Massachusetts 2015 Air Quality Report

Department of Environmental Protection
Bureau of Air and Waste
Division of Air and Climate Programs

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This 2015 Air Quality Report was prepared by the Massachusetts Department of Environmental Protection (MassDEP), Air Assessment Branch (AAB), which collects representative samples of ambient air for a number of pollutants at monitoring stations located across the Commonwealth. All samples are collected in a precise and scientifically sound manner in order to properly characterize the quality of the air in the Commonwealth.

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The photo on the cover is a view of the roof top air monitoring station at 1 South Street in Pittsfield.

This report is available on MassDEP's web site at
www.mass.gov/eea/agencies/massdep/air/quality/air-monitoring-reports-and-studies.html

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List of Abbreviations

AAB ..... Air Assessment Branch
AQS..... Air Quality System
AQI…… ... Air Quality Index
BAM..... Beta Attenuation Monitor
BC ..... Black Carbon
BP..... Barometric Pressure
CAA ..... Clean Air Act
CFR ..... Code of Federal Regulations
CO ..... Carbon Monoxide
COT…….Trace Carbon Monoxide
CO_2 ..... Carbon Dioxide
FEM..... Federal Equivalent Method
FRM ..... Federal Reference Method
EPA ..... United States Environmental Protection Agency
IMPROVE .... Interagency Monitoring of Protected Visual Environments
MassDEP ..... Massachusetts Department of Environmental Protection
NAAQS ..... National Ambient Air Quality Standards (for criteria pollutants)
NATTS ..... National Air Toxics Trends Station
NCore……..National Core Monitoring Network
NO ..... Nitric Oxide
NOT…….Trace Nitric Oxide
NO_x ..... Nitrogen Oxides
NO_y ..... Total Reactive Oxidized Nitrogen
NO_2 ..... Nitrogen Dioxide
NO_3 ..... Nitrate
O_3 ..... Ozone
PAH..... Polycyclic Aromatic Hydrocarbon
PAMS ..... Photochemical Assessment Monitoring Stations
Pb ..... Lead
pH..... Concentration of hydrogen cations (H^+) in solution (an indicator of acidity)
ppb..... parts per billion by volume
ppm..... parts per million by volume
$PM_{2.5}$ ..... Particulate matter ≤ 2.5 microns aerodynamic diameter
PM_{10}..... Particulate matter ≤ 10 microns aerodynamic diameter
QA/QC..... Quality Assurance and Quality Control
REL ..... Relative Humidity
SIP ..... State Implementation Plan
SO_2 ..... Sulfur Dioxide
SO2T……...Trace Sulfur Dioxide
SO_4 ..... Sulfate
SUN..... Solar Radiation
SVOC……..Semi-Volatile Organic Compounds
TEM……Temperature
TSA ..... Technical Systems Audit
TSP..... Total Suspended Particulates
$\mu g/m^3$ ..... micrograms per cubic meter
VOCs..... Volatile Organic Compounds
WS/WD ..... Wind Speed/Wind Direction
WSv/WDv..... Wind Speed/Wind Direction Vector

Section I
Ambient Air Monitoring Program

Program Overview

Introduction

The Massachusetts Department of Environmental Protection (MassDEP) is the state agency responsible for monitoring outdoor air quality in Massachusetts and developing plans and regulatory programs to reduce emissions of pollutants that adversely affect public health, welfare, and the environment.

MassDEP's Air Assessment Branch (AAB) operates an extensive network of air monitoring stations throughout the Commonwealth. During 2015, MassDEP operated a network of 24 monitoring stations located in 18 cities and towns. MassDEP also received data from the Wampanoag Tribe of Gay Head (Aquinnah), which operates an air monitoring station on Martha's Vineyard.

MassDEP submits all ambient air quality data to the national Air Quality System (AQS) database that is administered by the U.S. Environmental Protection Agency (EPA). Real time data is sent to AIRNOW, which reports all national sites. MassDEP's MassAir Online website provides air quality information and allows users to point and click on a map of the state to find current air quality data from the MassDEP continuous air monitoring network. MassAir Online is found at www.mass.gov/eea/agencies/massdep/air/quality/. EPA also makes historical AQS data for all U.S. sites available at www3.epa.gov/airquality/airdata/**.** Accounts are available to the public.

Why is Air Quality Data Collected?

Ambient air quality data is used for a number of purposes, including to:

- Provide information about air quality to the public;
- Provide short-term and long-term information regarding air pollution and public health;
- Verify compliance with National Ambient Air Quality Standards;
- Assess the effectiveness of current air pollution control regulations and initiatives;
- Support development of policies and regulations aimed at reducing air pollution;
- Support long-term trend analysis and special research; and
- Fulfill requirements to report ambient air quality data to EPA.

What is Monitored?

MassDEP monitors parameters in the following categories:

Criteria pollutants for which EPA has established National Ambient Air Quality Standards (NAAQS). The criteria pollutants monitored are:

- sulfur dioxide (SO_2)
- ozone (O_3)
- carbon monoxide (CO)
- nitrogen dioxide (NO_2)
- lead (Pb)
- particulate matter ≤10 microns (PM_{10})
- particulate matter ≤ 2.5 microns ($PM_{2.5}$)

Non-criteria pollutants do not have National Ambient Air Quality Standards, but can contribute to the formation of ozone and particulate matter and/or be toxic. The non-criteria pollutants monitored include:

- nitric oxide (NO)
- total nitrogen oxides (NO_x)
- total reactive oxidized nitrogen (NO_y)
- volatile organic compounds (VOCs) – ozone precursors and reaction product chemicals
- black carbon (i.e., soot)
- toxics – health-relevant VOCs, semi-volatile organic compounds (SVOCs), carbonyls and metals

Meteorological parameters monitored include:

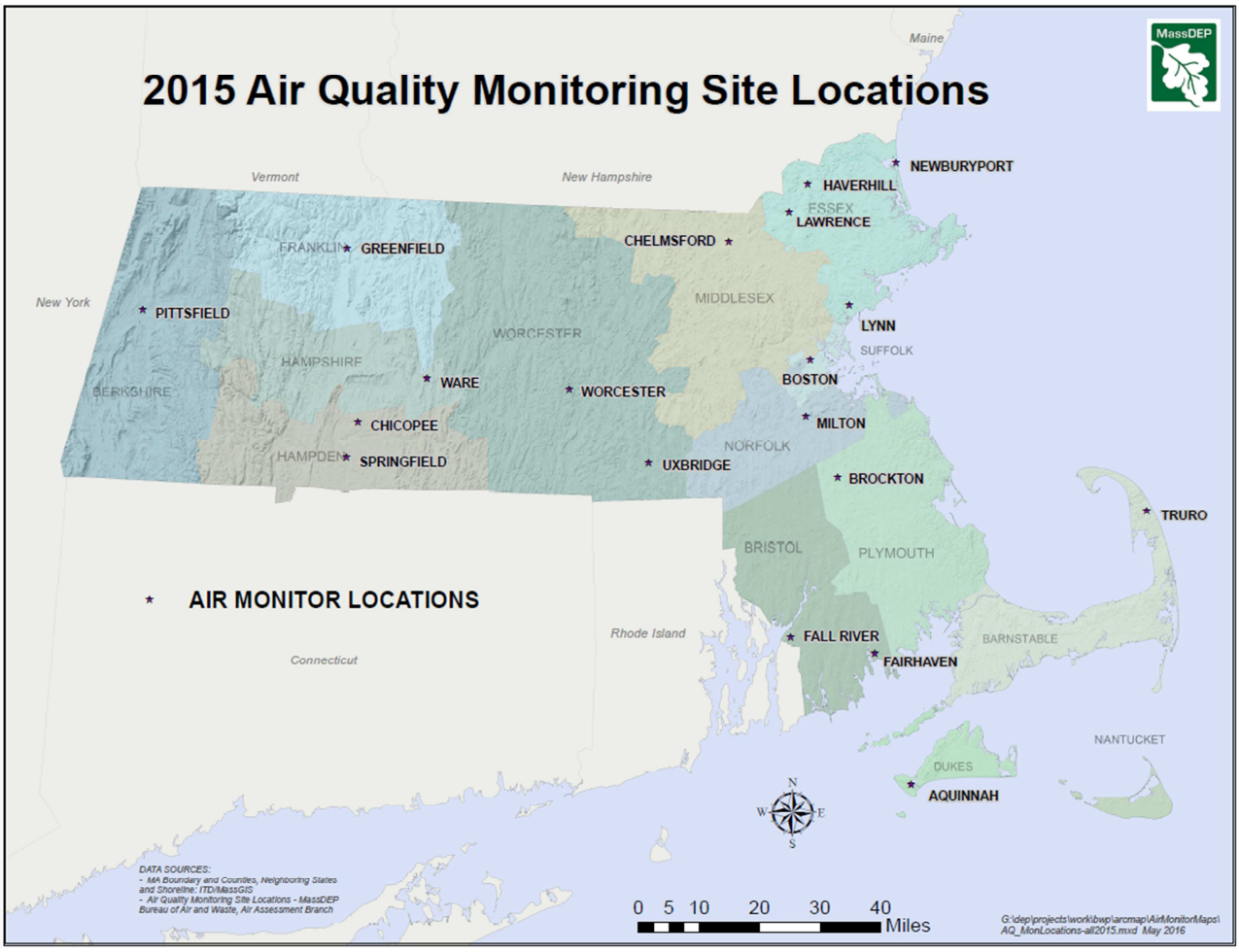
- wind speed/wind direction (WS/WD) and vector (WSv/WDv)
- relative humidity (REL)
- temperature (TEM)
- barometric pressure (BP)
- solar radiation (SUN)
- precipitation (PRECIP)

Monitoring Station Locations

Monitoring stations are sited to provide data for various purposes. Some are located where maximum pollutant concentrations are expected, while others are positioned in areas that will provide data that is representative of larger geographical areas. Local topography and pollutant source areas are factors that determine how well a particular monitor's location will represent a region.

Networks of monitors are located throughout the state. These networks are designed to reflect pollutant concentrations for all of Massachusetts. Section III of this report contains data summaries for each pollutant measured and maps showing the monitor locations for each network. Appendix A contains a list of monitor locations.

The map on page 3 shows Massachusetts cities and towns where air monitors were located during 2015.


2015 Air Quality Monitoring Site Locations
MassDEP
Maine
Vermont
New Hampshire
New York
Connecticut
Rhode Island
NEWBURYPORT
HAVERHILL
ESSEX
LAWRENCE
CHELMSFORD
FRANKLIN
GREENFIELD
MIDDLESEX
PITTSFIELD
WORCESTER
LYNN
SUFFOLK
HAMPSHIRE
BERKSHIRE
WARE
WORCESTER
BOSTON
MILTON
CHICOPEE
NORFOLK
HAMPDEN
SPRINGFIELD
UXBRIDGE
BROCKTON
TRURO
BRISTOL
PLYMOUTH
AIR MONITOR LOCATIONS
FALL RIVER
BARNSTABLE
FAIRHAVEN
NANTUCKET
DUKES
AQUINNAH
N
W
E
S
DATA SOURCES:
- MA Boundary and Counties, Neighboring States and Shoreline: ITD/MassGIS
- Air Quality Monitoring Site Locations - MassDEP Bureau of Air and Waste, Air Assessment Branch
0 5 10 20 30 40
Miles
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National Ambient Air Quality Standards

Below are the current National Ambient Air Quality Standards for criteria pollutants set by EPA. **Primary Standards** are designed to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. **Secondary Standards** are designed to protect public welfare, including protection against decreased visibility, damage to crops, vegetation, and buildings.

National Ambient Air Quality Standards					
Pollutant		**Primary/ Secondary**	**Averaging Time**	**Level**	**Form**
Carbon Monoxide		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		Primary and secondary	Rolling 3 month average	0.15 µg/m^3	Not to be exceeded
Nitrogen Dioxide		Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		Primary and secondary	Annual	0.053 ppm	Annual Mean
Ozone		Primary and secondary	8-hour	0.070 ppm 0.075 ppm (old std)	New standard effective 2016 Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution	$PM_{2.5}$	Primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
		Secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
		Primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	Primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		Primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

µg/m^3 = micrograms per cubic meter; ppm = parts per million; ppb = parts per billion

Pollutant Health Effects and Sources

Ozone (O_3)

- Tropospheric O_3 (ground-level) and Stratospheric O_3 (upper atmosphere) are the same chemical compound, just found at different places in the atmosphere. Stratospheric O_3 found at greater than 30,000 feet above the surface of the earth is beneficial to all life because it filters out the sun's harmful UV radiation before it reaches the earth's surface. Ground-Level O_3 on the other hand is a health and environmental problem. This report pertains exclusively to ground-level O_3.
- O_3 is a respiratory irritant and can reduce lung function and cause asthma attacks, nasal congestion, and throat irritation, and reduce resistance to infection. It can inflame and damage (possibly permanently) cells that line the lungs, and aggravate chronic lung diseases. In addition, a number of studies have found a strong link between increases in ground-level O_3 and increased risk of premature death.
- O_3 is toxic to vegetation, inhibiting growth and causing leaf damage.
- O_3 deteriorates materials such as rubber and fabrics.
- Ground-level O_3 is unique in that it is formed by the reactions that occur between certain pollutants in the presence of intense, high-energy sunlight during the hot summer months. The complexity of the reactions and the amount of time needed to complete these reactions can result in the buildup of ground-level ozone concentrations far downwind from the original source of the precursors.
- Sources of ground-level O_3 precursors, i.e., nitrogen oxides and hydrocarbons, include motor vehicles, lawn and garden equipment, power plants and other industrial sources.

Carbon Monoxide (CO)

- CO binds with hemoglobin in the blood, reducing the amount of oxygen carried to organs and tissues.
- Symptoms of high CO exposure include shortness of breath, chest pain, headaches, confusion, and loss of coordination. The health threat is most severe for those with cardiovascular disease.
- Motor vehicle emissions are the largest source of CO, which is produced from incomplete combustion of carbon in fuels.
- Industrial processes and non-transportation fuel combustion (e.g., boilers, lawn and garden equipment) also are sources of CO.

Sulfur Dioxide (SO_2)

- SO_2 combines with water vapor to form acidic aerosols harmful to the respiratory tract, aggravating symptoms associated with lung diseases such as asthma and bronchitis.
- SO_2 is a primary contributor to acid deposition. Impacts of acid deposition include: acidification of lakes and streams, damage to vegetation, damage to materials, and diminution of visibility.
- SO_2 is a product of fuel combustion (e.g., the burning of coal and oil that contains sulfur). Sources include power plants and business and residential sources burning heating oil.

Nitrogen Dioxide (NO_2)

- NO_2 lowers resistance to respiratory infections and aggravates symptoms associated with asthma and bronchitis.
- NO_2 contributes to acid deposition. Impacts of acid deposition include: acidification of lakes and streams, damage to vegetation, damage to materials, and diminution of visibility.
- NO_2 and NO contribute to the formation of ozone.
- NO_2 is formed from the oxidation of nitric oxide (NO). Major sources of NO are fuel combustion, space heating, power plants and motor vehicles.

Particulate Matter (PM_{10} and $PM_{2.5}$)

- Particulate matter is tiny airborne particles or aerosols, which include dust, dirt, soot, smoke, and liquid droplets. Fine particulate matter (mostly below 2.5 microns in size) are not only the result of direct emissions, but can be formed in the atmosphere by chemical reactions involving gaseous pollutants.
- The numbers 2.5 and 10 refer to the particle size (actually the particles equal to or less than that size), measured in microns, which are collected by the monitors. Several thousand $PM_{2.5}$ particles could fit on the period at the end of this sentence.
- The small size of these particles allows easy entry into the human respiratory system. Long-term exposure causes the particles to accumulate in the lungs and affects breathing and produces respiratory symptoms. The small particles can migrate through the lungs and into the circulatory system and potentially produce cardio-vascular symptoms, as well as impacts from toxic components contained in the particulate matter.
- Particulate matter causes soiling and corrosion of materials.
- Particulate matter contributes to atmospheric haze that degrades visibility.
- Sources of particulates include industrial process emissions, motor vehicles, incinerators, power plants, and other fuel combustion sources.

Lead (Pb)

- Lead is an elemental metal that is found in nature.
- Exposure to lead can occur by inhalation or ingestion with food, water, soil or dust particles.
- Children, infants, and fetuses are the most susceptible to the effects of lead exposure.
- Lead causes intellectual disability, brain damage, and liver disease. It may be a factor in high blood pressure and damages the nervous system.
- Lead enters the atmosphere from the incineration of lead containing materials and from the manufacture and processing of lead containing products or materials like storage batteries, smelting and removal of paint that contained lead.

Monitoring Network Description

The following describes the ambient air monitoring network in 2015.

Network Size

- 24 monitoring stations
- 18 cities and towns with monitoring stations

Number of Continuous Monitors

Continuous monitors measure air quality 24 hours per day. The data are reported as hourly means.

- Criteria pollutant monitors measure pollutants for which National Ambient Air Quality Standards (NAAQS) have been set.
  - 7 – CO (carbon monoxide), which includes 5 trace level CO monitors
  - 10 – NO_2 (nitrogen dioxide). NO (nitric oxide) and NO_x (total nitrogen oxides) also are measured by these monitors
  - 16 – O_3 (ozone)
  - 6 – SO_2 (sulfur dioxide), which includes 4 trace level SO_2 monitors
  - 14 – $PM_{2.5}$ (particulate matter – 2.5 microns) Beta Attenuation Monitors (BAMs)

- Meteorological monitors track weather conditions.
  - 13 – BP (barometric pressure)
  - 13 – REL (relative humidity)
  - 13 – SUN (solar radiation)
  - 13 – TEM (temperature)
  - 13 – WS/WD (wind speed/wind direction)
  - 1 – WSv/WDv (wind speed vector/wind direction vector)
  - 2 – Precipitation

- Other Monitors
  - 3– NOT/NO_y (Total Reactive Oxidized Nitrogen)
  - 4 – PAMS (photochemical assessment monitoring station) These monitors measure VOCs (volatile organic compounds) using automated gas chromatographs (GCs) on an hourly basis during the summer
  - 5 – Black Carbon

Number of Intermittent Monitors

Intermittent monitors take discrete samples for a specific time period. The samples are taken every day, every third day, or every sixth day. The data are averaged in 3-hour or 24-hour intervals.

- Criteria pollutant monitors measure pollutants that have National Ambient Air Quality Standards (NAAQS).
  - 3 – Pb (Lead)
  - 6 – PM_{10} (particulate matter – 10 microns)
  - 18 – $PM_{2.5}$ FRM (particulate matter – 2.5 microns Federal Reference Method)

- Non-criteria pollutant monitors measure pollutants that do not have NAAQS.
  - 4 – PAMS (photochemical assessment monitoring station). These monitors measure VOCs (volatile organic compounds) on a less intensive schedule than during the summer months.
  - 2 – Toxics. These monitors measure health-relevant VOCs.
  - 2 – Speciation. These monitors measure for $PM_{2.5}$, nitrates, and organics
  - 1 – PM_{10} (particulate matter – 10 microns) for metals analysis

Section II
Attainment of Air Quality Standards

Attainment Status Summary

The federal Clean Air Act (CAA) contains timeframes and milestones for states to meet and maintain National Ambient Air Quality Standards (NAAQS) for criteria pollutants, which include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. EPA sets NAAQS at levels to protect public health and the environment. The EPA must review each NAAQS every five years and may update the standards based on new scientific information as well as establish new monitoring requirements. Each state is required to monitor the ambient air to determine whether it meets each standard.[1] If monitoring shows that the air quality does not meet a standard, the state must develop and implement pollution control strategies to attain that standard. Once air quality meets a standard, a state must develop a plan to maintain that standard while accounting for future economic and emissions growth. Taken together, these plans and control strategies constitute the State Implementation Plan (SIP).

Carbon Monoxide

Monitored levels of CO in Massachusetts meet the CO standards. Prior to the mid-1980s, Massachusetts was in nonattainment of the CO standards. However, with the adoption of numerous control programs, CO emissions significantly decreased and monitored levels of CO met the standards beginning in 1987. Massachusetts is designated as attainment for the CO standards. Based on EPA's most recent review of the CO standards, in August 2011, EPA retained the existing primary CO standards of 9 ppm measured over 8 hours, and 35 ppm measured over 1 hour. Since EPA did not change the standards, no new designation process was triggered.

Lead

Monitored levels of lead in Massachusetts meet the lead standards. Based on EPA's most recent review of the lead standard, in October 2008, EPA lowered the lead standard from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$ averaged over a rolling 3-month period. In November 2011, EPA designated all of Massachusetts as unclassifiable/attainment for the 2008 standard.

Nitrogen Dioxide

Monitored levels of NO_2 in Massachusetts meet the NO_2 standards. Based on EPA's most recent review of the NO_2 standards, in January 2010, EPA established a new 1-hour NO_2 standard of 100 ppb and new near-road monitoring requirements. In January 2012, EPA designated all of Massachusetts as unclassifiable/attainment for the 2010 standard.

[1] MassDEP develops an annual Ambient Air Monitoring Network Plan that describes recent and planned changes to the statewide monitoring network, available at www.mass.gov/eea/agencies/massdep/air/reports/annual-ambient-air-quality-monitoring-network-plan.html .

Sulfur Dioxide

Monitored levels of SO_2 in Massachusetts meet the SO_2 standards. Based on EPA's most recent review of the SO_2 standards, in June 2010, EPA established a new 1-hour SO_2 standard of 75 ppb. EPA is still in the process of designating states (including Massachusetts) for the 1-hour SO_2 standard.

Particulate Matter

There are standards for two types of particulate matter: PM_{10} and $PM_{2.5.}$ Monitored levels of PM_{10} and $PM_{2.5}$ in Massachusetts meet the respective standards.

Based on EPA's most recent review of the $PM_{2.5}$ standards, in December 2012, EPA lowered the primary annual $PM_{2.5}$ standard to 12 $\mu g/m^3$. In December 2014, EPA designated all of Massachusetts as unclassifiable/attainment for the 2012 standard.

Ozone

Monitored levels of ozone in Massachusetts currently meet the ozone standards. In 1979, EPA established an ozone standard (0.12 ppm) based on the maximum 1-hour ozone concentration that occurred each day during the ozone monitoring season. Massachusetts was previously designated as nonattainment for the 1-hour ozone standard.

In 1997, EPA promulgated new 8-hour ozone standards (0.08 ppm) that were designed to be more representative of exposure over time, rather than just the maximum concentration. Massachusetts was designated as nonattainment for these standards at that time. Through a combination of state and regional controls, Massachusetts' air quality attained the 1997 standards by the 2009 attainment deadline.

In 2008, EPA lowered the 8-hour ozone standard to 0.075 ppm. In April 2012, EPA designated Dukes County as nonattainment (marginal classification) for the 2008 ozone standards and designated the remainder of Massachusetts as unclassifiable/attainment. Based on the most recent monitoring data, Dukes County attained the 2008 ozone standard by the 2015 attainment deadline.

Based on EPA's most recent review of the ozone standards, in October 2015, EPA lowered the 8-hour standards to 0.070 ppm. Based on 2014–2016 ozone monitoring data, by October 2016 Massachusetts will submit a recommendation to EPA on how Massachusetts should be designated for the 2015 standards. EPA will issue final designations for the 2015 ozone standards by October 2017.

2015 Ozone Season

In 2015, there were three days when the 8-hour ozone standard of 0.075 ppm was exceeded in Massachusetts. Based on the most recent three-years of data from 2013–2015, there were no violations of the 0.075 ppm standard in Massachusetts.

In general, the chemical reactions that produce elevated ozone concentrations occur when there are high levels of ozone "precursor" pollutants – VOCs and NOx – on hot sunny days. Typically, Massachusetts ozone exceedances occur when a high pressure area well south of New England creates a broad southwesterly airflow that travels along the coastal urban corridor before reaching New England, where it arrives with elevated levels of VOCs, NOx, and ozone. This typical pattern also moves slowly, promoting heat wave conditions that can last several days, allowing pollutants to build up.

Difference Between Ozone Exceedances and Violations

An ozone exceedance occurs when monitored ozone concentrations exceed the ozone NAAQS. Ozone monitoring data is collected as an hourly average of continuous data which is then used to determine the highest 8-hour average value for the day. An exceedance of the 8-hour standard is an 8-hour averaged value that is greater than 0.075 ppm (0.070 ppm beginning in 2016). An ozone exceedance occurs when a monitor records ambient levels of ozone above the standard. Monitoring an ozone exceedance does not mean that a violation of the ozone standard has occurred, because a violation of an ozone standard (as opposed to an exceedance) is based on three-year averages of data at each monitor.

An ozone violation of the 8-hour standard is determined using the annual 4th-highest daily maximum eight-hour ozone value at each monitor. A violation requires a three-year average of the annual 4th-highest daily maximum eight-hour value that is greater than 0.075 ppm (0.070 ppm beginning in 2016). In other words, the eight-hour values for each day during a year for a specific monitor are ranked from highest to lowest. Then, the 4th-highest value for three consecutive years is averaged. If the three-year average is greater than 0.075 ppm, a violation of the 8-hour standard has occurred at that monitoring site.

Exceedance Days and Total Exceedance Trends

Figures 1 and 2 show the trend in the number of 8-hour exceedance days, maximum one hour values, and the total number of exceedances for each year.

Figure 1 shows that, under the 0.075 ppm 8-hour standard, there were a greater number of exceedances and exceedance days when compared to the former 1-hour standard. The 8-hour standard is designed to be more protective of public health by being more representative of exposure over time rather than a maximum concentration. Figure 2 shows a decline in the number of days in which ozone concentrations exceeded the former 1-hour standard of 0.12 ppm.

Figure 1
8-hr Ozone Exceedance Days and Total Exceedances 1987-2015
8-hour standard = 0.075 ppm
Years 1987-2007 show what exceedances
would have been with a 0.075 ppm 8-hour standard

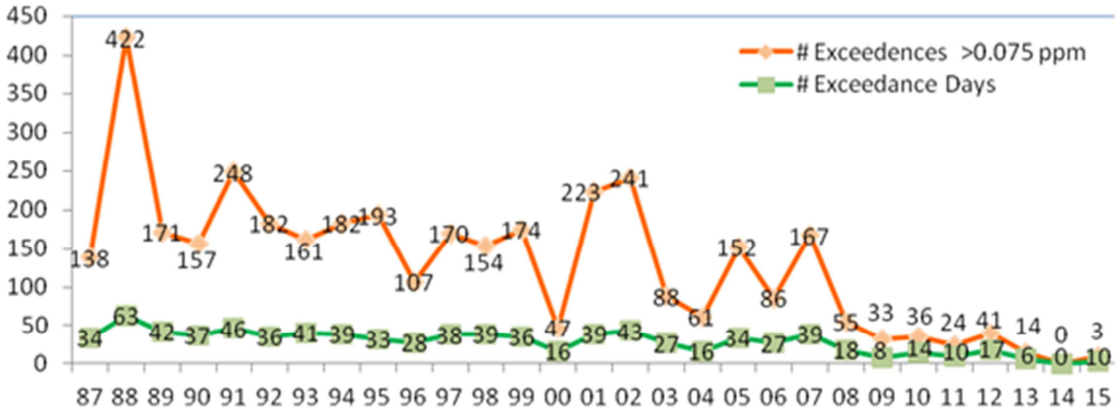
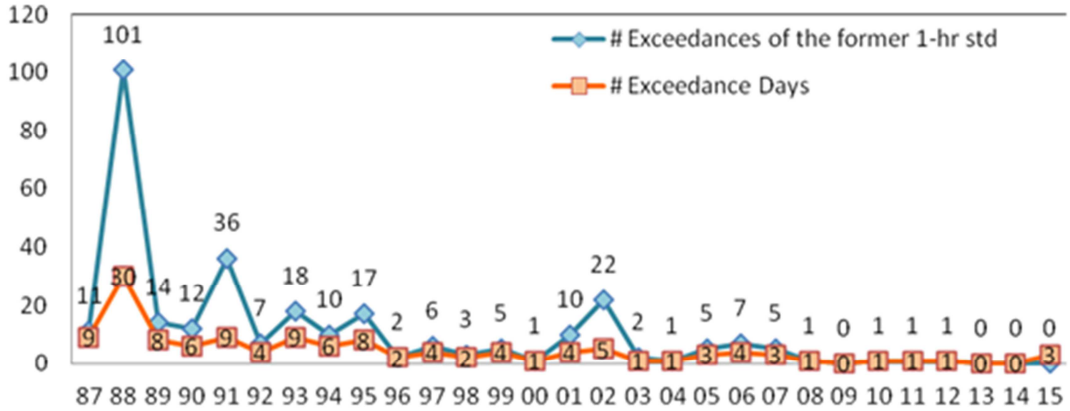


Figure 2
1-hr Ozone Exceedance Days and Total Exceedances 1987-2015
1-hour standard = 0.12 ppm (revoked June 15, 2005)



Daily Ozone and PM Forecasts

MassDEP provides the public with daily air quality forecasts for ozone from April through September and for fine particles all year round using weather maps and meteorological factors to predict whether or not conditions will result in elevated pollution levels. The daily air quality forecasts are available from www.mass.gov/eea/agencies/massdep/air/quality/ or by calling the Air Quality Hotline (1-800-882-1497). EPA web sites that contain regional and national pollution forecasts using data that is provided by participating states are located at www.epa.gov/region01/airquality/forecast.html and http://airnow.gov/. The table below describes the ratings used in the daily air quality forecasts.

Air Quality Index (AQI): Ozone

Index Values	Levels of Health Concern	Cautionary Statements
0-50	Good	None
51-100*	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
101-150	Unhealthy for Sensitive Groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.
151-200	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
201-300	Very Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors.

* An AQI of 100 for ozone corresponds to an ozone level of 0.070 parts per million (averaged over 8 hours).

Air Quality Index (AQI): Particle Pollution

Index Values	Levels of Health Concern	Cautionary Statements
0-50	Good	None
51-100*	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101-150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
151-200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
201-300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

*An AQI of 100 for particles up to 2.5 micrometers in diameter corresponds to a level of 35 micrograms per cubic meter (averaged over 24 hours). An AQI of 100 for particles up to 10 micrometers in diameter corresponds to a level of 150 micrograms per cubic meter (averaged over 24 hours).

Section III
Massachusetts Air Quality Data Summaries

Ozone Summary

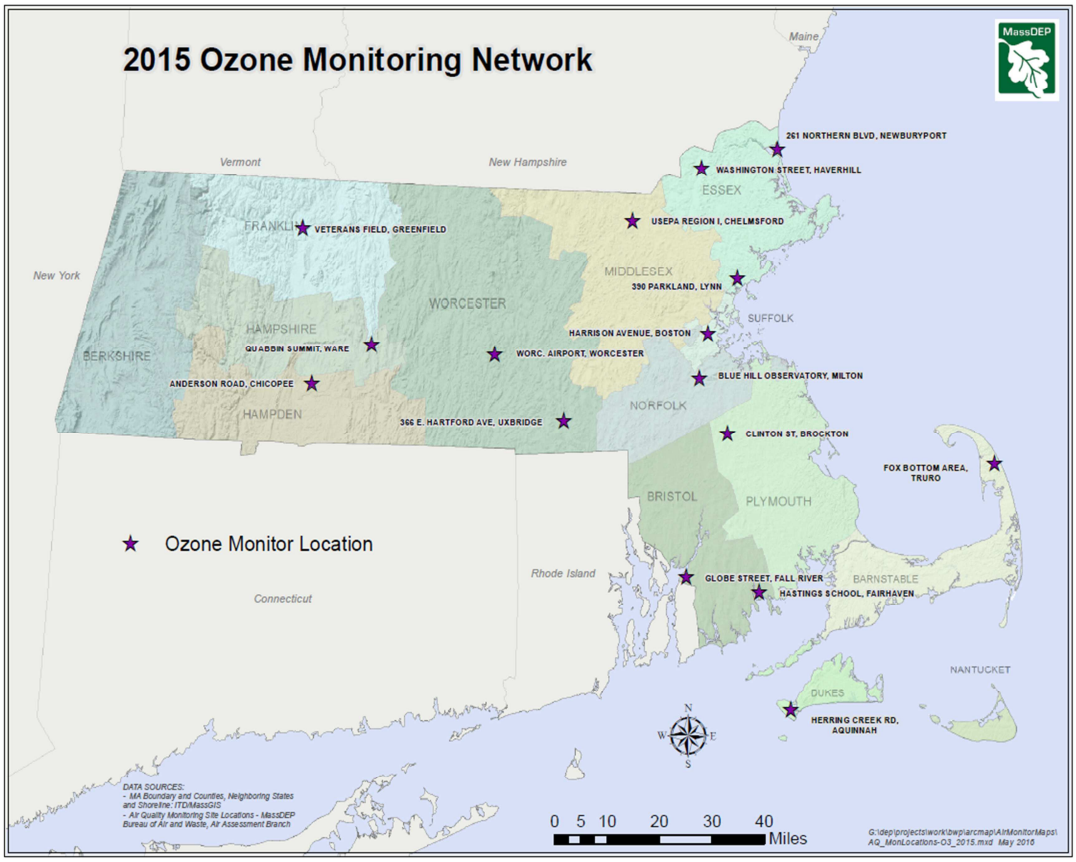
2015 Ozone Data Summary

A summary of the data collected during the 2015 ozone season (March 1 – Sept. 30) is shown below (in parts per million). MassDEP operated 15 ozone sites during 2015. The Wampanoag Tribe operated one site in Aquinnah on Martha's Vineyard.

Ozone 2015					1ST	2ND	3RD	4TH	8-HR	1ST	2ND
				%	MAX	MAX	MAX	MAX	MAX>.075	MAX	MAX
SITE ID	CITY	COUNTY	ADDRESS	OBS	8-HR	8-HR	8-HR	8-HR	STD	1-HR	1-HR
25-007-0001	Aquinnah	Dukes	1 HERRING CREEK RD	45	0.074	0.074	0.068	0.068	0	0.087	0.081
25-025-0042	Boston	Suffolk	HARRISON AVE	96	0.078	0.059	0.057	0.056	1	0.086	0.070
25-023-0005	Brockton	Plymouth	1 CLINTON ST	94	0.078	0.068	0.068	0.065	1	0.096	0.075
25-017-0009	Chelmsford	Middlesex	11 TECHNOLOGY	97	0.076	0.070	0.063	0.061	1	0.088	0.077
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	97	0.084	0.074	0.071	0.070	1	0.102	0.097
25-005-1006	Fairhaven	Bristol	30 SCHOOL ST	95	0.075	0.072	0.071	0.067	0	0.094	0.084
25-005-1004	Fall River	Bristol	659 GLOBE ST	97	0.077	0.073	0.072	0.070	1	0.094	0.086
25-011-2005	Greenfield	Franklin	VETERANS FIELD	96	0.070	0.068	0.065	0.064	0	0.082	0.081
25-009-5005	Haverhill	Essex	685 WASHINGTON	96	0.077	0.067	0.062	0.059	1	0.086	0.084
25-009-2006	Lynn	Essex	390 PARKLAND	96	0.075	0.074	0.066	0.065	0	0.088	0.087
25-021-3003	Milton	Norfolk	BLUE HILL OBSERV	97	0.088	0.072	0.068	0.067	1	0.097	0.083
25-009-4005	Newburyport	Essex	HARBOR STREET	94	0.077	0.071	0.070	0.065	1	0.088	0.085
25-001-0002	Truro	Barnstable	FOX BOTTOM AREA	60	0.077	0.076	0.071	0.071	2	0.097	0.089
25-027-0024	Uxbridge	Worcester	366 E HARTFORD DR	89	0.069	0.066	0.065	0.064	0	0.084	0.080
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	94	0.073	0.072	0.072	0.071	0	0.089	0.088
25-027-0015	Worcester	Worcester	375 AIRPORT	97	0.068	0.068	0.063	0.063	0	0.077	0.075

STANDARDS: 8-hour = 0.075 ppm (0.070 ppm beginning in 2016)

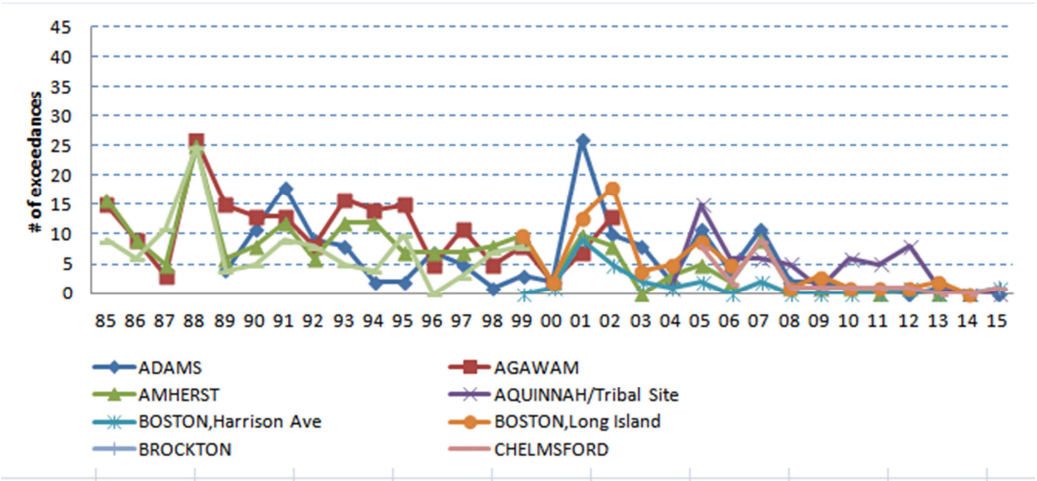
ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER; **% OBS** = PERCENTAGE OF VALID DAYS MONITORED DURING O3 SEASON; **1ST, 2ND, 3RD, 4TH MAX 8-HR** = MAXIMUM 8-HR VALUE FOR THE 1ST, 2ND, 3RD AND 4TH HIGHEST DAY; **8-HR MAX > .075 STD** = NUMBER OF MEASURED DAILY 8-HOUR MAXIMUM VALUES GREATER THAN 0.075 PPM 8-HR STANDARD; **1ST, 2nd MAX 1-HR** = MAXIMUM 1-HR VALUE FOR THE 1st AND 2nd HIGHEST DAY

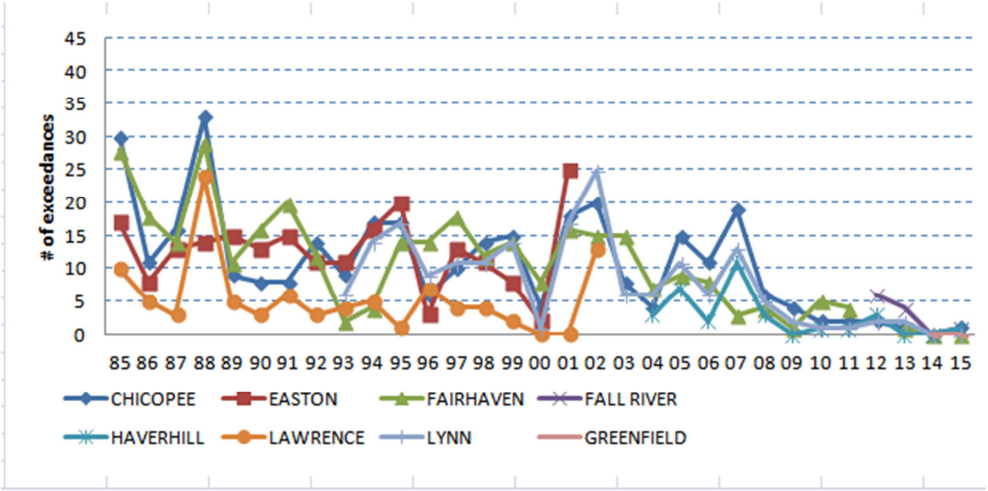

2015 Ozone Monitoring Network
MassDEP
Maine
Vermont
New Hampshire
New York
Connecticut
Rhode Island
261 NORTHERN BLVD, NEWBURYPORT
WASHINGTON STREET, HAVERHILL
ESSEX
USEPA REGION I, CHELMSFORD
MIDDLESEX
390 PARKLAND, LYNN
SUFFOLK
HARRISON AVENUE, BOSTON
BLUE HILL OBSERVATORY, MILTON
NORFOLK
CLINTON ST, BROCKTON
FOX BOTTOM AREA, TRURO
BRISTOL
PLYMOUTH
GLOBE STREET, FALL RIVER
HASTINGS SCHOOL, FAIRHAVEN
BARNSTABLE
NANTUCKET
DUKES
HERRING CREEK RD, AQUINNAH
FRANKLIN
VETERANS FIELD, GREENFIELD
WORCESTER
HAMPSHIRE
QUABBIN SUMMIT, WARE
WORC. AIRPORT, WORCESTER
BERKSHIRE
ANDERSON ROAD, CHICOPEE
HAMPDEN
366 E. HARTFORD AVE, UXBRIDGE
Ozone Monitor Location
N
W
E
S
0 5 10 20 30 40
Miles
DATA SOURCES:
- MA Boundary and Counties, Neighboring States and Shoreline: ITD/MassGIS
- Air Quality Monitoring Site Locations - MassDEP Bureau of Air and Waste, Air Assessment Branch
G:\dep\projects\work\bwp\arcmap\Air\Monitor\Maps\AQ_MonLocations-O3_2015.mxd May 2016

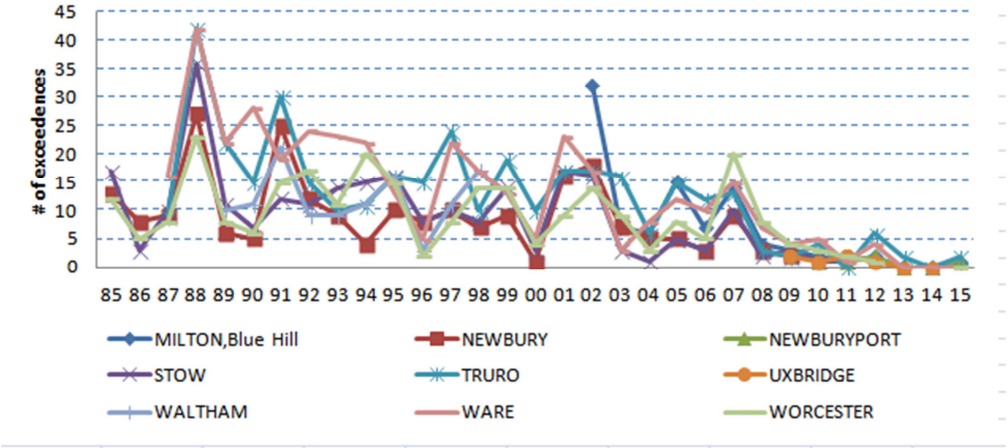
8-hour Ozone Exceedance Trends

Shown below are the long-term trends of 8-hour ozone exceedances for each site based on the 2008 standard of 0.075 ppm.

Figure 3
8-hour Ozone Exceedance Trends 1985 – 2015
Standard = 0.075 ppm







Sulfur Dioxide (SO_2) Summary

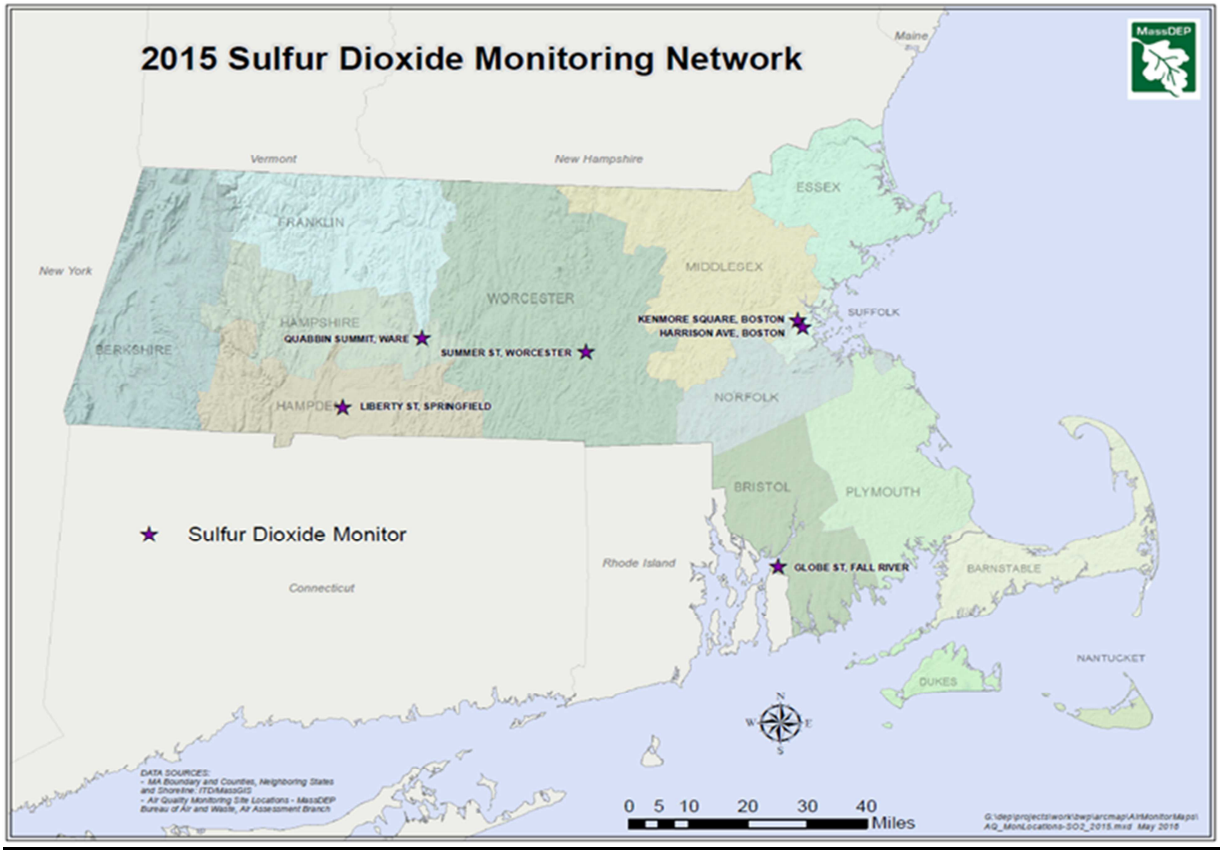
2015 SO_2 Data Summary

A summary of the 2015 SO_2 data is shown below (in parts per billion). MassDEP operated six SO_2 sites during 2015. SO_2 monitors in Boston (Kenmore Square and Harrison Avenue), Worcester, and Ware are trace-level instruments that measure a lower concentration range than standard instruments to obtain more precise concentration resolution to better track SO_2 trends.

SO2 2015				1ST	2ND	99TH		1ST	2ND
			%	MAX	MAX	PCTL	ARITH	MAX	MAX
CITY	COUNTY	ADDRESS	OBS	1-HR	1-HR	1-HR	MEAN	24-HR	24-HR
Boston	Suffolk	KENMORE SQ	94	10.1	5.8	5.5	0.53	2.9	2.9
Boston	Suffolk	HARRISON AVE	95	12.4	12.3	9.4	0.80	4.6	4.3
Fall River	Bristol	659 GLOBE ST	96	21.2	11.3	9.9	0.71	4.0	3.9
Springfield	Hampden	LIBERTY ST	95	7.1	5.2	4.8	1.10	3.3	3.0
Ware	Hampshire	QUABBIN SUMMIT	95	5.5	4.9	4.6	0.64	2.9	2.6
Worcester	Worcester	SUMMER ST	92	8.0	5.9	4.9	0.52	3.1	2.8

STANDARDS: 1-hour = 75 ppb 3-hour = 0.5 ppm (500 ppb)

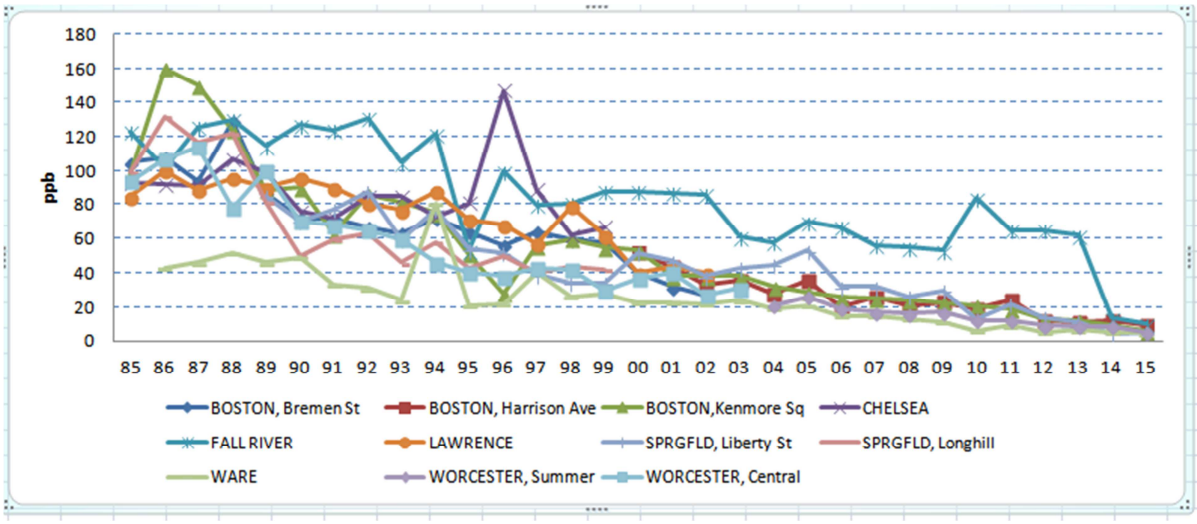
ABBREVIATIONS AND SYMBOLS USED IN TABLE
% OBS = PERCENT OBSERVATIONS; **1ST, 2ND MAX 1-HR** = FIRST AND SECOND HIGHEST 1-HOUR VALUE; **99TH PCTL 1-HR** = 99th PERCENTILE OF THE 1-HOUR MAX; **ARITH MEAN** = ANNUAL ARITHMETIC MEAN; **1st, 2nd MAX 24-HR** = FIRST AND SECOND HIGHEST 24-HOUR VALUE



SO_2 Trends

The long-term trends of the 1-hour 99th percentile for each SO_2 site are shown below. The trend has been downward and Massachusetts is below the 1-hour standard.

Figure 4
SO_2 Trends 1986 – 2015
1-hour 99th Percentile Annual Average
Standard = 75 ppb



Nitrogen Dioxide (NO_2) Summary

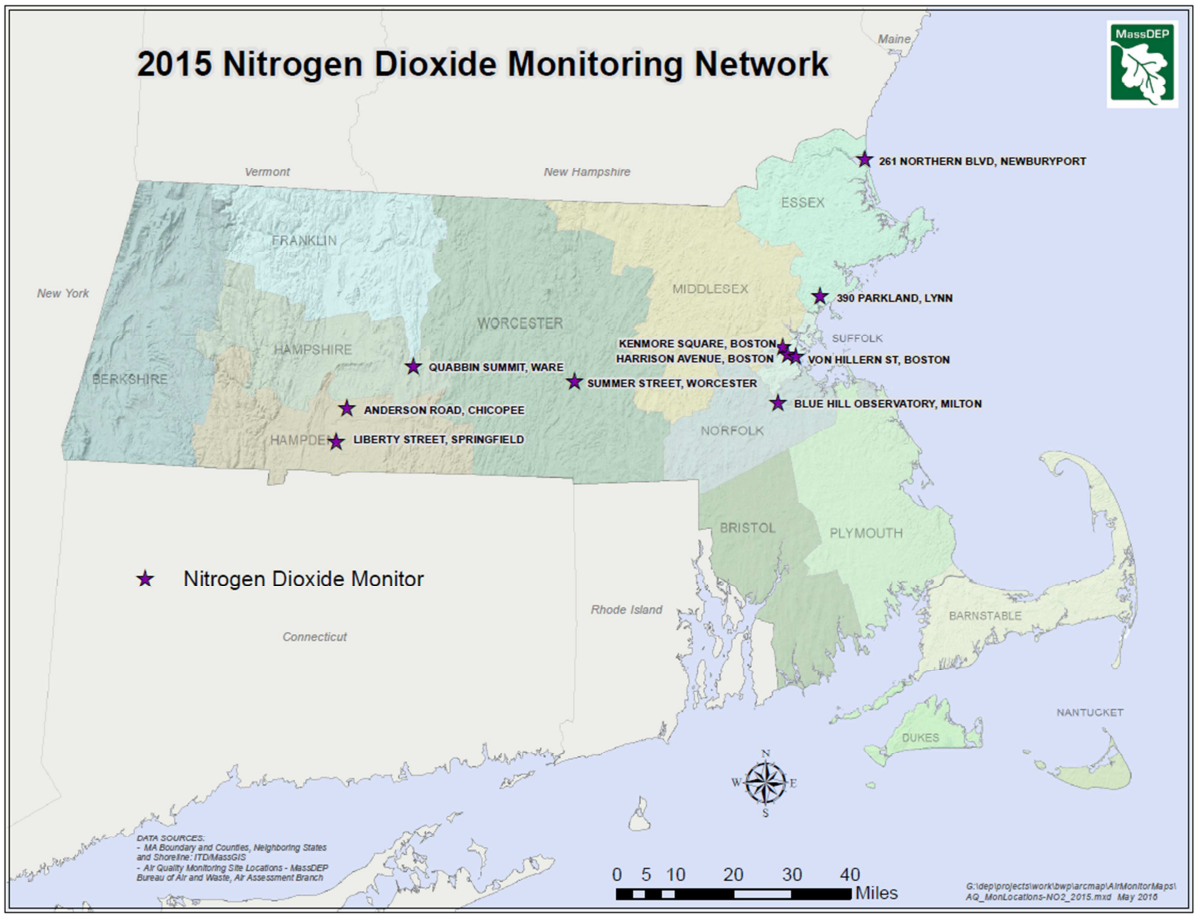
2015 NO_2 Data Summary

A summary of the 2015 NO_2 data is shown below (in parts per billion). MassDEP operated 10 NO_2 sites during 2015.

NO2 2015					1ST	2ND	98TH	
				%	MAX	MAX	PERCENTILE	ARITH
SITE ID	CITY	COUNTY	ADDRESS	OBS	1-HR	1-HR	VALUE	MEAN
25-025-0002	Boston	Suffolk	KENMORE SQ	94	61	60	56	17.3
25-025-0042	Boston	Suffolk	HARRISON AVE	93	60	57	53	14.97
25-025-0044	Boston	Suffolk	19 VON HILLERN	93	61	57	51	16.37
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	95	48	46	42	7.21
25-009-2006	Lynn	Essex	390 PARKLAND	95	48	48	41	6.81
25-021-3003	Milton	Norfolk	695 HILLSIDE ST	95	39	39	32	4.98
25-009-4005	Newburyport	Essex	HARBOR STREET	94	30	29	24	3.96
25-013-0016	Springfield	Hampden	LIBERTY STREET	94	67	64	51	13.35
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	94	35	32	28	2.52
25-027-0023	Worcester	Worcester	SUMMER ST	94	80	74	55	13.39

STANDARDS: Annual Arithmetic Mean = 53 ppb 1-hour = 100 ppb

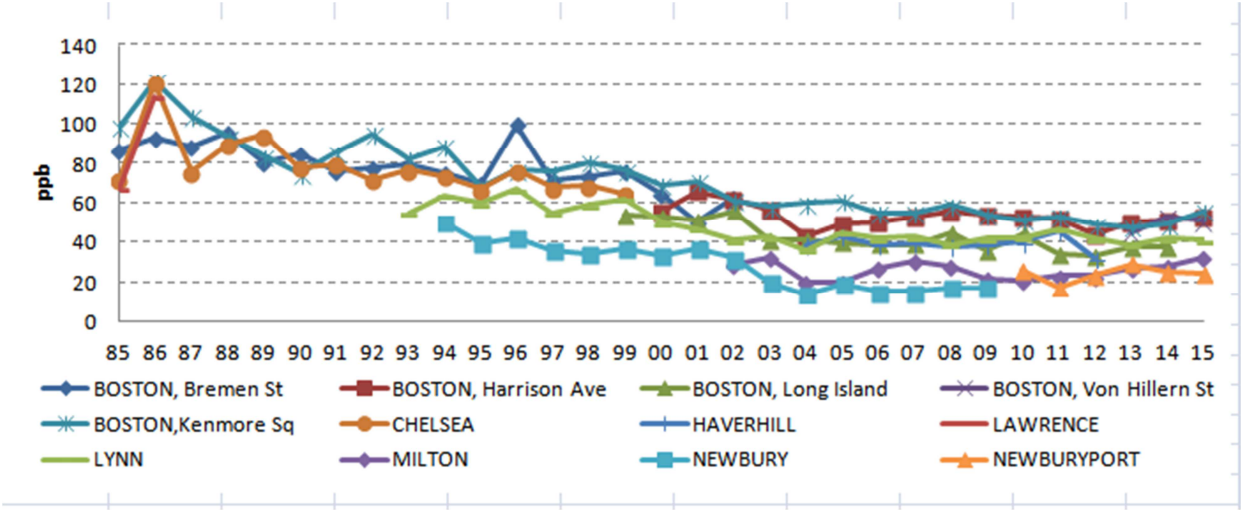
ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER; **% OBS** = PERCENTAGE OF COMPLETED OBSERVATIONS; **1ST, 2ND MAX 1-HR** = FIRST AND SECOND HIGHEST 1-HOUR VALUE; **98TH PERCENTILE VALUE** = 98TH PERCENTILE VALUE; **ARITH MEAN** = ANNUAL ARITHMETIC MEAN

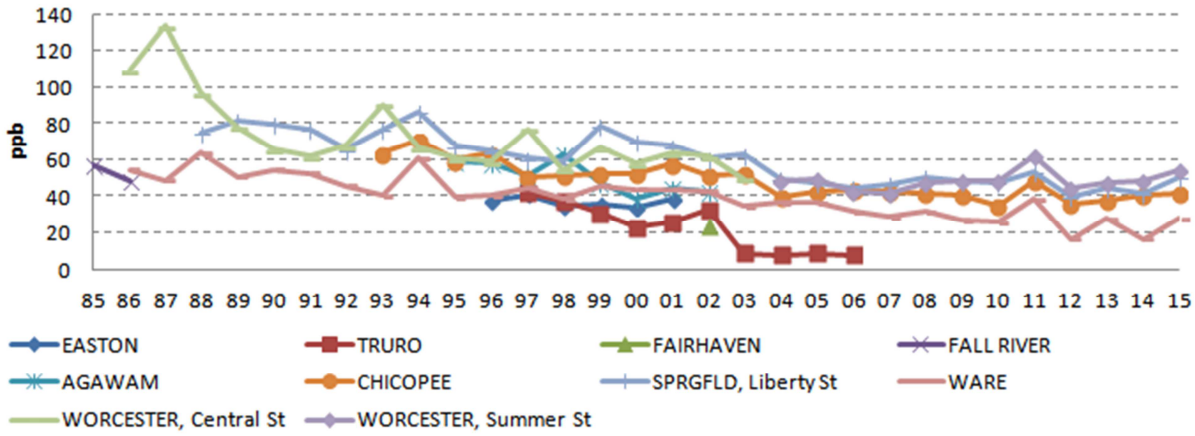


NO_2 Trends

The long-term trends of the 1-hour 98th percentile annual average for each NO_2 site are shown below. The trend has been stable the last few years and downward for the entire period. Massachusetts is below the 1-hour standard.

Figure 5
NO_2 Trends 1986 – 2015
1-hour 98th Percentile Annual Average
Standard = 100 ppb





Carbon Monoxide (CO) Summary

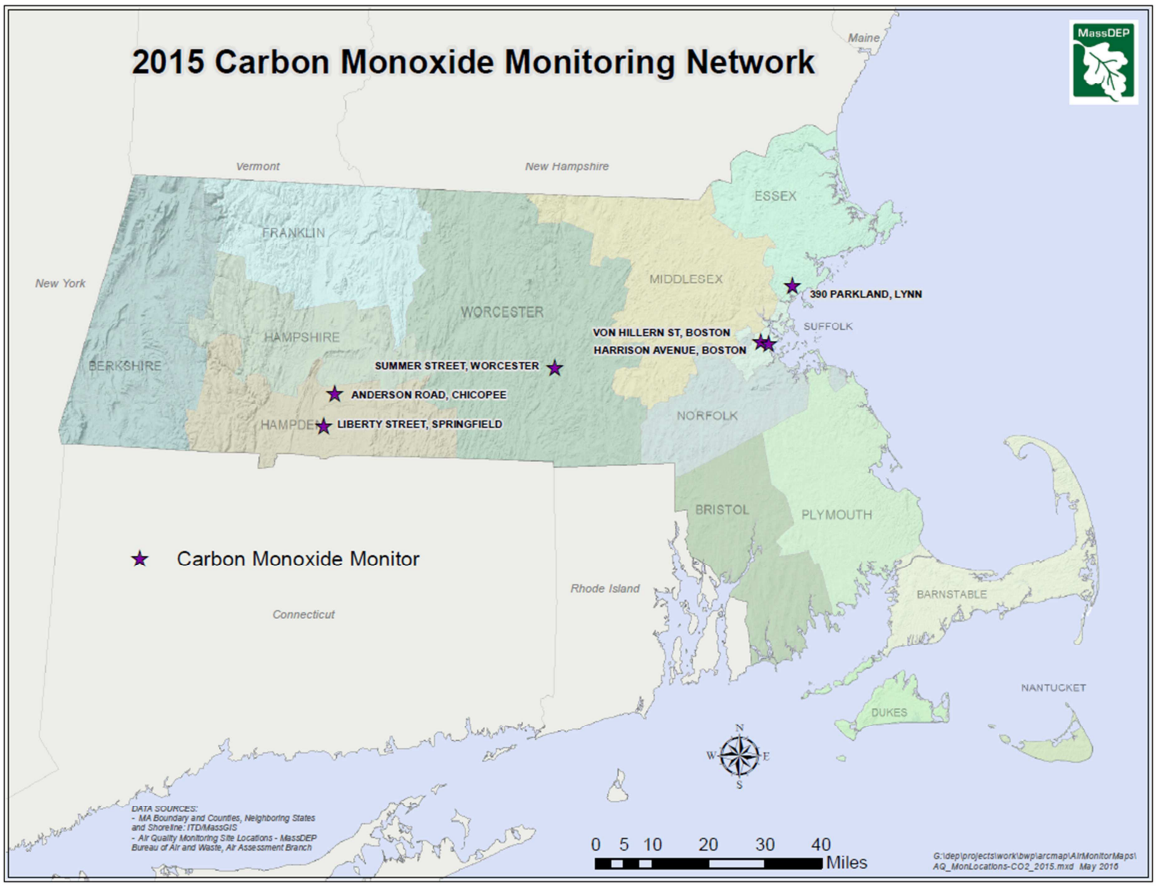
2015 CO Data Summary

A summary of the 2015 CO data is shown below (in parts per million). MassDEP operated seven CO sites during 2015, with Kenmore discontinued in January. CO monitors in Boston (Harrison Avenue and Von Hillern), Lynn, Worcester, and Chicopee are trace-level instruments that measure a lower concentration range than standard instruments to obtain more precise concentration resolution to better track CO trends.

CO 2015 SITE ID	CITY	COUNTY	ADDRESS	% OBS	1ST MAX 1-HR	2ND MAX 1-HR	1ST MAX 8-HR	2ND MAX 8-HR
25-025-0002	Boston	Suffolk	KENMORE SQ	83	0.300	0.300	0.3	0.3
25-025-0042	Boston	Suffolk	HARRISON AVE	87	1.437	1.362	0.9	0.9
25-025-0044	Boston	Suffolk	19 VON HILLERN	90	1.792	1.681	1.1	0.9
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	93	1.803	1.289	0.8	0.8
25-009-2006	Lynn	Essex	390 PARKLAND	83	1.554	1.502	1.1	0.7
25-013-0016	Springfield	Hampden	LIBERTY STREET	93	1.500	1.400	1.3	1.2
25-027-0023	Worcester	Worcester	SUMMER ST	85	1.725	1.474	1.0	1.0

STANDARDS: 1-hour = 35 ppm 8-hour = 9 ppm

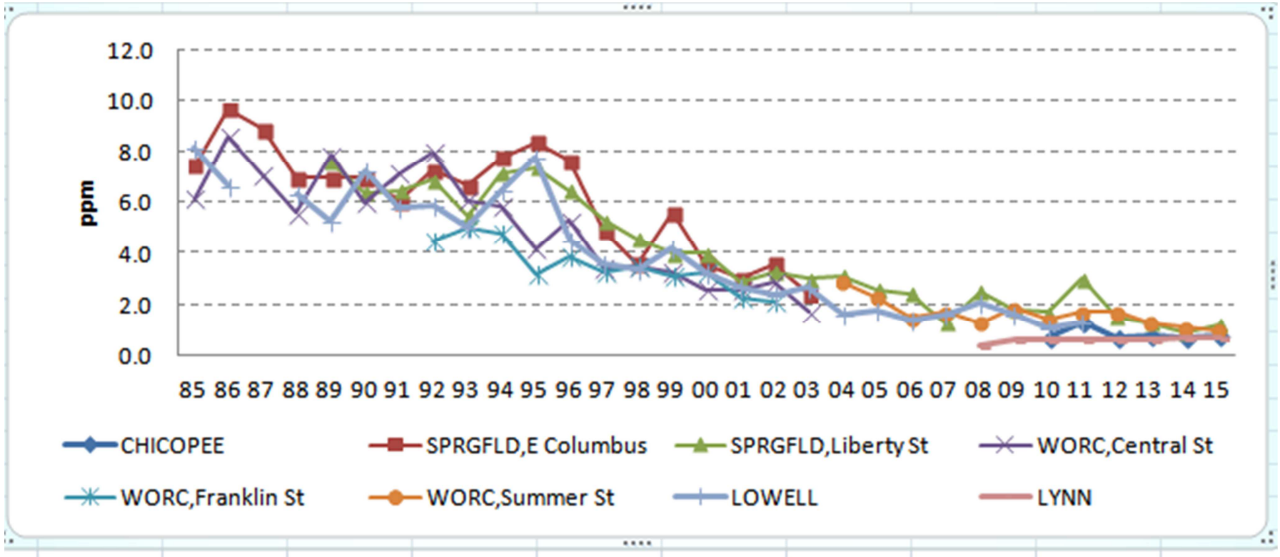
ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER; **% OBS** = PERCENT OBSERVATIONS; **1ST, 2ND MAX 1-HR** = FIRST AND SECOND HIGHEST 1-HOUR VALUE; **1ST, 2ND MAX 8-HR** = FIRST AND SECOND HIGHEST 8-HOUR VALUE

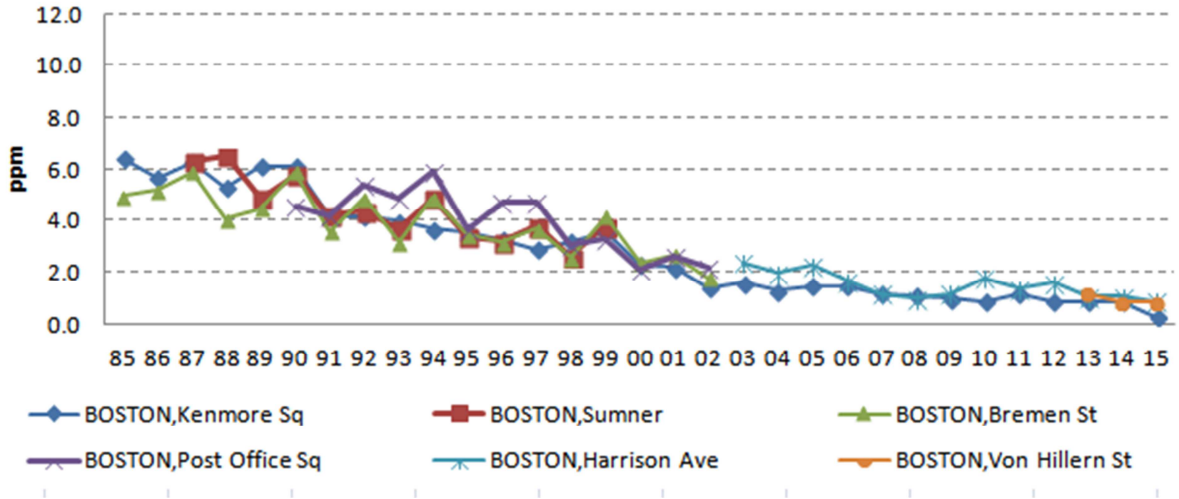


CO Trends

The long-term trends of the 2nd maximum 8-hour average for each CO site are shown below. Massachusetts is below the 8-hour standard.

Figure 6
CO Trends 1986-2015
2nd Maximum 8-hour Values
Standard = 9 ppm





Particulate Matter 10 Microns (PM_{10}) Summary

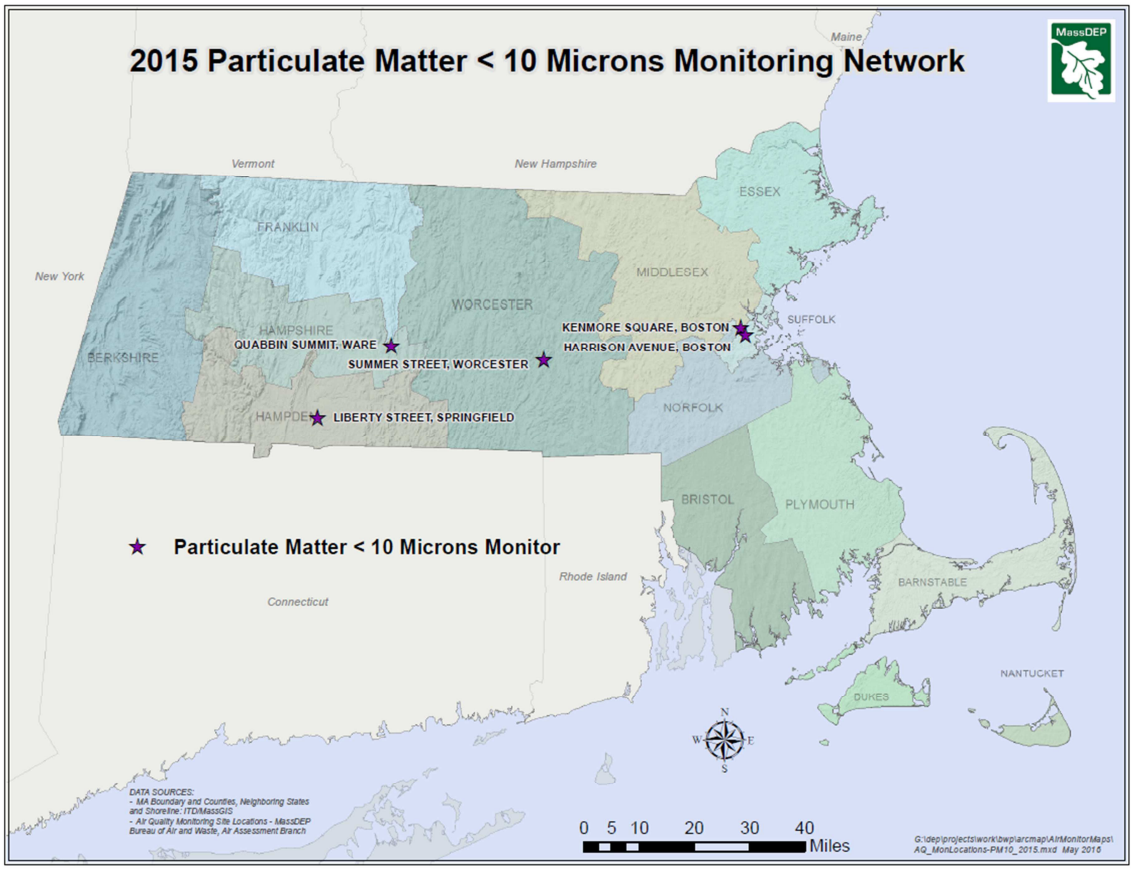
2015 PM_{10} Data Summary

A summary of the 2015 PM_{10} data is shown below (in $\mu g/m^3$). MassDEP operated six PM_{10} sites in 2015.

PM10 2015						1ST MAX	2ND MAX	3RD MAX	4TH MAX	
SITE ID		CITY	COUNTY	ADDRESS	%OBS	24-HR	24-HR	24-HR	24-HR	ARITH MEAN
25-013-0016		Springfield	Hampden	LIBERTY	98	36	28	26	26	14.3
25-015-4002		Ware	Hampshire	QUABBIN SUMMIT	98	24	21	19	16	7.6
25-025-0002		Boston	Suffolk	KENMORE SQ	98	33	30	26	26	14.2
25-025-0042		Boston	Suffolk	HARRISON AVE	98	32	26	26	23	11.7
25-025-0042	colloc	Boston	Suffolk	HARRISON AVE	98	32	28	26	26	12.4
25-027-0023		Worcester	Worcester	SUMMER ST	98	38	35	33	30	15.1

STANDARDS: 24-hour = 150 $\mu g/m^3$

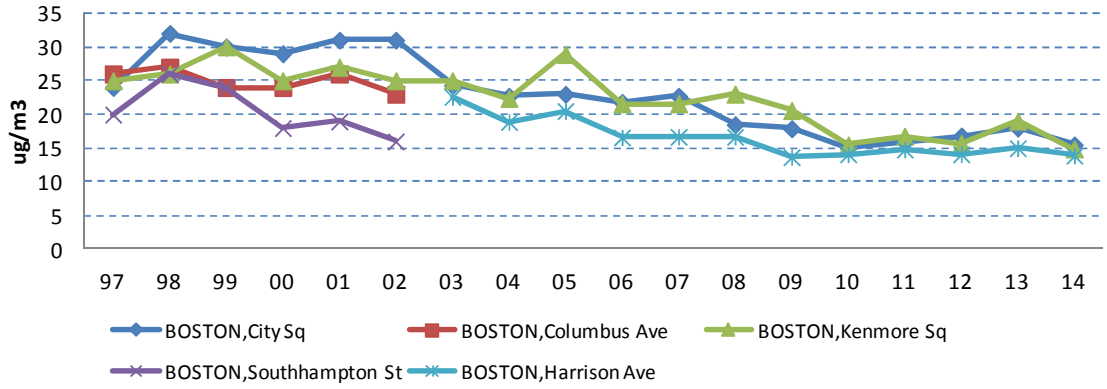
ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER; **% OBS** = PERCENT OF OBSERVATIONS; **1ST, 2ND, 3RD, 4TH 24-HR MAX** = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR; **ARITH MEAN** = ANNUAL ARITHMETIC MEAN

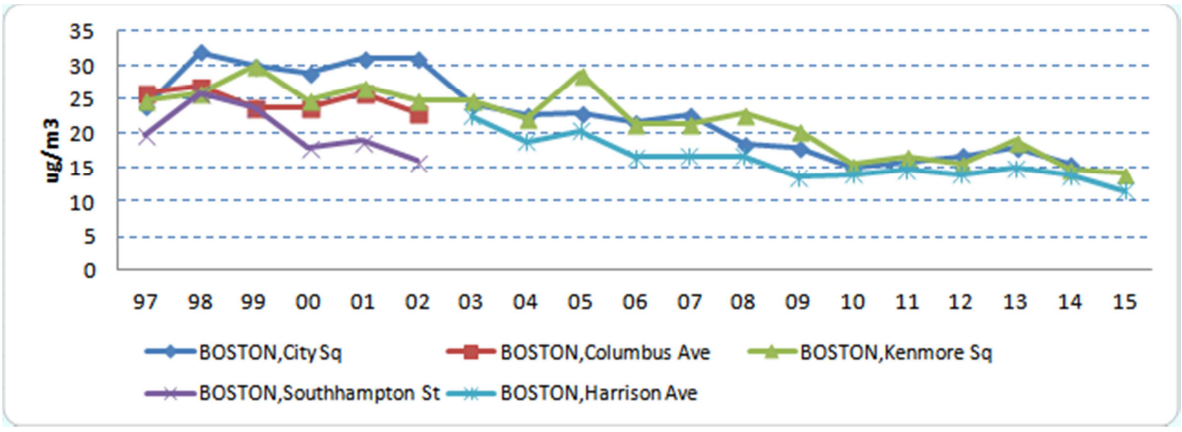


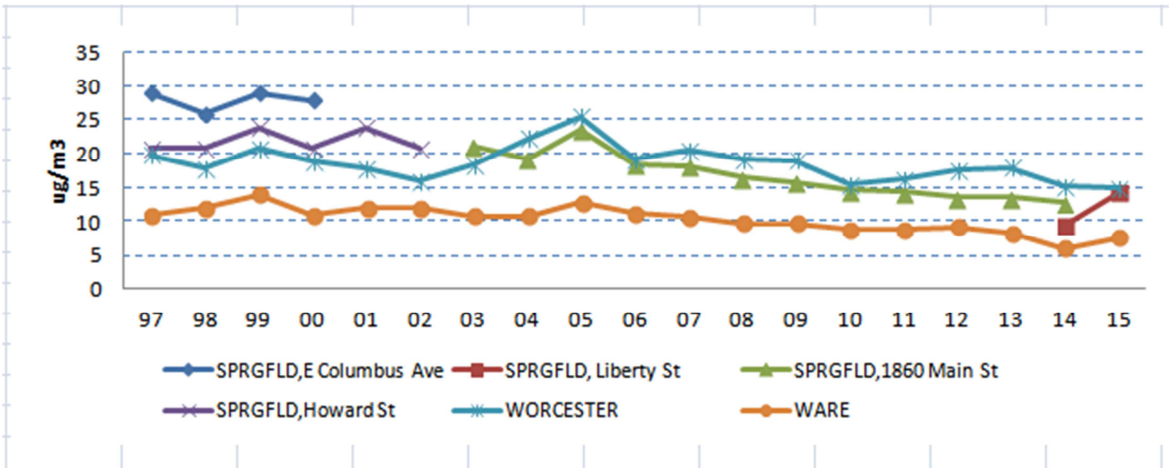
PM_{10} Trends

Long-term trends of the annual arithmetic mean for each PM_{10} site are shown below. The data shows an overall downward trend and Massachusetts is below the annual standard.

Figure 7
PM_{10} Trends 1997-2015
Annual Arithmetic Mean
Standard = 150 µg/m^3







Particulate Matter 2.5 Microns ($PM_{2.5}$) Summary

MassDEP operated 18 Federal Reference Method (FRM) filter-based $PM_{2.5}$ sites during 2015, and operated 14 Beta Attenuation Monitor (BAM) Federal Equivalent Method (FEM) $PM_{2.5}$ sites that provide near real-time data on MassDEP's MassAir Online website (www.mass.gov/eea/agencies/massdep/air/quality/) and on EPA's AirNOW website (www.epa.gov/airnow/).

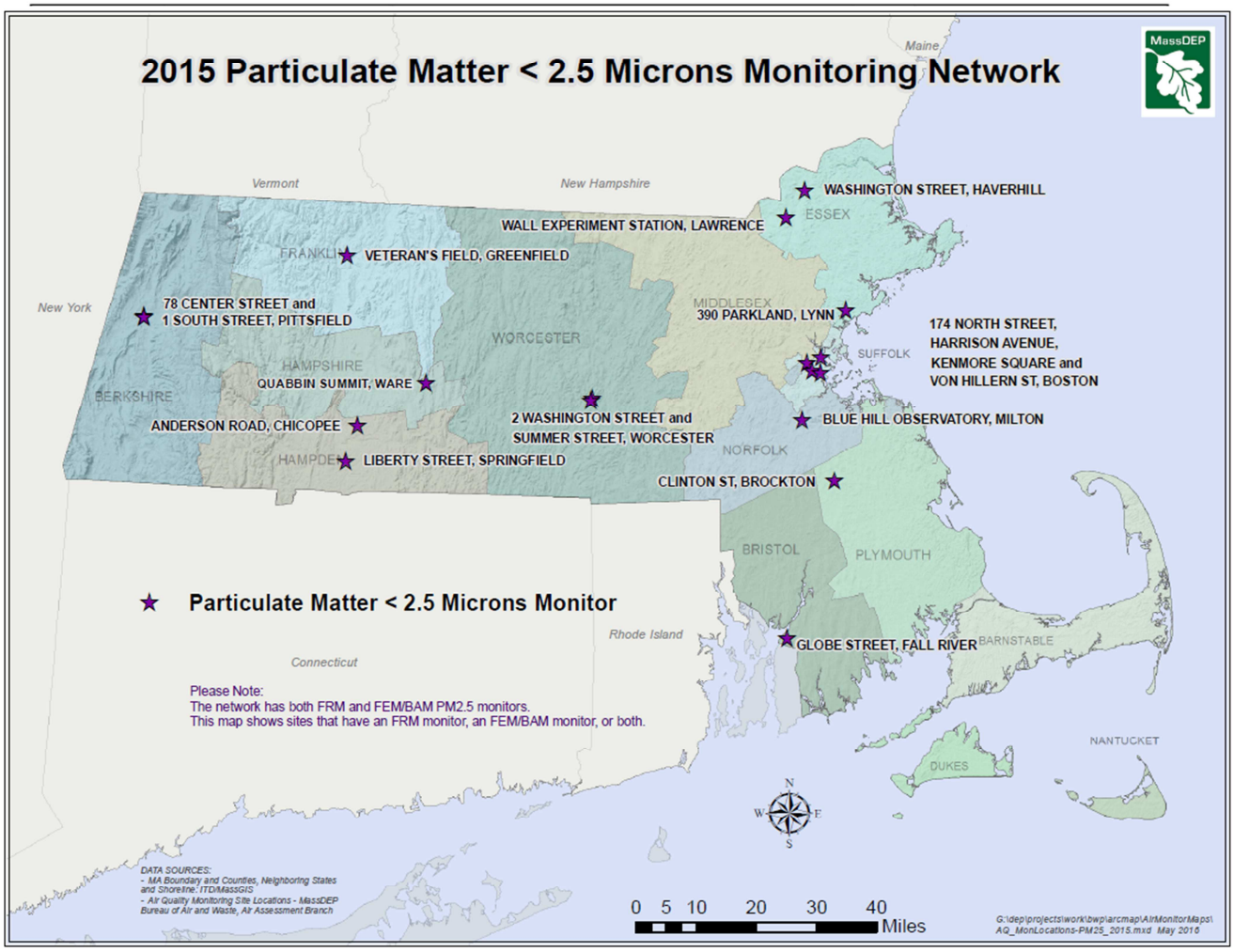
2015 $PM_{2.5}$ FRM Data Summary

A summary of the 2015 $PM_{2.5}$ FRM data is shown below (in $\mu g/m^3$).

PM2.5 2015					1ST MAX	2ND MAX	3RD MAX	4TH MAX	98TH PERCENTILE	ARITH
SITE ID		CITY	COUNTY	ADDRESS	24-HR	24-HR	24-HR	24-HR	24-HOUR	MEAN
25-025-0002		Boston	Suffolk	KENMORE	17.9	15.6	14.5	13.3	14.5	6.49
25-025-0042		Boston	Suffolk	HARRISON AVE	20.7	15.6	15.4	14.9	15.4	6.08
25-025-0043		Boston	Suffolk	174 NORTH ST	20.3	19.7	18.9	18.4	16.6	7.40
25-025-0043	colloc	Boston	Suffolk	174 NORTH ST	20.1	19.9	19.4	17.8	16.7	7.26
25-025-0044		Boston	Suffolk	19 VON HILLERN	20.8	16.5	16.1	15.6	16.1	6.66
25-023-0005		Brockton	Plymouth	170 CLINTON	21.1	18.4	17.7	15.0	17.7	5.55
25-023-0005	colloc	Brockton	Plymouth	170 CLINTON	21.2	18.8	18.8	15.2	18.8	5.66
25-013-0008		Chicopee	Hampden	ANDERSON RD AFB	18.1	17.7	16.3	16.1	16.3	6.21
25-013-0008	colloc	Chicopee	Hampden	ANDERSON RD AFB	18.4	16.7	16.5	16.3	16.5	6.19
25-005-1004		Fall River	Bristol	659 GLOBE ST	21.7	19.4	19.0	15.5	19.0	5.68
25-011-2005		Greenfield	Franklin	VETERANS FIELD	24.4	19.7	15.6	15.3	15.6	6.83
25-009-5005		Haverhill	Essex	685 WASHINGTON	16.6	15.0	14.1	13.7	14.1	5.59
25-009-6001		Lawrence	Essex	37 SHATTUCK	17.2	15.3	14.6	13.7	14.6	5.70
25-009-2006		Lynn	Essex	390 PARKLAND	18.7	15.1	13.0	12.4	13.0	5.11
25-003-5001		Pittsfield	Berkshire	78 CENTER ST	21.0	20.0	19.4	17.4	19.4	7.07
25-013-0016		Springfield	Hampden	LIBERTY STREET	20.7	19.4	19.2	18.9	19.2	7.55
25-027-0016		Worcester	Worcester	WASHINGTON ST	25.1	16.2	16.0	15.1	16.0	6.33
25-027-0023		Worcester	Worcester	SUMMER ST	20.1	16.5	16.3	14.9	16.3	6.15

STANDARDS: Annual Mean = 12.0 $\mu g/m^3$ (primary) 24-hour (98th percentile) = 35 $\mu g/m^3$

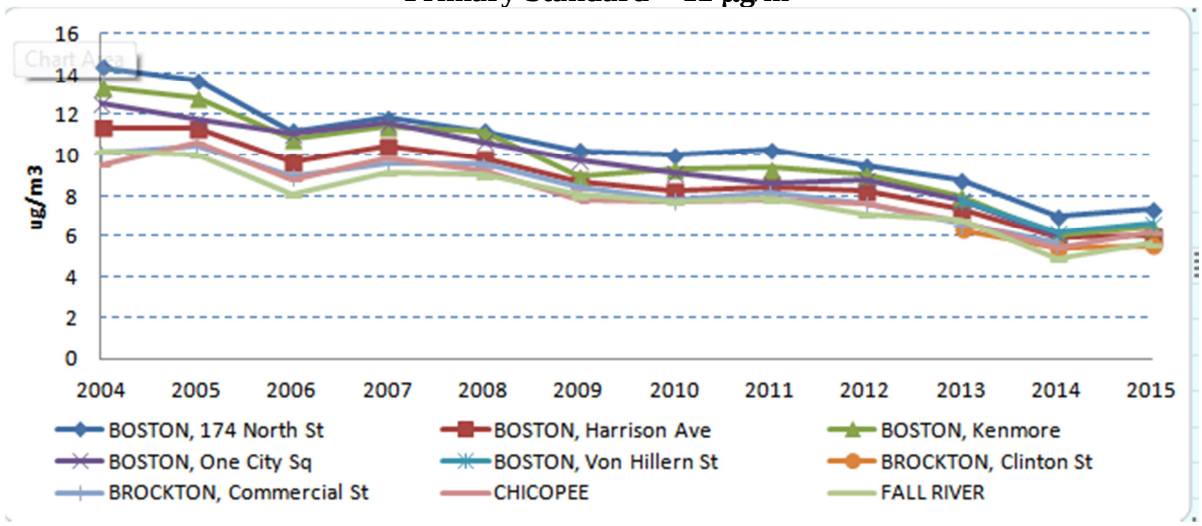
ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION; **COLLOC** = COLLOCATED; **#OBS** = NUMBER OF OBSERVATIONS; **1ST, 2ND, 3RD, 4TH 24-HR MAX** = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR; **98TH PERCENTILE 24-HR** = 98TH PERCENTILE VALUE FOR THE YEAR; **ARITH MEAN** = ANNUAL ARITHMETIC MEAN

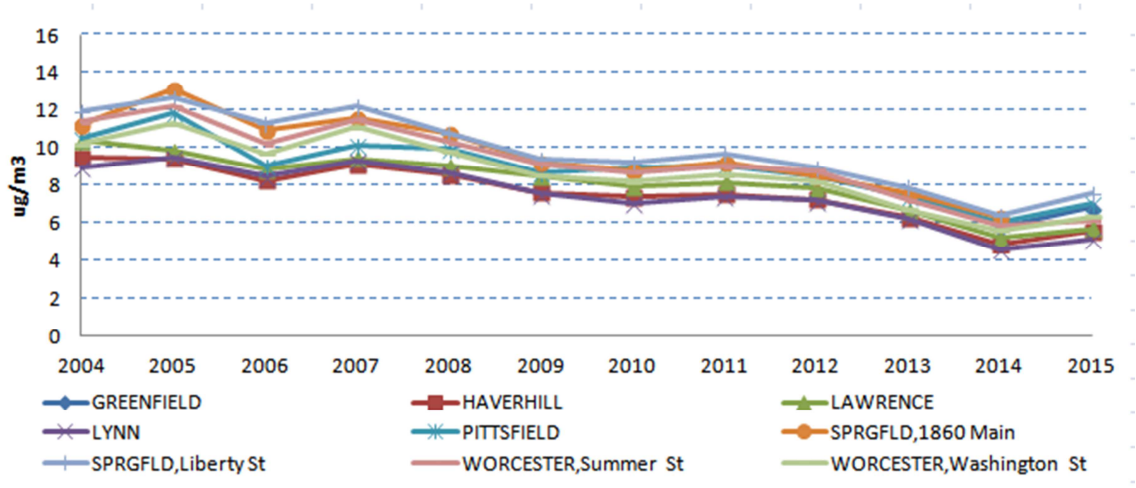

2015 Particulate Matter < 2.5 Microns Monitoring Network
MassDEP
Maine
Vermont
New Hampshire
New York
Rhode Island
Connecticut
WASHINGTON STREET, HAVERHILL
ESSEX
WALL EXPERIMENT STATION, LAWRENCE
FRANKLIN
VETERAN'S FIELD, GREENFIELD
78 CENTER STREET and
1 SOUTH STREET, PITTSFIELD
MIDDLESEX
390 PARKLAND, LYNN
WORCESTER
174 NORTH STREET,
HARRISON AVENUE,
KENMORE SQUARE and
VON HILLERN ST, BOSTON
SUFFOLK
HAMPSHIRE
QUABBIN SUMMIT, WARE
BERKSHIRE
ANDERSON ROAD, CHICOPEE
2 WASHINGTON STREET and
SUMMER STREET, WORCESTER
BLUE HILL OBSERVATORY, MILTON
NORFOLK
HAMPDEN
LIBERTY STREET, SPRINGFIELD
CLINTON ST, BROCKTON
BRISTOL
PLYMOUTH
Particulate Matter < 2.5 Microns Monitor
GLOBE STREET, FALL RIVER
BARNSTABLE
Please Note:
The network has both FRM and FEM/BAM PM2.5 monitors.
This map shows sites that have an FRM monitor, an FEM/BAM monitor, or both.
NANTUCKET
DUKES
N
W
E
S
DATA SOURCES:
- MA Boundary and Counties, Neighboring States and Shoreline: ITD/MassGIS
- Air Quality Monitoring Site Locations - MassDEP Bureau of Air and Waste, Air Assessment Branch
0 5 10 20 30 40
Miles
G:\dep\projects\work\bwp\arcmap\AirMonitorMaps\AQ_MonLocations-PM25_2015.mxd May 2015

$PM_{2.5}$ FRM Trends

Long-term trends of the annual arithmetic mean for each $PM_{2.5}$ FRM site are shown below using the annual arithmetic mean as an indicator. The data shows an overall downward trend.

Figure 8
$PM_{2.5}$ FRM Trends 2005-2015
Annual Arithmetic Mean
Primary Standard = 12 µg/m^3





2015 $PM_{2.5}$ FEM Data Summary

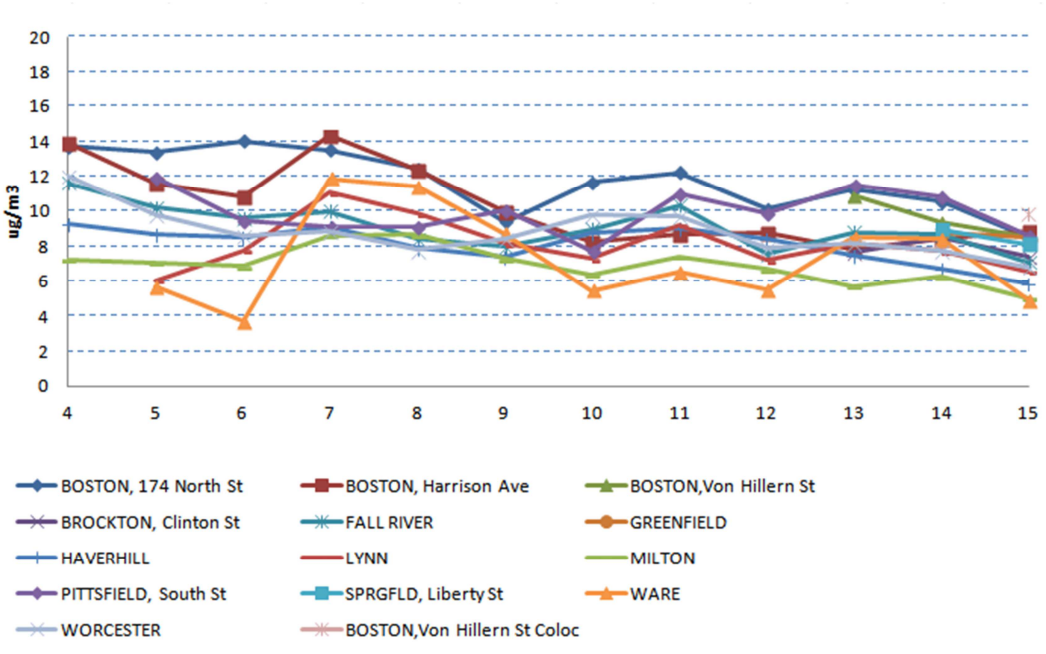
A summary of the 2015 $PM_{2.5}$ FEM data is shown below (in $\mu g/m^3$).

Continuous PM 2.5 2015									98TH	
SITE ID	CITY	COUNTY	ADDRESS	% Obs	1ST MAX	2ND MAX	3RD MAX	4TH MAX	PERCENTILE 24-HOUR	ARITH MEAN
25-025-0042	Boston	Suffolk	HARRISON AVE	97	29.8	22.3	21.3	20.9	24.9	8.84
25-025-0043	Boston	Suffolk	174 NORTH ST	94	23.2	22.4	22.1	21.9	22.7	8.50
24-025-0044	Boston	Suffolk	VON HILLERN ST	97	31.0	21.4	21.3	21.2	24.0	8.55
24-025-0044	Boston	Suffolk	VON HILLERN ST Coloc	91	25.1	23.5	20.5	20.2	25.1	9.89
25-023-0005	Brockton	Plymouth	1 CLINTON ST	96	28.8	26.5	23.4	21.6	22.4	7.44
25-005-1004	Fall River	Bristol	659 GLOBE ST	97	24.3	22.1	22.1	19.1	21.7	7.11
25-011-2005	Greenfield	Franklin	VETERANS FIELD	97	24.4	23.3	23.2	22.7	26.2	8.49
25-009-5005	Haverhill	Essex	685 WASHINGTON	96	19.3	18.3	17.3	17.3	20.4	5.84
25-009-2006	Lynn	Essex	390 PARKLAND	97	29.5	21.4	20.0	19.0	21.0	6.58
25-021-3003	Milton	Norfolk	BLUE HILL OBSERV	95	20.3	17.1	15.8	14.8	17.0	5.02
25-003-0006	Pittsfield	Berkshire	1 SOUTH ST	96	32.6	26.8	26.5	25.5	30.6	8.65
25-013-0016	Springfield	Hampden	LIBERTY ST	94	25.3	23.9	23.8	22.8	25.2	8.12
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	89	17.6	17.4	16.5	16.3	20.1	4.96
25-027-0023	Worcester	Worcester	SUMMER ST	96	22.9	21.8	20.7	19.1	23.6	6.84

STANDARDS: Annual Mean = 12.0 µg/m3 (primary) 24-hour (98th percentile) = 35 µg/m3

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION; **% OBS** = PERCENT OF OBSERVATIONS; **1ST, 2ND, 3RD, 4TH MAX** = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR; **98TH PERCENTILE 24-HR** = 98TH PERCENTILE VALUE FOR THE YEAR; **ARITH MEAN** = ANNUAL ARITHMETIC MEAN

Figure 9
$PM_{2.5}$ FEM Trends 2005-2015
Annual Arithmetic Mean
Primary Standard = 12 $\mu g/m^3$



$PM_{2.5}$: FRM vs. FEM

The FRM (Federal Reference Method) has been used to measure $PM_{2.5}$ since the beginning of the $PM_{2.5}$ monitoring program in 1999. This method requires the manual set up and collection of filters that collect 24-hour samples every three days. The filters must be weighed prior to placement in the field and then weighed again after the sample is collected by a scale in an environmentally controlled chamber. EPA has designated several Beta Attenuation Monitors (BAMs) and other continuous $PM_{2.5}$ monitors as FEM (Federal Equivalent Method) monitors. This allows states to use both FEM and FRM data to determine compliance with the $PM_{2.5}$ NAAQS. Since 2001, MassDEP has added 14 FEM BAMs to the network that take hourly samples of $PM_{2.5,}$ many alongside the existing filter-based FRM $PM_{2.5}$ monitors. These continuous $PM_{2.5}$ monitors provide hourly concentrations every day of the year, which FRMs are not capable of doing.

While MassDEP is using continuous $PM_{2.5}$ FEM monitors to determine compliance with the NAAQS, MassDEP runs FEM and FRM monitor side-by-side at some locations for comparison. In general, FEM monitors provide slightly higher results than FRM, which may be due to hourly measurement of fresh $PM_{2.5}$ samples versus slightly aged samples via the FRM filter method. Results from the two different methods for the same pollutant ($PM_{2.5}$) are presented separately in the preceding tables.

Speciation

MassDEP collects $PM_{2.5}$ samples for speciation in Boston (Harrison Avenue) and Chicopee. Speciation involves analysis of particulate matter to determine its chemical composition and to identity air pollution sources that affect the area around the monitoring station. Pollutants analyzed include elements (e.g., metals), sulfates, nitrates, and carbon (total and organic).

IMPROVE (Interagency Monitoring of Protected Visual Environments)

IMPROVE is a nationwide program designed to assess air quality at rural locations where air pollution may affect visibility over long distances (e.g., mountain ranges or scenic vistas). During 2015, Massachusetts had IMPROVE samplers at the Ware and Truro sites (the Ware sampler was discontinued at the end of 2015). The Wampanoag Tribe operates a third IMPROVE sampler at its Martha's Vineyard monitoring site. These samplers acquire $PM_{2.5}$ filter samples for speciation analysis to determine effects on visibility. Data can be viewed at the IMPROVE web site at http://vista.cira.colostate.edu/improve/Data/data.htm.

Lead (Pb) Summary

2015 Pb Data Summary

MassDEP uses a low-volume PM_{10}-based methodology for measuring lead on particulates. Because of historical low lead levels, the 2016 network was reduced to one site in Boston operating a primary and collocated sampler. A summary of 2015 lead data using the PM_{10}-based method is shown below (in $\mu g/m^3$). All samples (including 3-month rolling averages) were below the lead standard of 0.15 $\mu g/m^3$.

2015 Lead SITE ID		CITY	COUNTY	ADDRESS	1ST MAX	2ND MAX	3RD MAX	4TH MAX	ARITH MEAN
25-013-0016		Springfield	Hampden	LIBERTY ST	0.016	0.008	0.007	0.007	0.0033
25-025-0042		Boston	Suffolk	HARRISON AVE	0.0157	0.0114	0.0096	0.0095	0.00367
25-025-0042	colloc	Boston	Suffolk	HARRISON AVE	0.0147	0.013	0.0118	0.0109	0.00445

STANDARD: 0.15 µg/m³ (rolling 3-month average)

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION; **1ST, 2ND, 3rd, 4th MAX VALUE** = 1ST, 2ND, 3rd, 4th MAXIMUM 24-HOUR VALUES; **ARITH MEAN** = ARITHMETIC MEAN

QUALITY CONTROL AND QUALITY ASSURANCE

In order to ensure that all air quality data is of acceptable and consistent quality, MassDEP has developed standard operating procedures (SOPs) based on federal requirements that include quality control and quality assurance techniques that systematically assess the entire sample collection and data handling system on an ongoing basis. Quality Assurance requirements for ambient air monitoring are contained in the federal regulations at 40 CFR Part 58, Appendix A – E. Each year MassDEP certifies that it is in compliance with the federal requirements.

A few of the considerations that affect sample collection data quality are:

- Site Placement
- Intake Probe Material
- Intake Probe Height
- Spacing from roadways and trees

For data processing there are quantitative statistics and qualitative descriptors used to interpret the degree of acceptability or utility of data. Examples of these data quality indicators are:

- Representativeness
- Precision
- Bias
- Detectability
- Completeness
- Comparability

MassDEP's Air Assessment Branch maintains a Quality Assurance Group that ensures that samples are collected correctly and conducts performance audits throughout the air monitoring network to verify data validity. There also is a Quality Control Group that reviews daily monitored data for validity, records precision results, finalizes monthly values, and submits air quality data to EPA's database in a timely manner. Computer software tools, report queries and "eyes on" data reviews all are used to validate data before it is submitted to EPA. EPA also conducts its own performance audits on MassDEP samplers and every three years conducts thorough Technical Systems Audit.

Section IV
PAMS/Air Toxics Monitoring

PAMS Monitoring

Ground-level ozone is a secondary pollutant and is not discharged directly to the atmosphere from a stack or tailpipe, but forms in the atmosphere from the photochemical reactions of other pollutants such as volatile organic compounds (VOCs) and NO_x. Ozone formation can occur many miles downwind from the source of the original emissions. These reactions occur in the presence of strong sunlight and are most pronounced during the hottest days of the summer. The PAMS (Photochemical Assessment Monitoring Stations) program was established by the 1990 Clean Air Act Amendments as a way to collect data for assessing NAAQS attainment progress independent of the meteorological variation that occurs between years and for identifying appropriate pollution control strategies.

PAMS is a special designation for enhanced monitoring stations that are designed to gather information on the ozone formation process. Instruments at these sites measure pollutants and meteorological parameters that are specific to the photochemical processes by which ozone is created in the atmosphere at ground level. In addition to the pertinent NAAQS pollutants (ozone, NO_2, etc.), non-criteria pollutants, including VOCs, are measured at PAMS stations on either an hourly basis or at regular intervals during the hottest part of the summer in June, July and August. Meteorology is a critical component of ozone formation and each PAMS site has a full complement of meteorological sensors including wind speed, wind direction, temperature, relative humidity, barometric pressure, solar radiation and at some sites, total ultraviolet light and precipitation.

Since the PAMS project started in 1993, MassDEP has conducted enhanced ozone precursor measurements in the Boston and Springfield Metropolitan Areas. MassDEP currently operates four PAMS stations, in Lynn, Newburyport, Chicopee and Ware.

Air Toxics Monitoring

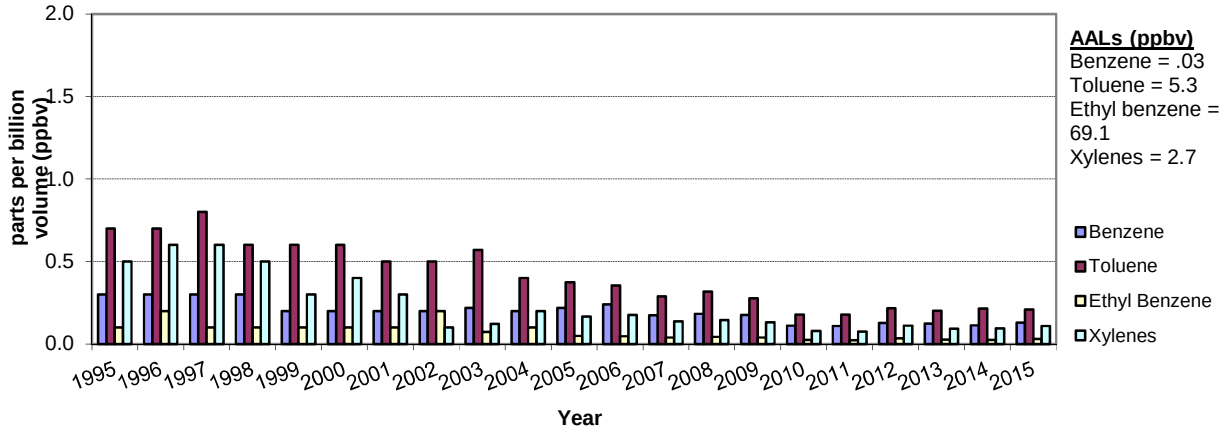
Toxic air pollutants are distinct from criteria air pollutants such as ozone and CO and are known or suspected to cause cancer or other serious health effects. Air toxics include certain volatile organic compounds (VOCs) and toxic metals (e.g., arsenic, cadmium).

MassDEP monitors VOCs as part of the PAMS monitoring program, some of which are classified as air toxics. MassDEP obtains health-relevant VOC concentration data throughout the year at the PAMS Type 2 sites.

The Boston (Harrison Avenue) monitoring site is designated as a National Air Toxics Trends Station (NATTS) designed to collect and quantify a number of toxic air pollutants, including VOCs, metals, carbonyls, black carbon and polycyclic aromatic hydrocarbons (PAHs). Data from this site is compared with data from a network of similar sites across the country to identify transport, trends and site-specific characteristics of these pollutants.

Figure 10 summarizes concentrations of 24-hour health-relevant target compounds for samples taken at the Lynn PAMS site from 1994 to 2015. Allowable Ambient Limit (AAL) values are presented next to Figure 9 for reference. AALs are health-based air toxics guidelines developed by MassDEP based on known or suspected carcinogenic and toxic health properties of individual compounds. AAL concentrations were developed for a 70-year lifetime exposure, but are used for comparison with annual averages.

Figure 10
Lynn Toxics Summary 1994 – 2015
24-hour samples



Below is a table that summarizes results from the analysis of 24-hour samples for target VOCs from the Boston - Harrison Ave and Lynn sites for 2015. Harrison Avenue serves as the central city sampling location and Lynn serves as the area background site.

2015 Compound	BOSTON (Harrison Ave)		Lynn	
	Max Value ppb	Mean ppb	Max Value ppb	Mean ppb
1,3-butadiene	**0.082**	**0.026**	**0.070**	**0.013**
1,1,1-trichloroethane	**0.012**	**0.004**	**0.005**	**0.004**
trichloroethylene	**0.011**	**0.004**	**0.009**	**0.003**
tetrachloroethylene	**0.058**	**0.016**	**0.059**	**0.013**
Benzene	**0.470**	**0.181**	**0.434**	**0.132**
Toluene	**0.979**	**0.355**	**0.795**	**0.206**
Xylenes	**0.767**	**0.210**	**0.433**	**0.109**
Ethylbenzene	**0.164**	**0.052**	**0.100**	**0.028**

Samples collected at the Harrison Avenue site are analyzed for a suite of metals that are known to be toxic in the environment. The table below summarizes the 2015 metals data.

BOSTON (Harrison Ave)			
2015 METAL	# of Samples	Max Value ug/m3	Mean ug/m3
Chromium	58	0.010200	0.004830
Antimony	58	0.004470	0.001637
Arsenic	58	0.005830	0.000561
Berylium	58	0.000040	0.000006
Cadmuim	58	0.000180	0.000085
Cobalt	58	0.000440	0.000124
Lead	58	0.015700	0.003670
Manganese	58	0.016700	0.005221
Nickle	58	0.004640	0.001085
Mercury	58	0.000030	0.000011
Selenium	58	0.000720	0.000253

As part of a special monitoring project in 2015, MassDEP placed a monitor at Kenmore Square to measure hourly concentrations of the hydrocarbons benzene, toluene, ethyl benzene and xylenes, which are health-relevant VOCs associated with vehicle emissions. In contrast to typical 24-hour VOC samples, hourly concentrations provide greater time resolution. Figure 11 shows monthly average concentrations for all of the target hydrocarbons, while Figures 12 and 13 show average hourly concentrations and average day of the week concentrations for benzene and toluene, respectively. For 2016, MassDEP will move the monitor to the near-road monitoring site on Von Hillern Street in Boston where vehicle traffic is greater than in Kenmore Square.

Figure 11
Concentrations of Hydrocarbons at Kenmore Square
Average by Month 2015

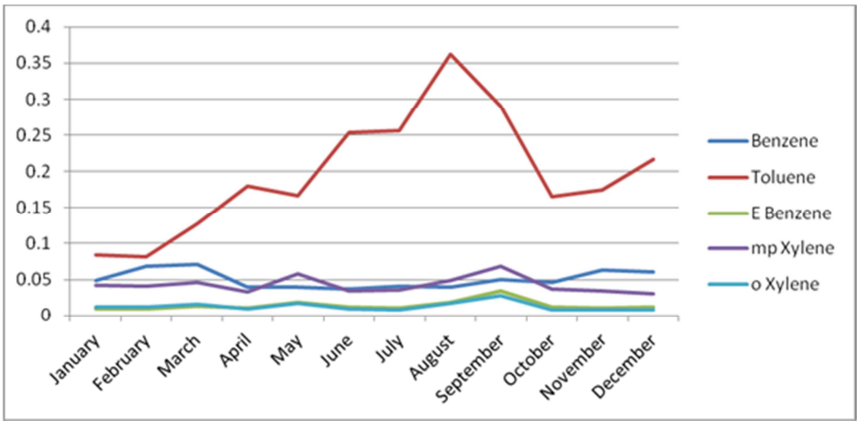


Figure 12
Concentration of Benzene and Toluene at Kenmore Square
Average by Hour of the Day 2015

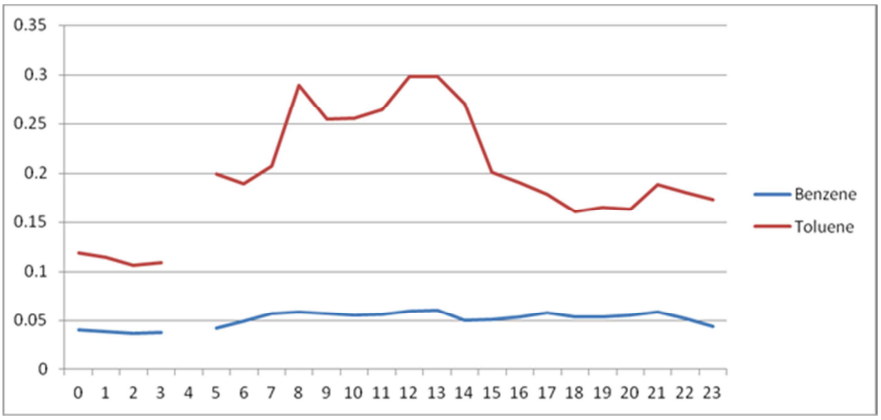
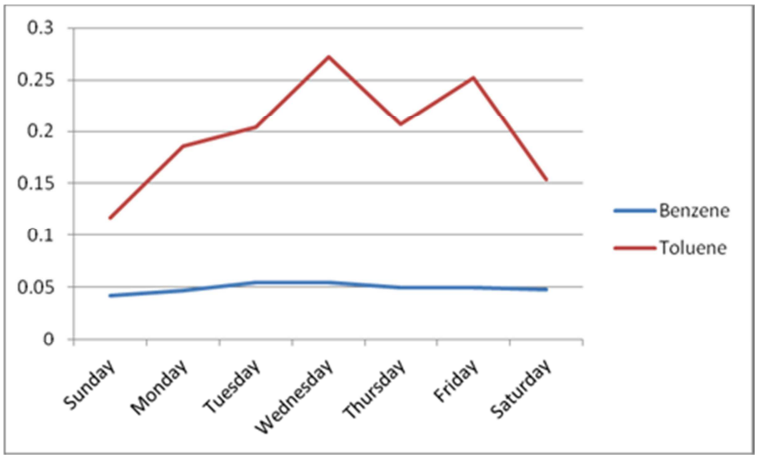


Figure 13
Concentration of Benzene and Toluene at Kenmore Square
Average by Day of the Week 2015



Appendix A
2015 Monitoring Station Locations

SITE ID	CITY	COUNTY	ADDRESS	DATE SITE ESTABLISHED	PARAMETERS MONITORED
25-007-0001	*AQUINNAH	DUKES	HERRING CREEK RD	4/1/2004	O3, IMPROVE
25-025-0002	BOSTON	SUFFOLK	KENMORE SQUARE	1/1/1965	NO, NO2, NOx, SO2T, PM2.5 FRM, PM10
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	12/15/1998	PM2.5 FRM, PM2.5 BAM, (2) PM10, PM Coarse. PM2.5 Speciation, Lead, Toxics, Carbonyls, Black Carbon, WS/WD, WSv/WDv, TEM, SUN, REL, BP
25-025-0043	BOSTON	SUFFOLK	174 NORTH ST	1/1/2000	(2) PM2.5 FRM, PM2.5 BAM, Black Carbon
25-025-0044	BOSTON	SUFFOLK	VON HILLERN ST	8/29/2013	BAM,Black Carbon, WS/WD, TEM, SUN, REL, BP
25-023-0005	BROCKTON	PLYMOUTH	170 CLINTON ST	9/19/2013	O3, PM2.5 BAM, (2) PM2.5 FRM
25-017-0009	CHELMSFORD	MIDDLESEX	11 TECHNOLOGY DR	4/1/2005	O3
25-013-0008	CHICOPEE	HAMPDEN	ANDERSON RD	1/1/1983	O3, NO, NO2, NOx, COT, (2) PM2.5 FRM, PM2.5 speciation, VOCs, Carbonyls, WS/WD, TEM, SUN, REL, BP
25-005-1006	FAIRHAVEN	BRISTOL	HASTINGS SCHOOL	7/29/2013	O3, WS/WD, TEM, SUN, REL, BP
25-005-1004	FALL RIVER	BRISTOL	GLOBE ST	2/1/1975	O3, SO2, PM2.5 FRM, PM2.5 BAM
25-011-2005	GREENFIELD	FRANKLIN	16 BARR AVE	2/27/2014	O3, PM2.5 FRM, PM2.5 BAM, Black Carbon, WS/WD, TEM, SUN, REL, BP
25-009-5005	HAVERHILL	ESSEX	WASHINGTON ST	7/19/1994	O3, PM2.5 FRM, PM2.5 BAM, WS/WD, TEM, SUN, REL, BP
25-009-6001	LAWRENCE	ESSEX	WALL EXPERIMENT S	4/3/1999	PM2.5 FRM
25-009-2006	LYNN	ESSEX	390 PARKLAND	1/1/1992	O3, NO, NO2, NOx, COT, PM2.5 FRM, PM2.5 BAM, VOCs, Toxics, Carbonyls, WS/WD, TEM, SUN, REL, BP, PRECIP
25-021-3003	MILTON	NORFOLK	BLUE HILL	4/2/2002	O3, NO, NO2, NOx, PM2.5 BAM, VOCs, WS/WD, TEM, SUN, REL, BP
25-009-4005	NEWBURYPORT	ESSEX	HARBOR STREET	7/6/2010	O3, NO, NO2, NOx, NOT, NOy, VOCs, WS/WD, TEM, SUN, REL, BP
25-003-5001	PITTSFIELD	BERKSHIRE	78 CENTER STREET	11/6//98	PM2.5 FRM
25-003-0006	PITTSFIELD	BERKSHIRE	BERKSHIRE COMMOI	1/1/1979	PM2.5 BAM
25-013-0016	SPRINGFIELD	HAMPDEN	LIBERTY STREET	4/1/1988	NO, NO2, NOx,SO2, CO, PM2.5 FRM, PM2.5 BAM, PM10, Black Carbon, Lead
25-001-0002	TRURO	BARNSTABLE	FOX BOTTOM AREA	4/1/1987	O3, WS/WD, TEM, SUN, REL, BP, IMPROVE
25-027-0024	UXBRIDGE	WORCESTER	366 E HARTFORD AVE	11/13/2008	O3, WS/WD, TEM, SUN, REL, BP
25-015-4002	WARE	HAMPSHIRE	QUABBIN SUMMIT	6/1/1985	O3, NO, NO2, NOx, NOT, NOy, SO2T, PM10, VOCs, PM2.5 BAM, WS/WD, TEM, SUN, REL, BP, PRECIP, IMPROVE
25-027-0015	WORCESTER	WORCESTER	WORC. AIRPORT	5/7/1979	O3, WS/WD, TEM, SUN, REL, BP
25-027-0016	WORCESTER	WORCESTER	2 WASHINGTON ST	12/31/2002	PM2.5 FRM
25-027-0023	WORCESTER	WORCESTER	SUMMER STREET	1/1/2004	NO, NO2, NOx, SO2T, COT, PM2.5 FRM, PM2.5 BAM, PM10
* Wampanoag Tribal Site					