Jersey
Maryland
Minneapolis
Chicago
Toronto
Ottawa
Montreal
Buffalo
Rochester
Cleveland
Pittsburgh
Philadelphia
New York
Boston
United States

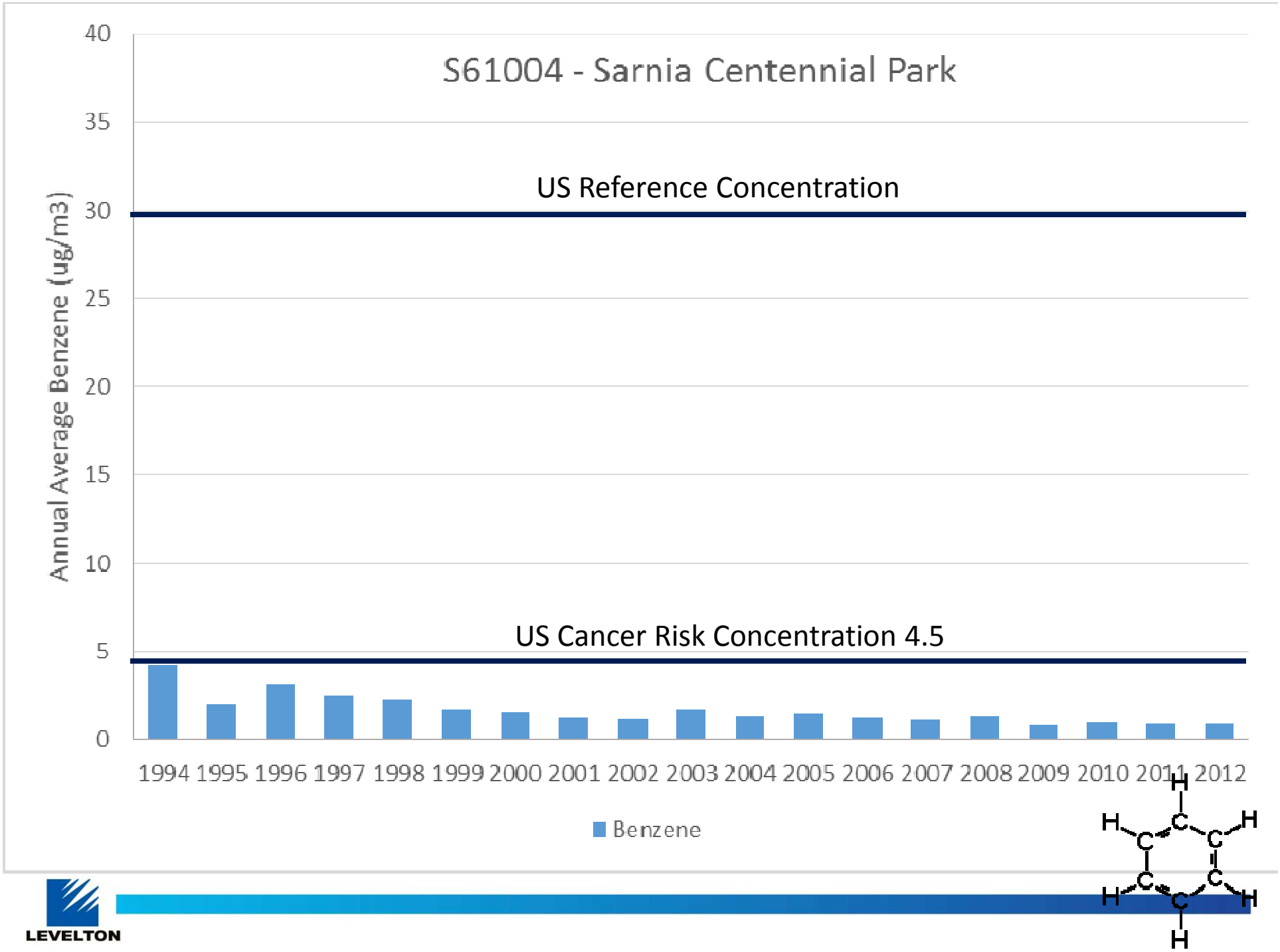

Legend
2012 Annual 1,3-Butadiene
0.0 - 0.7 ug/m3
0.7 - 1.3 ug/m3
1.3 - 2.0 ug/m3
N
Ottawa
Newmarket
Richmond Hill
Markham
Vaughan
Oshawa
Brampton
Toronto
Mississauga
Oakville
Guelph
Kitchener
Cambridge
Hamilton
St. Catharines
Niagara Falls
Buffalo
Brantford
London
Sarnia
Chatham-Kent
Detroit
Kingston
Peterborough
Barrie
Rochester
Syracuse
Lake Ontario
Lake Erie
Lake Huron
H
C
H
C
H
C
H
C
H
H


Legend
NAPS Network - 1,3 Butadiene
>80% Reduction
60% - 80% Reduction
40% - 60% Reduction
20% - 40% Reduction
20% - 0% Reduction
No Reduction
NAPS Station (No VOCs Recorded)
N
Toronto
Hamilton
Buffalo
Rochester
Detroit
Windsor
Ottawa
Kingston
Peterborough
Barrie
Kitchener
London
Niagara Falls
Lake Ontario
Lake Erie
Lake Huron
Lake St Clair


Legend
2012 Annual Benzene
0.0 - 0.15 ug/m3
0.15 - 0.3 ug/m3
0.3 - 0.45 ug/m3
0.45 - 0.54 ug/m3 (Exeeds Proposed Objective)
0.54 - 0.62 ug/m3 (Exeeds Proposed Objective)
0.62 - 0.98 ug/m3 (Exeeds Proposed Objective)
N
Ottawa
Toronto
Mississauga
Hamilton
Kitchener
Guelph
Oshawa
Peterborough
Kingston
Barrie
Detroit
Windsor
Chatham-Kent
London
Niagara Falls
Buffalo
Rochester
Syracuse
Erie
Lake Ontario
Lake Erie
Lake St Clair


Legend
NAPS Network
No Exceedance of Proposed Annual Benzene Objective in 2012
Exceedance of Proposed Annual Benzene Objective in 2012
NAPS Station (No VOCs Recorded)
N
Ottawa
Nepean
Kingston
Belleville
Peterborough
Kawartha Lakes
Barrie
Newmarket
Richmond Hill
Whitby
Oshawa
North York
Toronto
Mississauga
Oakville
Milton
Guelph
Kitchener
Cambridge
Hamilton
St. Catharines
Niagara Falls
Brantford
London
Sarnia
Chatham-Kent
Detroit
Buffalo
Rochester
Syracuse
Watertown
Oswego
Lake Huron
Lake Ontario
Lake Erie
Flint
Ann Arbor
Erie
H
C


Legend
NAPS Network - Benzene
Greater than 80% Reduction
60% - 80% Reduction
40% - 60% Reduction
20% - 40% Reduction
20% - 0% Reduction
No Reduction
NAPS Station (No VOCs Recorded)
N
Toronto
Buffalo
Detroit
Ottawa
Kingston
Peterborough
Hamilton
London
Windsor
Sarnia
Niagara Falls
Rochester
Syracuse
Lake Ontario
Lake Erie
Lake Huron


S61004 - Sarnia Centennial Park
Annual Average Benzene (ug/m3)
40
35
30
25
20
15
10
5
0
US Reference Concentration
US Cancer Risk Concentration 4.5
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Benzene

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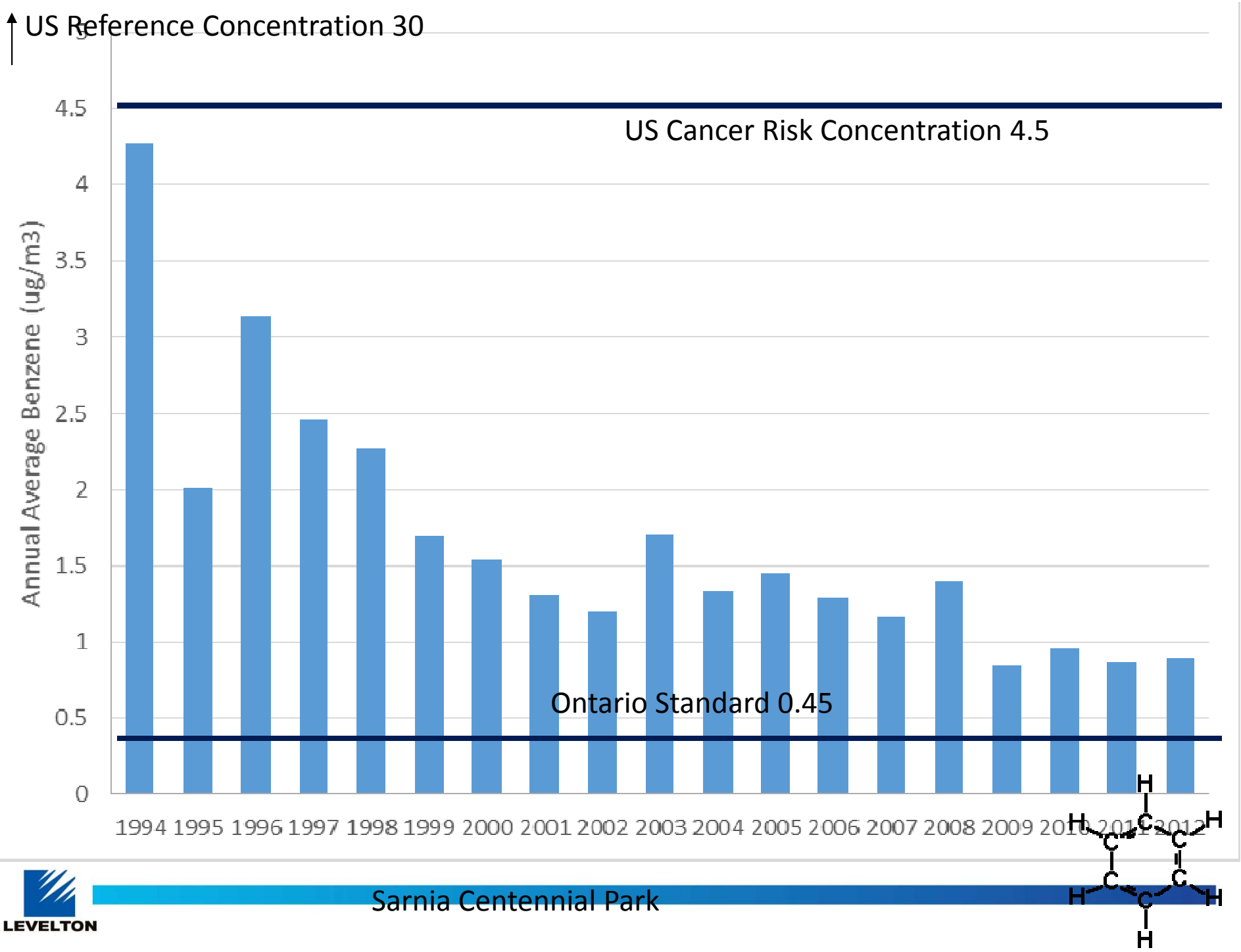

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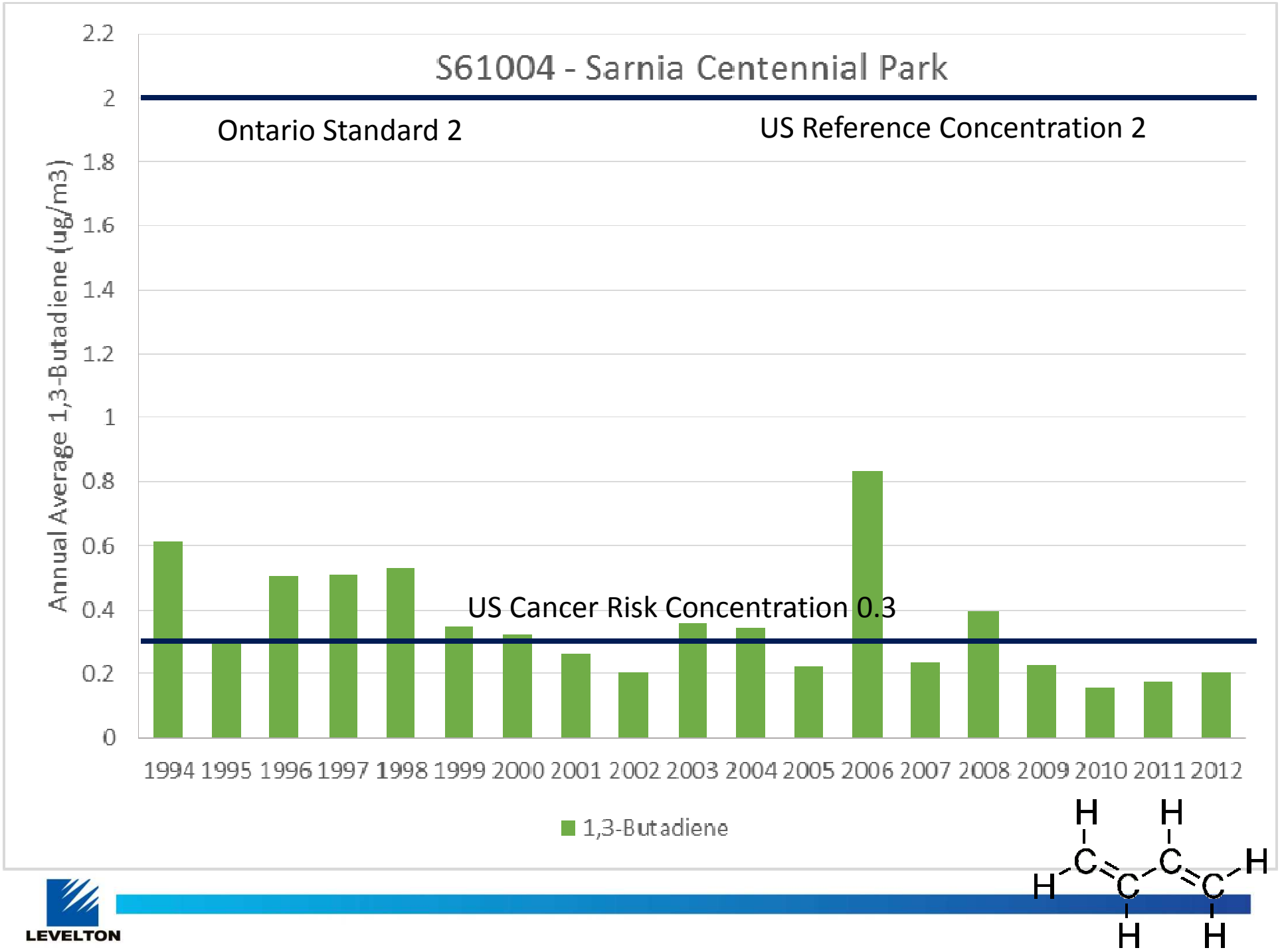
Sarnia Centennial Park


S61004 - Sarnia Centennial Park
Ontario Standard 2
US Reference Concentration 2
US Cancer Risk Concentration 0.3
Annual Average 1,3-Butadiene (ug/m3)
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
1,3-Butadiene

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Potential Emission Sources in Refineries

- Equipment Leaks
- Process Vents
- Storage Tanks
- Transfer Operations
- Blowdown Releases
- Wastewater Oil/Water Separators, Air Flotation Systems & Others
- Combustion Stack Exhaust
- Spills & Emergency Releases

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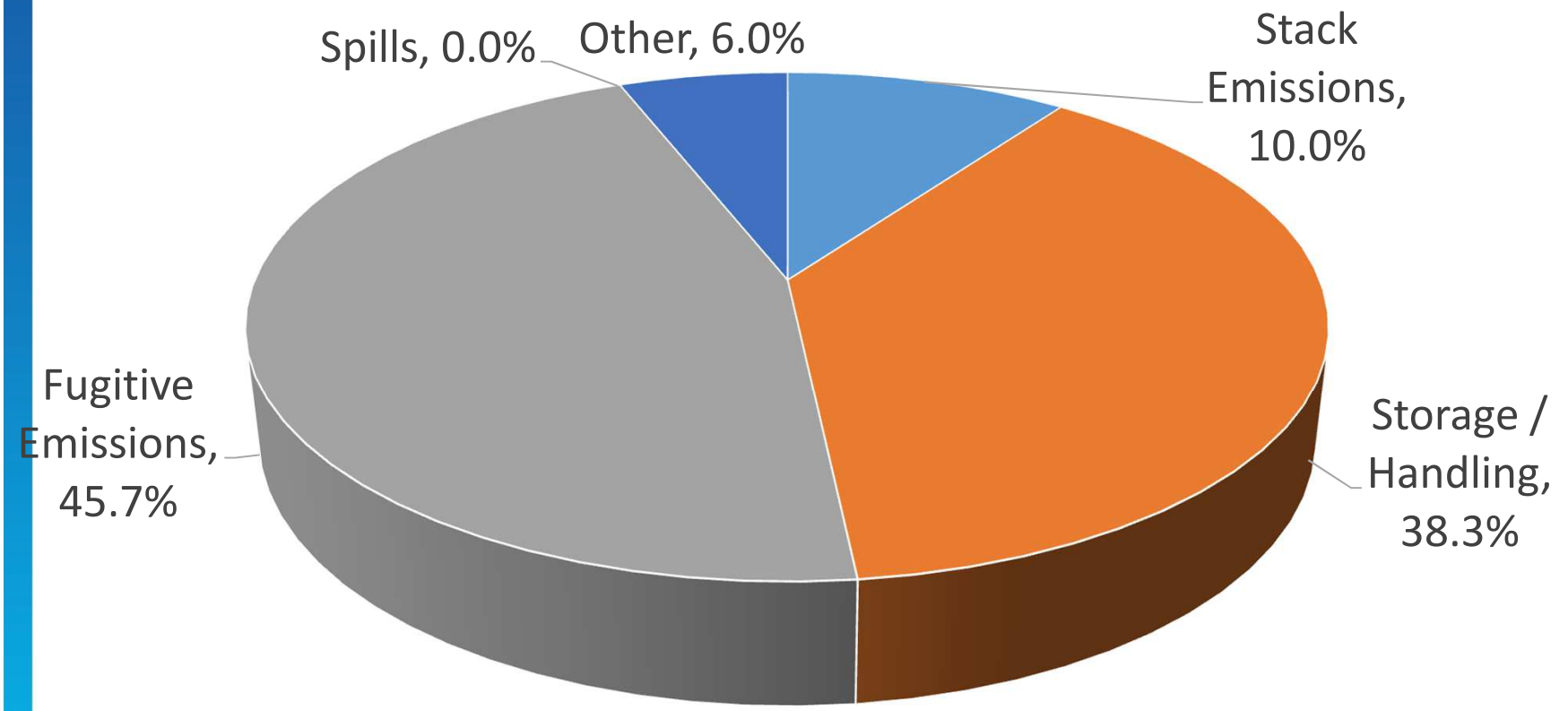
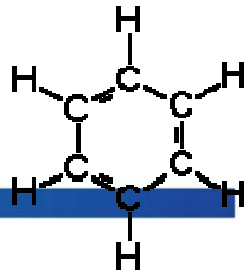
Benzene Emissions Distribution in Ontario Refineries (2012)





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Potential Emission Sources in Chemical Plants

- Equipment Leaks
- Process Vents
- Storage & Handling
- Wastewater
- Combustion Exhaust
- Spills & Emergency Releases

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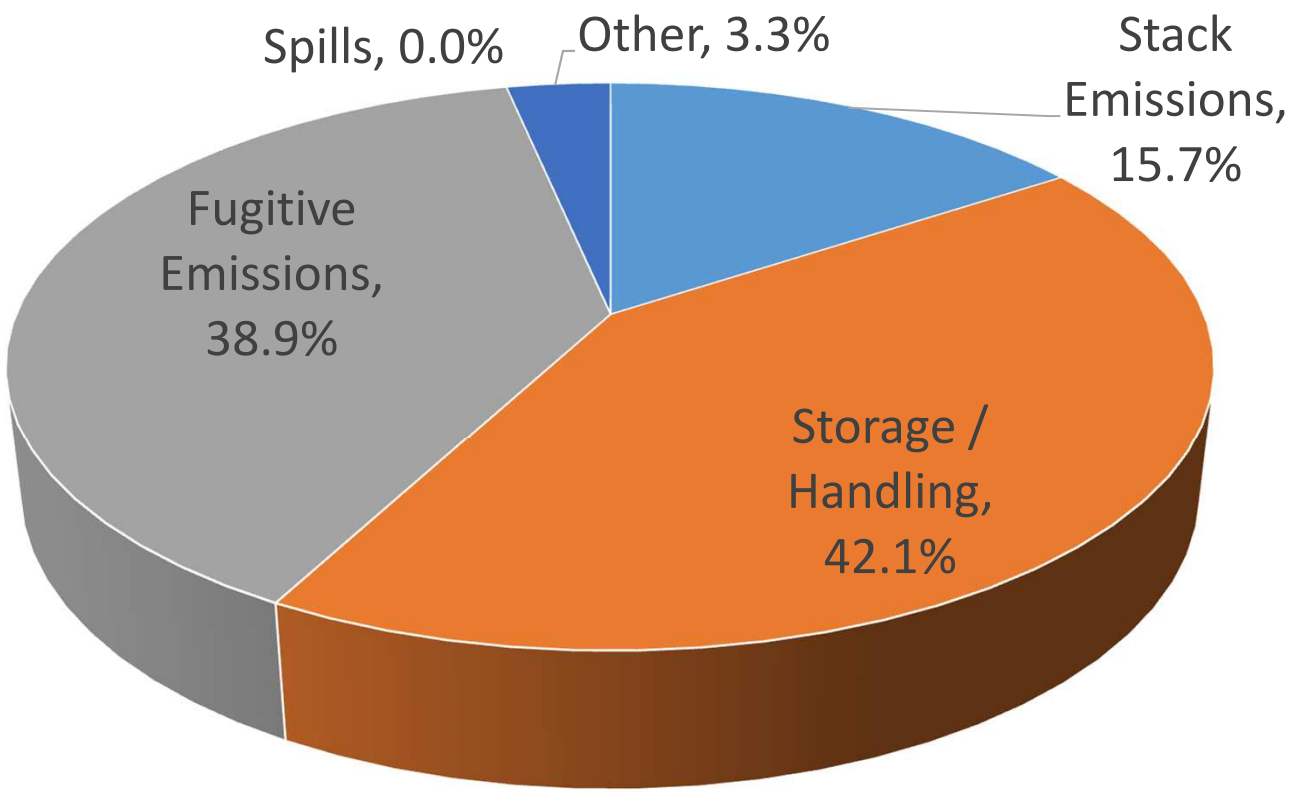
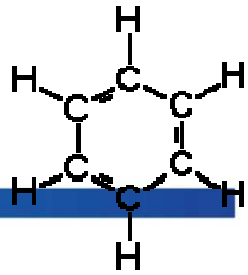
Benzene Emissions Distribution in Ontario Chemical Plants (2012)





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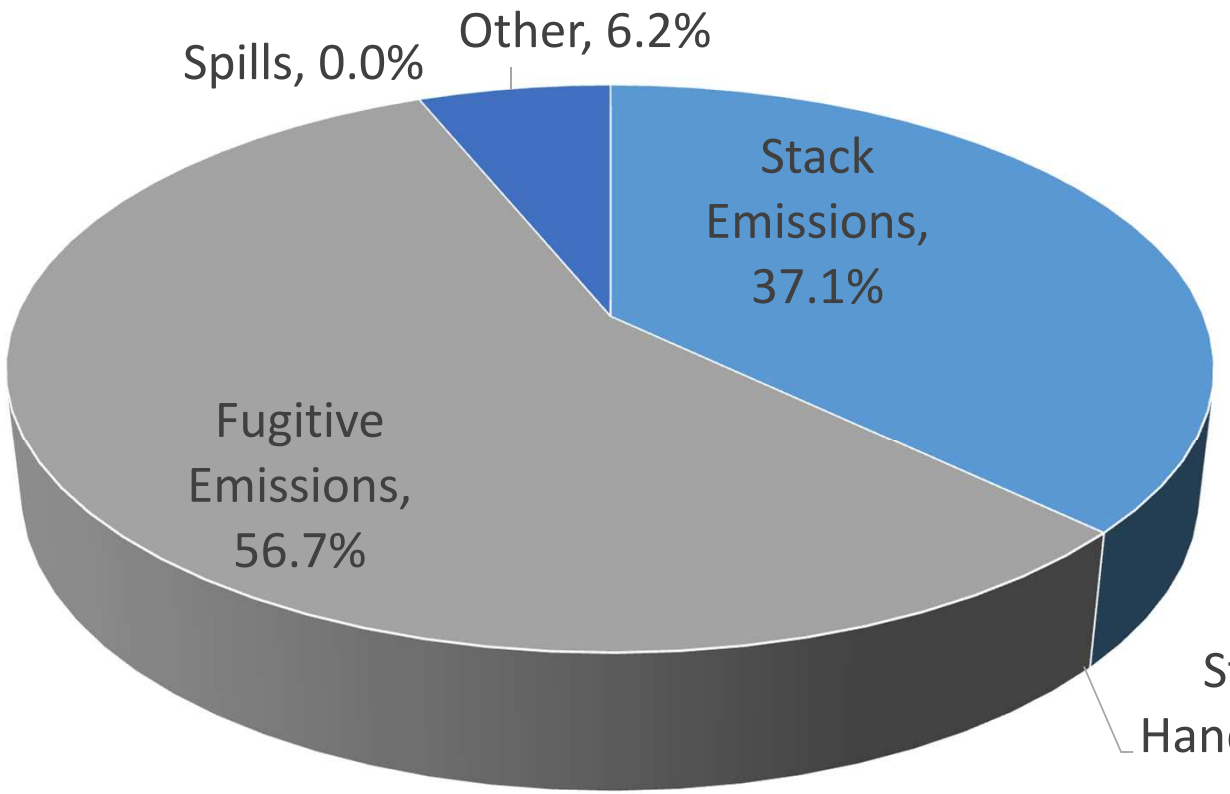
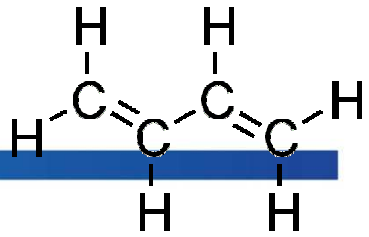
1,3 Butadiene Emissions Distribution in Ontario Chemical Plants (2012)





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Existing Reduction Techniques

- Flaring/combustion
- Condensation
- Adsorption
- Use of Floating Roof Tanks
- LDAR

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Fugitive Emissions Sampling & Monitoring Techniques

- EPA Reference Method 21 (e.g. OVA w/ FID/GC)
- Optical Imaging
- Bagging Method
- High-volume Sampler
- LDAR
- Remote Sensing

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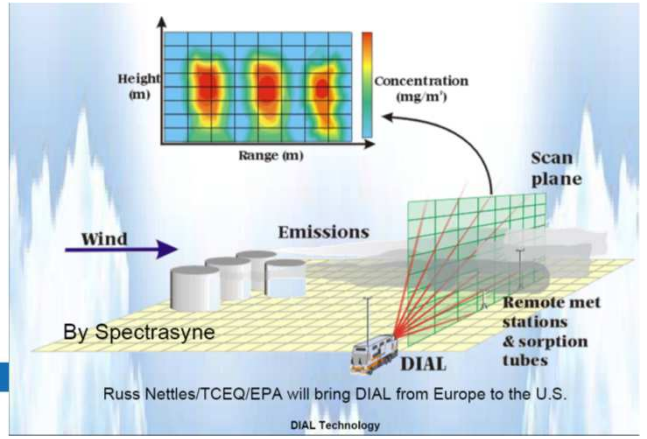
Remote Sensing Technologies

- UV differential optical absorption spectra (UV-DOAS)
- Open-path Fourier transform IR spectroscopy (OP-FTIR)
- Rama-spectroscopy
- Tunable diode laser (TDL)
- Differential absorption light detection and ranging (DIAL/LIDAR)
- Thermal Infrared Cameras
- Cavity Ring Down spectroscopy



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CDN/US Comparison

2012 Emissions in Canada and US

Sector	Substance	Cdn (tonnes)	US (tonnes)	Ratio
Chemical	1,3 Butadiene	16.2	435.8	3.7%
	Benzene	64.5	460.0	14.0%
Refining	Benzene	75.7	626.0	12.1%
Population		34,482,779	312,780,968	11.0%

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Summary

- Benzene and 1,3 Butadiene have "Come along way" and are significantly lower
- There is still some potential for "Continuous improvement"
- "Challenges" will become greater as technology thresholds are met

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Thank You!
Questions?

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