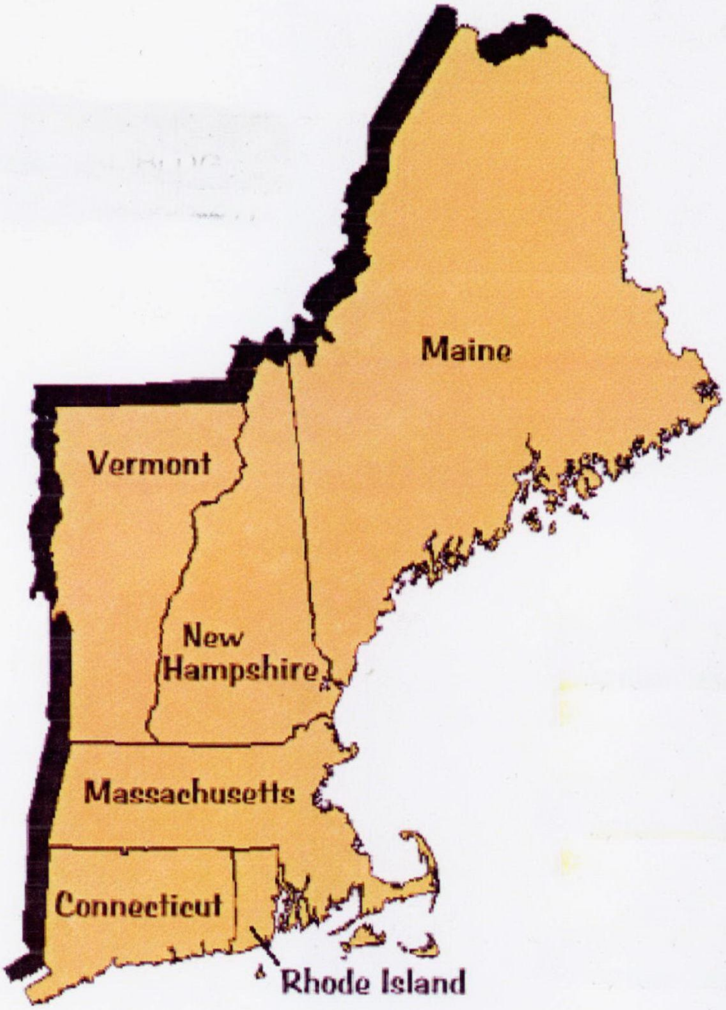


# Trend Analysis of Ozone in EPA Region 1 Using 1983-1997 Ozone Data

EPA
Region 1, New England

October 1998

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# I. Introduction

In the past several decades, the public has shown concern about air quality, focusing on ground-level ozone or smog. Ozone results from the combination in the atmosphere of volatile organic compounds (VOCs) and nitrogen oxides (NOx). These primary pollutants have a variety of sources including automobiles and industrial plants. In a warm, sunny atmosphere, chemical reactions of these pollutants produce ozone.

Research has determined that inhalation of ozone causes harm to the human respiratory system. Four groups of people are particularly sensitive to ozone. These groups become sensitive to ozone when they are active outdoors because physical activity (such as jogging or outdoor work) causes people to breathe faster and more deeply. During activity, ozone penetrates deeper into the parts of the lungs that are more vulnerable to injury. Sensitive groups include: 1) Children, 2) Adults who are active outdoors, 3) People with respiratory diseases, such as asthma, and 4) People with unusual susceptibility to ozone.

Scientists have been studying the effects of ozone on human health for many years. So far, they have found that ozone can cause several types of short-term health effects in the lungs: 1) Ozone can irritate the respiratory system, 2) Ozone can reduce lung function, 3) Ozone can aggravate asthma, and 4) Ozone can inflame and temporarily damage the lining of the lung. Scientists suspect that ozone may have other effects on people's health. Ozone may aggravate chronic lung diseases, such as emphysema and bronchitis. Also, studies in animals suggest that ozone may reduce the immune system's ability to fight off bacterial respiratory infections.

In addition to the direct effects on human health, the environment at large suffers effects from poor air quality. Ozone interferes with a plant's ability to produce and store food. This can result in decreased crop yield and over the long term, may disrupt entire ecosystems. Vegetation may be more prone to disease, pests and other environmental stress when exposed to ozone. The dangers of poor air quality led to the passage of the Clean Air Act in 1970.

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In the 1970's the United States Environmental Protection Agency (US EPA) implemented a national ambient air quality standard (NAAQS) for ozone to help protect the environment and human health. Hourly averaged values of 0.125 parts per million (ppm) and above were considered exceedances of the standard. Regions experiencing more than one exceedance per year averaged over three years were determined to be in non-attainment. These non-attainment areas were classified as marginal, moderate, serious, severe or extreme depending on the extent of the air quality problem in 1990. Southern New England and coastal northern New England as of 1997 are non-attainment for ozone based on the one-hour standard.

In July of 1997, the EPA issued a new standard set at 0.08 ppm averaged over eight hours. To be in attainment for this more stringent standard, the 3-year average of the annual fourth highest daily maximum 8-hour ozone concentration must not exceed 0.08 ppm. The EPA will designate areas as non-attainment for this new standard based in 2000 based on the years 1997-1999. Areas in non-attainment of the one-hour standard will remain as such until they average 1 or fewer 1-hour exceedances over three years.

This document provides a summary of the ozone data in New England over the fifteen-year period 1983-1997. The number of ozone-monitoring sites operated in New England during this period ranged from 39 to 66 sites. Data available for the ozone season (until recently April 1 to October 31 in each New England state) for these years are used to determine exceedances of both the old and new National Ambient Air Quality Standards (NAAQS). The data used in this report were collected from eighty-eight distinct stations, though only eighteen operated throughout the entire period.

Trends in both one and eight hour average ozone are compared for Region 1 and each individual state. In general, air quality as measured by average ozone concentrations has improved from the 1980's to the 1990's. The trend in both the old and new standards shows decreasing ozone in the troposphere. In addition, temperature data from seven meteorological stations is analyzed and plotted along with 8-hour ozone averages for the regions surrounding each site. These plots provide evidence for the positive correlation between high temperature and high ozone. A final set of graphs displays 8-hour design value trends for counties throughout New England covering the years 1985-1997. A tabulated data summary is supplied at the end of the report.

## II. Sources of Data

US EPA Region 1 includes the six New England states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. Ozone monitors exist in each state, though only eighteen have existed for the entire 1983-97 period. The year to year changes of monitor numbers and location may have some influence on the reported results. When results are given for an individual state, the values are based upon all operating monitors for each year within the state. For the purposes of temperature based analysis, seven geographical regions were chosen as follows:

**Coastal Connecticut** (meteorological station: Bridgeport Sikorsky Memorial AP)
Data from Fairfield (excluding Danbury), New Haven and New London counties in Connecticut. Sites include Greenwich, Westport, Bridgeport, Stratford, New Haven, Madison and Groton.

**Interior Connecticut** (meteorological station: Bradley International AP)
Data from Fairfield (Danbury only), Hartford, Litchfield, Middlesex, Tolland and Windham counties in Connecticut. Sites include Danbury, East Hartford, Middletown, Stafford and Torrington.

**Interior/Coastal Maine** (meteorological station: Portland International Jetport)
Data from Cumberland, Franklin, Hancock, Kennebec, Knox, Sagadahoc, Somerset, Waldo, Washington and York counties in Maine and Rockingham County in New Hampshire. Sites include MacFarland Hill, Gardiner, Port Clyde, Phippsburg, Cape Elizabeth, Kennebunkport, Hollis, Kittery, Rye and Portsmouth.

**Metropolitan Boston-Coastal NH** (meteorological station: Logan International AP)
Data from Essex (excluding Lawrence), Middlesex, Norfolk, and Suffolk counties in Massachusetts and Rockingham county in New Hampshire. Sites include Newburyport, Lynn, Chelsea, Sudbury, Waltham, Rye and Portsmouth.

**Western Massachusetts** (meteorological station: Worcester Municipal AP)
Data from Berkshire, Hampden, Hampshire and Worcester counties in Massachusetts. Sites include Adams, Amherst, Agawam, Chicopee, Ware and Worcester.

**Southern New Hampshire** (meteorological station: Concord Municipal AP)
Data from Belknap, Cheshire, Hillsborough, Merrimack, Strafford and Sullivan counties in New Hampshire and Essex (Lawrence only) county in Massachusetts. Sites include Claremont, Keene, Laconia, Concord, Manchester, Nashua, Rochester and Lawrence.

**Rhode Island-SE Massachusetts** (meteorological station: Providence T F Green State AP)
Data from Kent, Providence and Washington counties in Rhode Island and Barnstable, Bristol and Plymouth counties in Massachusetts. Sites include Alton Jones, Narragansett, Providence, Easton, Fairhaven, Scituate and Truro.

# III. Discussion of Trends

From the 1985 to 1997, the three-year moving average of exceedance days in New England has dropped over 60%. The average number of exceedance days for the region was in the forties for the second half of the last decade and now hovers around thirty exceedances per year. Connecticut and Massachusetts dominate this trend while Vermont and New Hampshire have relatively little impact. It is rare for an 8-hour exceedance to occur in Maine, Vermont, New Hampshire or Rhode Island if no exceedance was observed in Massachusetts or Connecticut. Graphs of these trends are given in Appendix B.

In Appendix C, exceedance days of the old and new ozone standard are compared. The trends are well correlated, having an r-squared value greater than 0.88 for those areas having more than one exceedance day of each standard per year. As would be expected, the shapes of the curves are very similar. Roughly, Region 1 states exceed the 8-hour standard on fifteen to twenty more days than they exceed the 1-hour standard.

The graphs in Appendix D compare 8-hour exceedance days and number of days the air temperature was above 85 °F. Seven meteorological stations were used for temperature data. Ozone stations located near each of the seven sites were grouped together, making the assumption that the meteorological conditions were similar. In general, areas were represented as coastal or inland. Reasonable correlations exist between the two curves with increased numbers of exceedances corresponding to an increased number of days of high temperature. From the graphs, more recent years require higher temperatures for 8-hour exceedances to occur.

In Appendix E, the 8-hour design value for counties in New England with monitors operating since 1985/1986 are plotted. The design value for each site is calculated as the 3-year average of the annual fourth highest daily maximum 8-hour ozone concentration. For a county with multiple monitoring sites, the design value is the same as the highest design value of an individual site in the county. The general features of the graphs show a maximum design value for years including the high ozone season in 1988. In the 1990's, the trend in design values level off to values significantly below those seen in the 1980's. Contoured maps clearly show improving air quality from 1983 to 1997. At the start of the period, Massachusetts, Connecticut, Rhode Island, coastal Maine and part of southern New Hampshire suffered from poor air quality, with coastal Connecticut having a design value above 125 ppb. By the middle of the period, the area covered by design values above 105 ppb was significantly reduced. Some regions in the most recent 3-year period have design values below 65 ppb and very few are above 105 ppb.

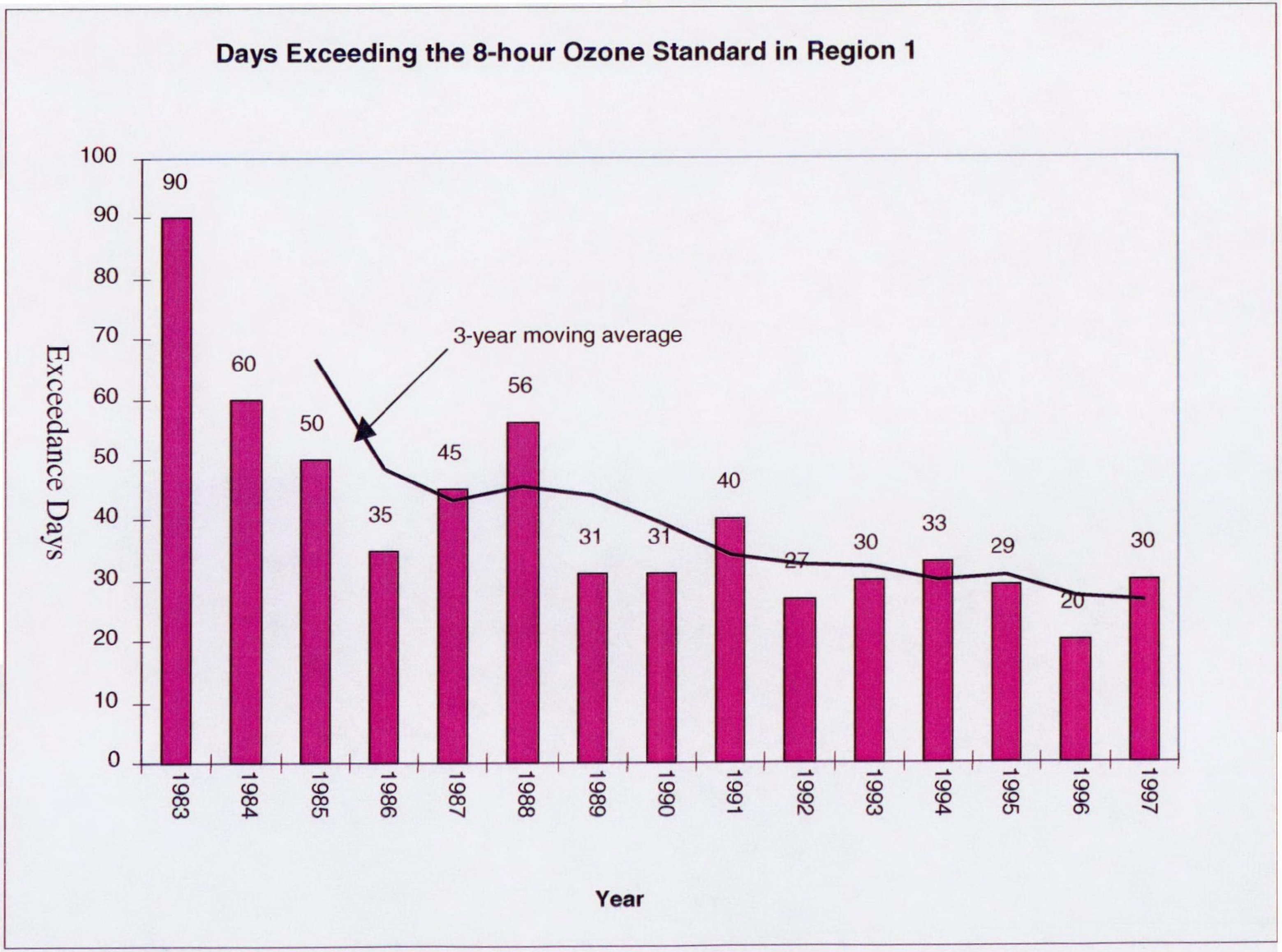
The next set of figures in Appendix F track exceedances in Region 1 and individual states therein by month and year. At the beginning of the period, exceedances could potentially occur in any month. During June, July and August, the likelihood of exceeding the standard was often better than fifty-fifty. In the nineties, the distribution of exceedances has changed. The months of April, September and October are much less likely to experience high levels of ozone. The frequency of exceedances in the central summer months has declined to roughly one day in three. It should be noted that the ozone season changed in 1997, no longer extending into October. This change is justified since the period of 1983-1997 had only five exceedances in the month of October, with the last one occurring in 1990.

Weekday is used to partition exceedances in the next set of graphs (Appendix G). In Region 1, no obvious trend is apparent. Each weekday has at least one year in which the most exceedances occurred on that weekday. Similar results were found for average and median ozone concentration. For thirteen of the fifteen years, the weekday with the most days over 85 °F at Bradley AP also had the most exceedances.

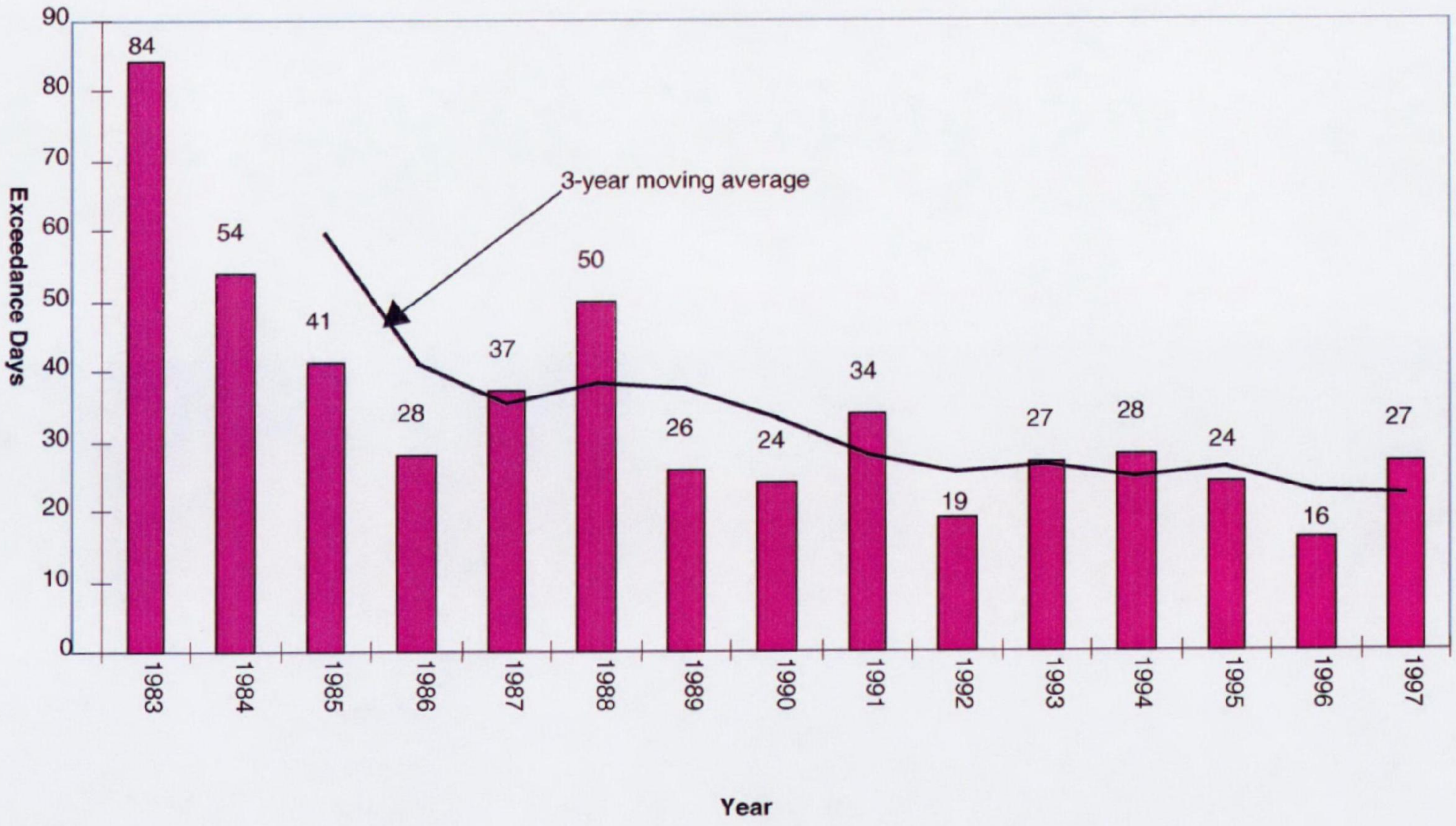
# Appendix A

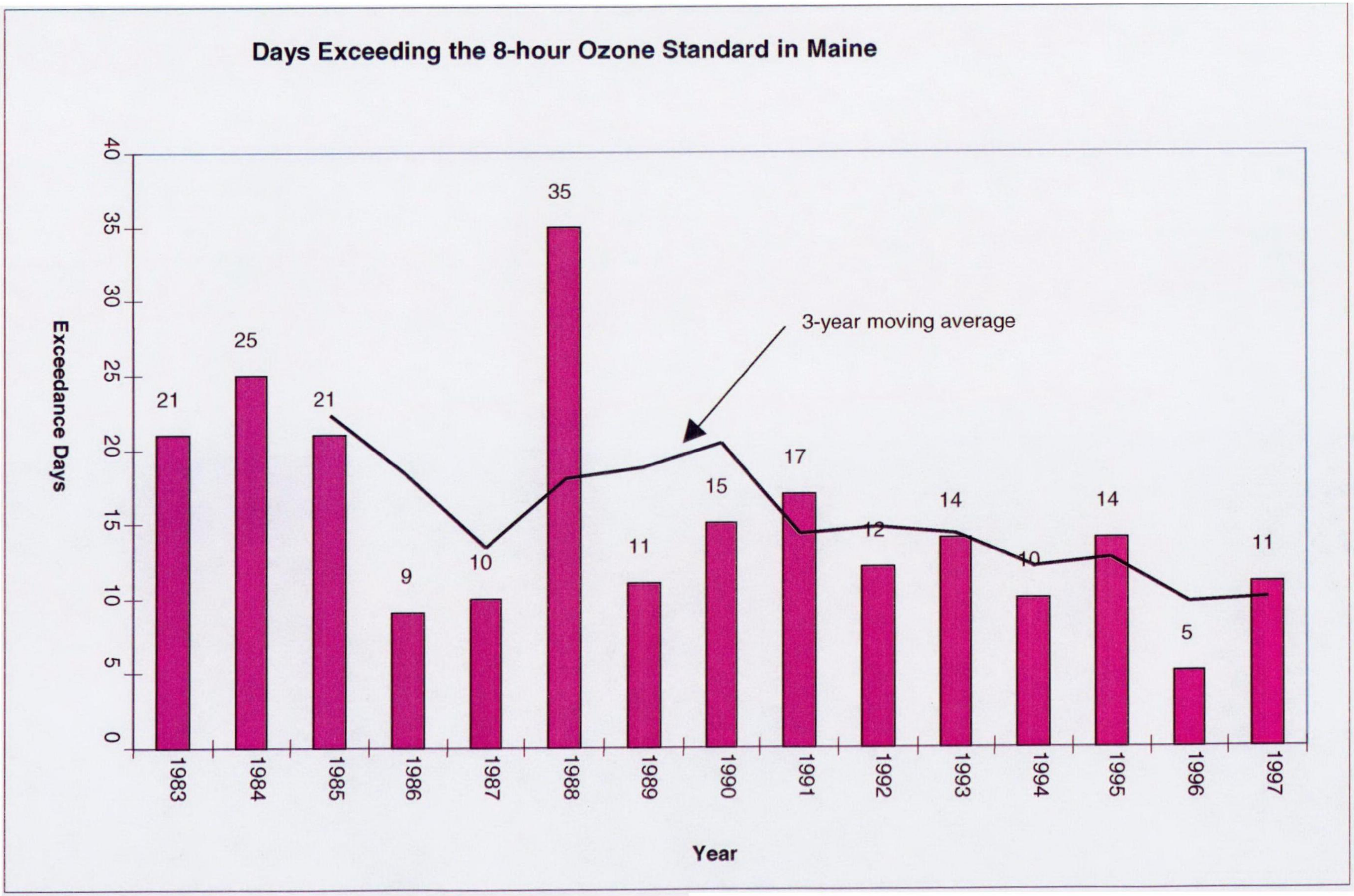
## Procedure for calculating the 8-hour ozone standard

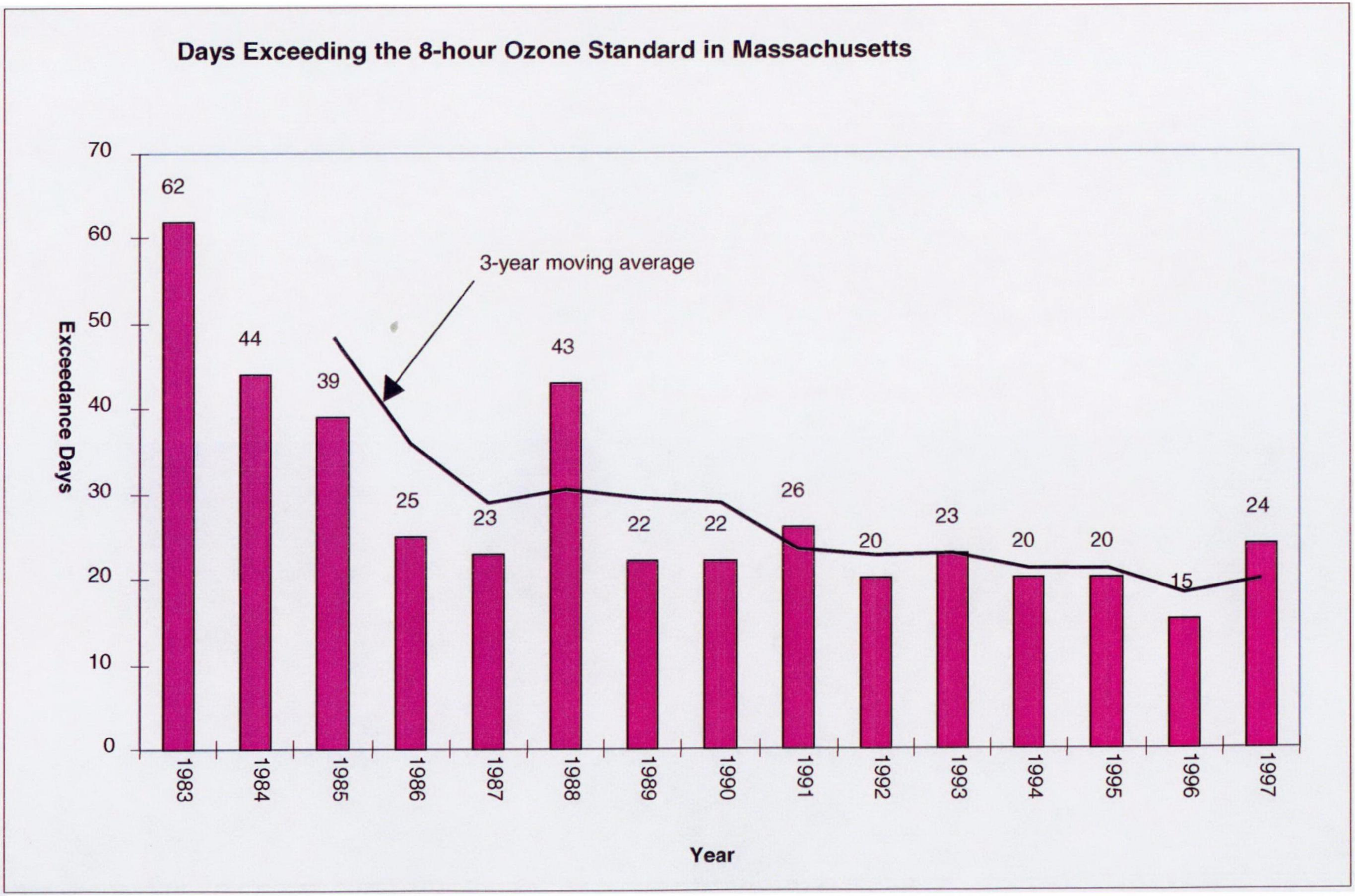
The following computations were performed on ozone data residing in the Aerometric Information Retrieval System to determine the maximum daily 8-hour ozone average. First, running 8-hour averages are computed from the hourly ozone concentration data for each hour of the year and the result is stored in the first, or start, hour of the 8-hour period. In the event that only 6 (or 7) hourly averages are available, the 8-hour average is computed using 6 (or 7) as the divisor. (Note: 8-hour periods with three or more missing hours will be counted as missing unless, after substituting one-half the minimum detectable limit for the missing hourly concentrations, the 8-hour average concentration is greater than the level of the standard). If fewer than 18 hours of valid ozone concentration measurements are available for the day, then the day is not counted as a valid day and the daily maximum 8-hour average is not determined. The computed 8-hour average ozone concentration is reported in parts per million (ppm) to three decimal places (the insignificant digits to the right of the third decimal place are truncated). By comparing the running 8-hour average ozone values over the course of a 24-hour period, a maximum is determined for each day.

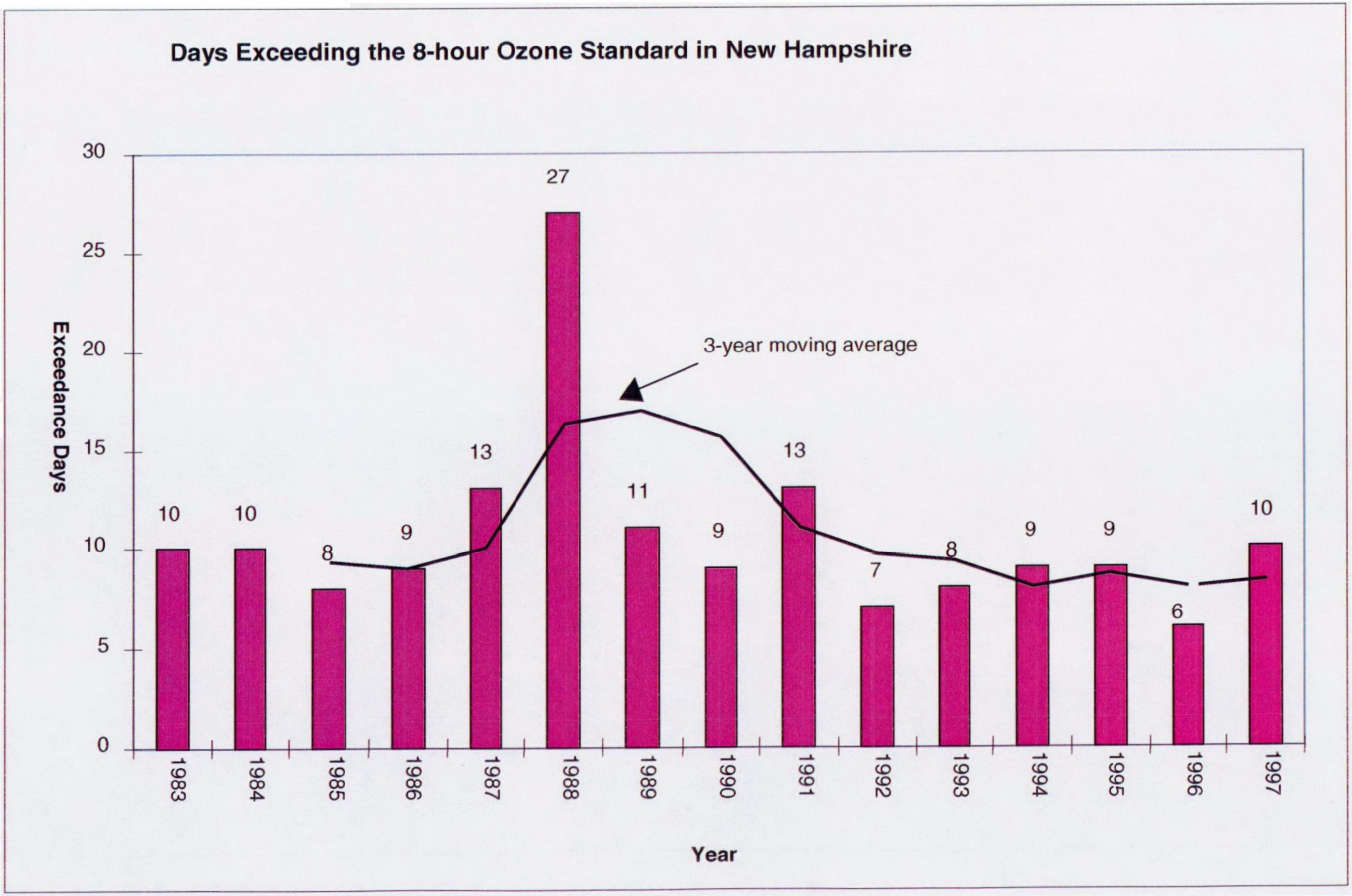

Days Exceeding the 8-hour Ozone Standard in Region 1
Exceedance Days
Year
3-year moving average
100
90
80
70
60
50
40
30
20
10
0
90
60
50
35
45
56
31
31
40
27
30
33
29
20
30
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

**Days Exceeding the 8-hour Ozone Standard in Connecticut**

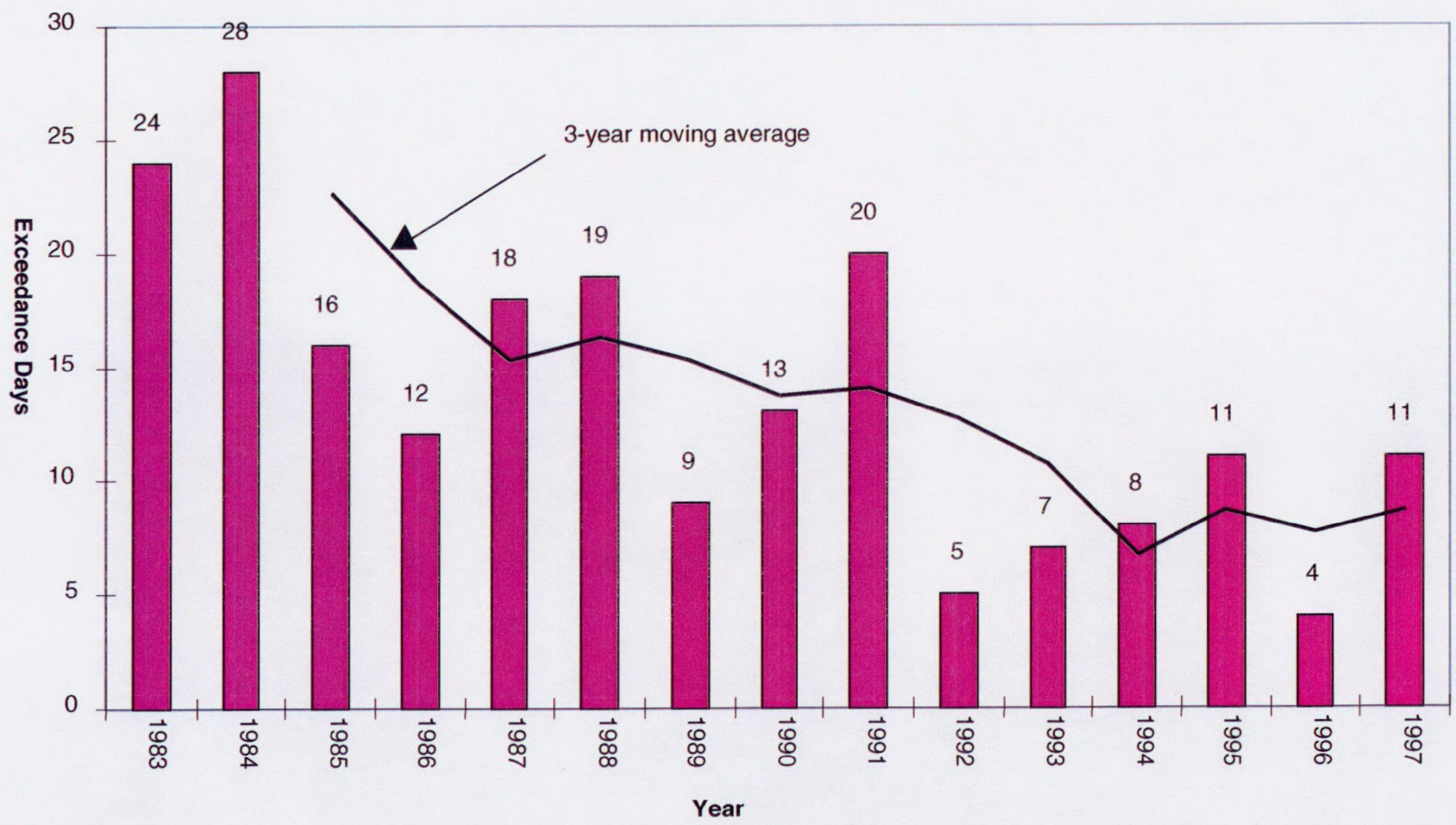


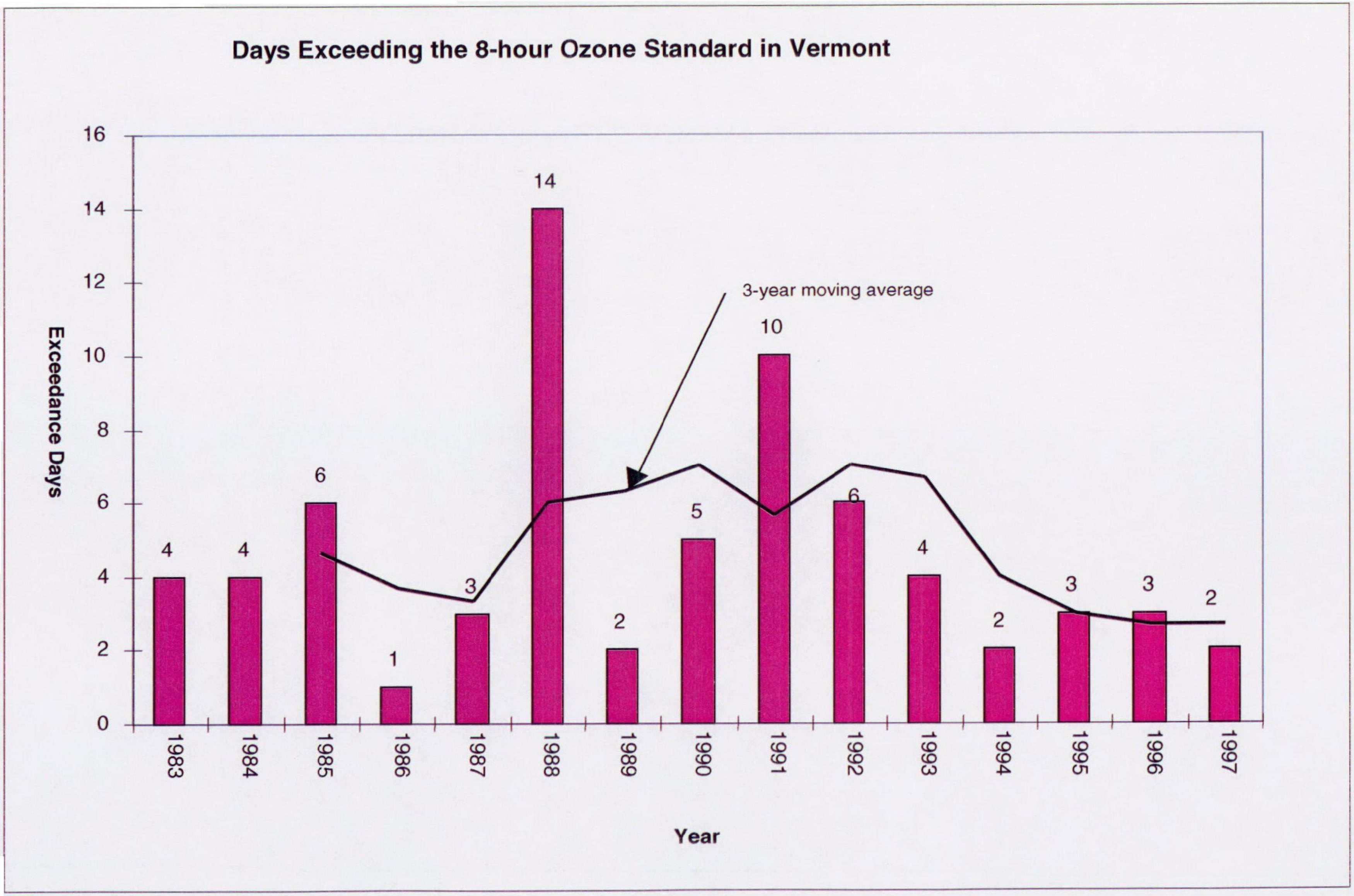

Days Exceeding the 8-hour Ozone Standard in Maine
Exceedance Days
0
5
10
15
20
25
30
35
40
21
25
21
9
10
35
11
15
17
12
14
10
14
5
11
3-year moving average
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year


Days Exceeding the 8-hour Ozone Standard in Massachusetts
Exceedance Days
Year
3-year moving average
70
60
50
40
30
20
10
0
62
44
39
25
23
43
22
22
26
20
23
20
20
15
24
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997


Days Exceeding the 8-hour Ozone Standard in New Hampshire
Exceedance Days
Year
3-year moving average
30
25
20
15
10
5
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
10
10
8
9
13
27
11
9
13
7
8
9
9
6
10

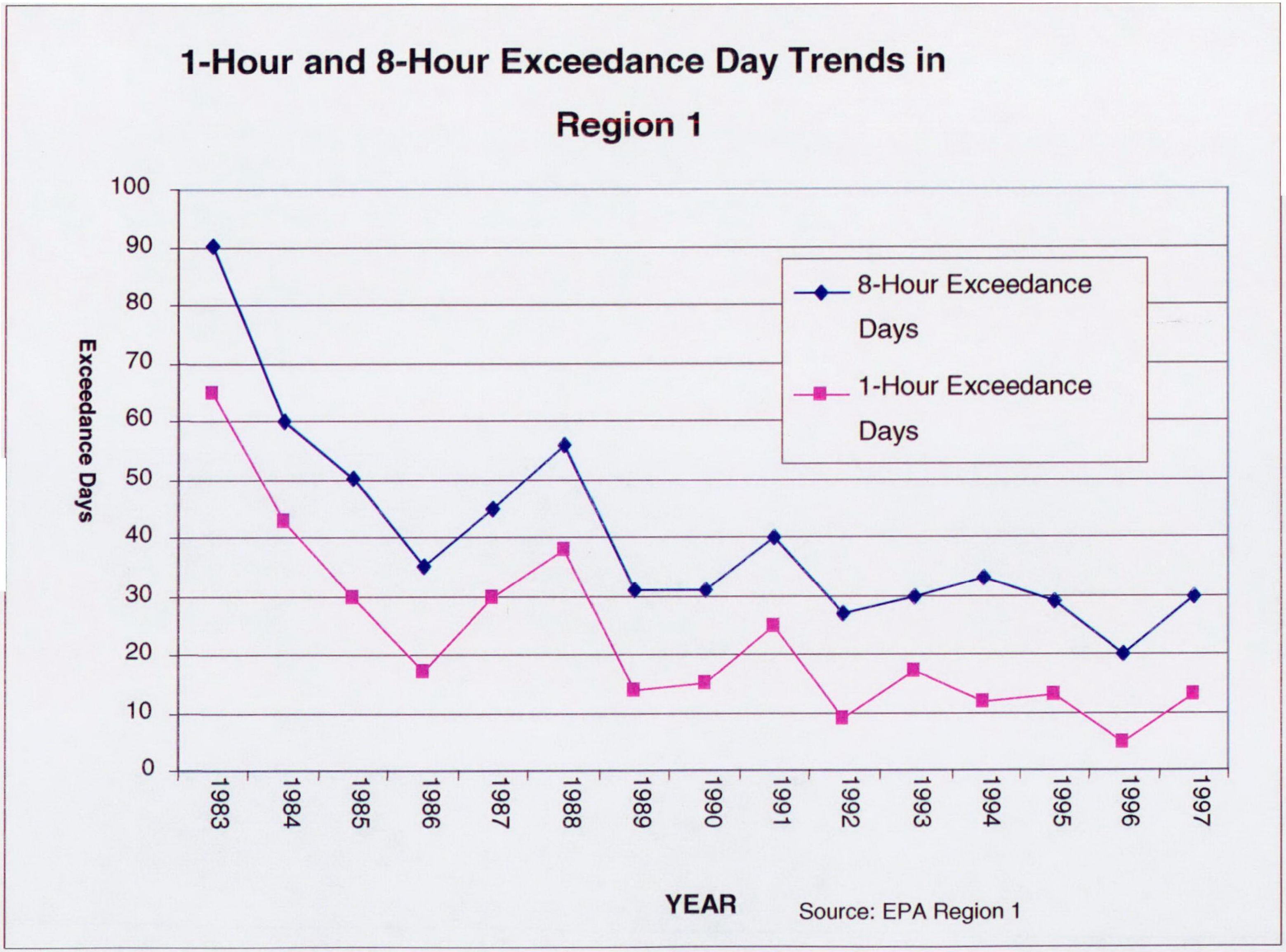
**Days Exceeding the 8-hour Ozone Standard in Rhode Island**

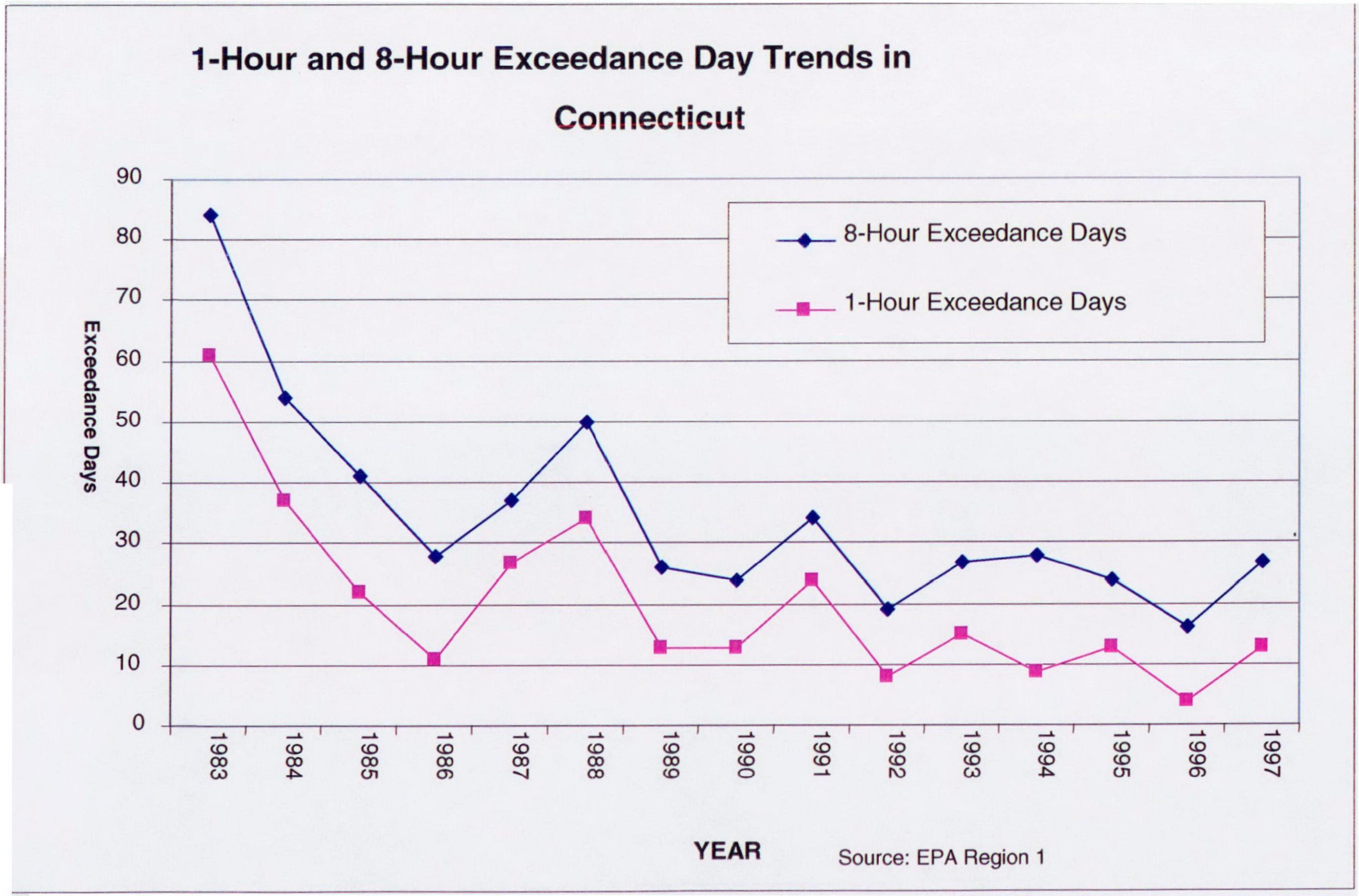


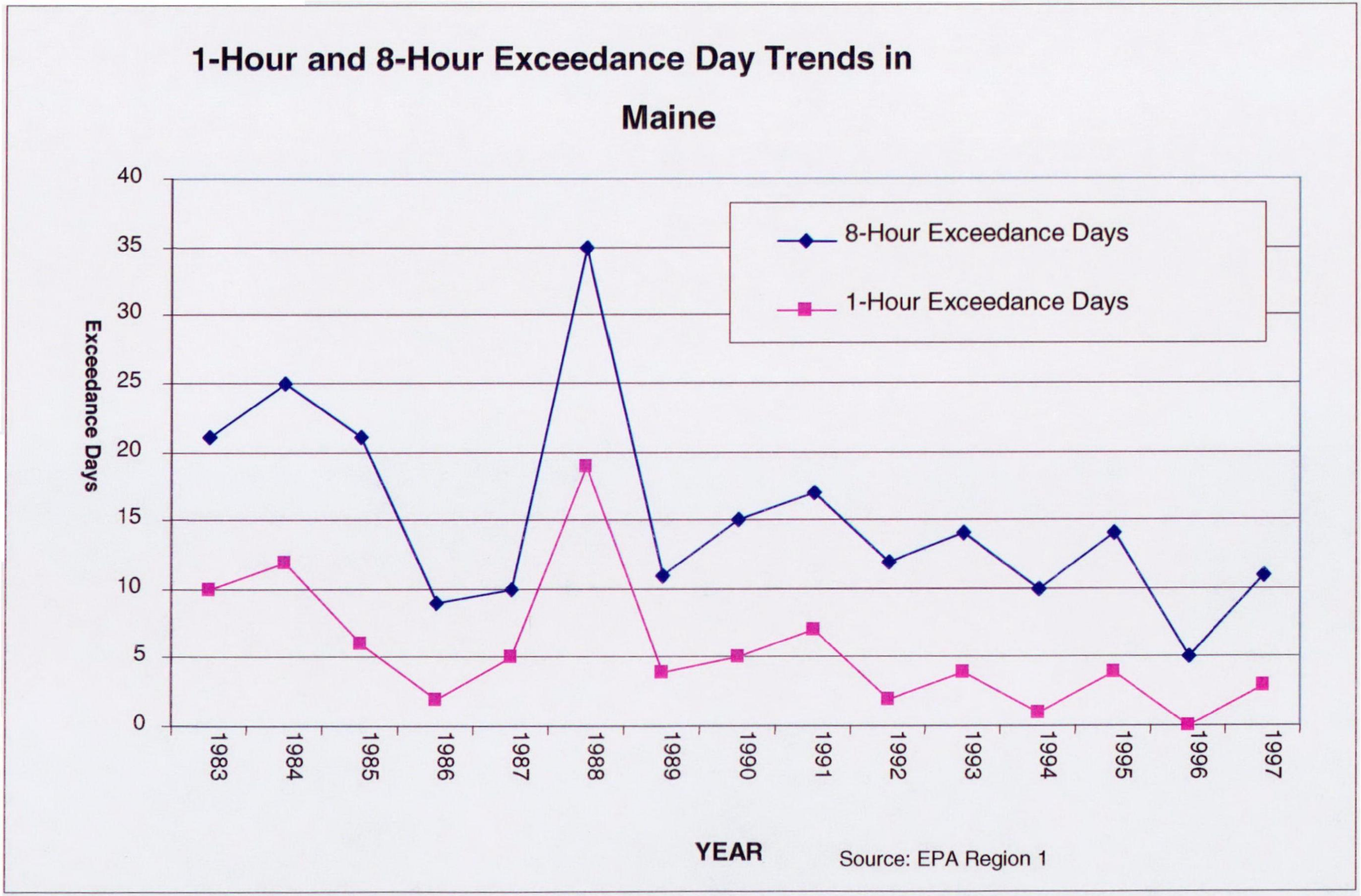

Days Exceeding the 8-hour Ozone Standard in Vermont
3-year moving average
Exceedance Days
Year
16
14
12
10
8
6
4
2
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
4
4
6
1
3
14
2
5
10
6
4
2
3
3
2

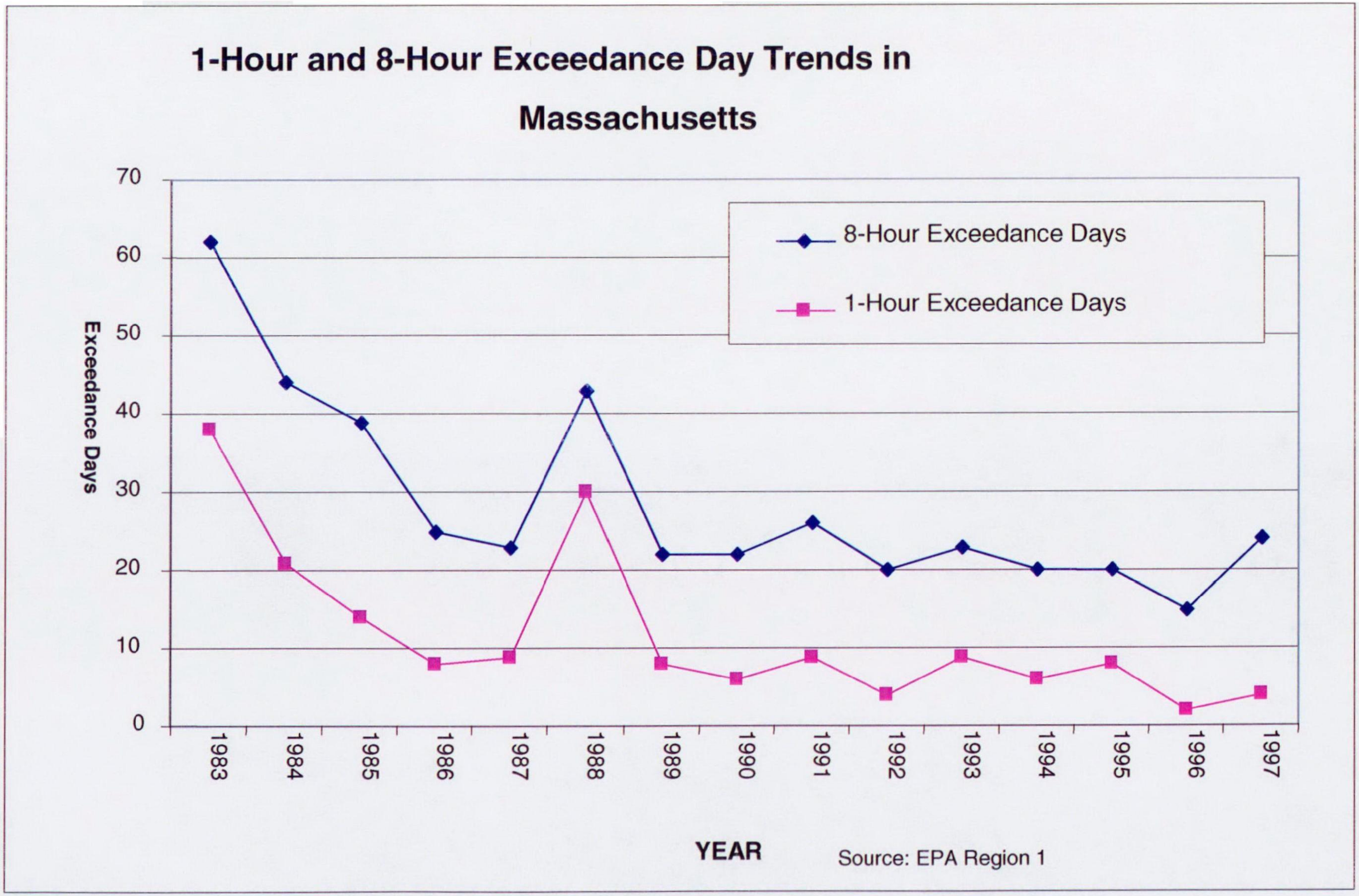
# Appendix C

## Comparison of the 1-hour and 8-hour Trends




1-Hour and 8-Hour Exceedance Day Trends in Connecticut
8-Hour Exceedance Days
1-Hour Exceedance Days
Exceedance Days
0
10
20
30
40
50
60
70
80
90
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1


1-Hour and 8-Hour Exceedance Day Trends in Maine
8-Hour Exceedance Days
1-Hour Exceedance Days
Exceedance Days
0
5
10
15
20
25
30
35
40
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1


1-Hour and 8-Hour Exceedance Day Trends in Massachusetts
8-Hour Exceedance Days
1-Hour Exceedance Days
Exceedance Days
70
60
50
40
30
20
10
0
1983
1984
1985
1986
1987
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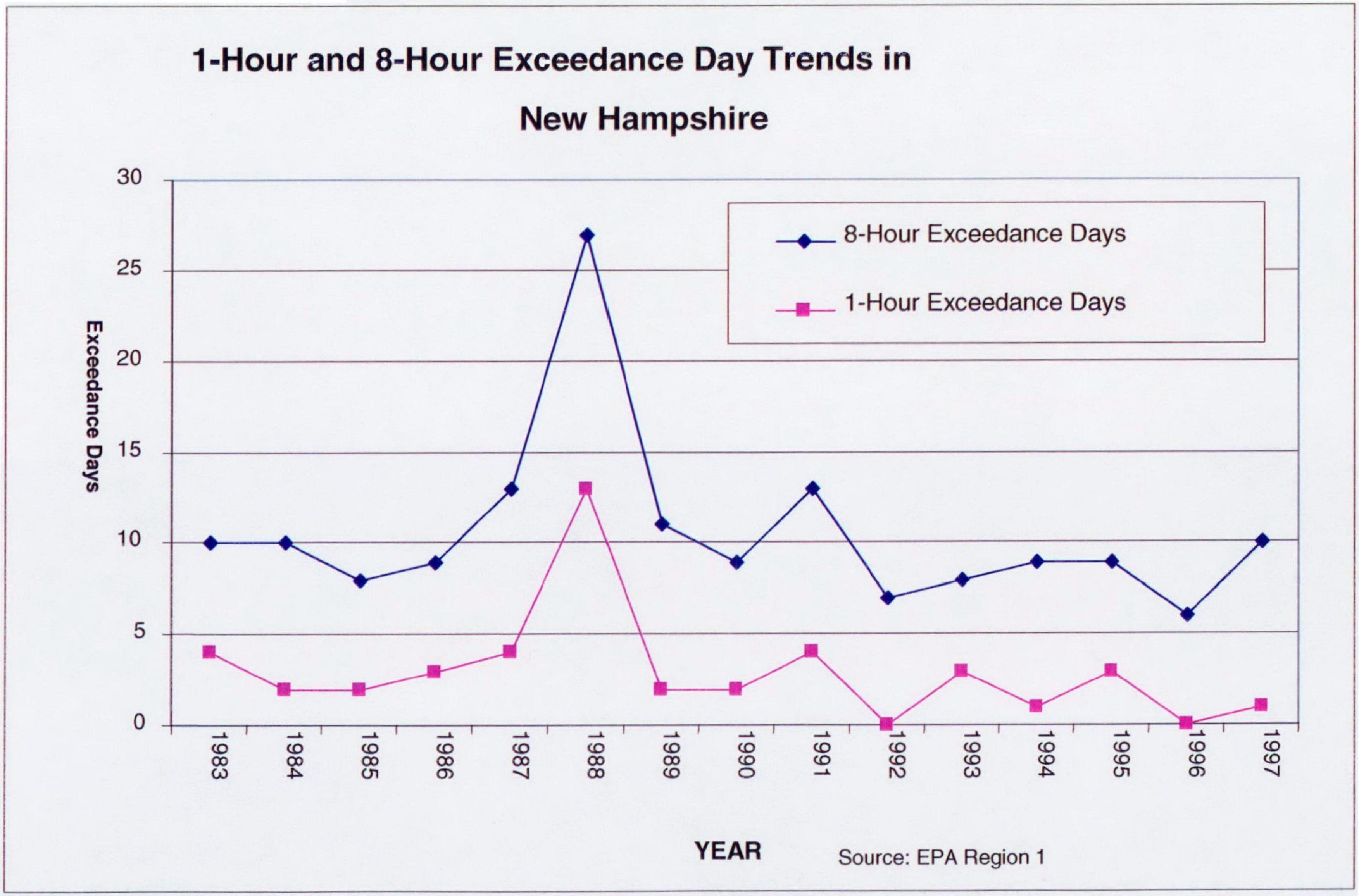
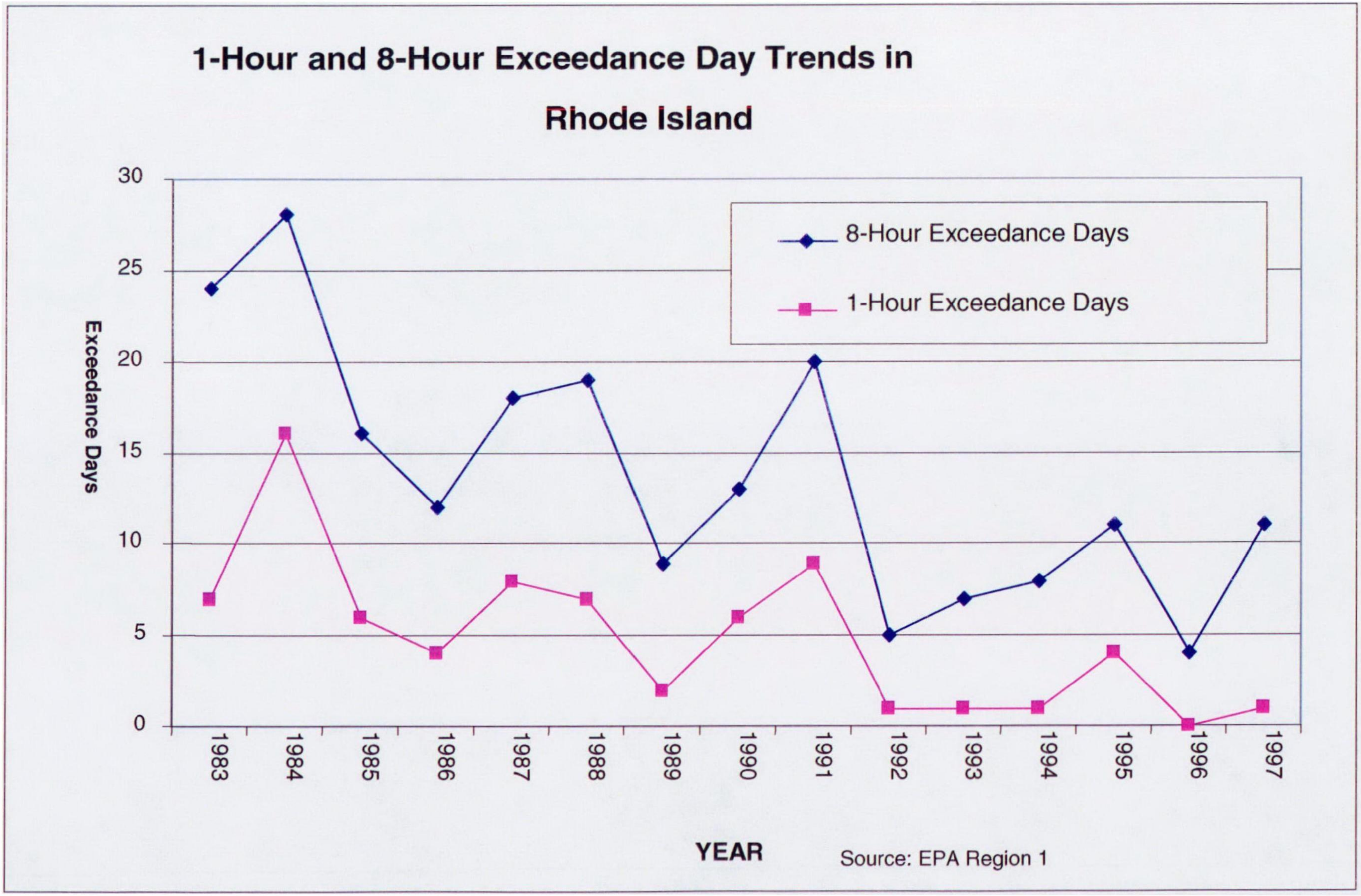
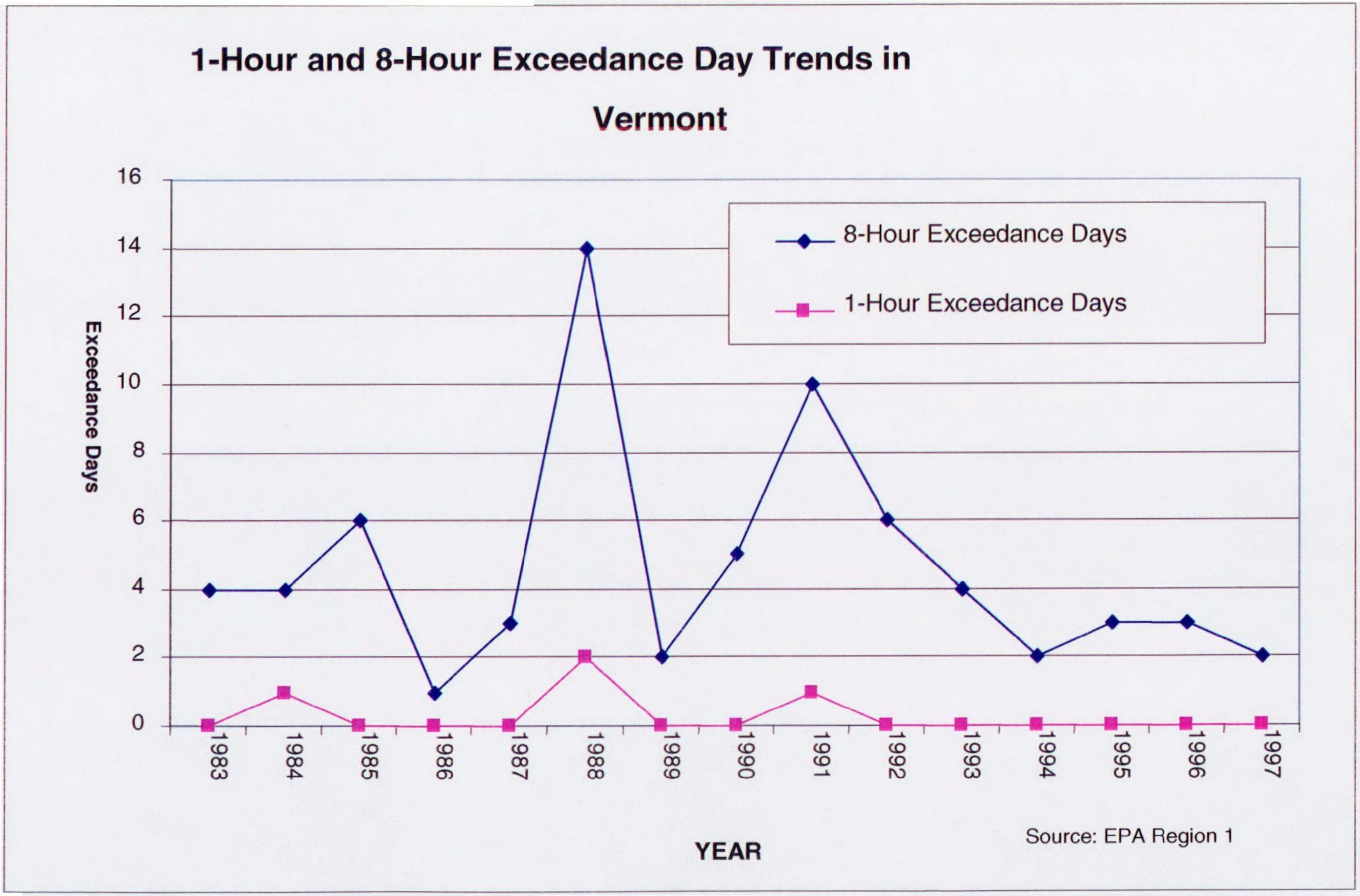
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1

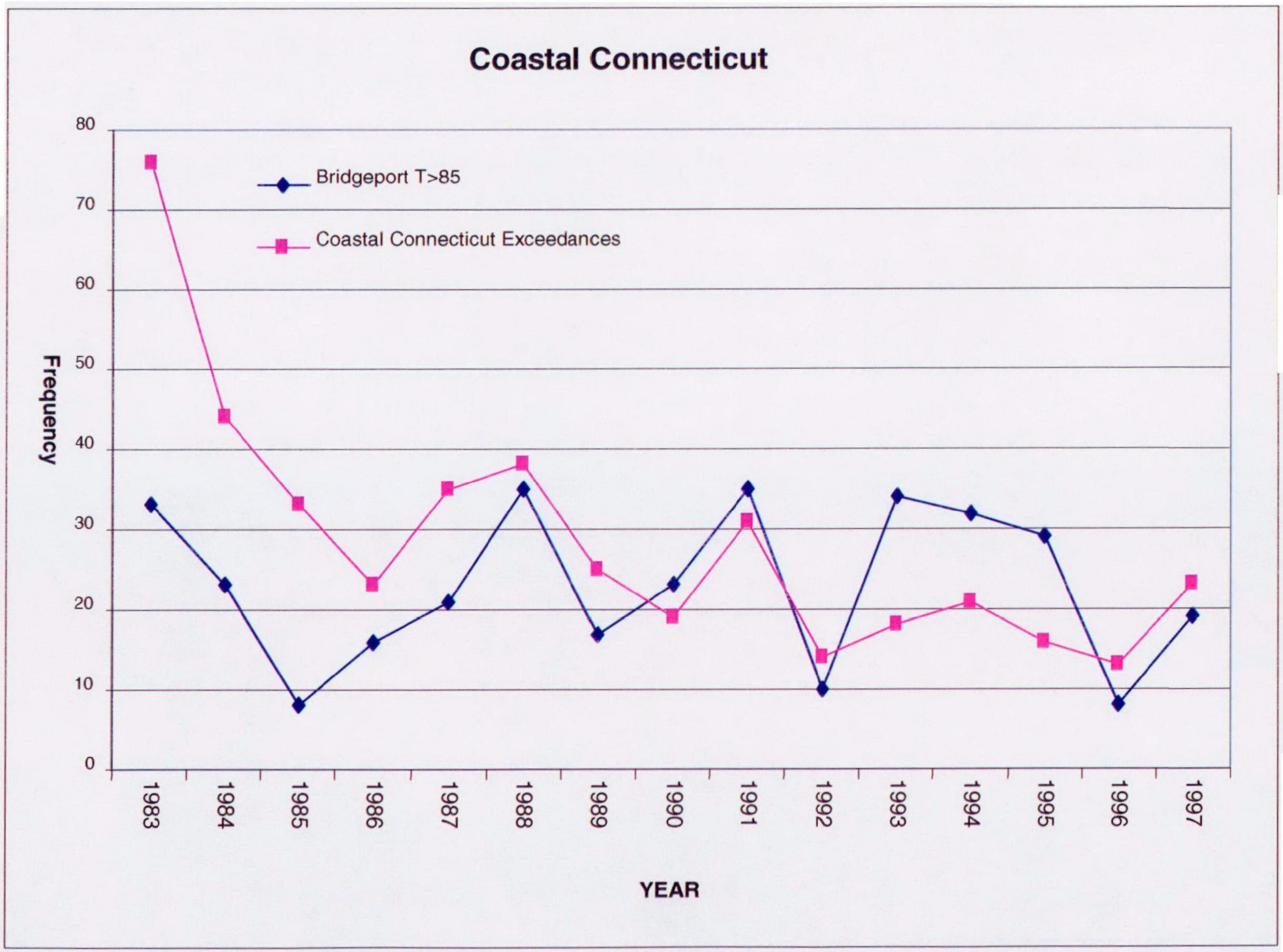


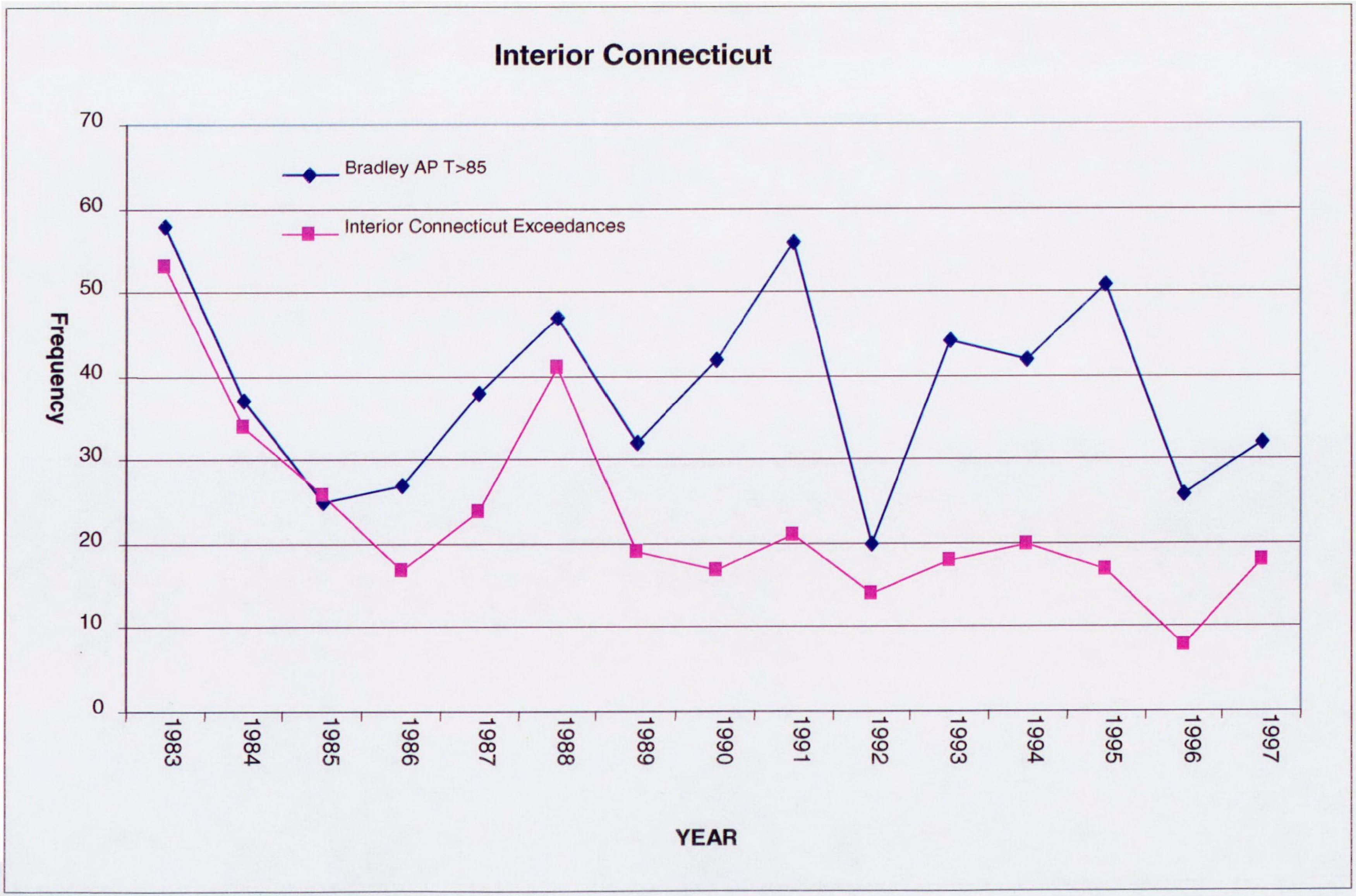
1-Hour and 8-Hour Exceedance Day Trends in New Hampshire
8-Hour Exceedance Days
1-Hour Exceedance Days
Exceedance Days
0
5
10
15
20
25
30
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1


1-Hour and 8-Hour Exceedance Day Trends in
Rhode Island
8-Hour Exceedance Days
1-Hour Exceedance Days
Exceedance Days
30
25
20
15
10
5
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1

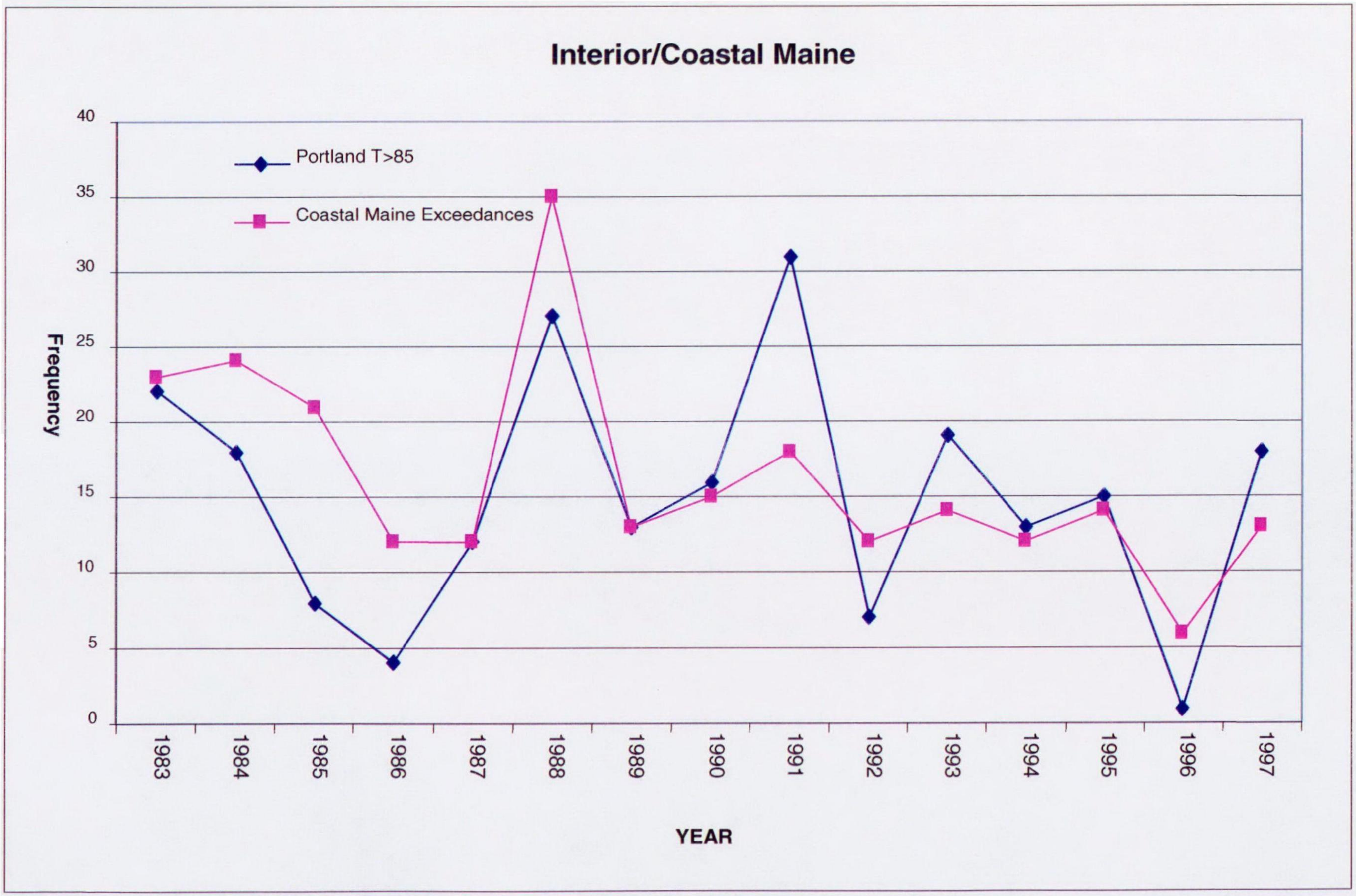


1-Hour and 8-Hour Exceedance Day Trends in Vermont
Exceedance Days
16
14
12
10
8
6
4
2
0
8-Hour Exceedance Days
1-Hour Exceedance Days
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR
Source: EPA Region 1

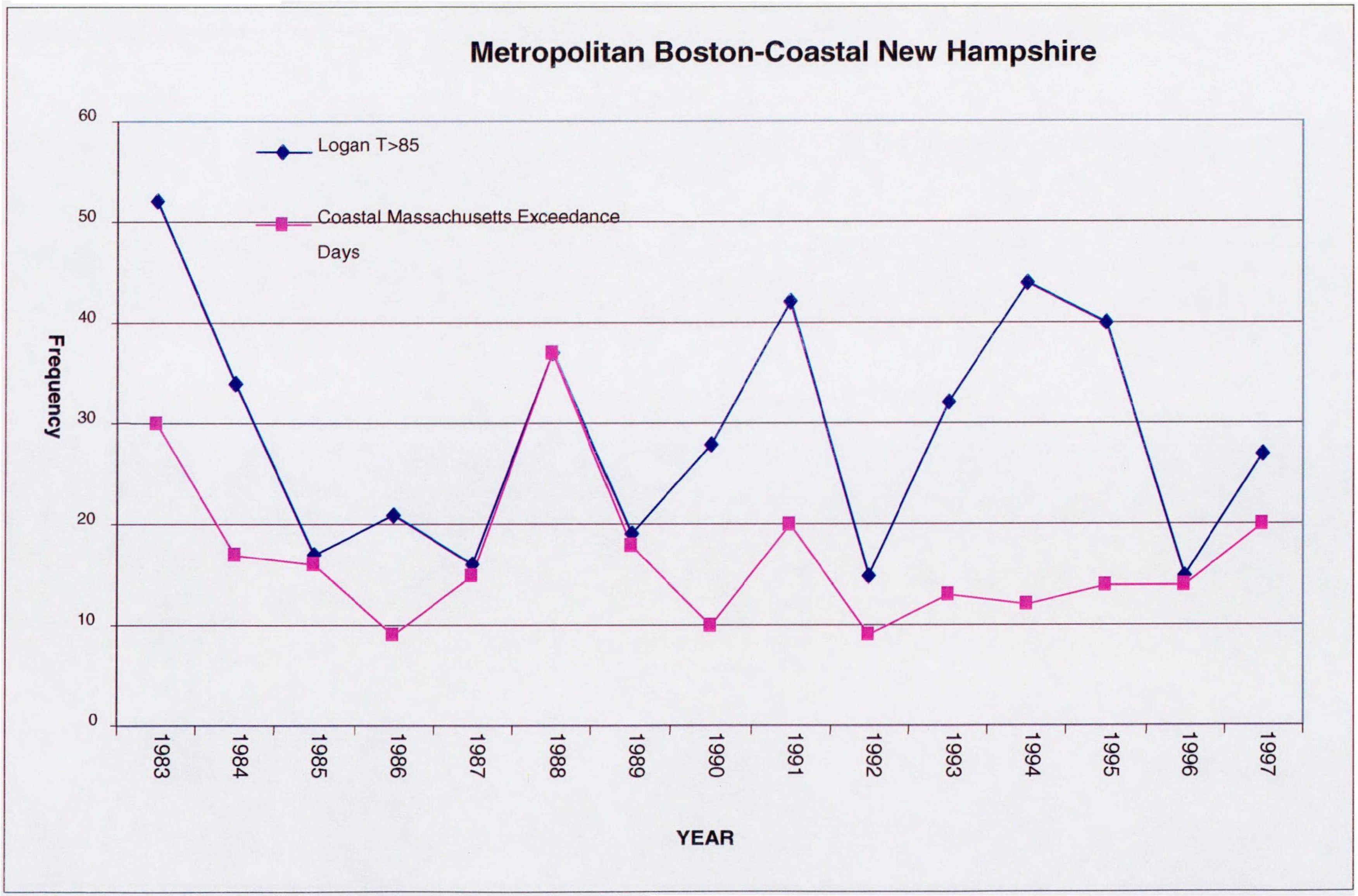

Coastal Connecticut
Bridgeport T>85
Coastal Connecticut Exceedances
Frequency
80
70
60
50
40
30
20
10
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR

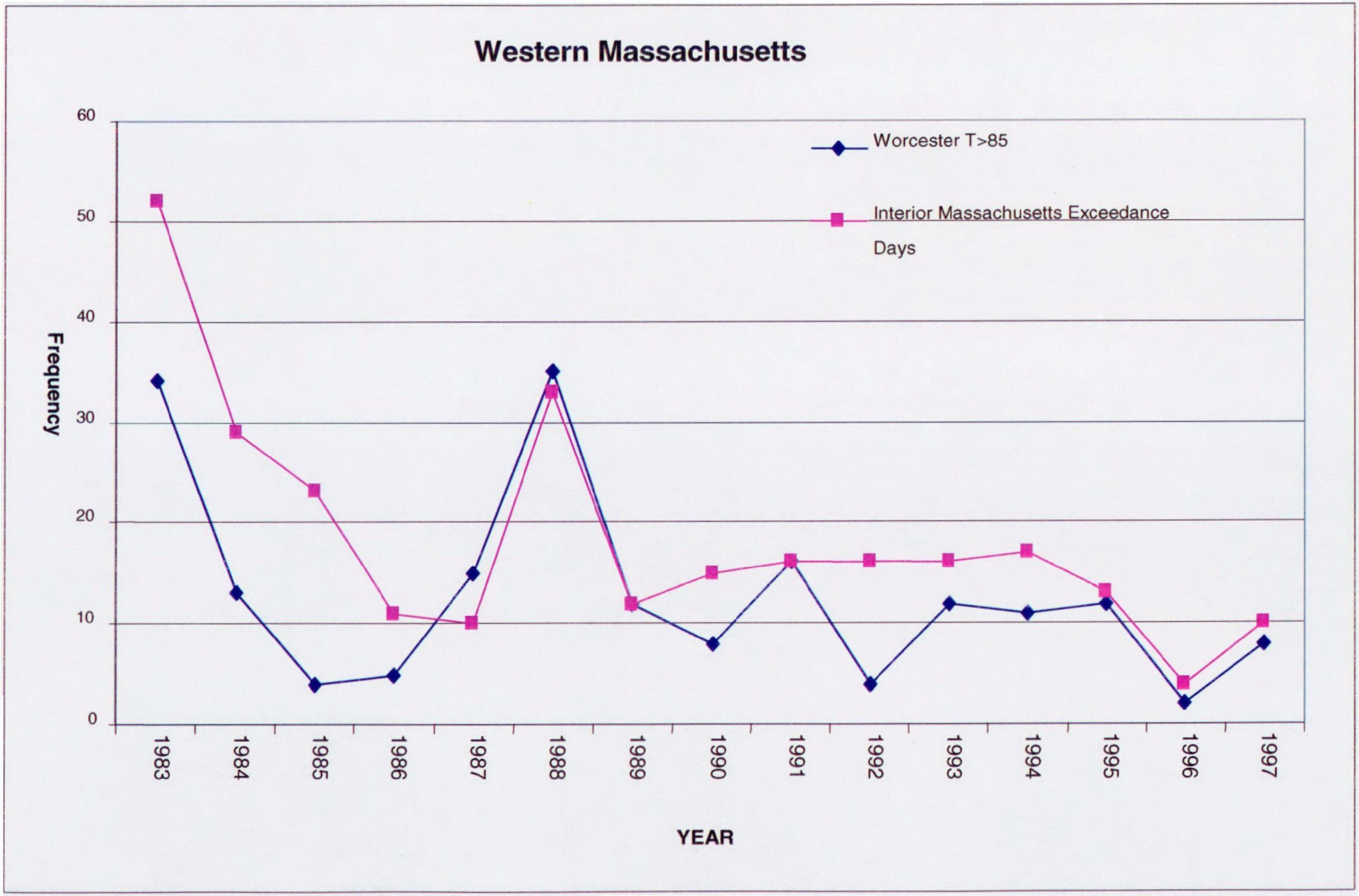


Interior Connecticut
Bradley AP T>85
Interior Connecticut Exceedances
Frequency
70
60
50
40
30
20
10
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR

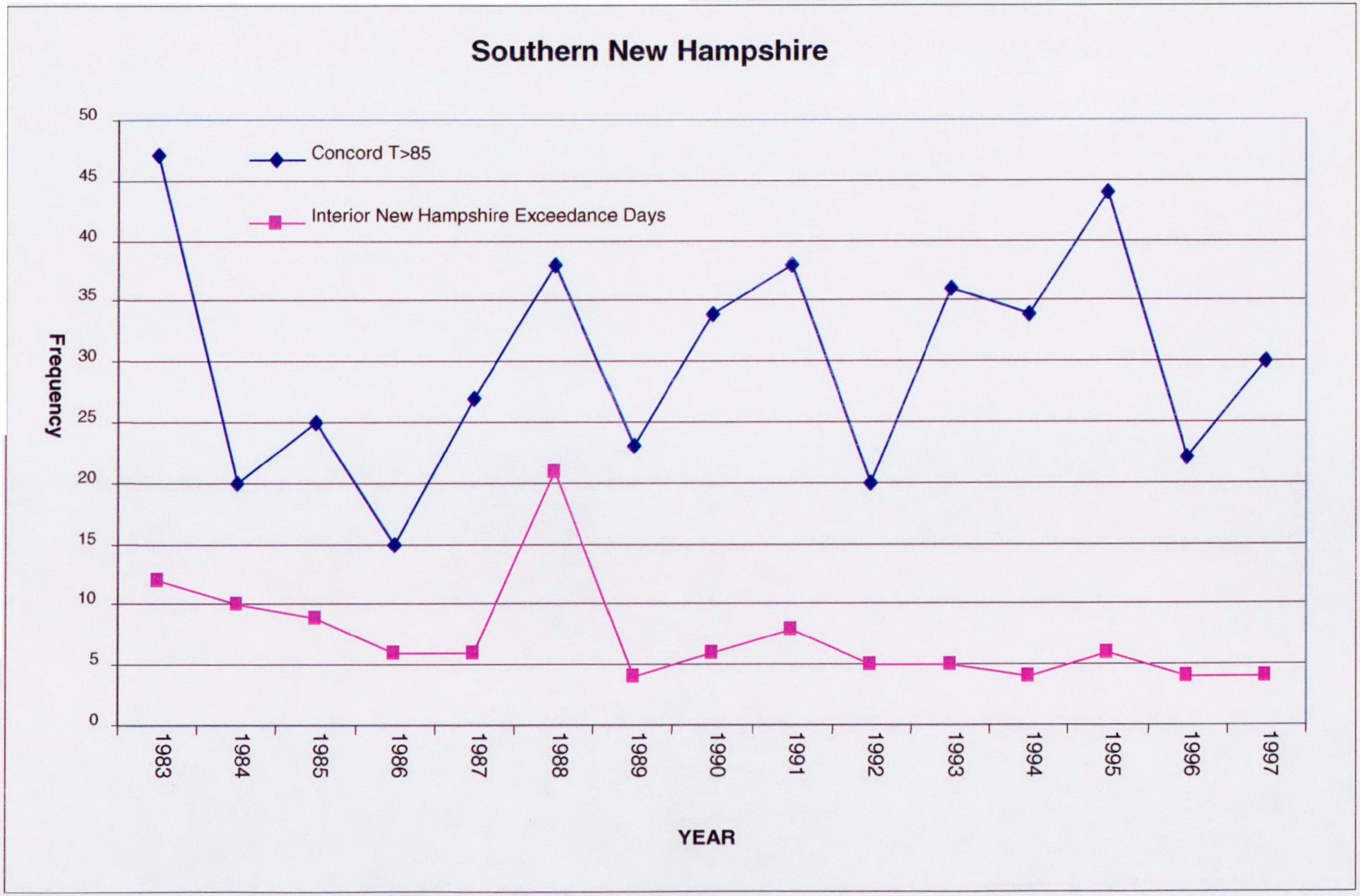


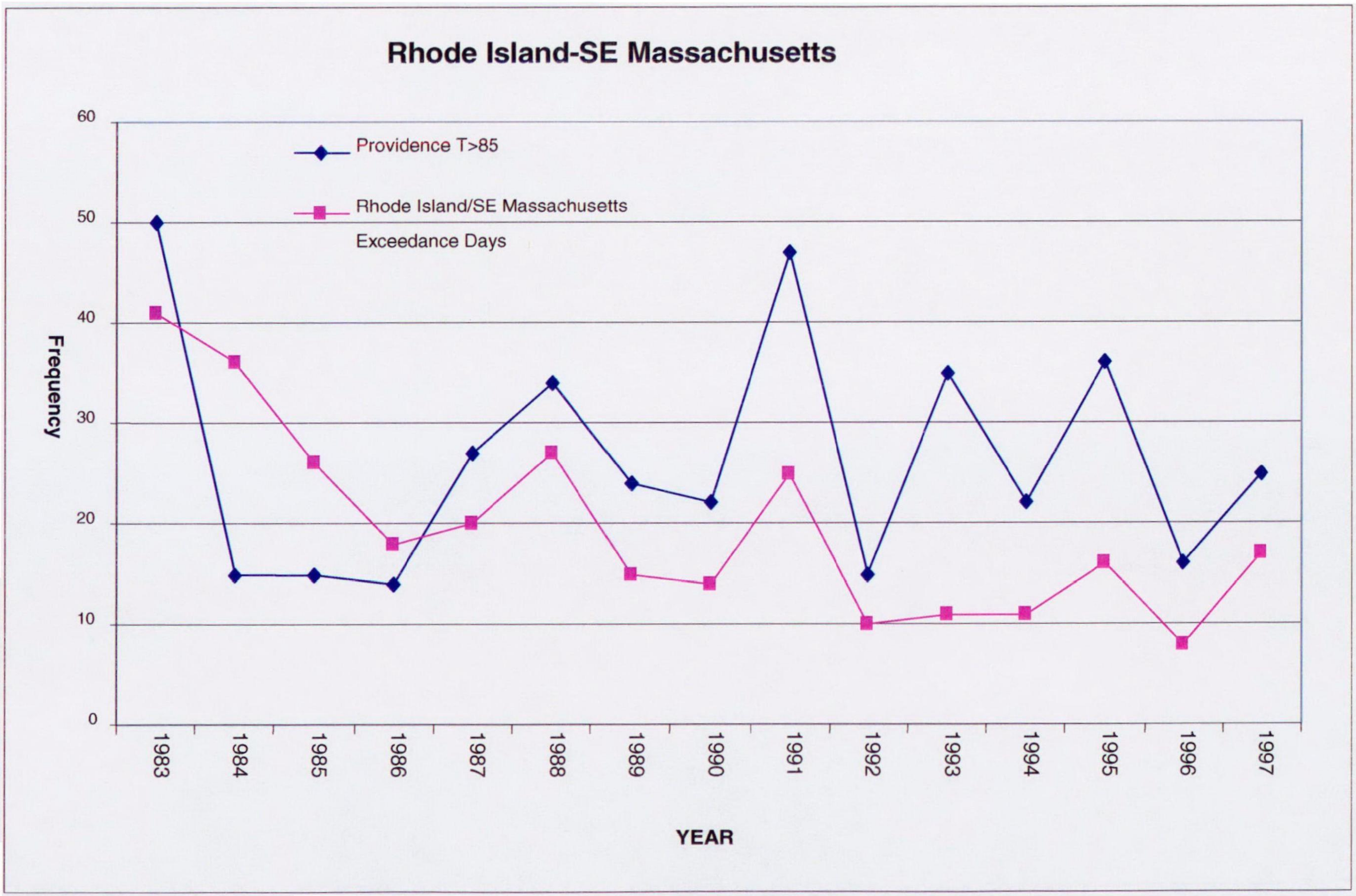
Interior/Coastal Maine
Portland T>85
Coastal Maine Exceedances
Frequency
0
5
10
15
20
25
30
35
40
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR


Metropolitan Boston-Coastal New Hampshire
Logan T>85
Coastal Massachusetts Exceedance Days
Frequency
0
10
20
30
40
50
60
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR



Western Massachusetts
Worcester T>85
Interior Massachusetts Exceedance Days
Frequency
60
50
40
30
20
10
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
YEAR


Southern New Hampshire
Concord T>85
Interior New Hampshire Exceedance Days
Frequency
YEAR
0
5
10
15
20
25
30
35
40
45
50
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997


Rhode Island-SE Massachusetts
Providence T>85
Rhode Island/SE Massachusetts
Exceedance Days
Frequency
60
50
40
30
20
10
0
1983
1984
1985
1986
1987
1988
1989
1990
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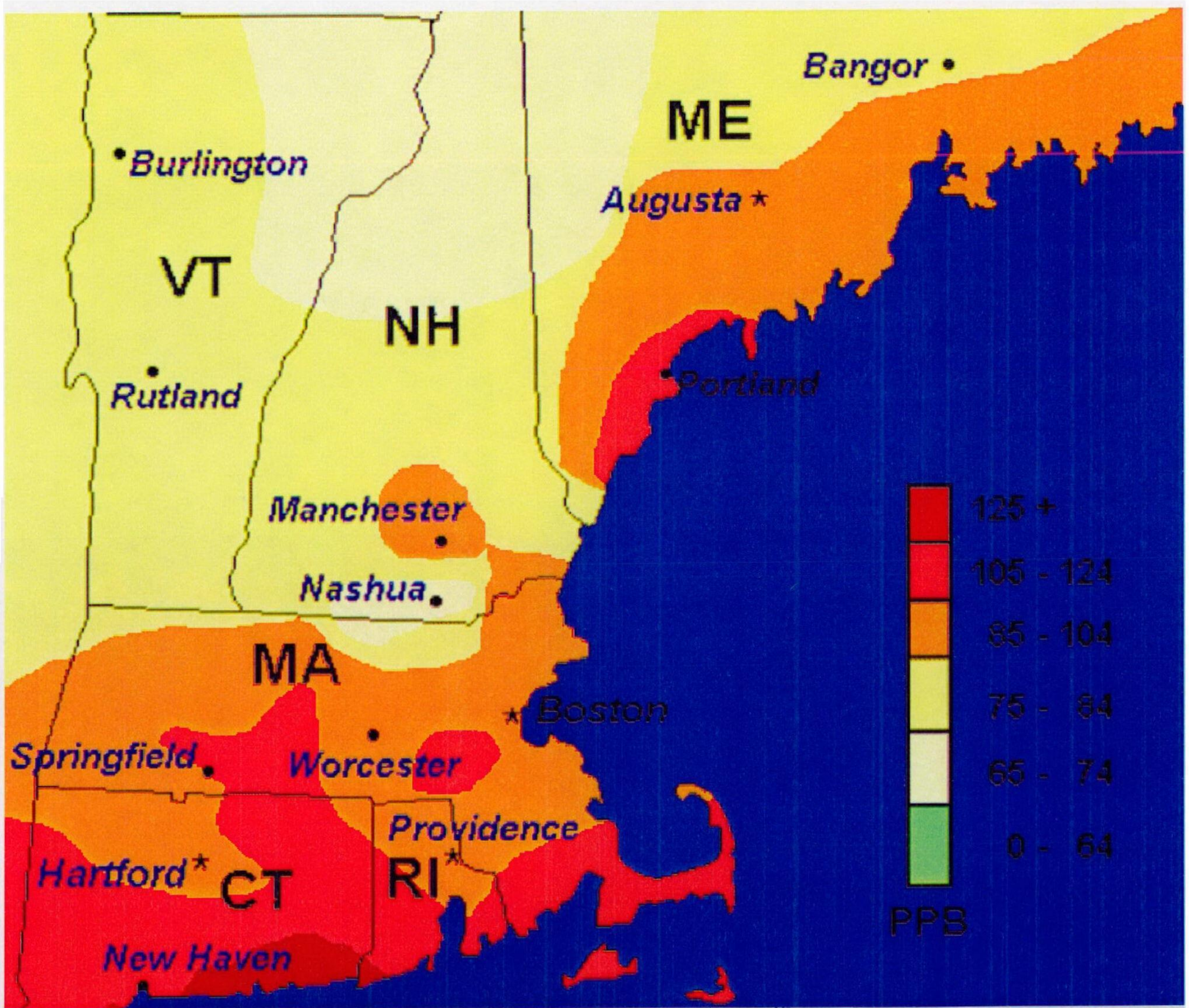
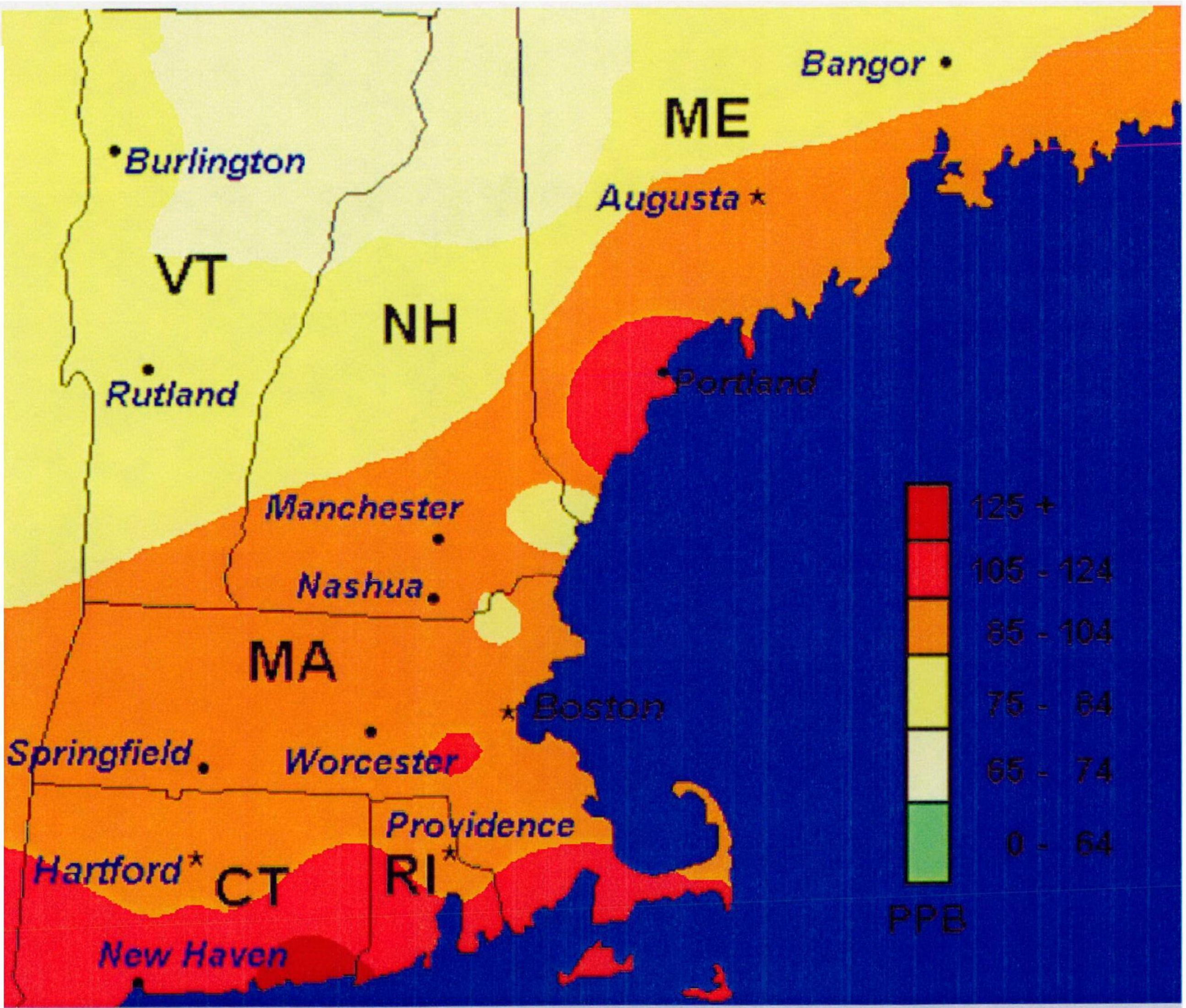
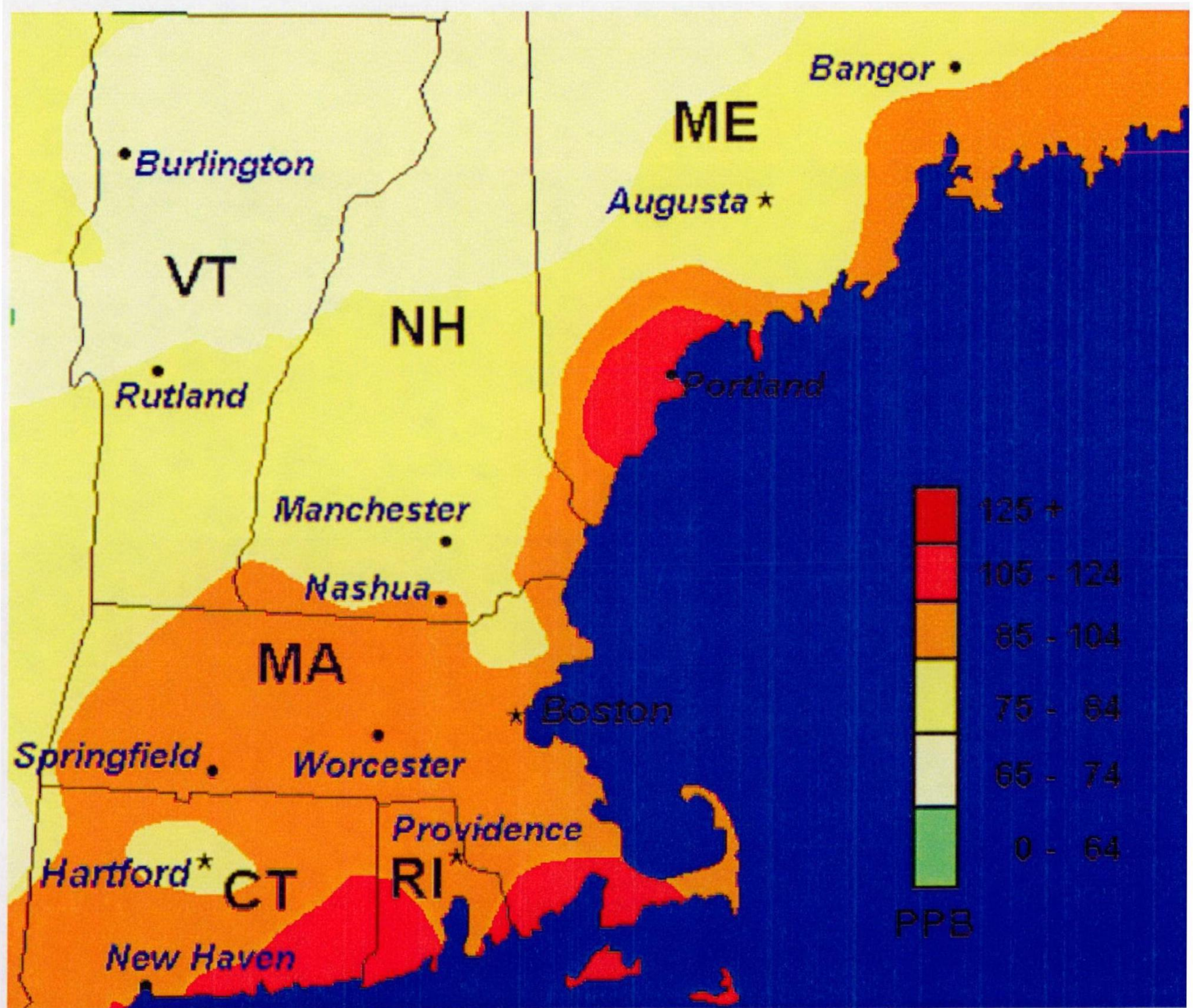
1993
1994
1995
1996
1997
YEAR



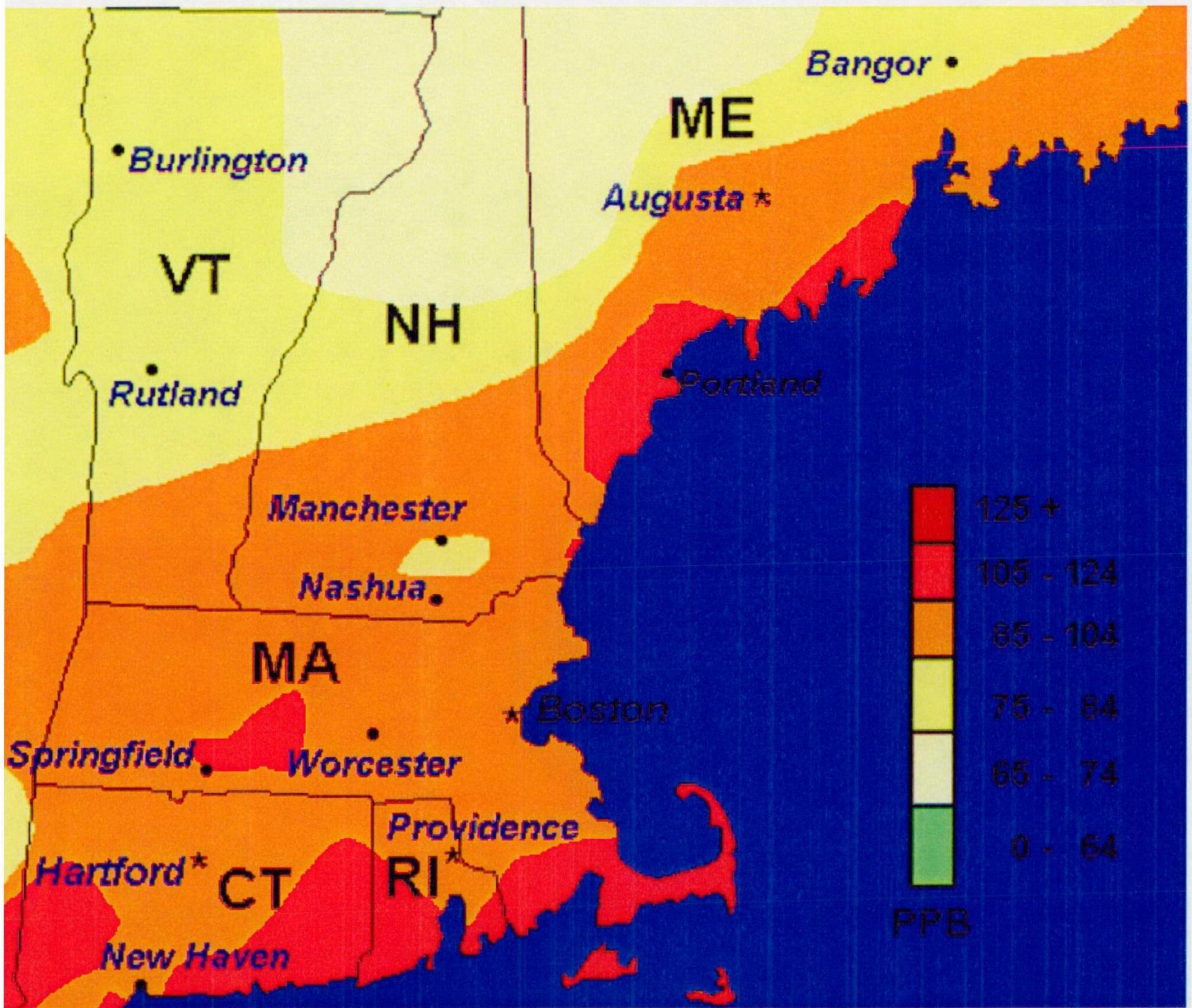

8-hour Design Values for 1983-1985



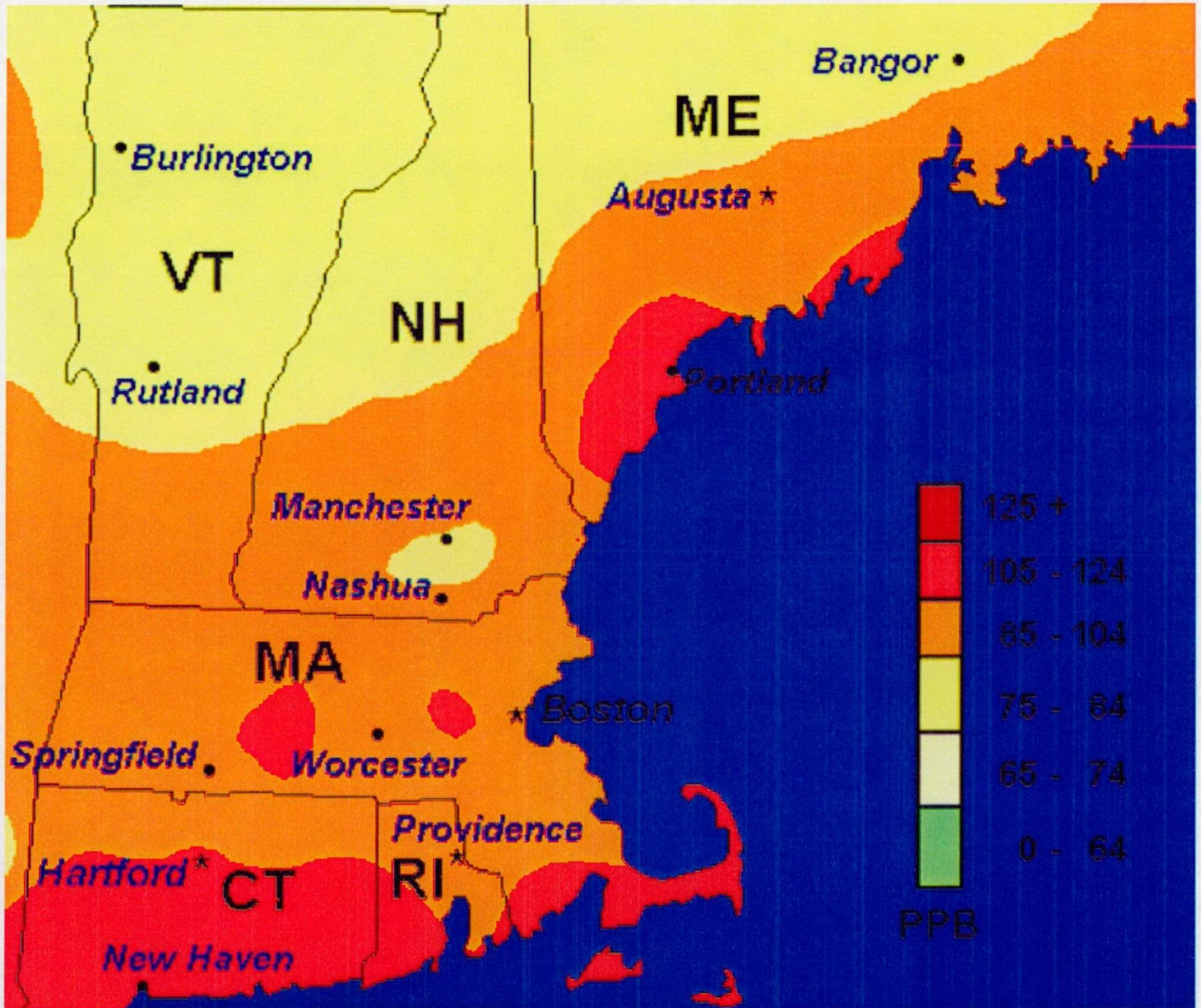

8-hour Design Values for 1984-1986



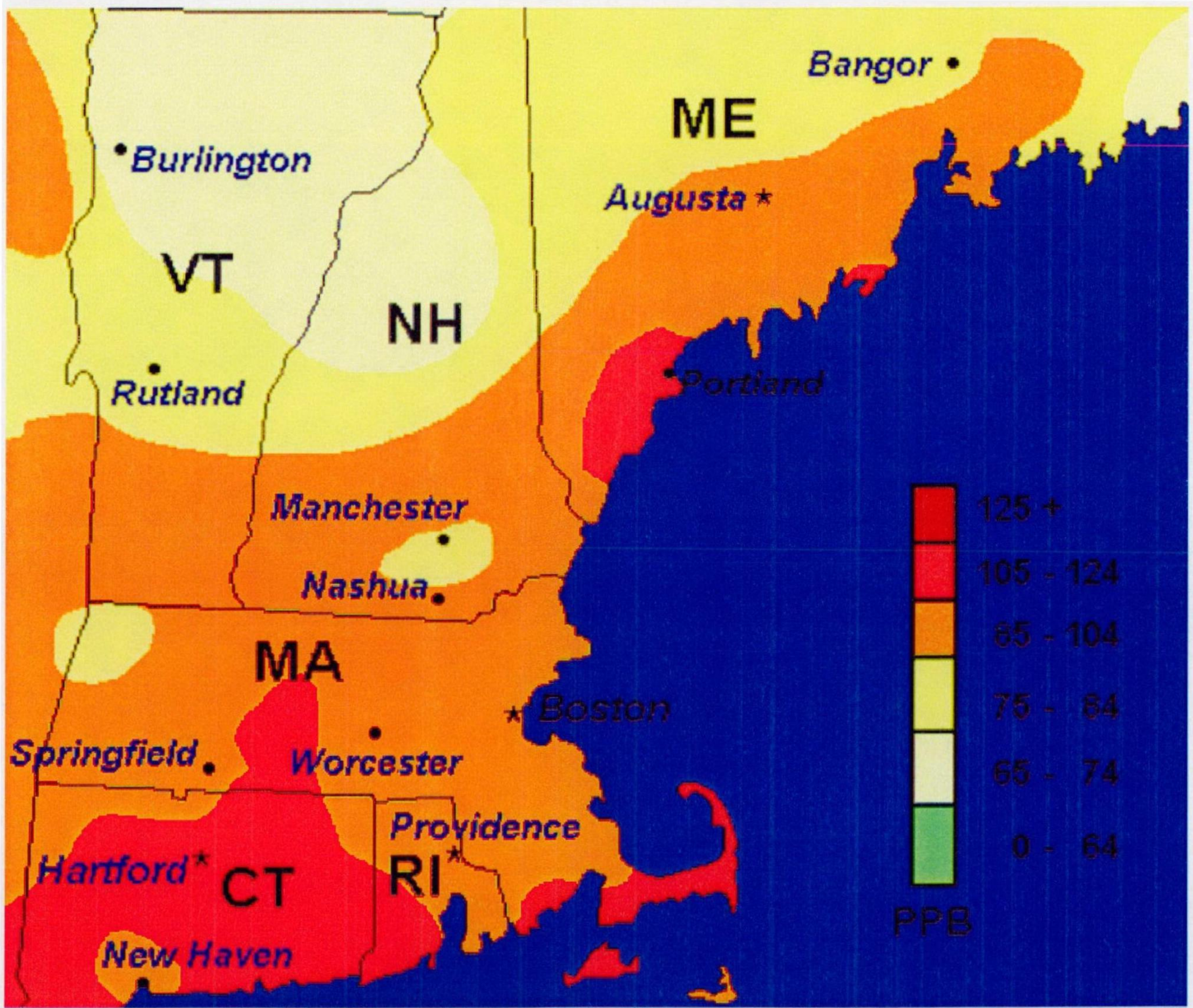

8-hour Design Values for 1985-1987



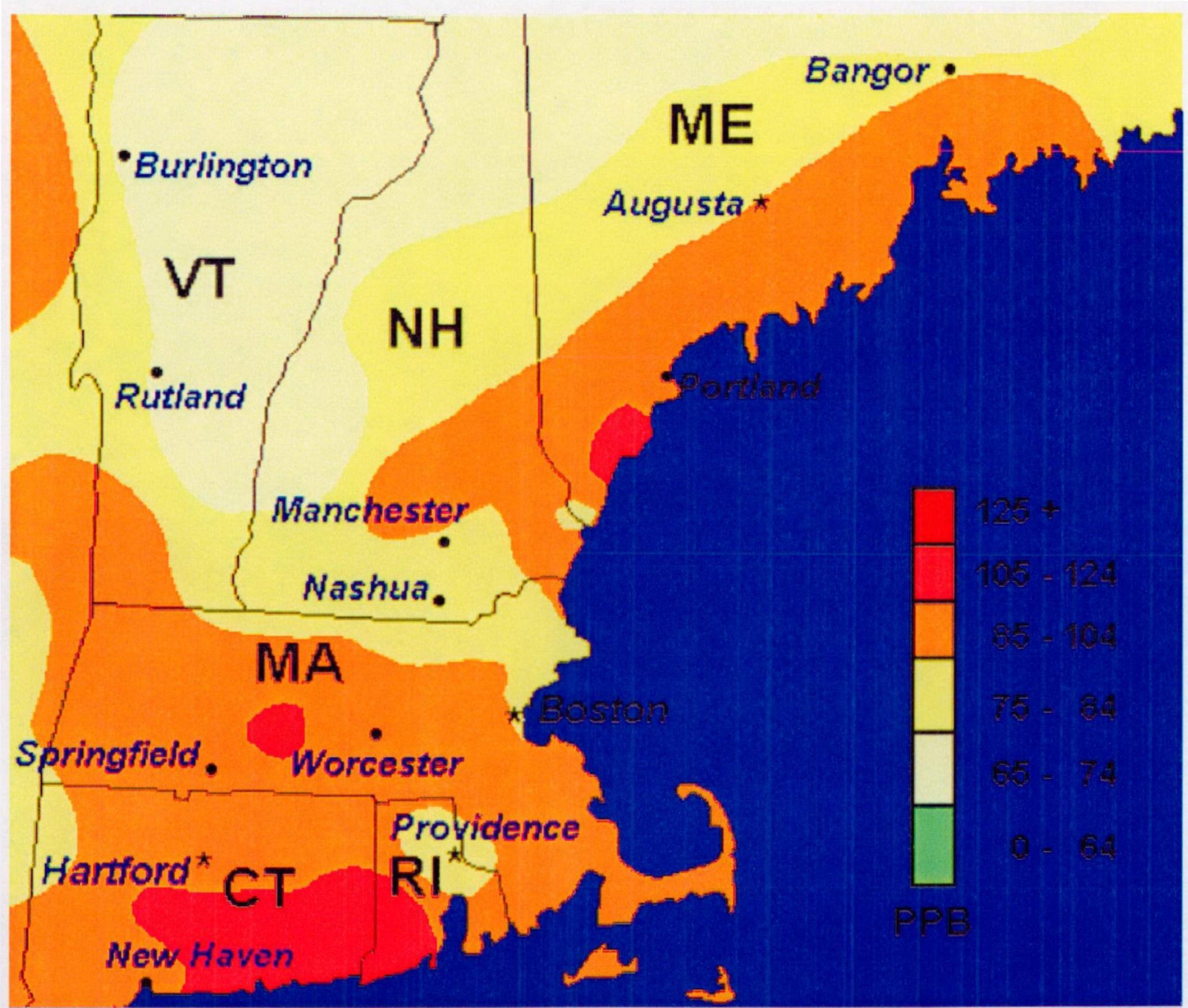

8-hour Design Values for 1986-1988



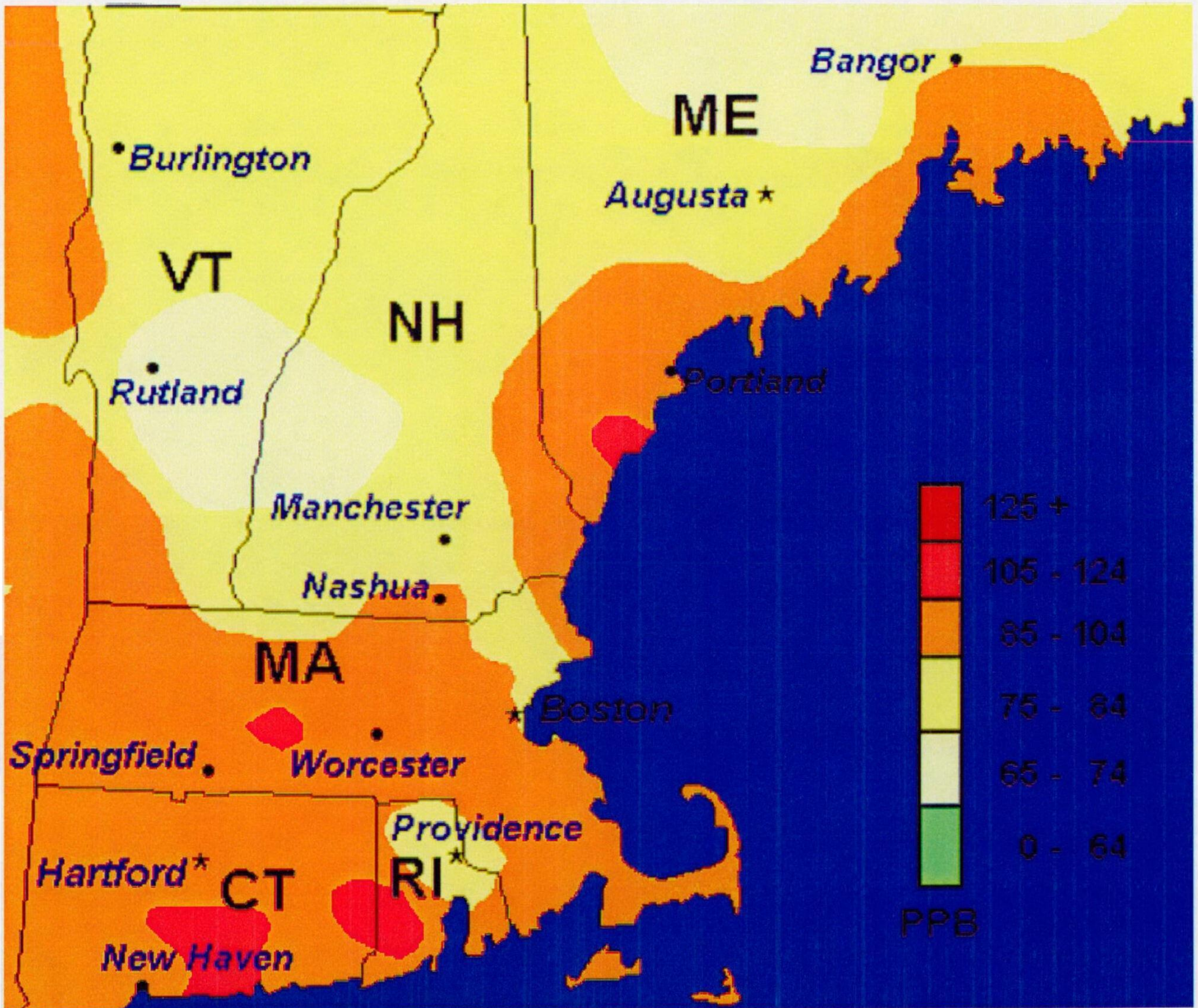

8-hour Design Values for 1987-1989



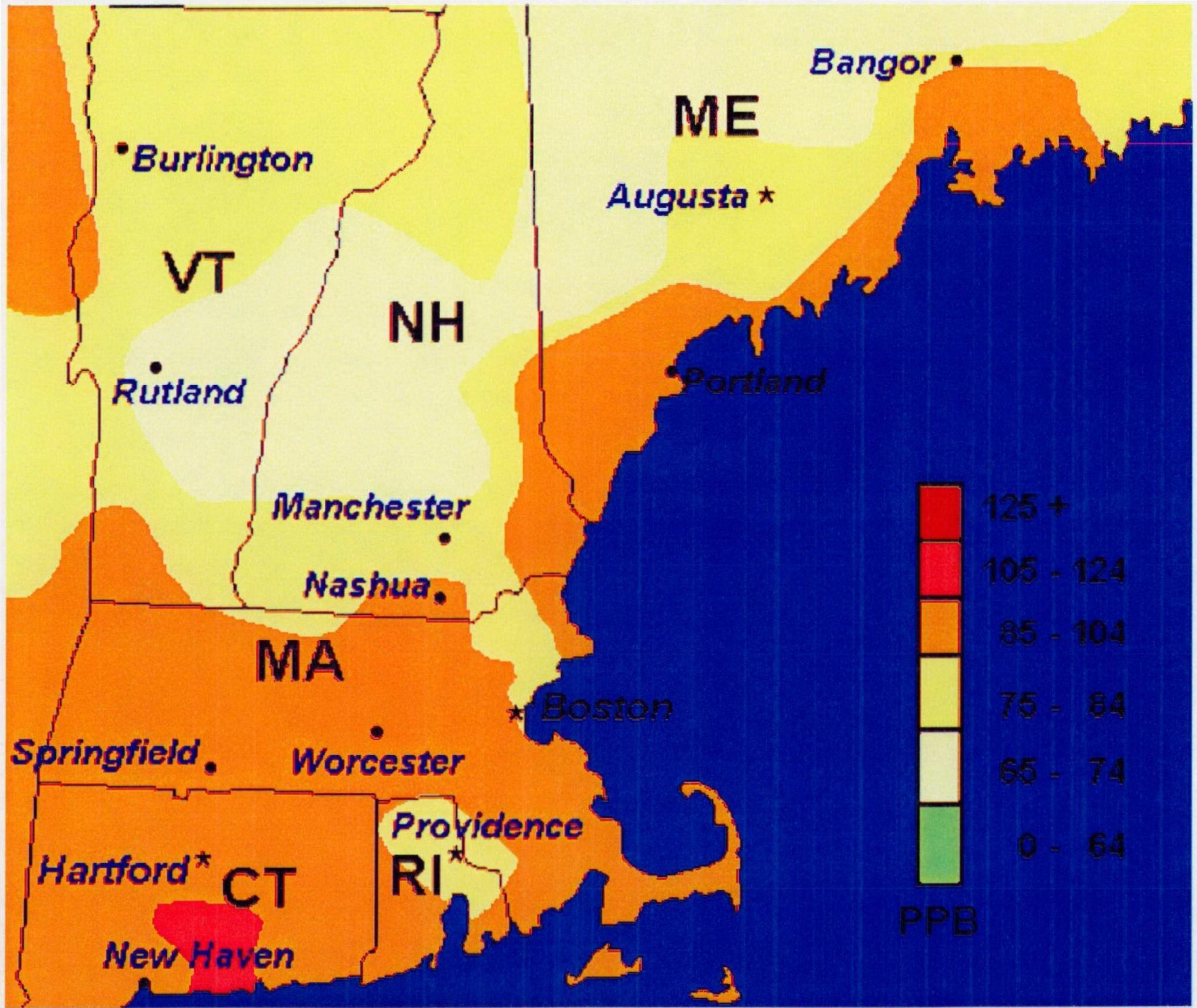

8-hour Design Values for 1988-1990



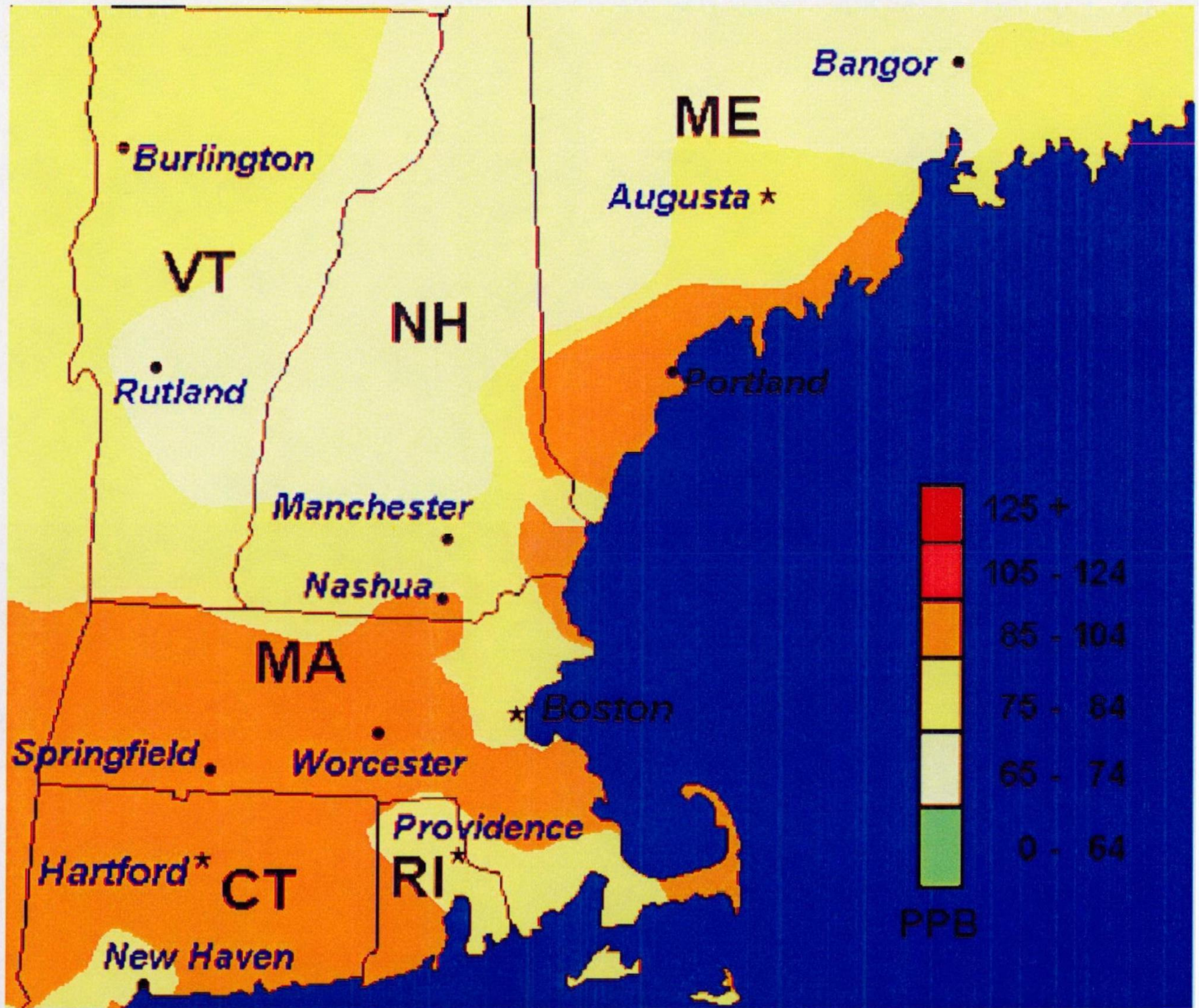

8-hour Design Values for 1989-1991



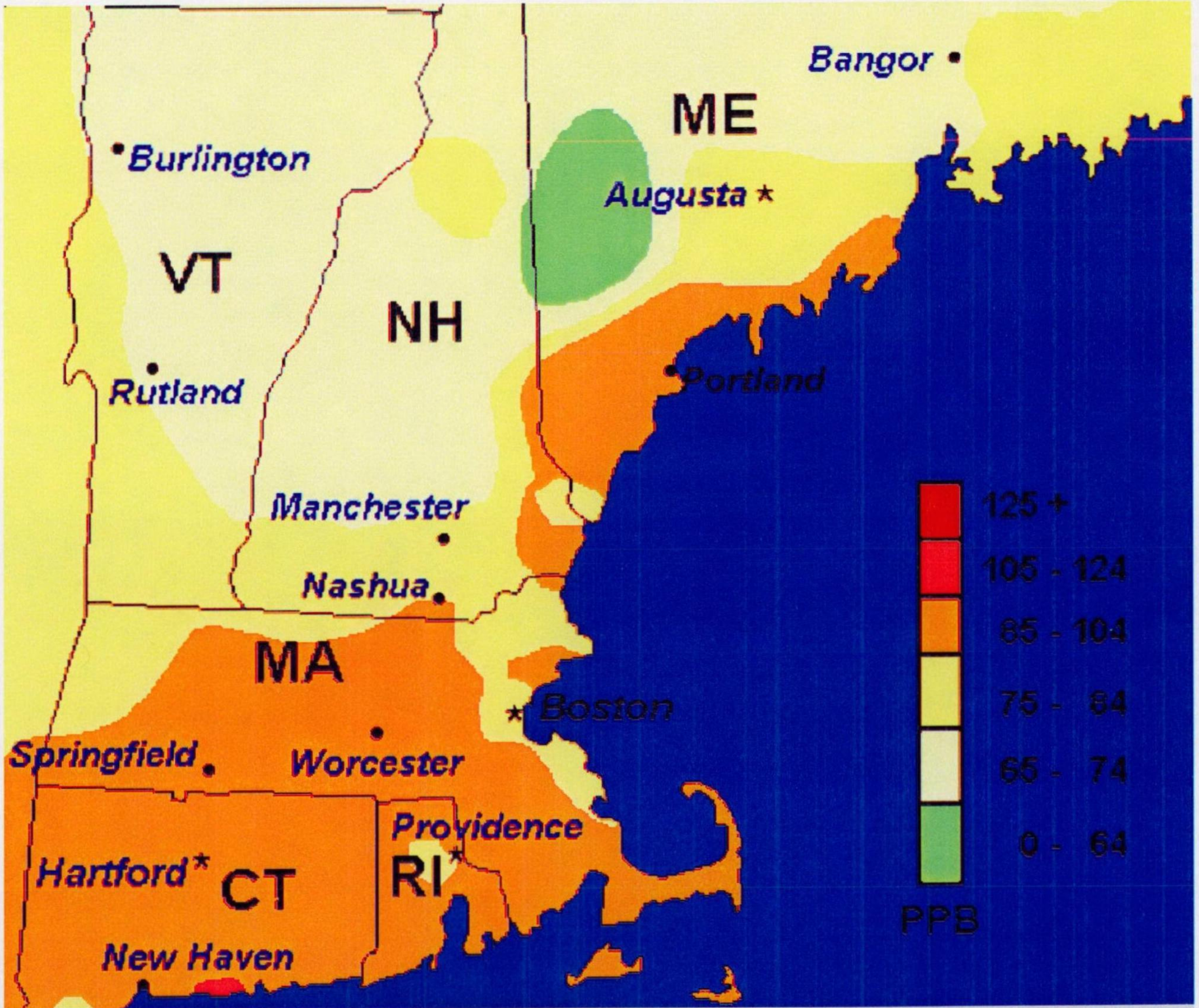

8-hour Design Values for 1990-1992



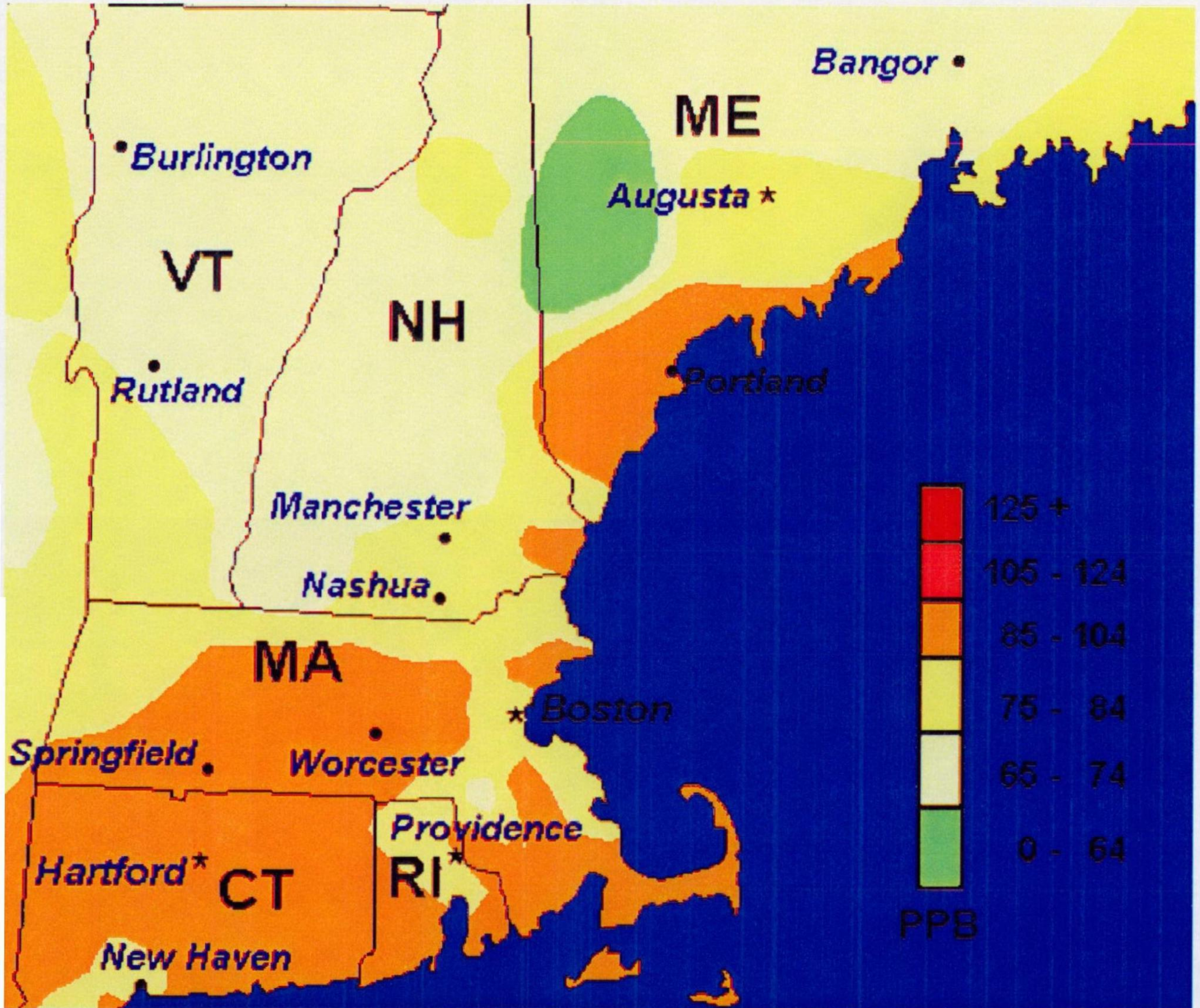

8-hour Design Values for 1991-1993



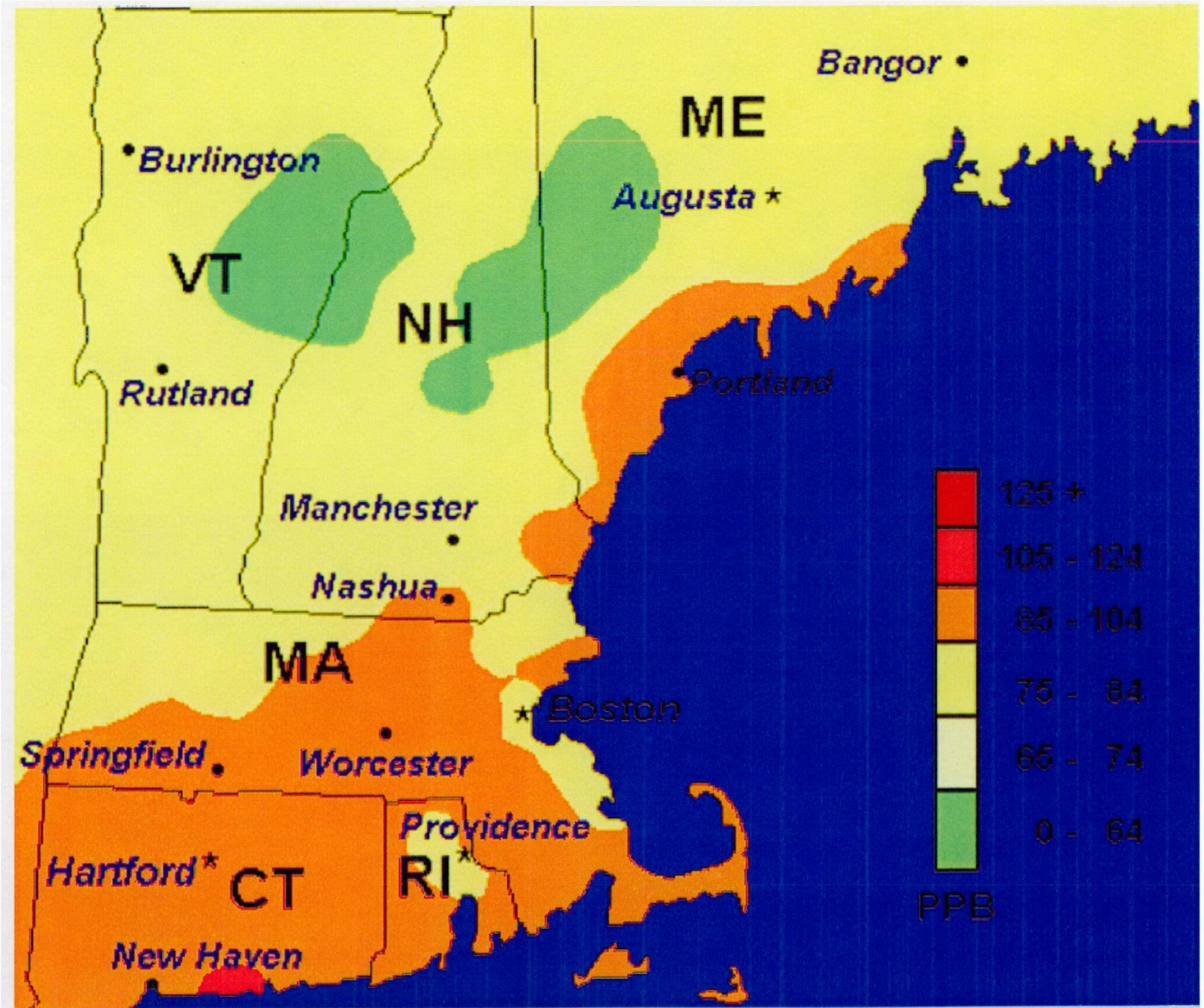

8-hour Design Values for 1992-1994



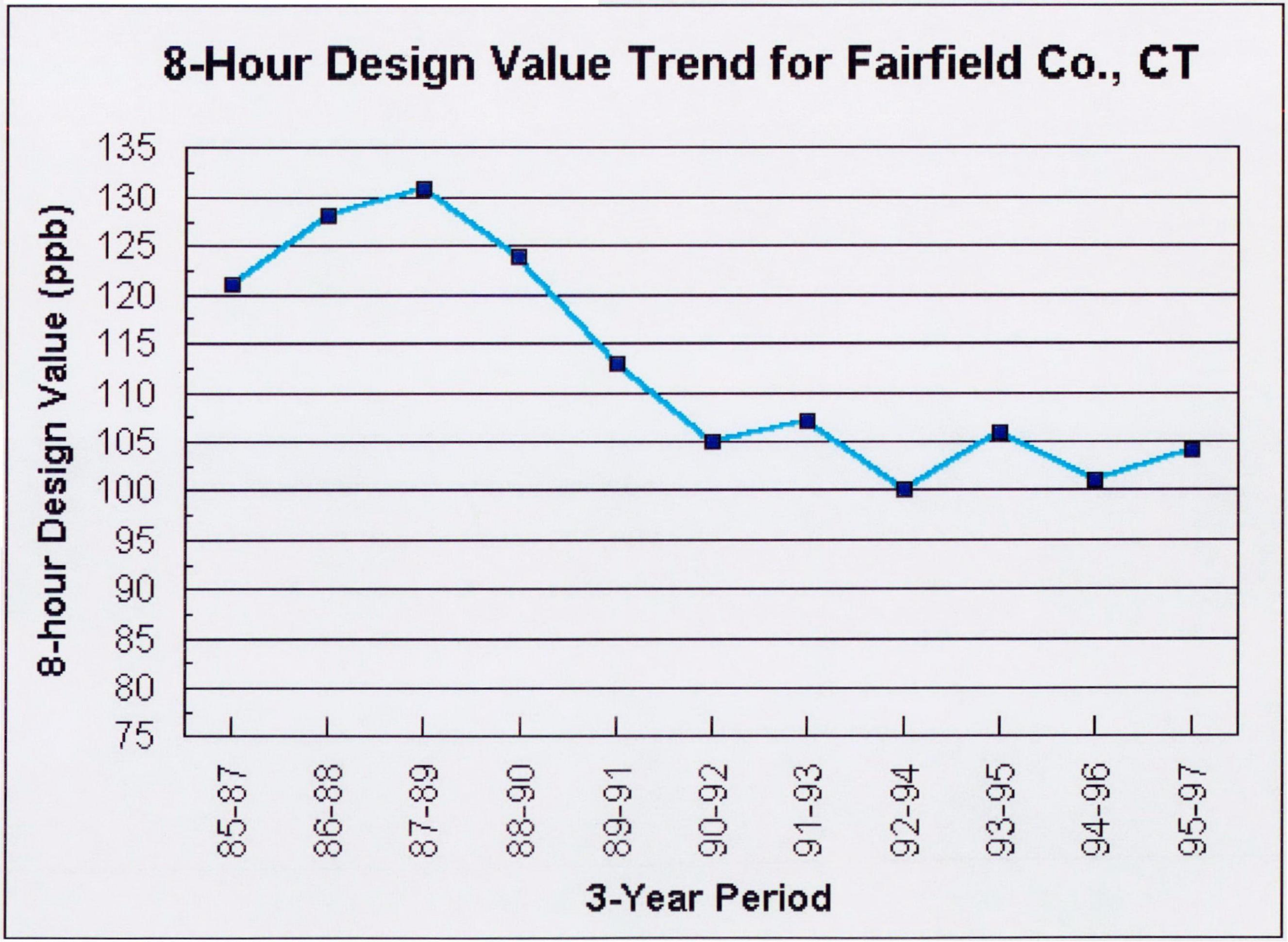

8-hour Design Values for 1993-1995

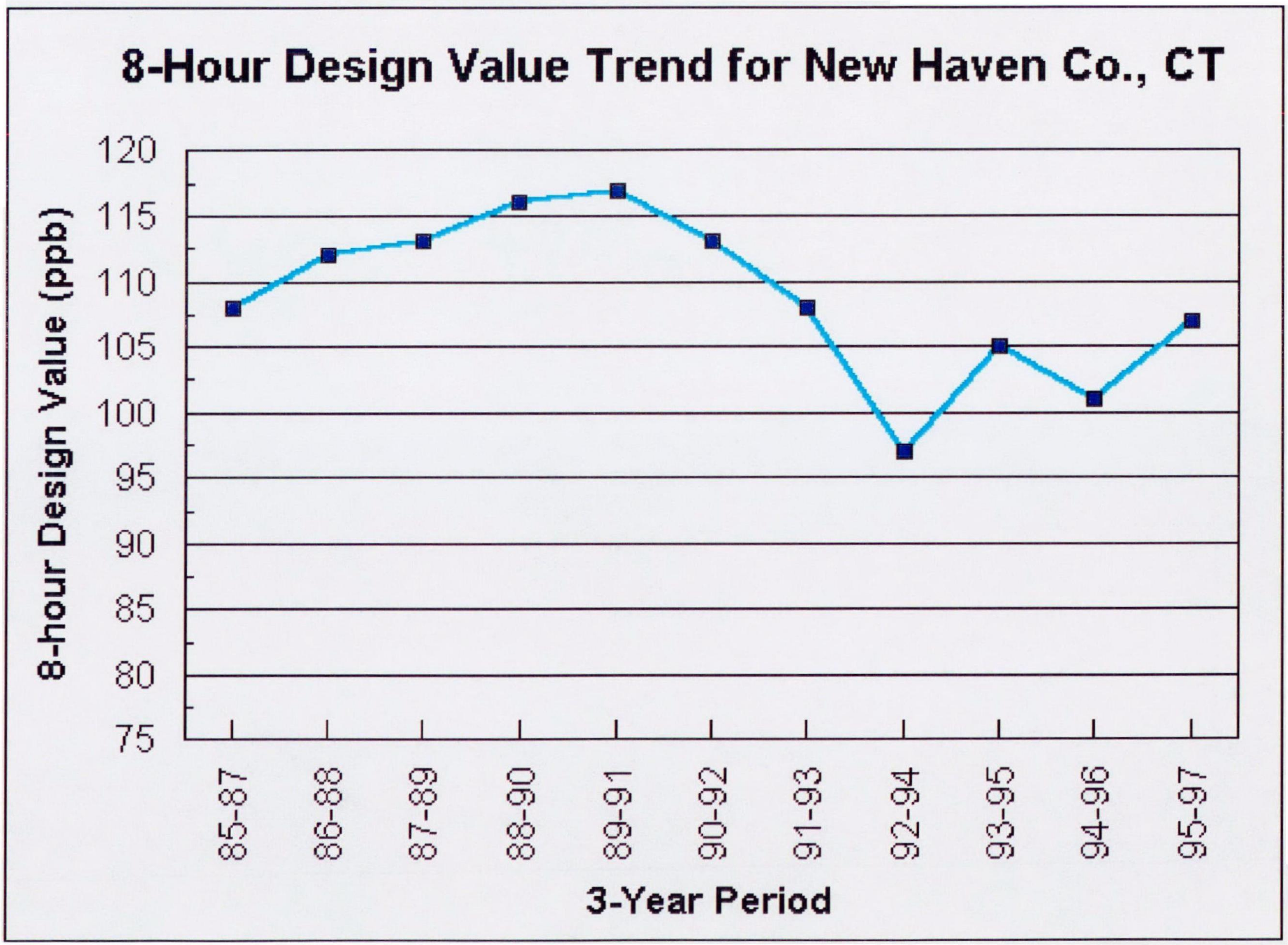


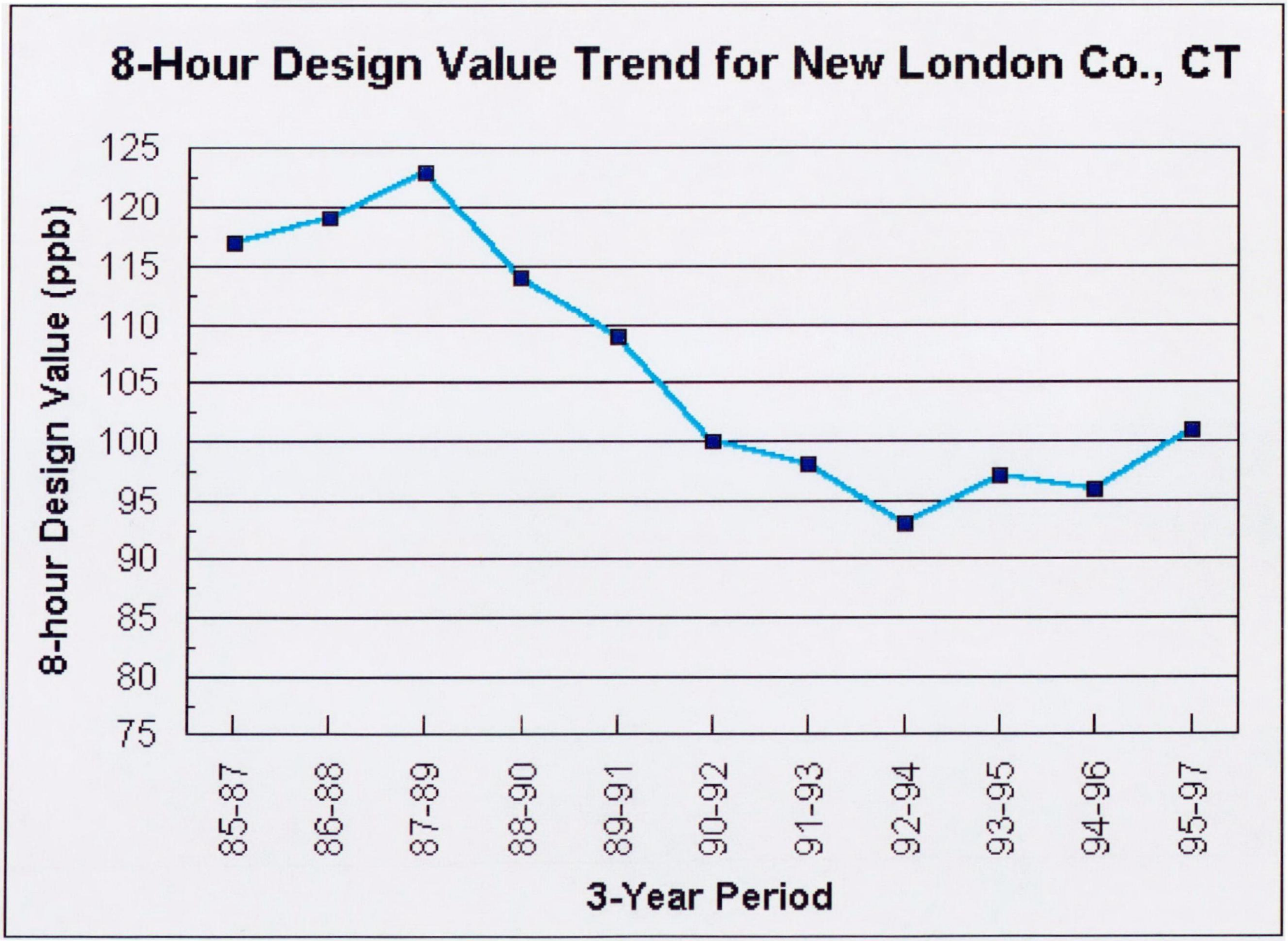

8-hour Design Values for 1994-1996

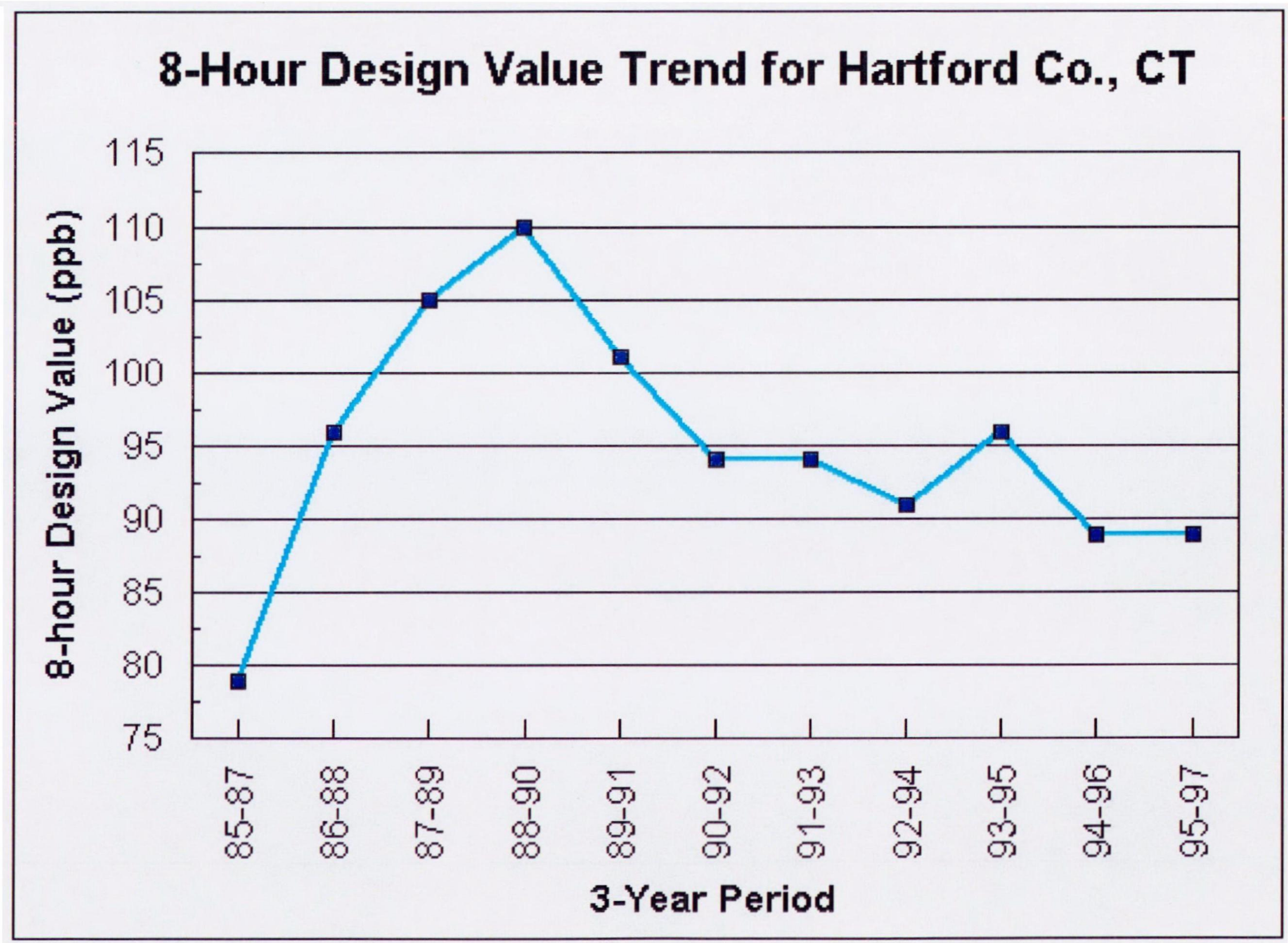


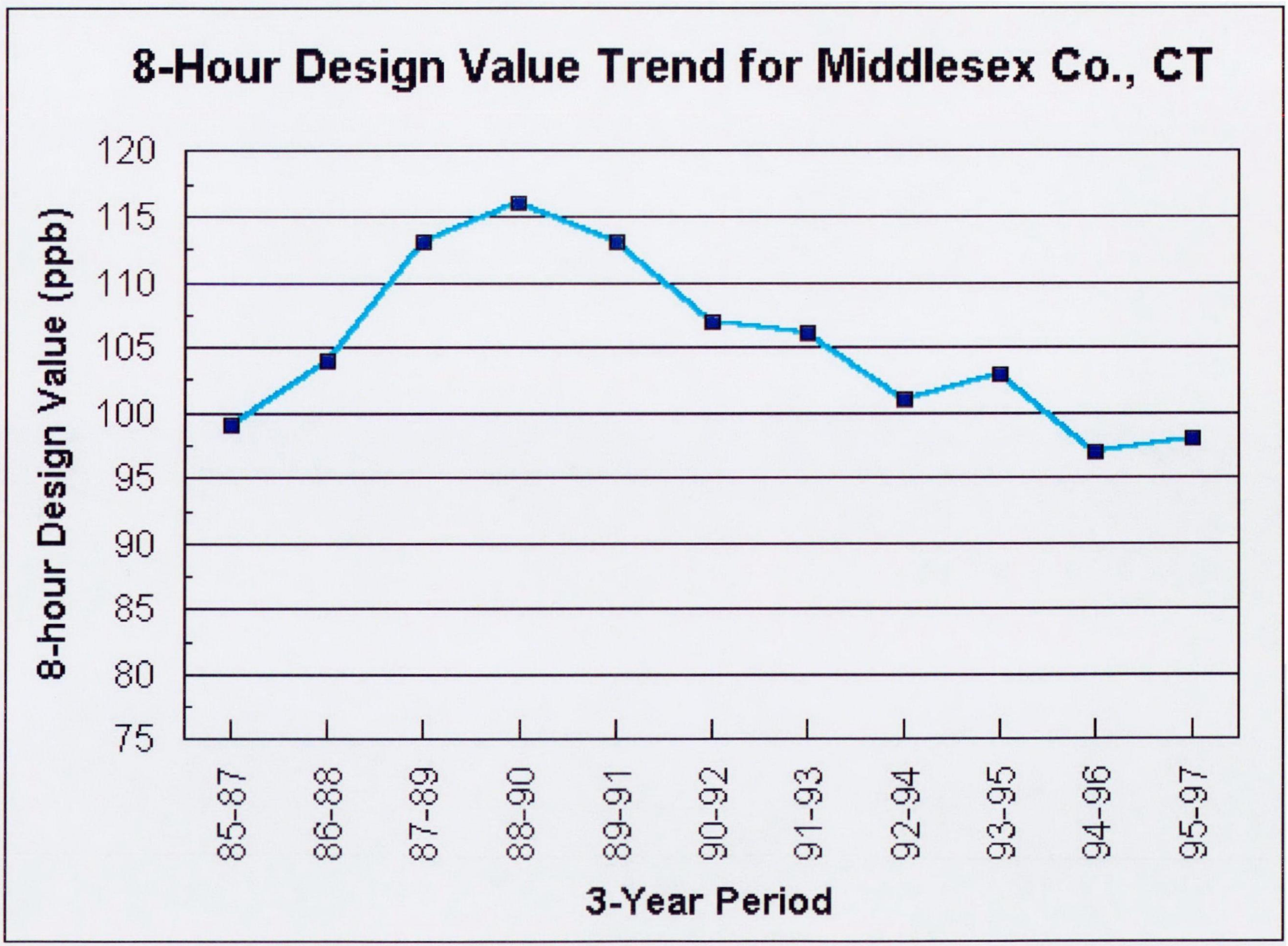

8-hour design values for 1995-1997

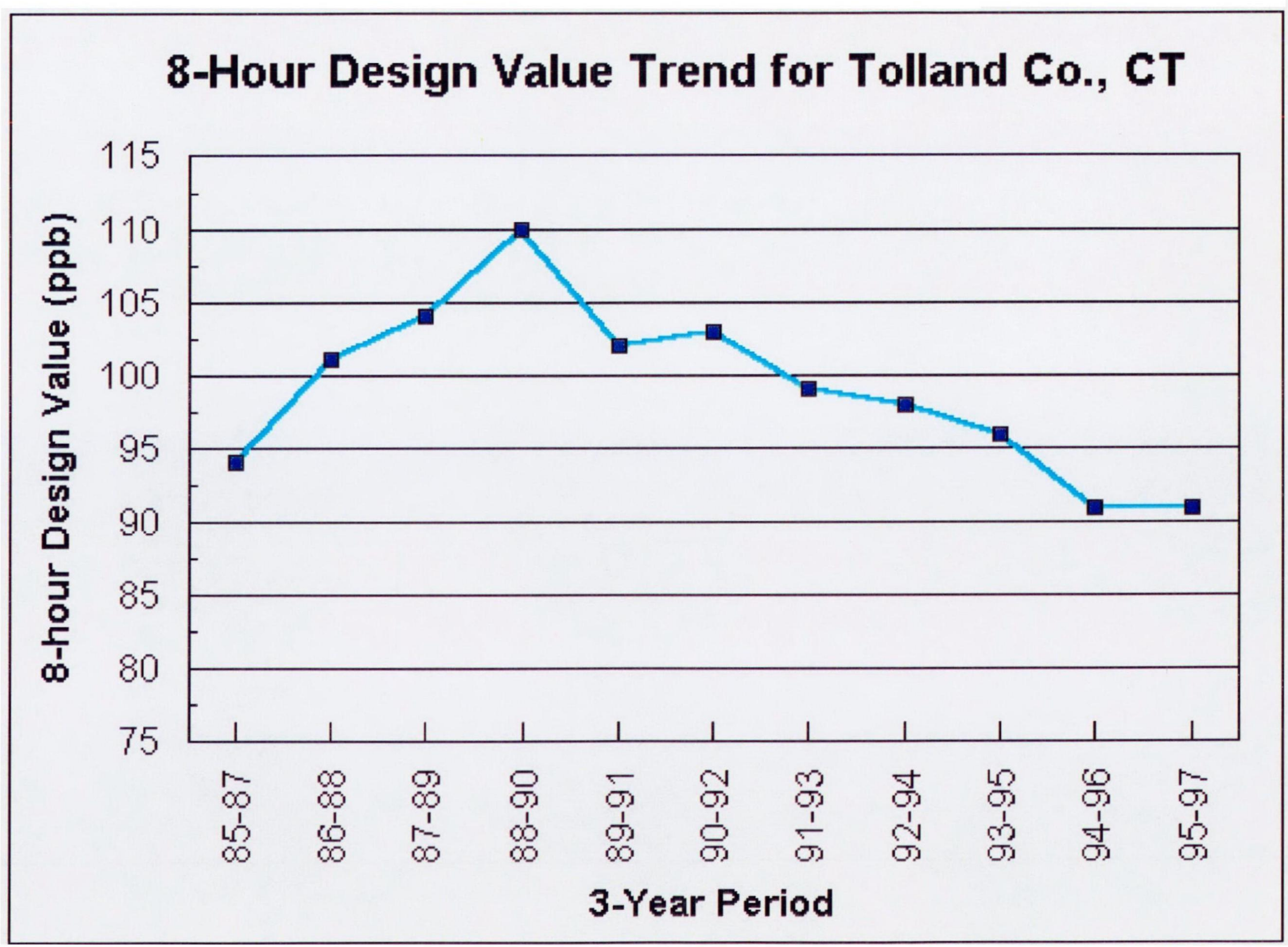

8-Hour Design Value Trend for Fairfield Co., CT
8-hour Design Value (ppb)
135
130
125
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period


8-Hour Design Value Trend for New Haven Co., CT
8-hour Design Value (ppb)
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

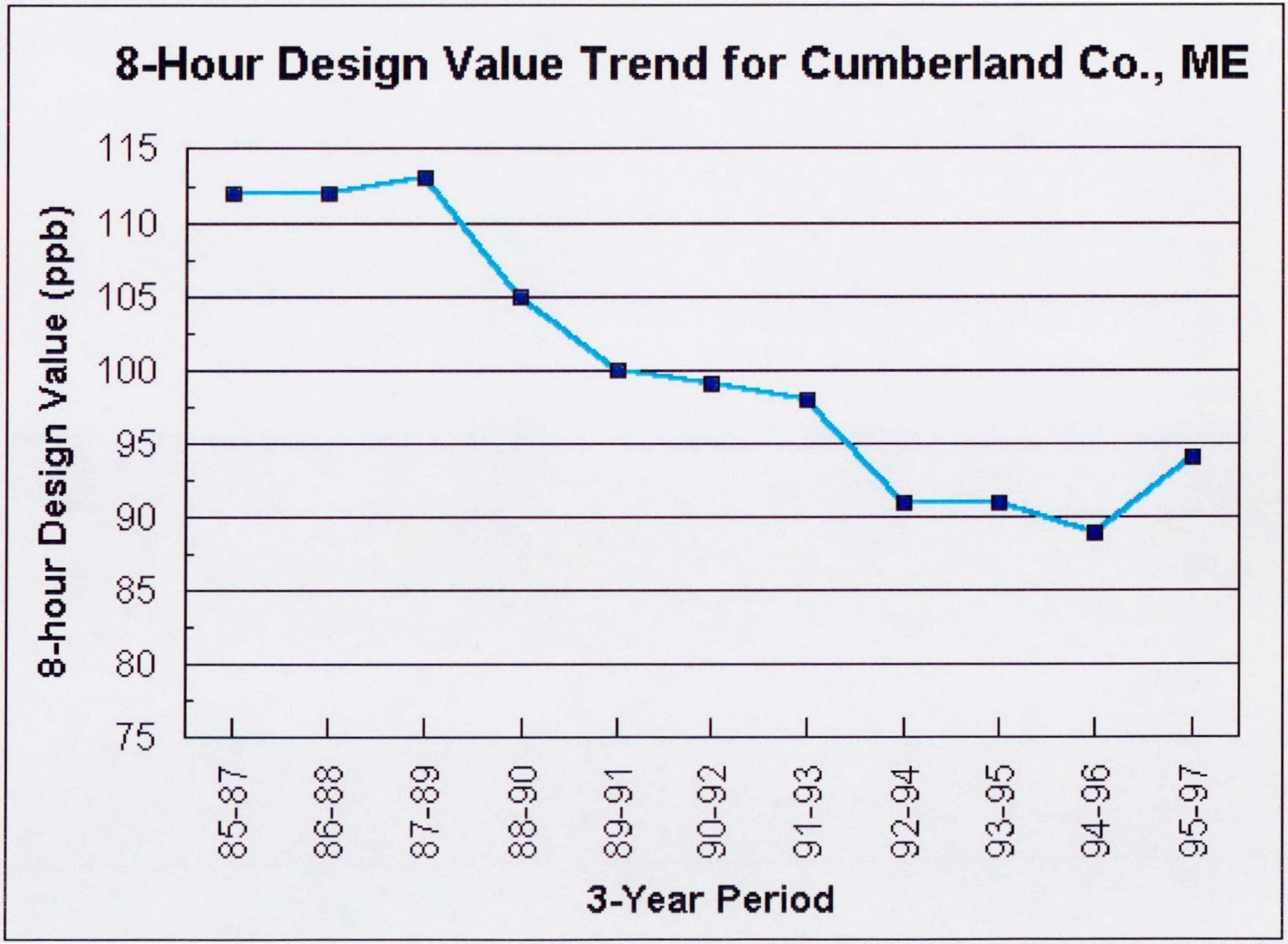

8-Hour Design Value Trend for New London Co., CT
8-hour Design Value (ppb)
125
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

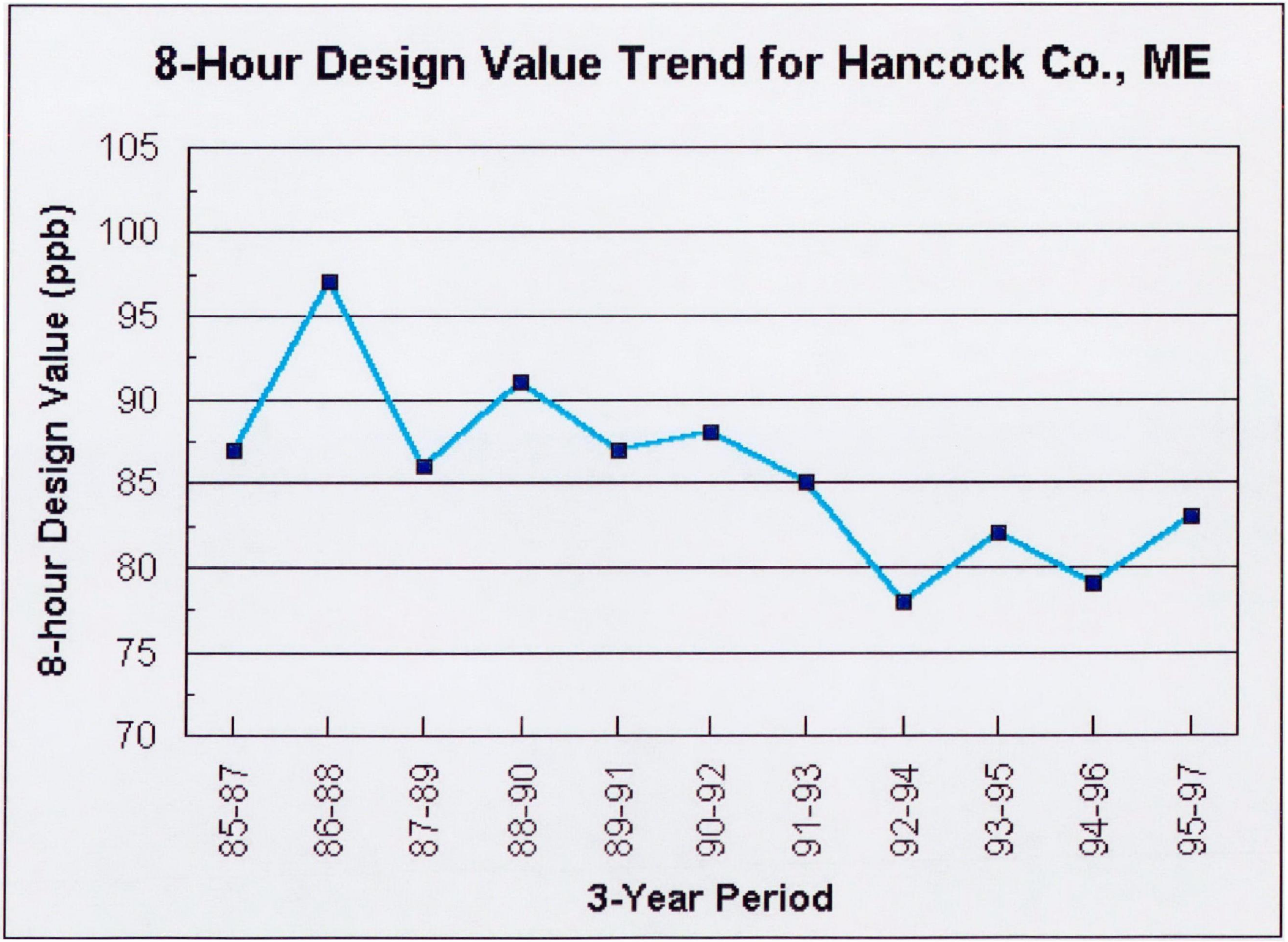

8-Hour Design Value Trend for Hartford Co., CT
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

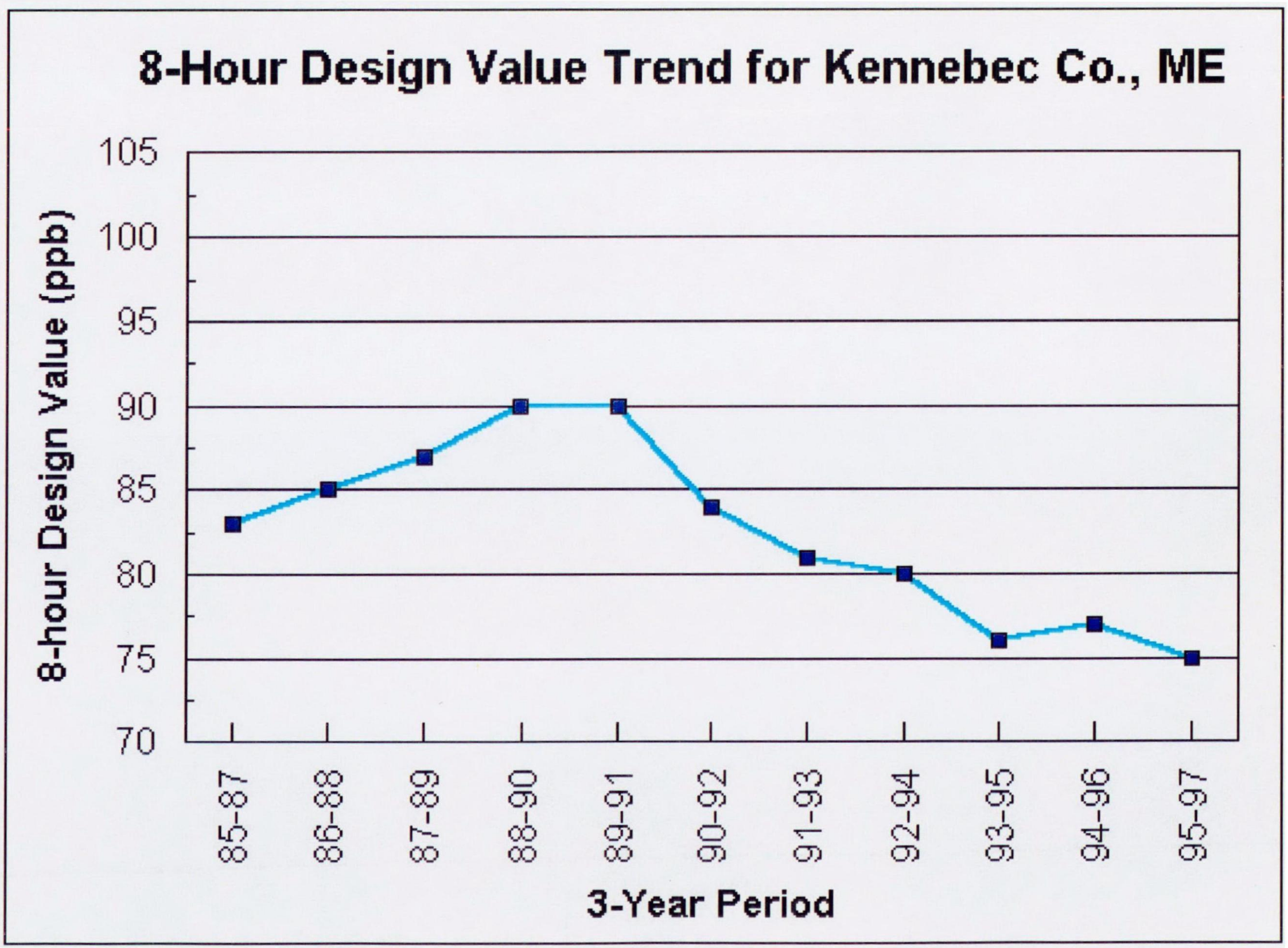

8-Hour Design Value Trend for Middlesex Co., CT
8-hour Design Value (ppb)
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

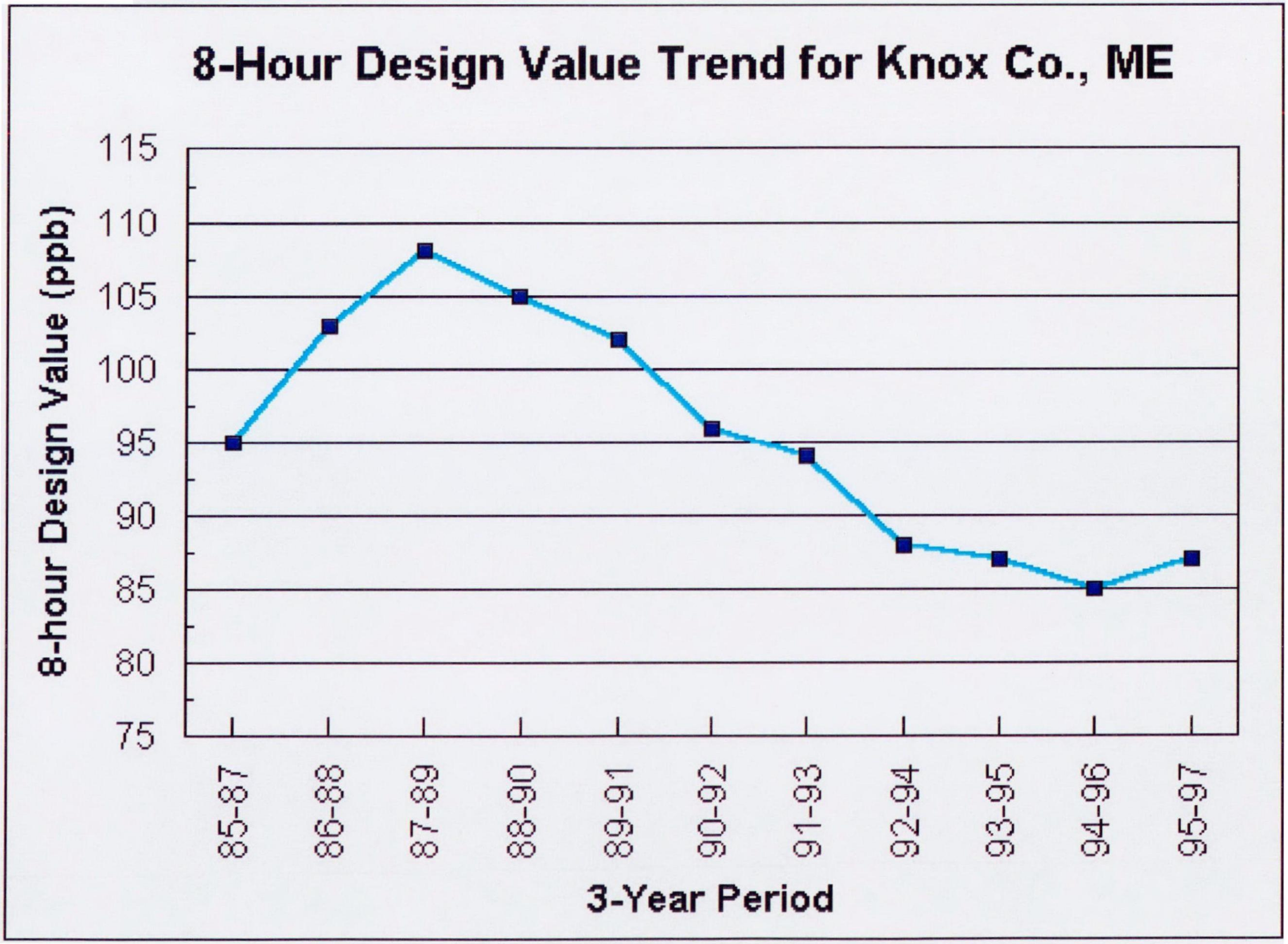


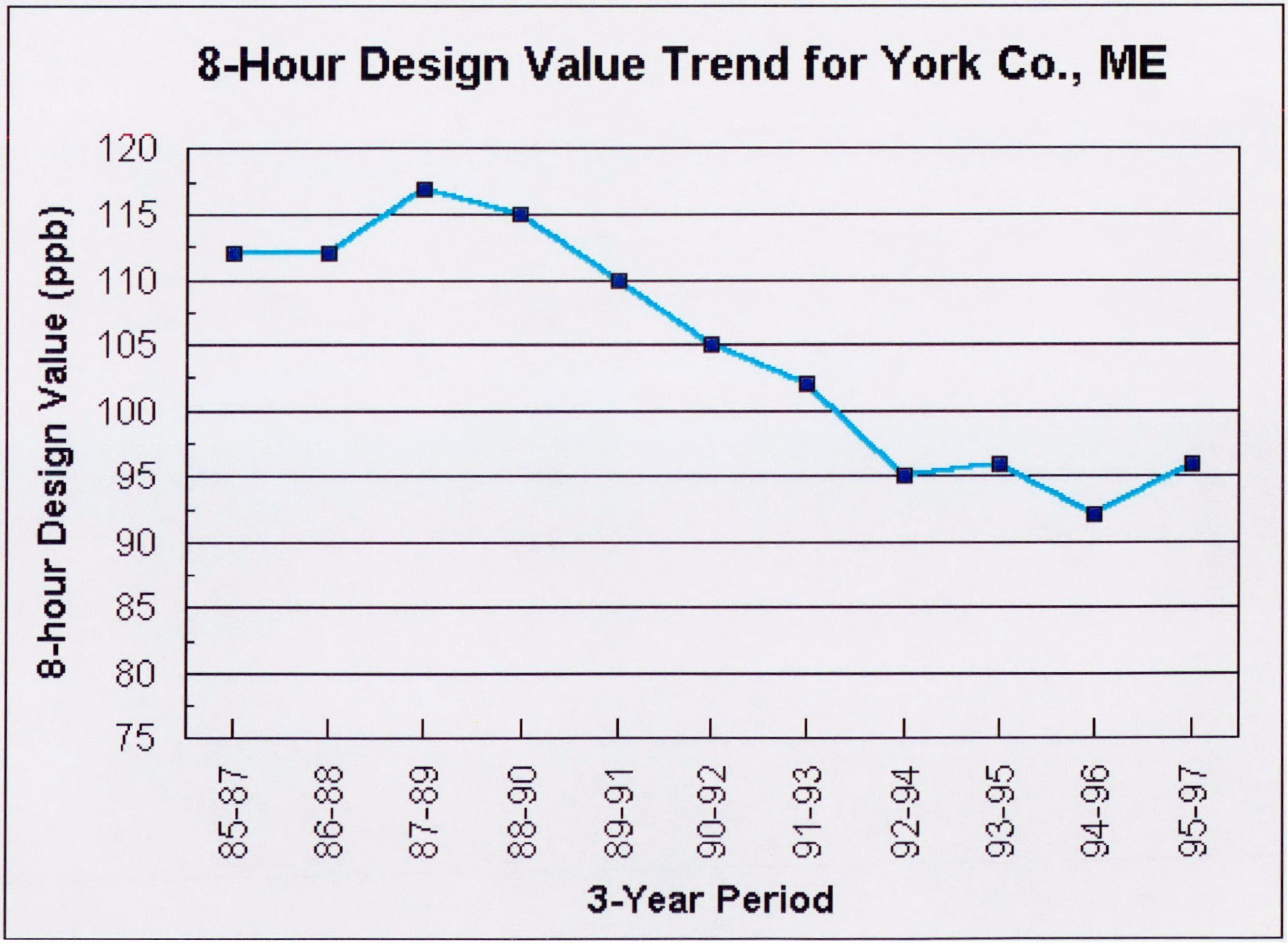
8-Hour Design Value Trend for Tolland Co., CT
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

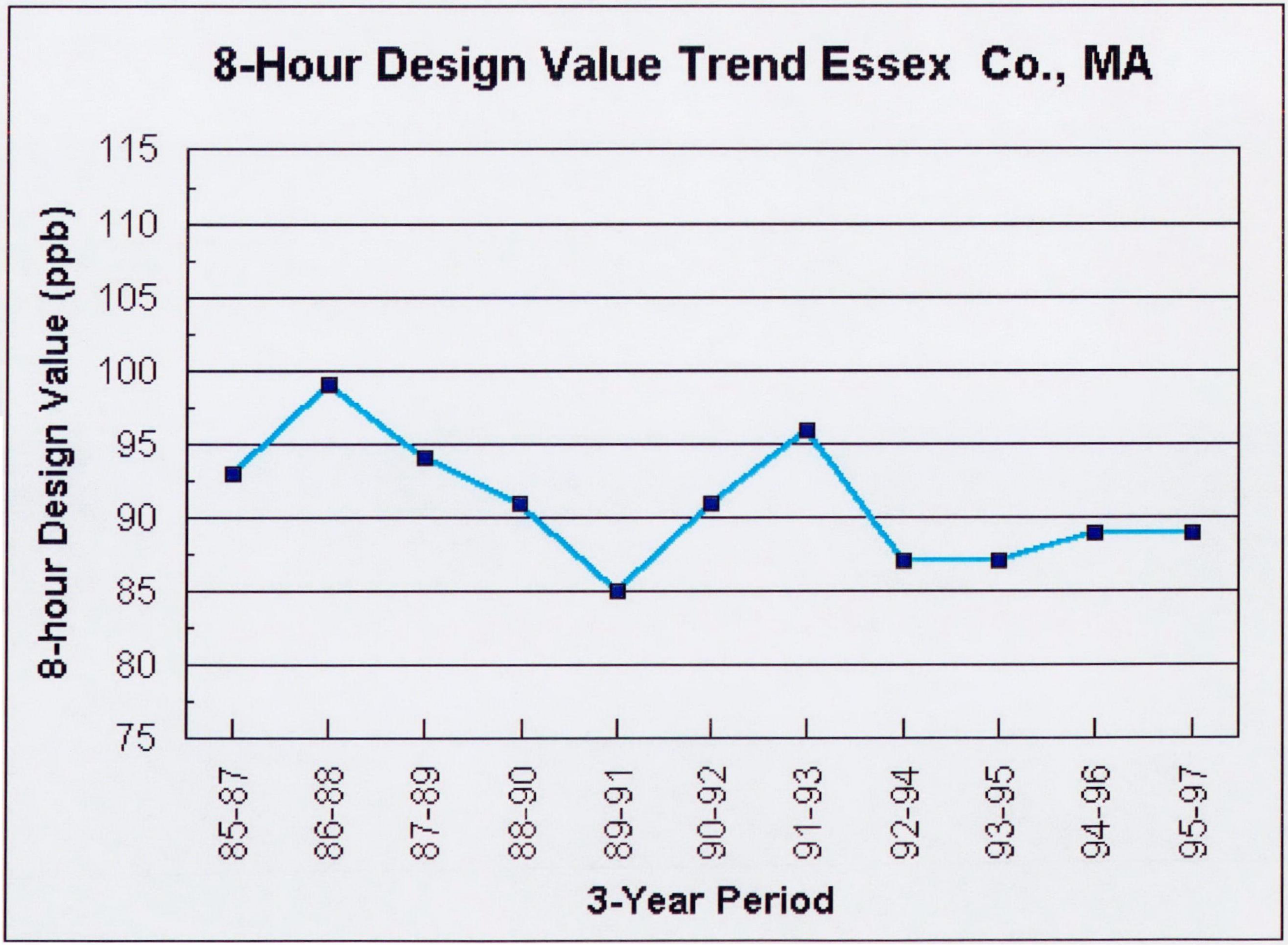

8-Hour Design Value Trend for Cumberland Co., ME
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

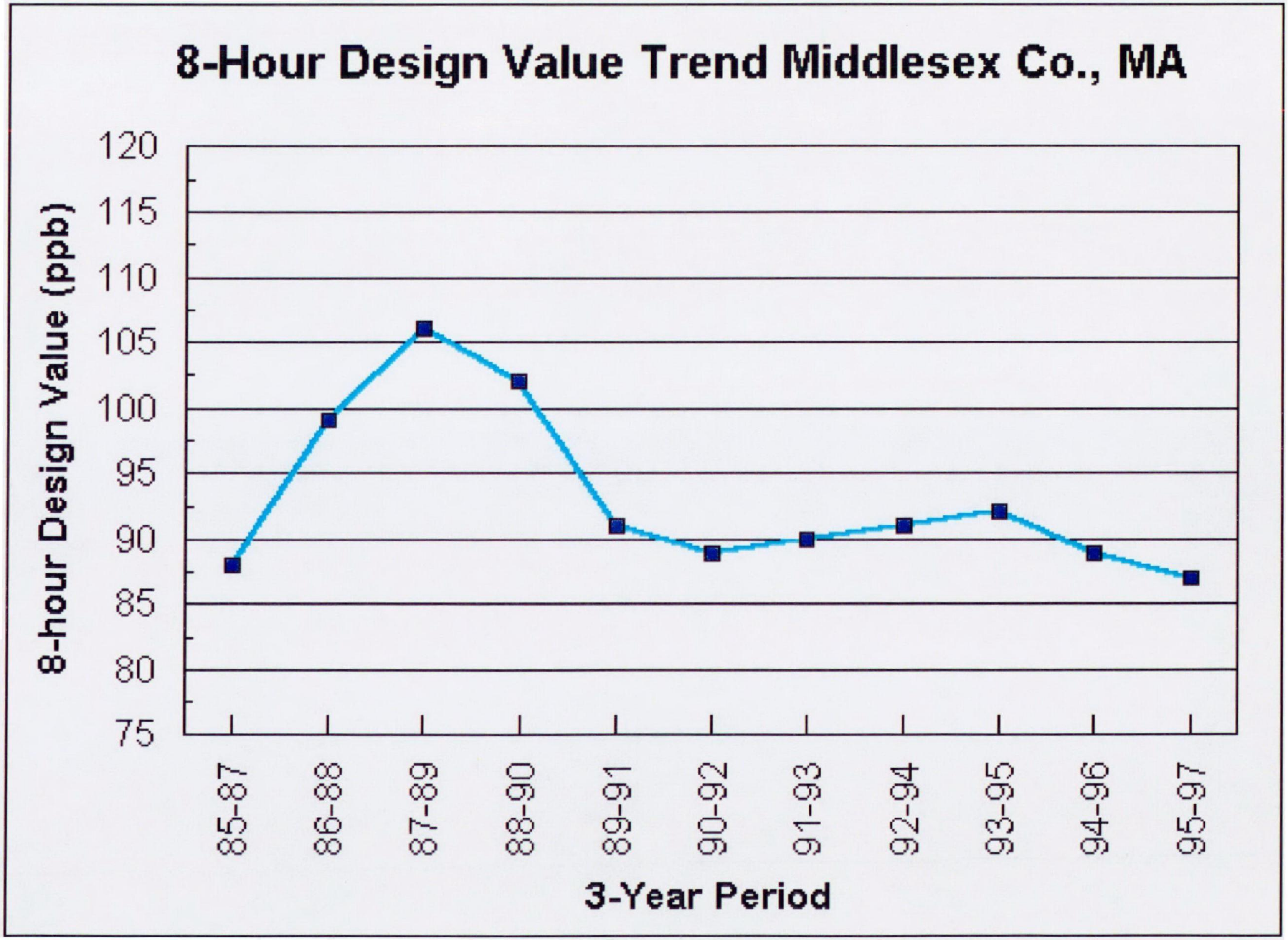

8-Hour Design Value Trend for Hancock Co., ME
8-hour Design Value (ppb)
105
100
95
90
85
80
75
70
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

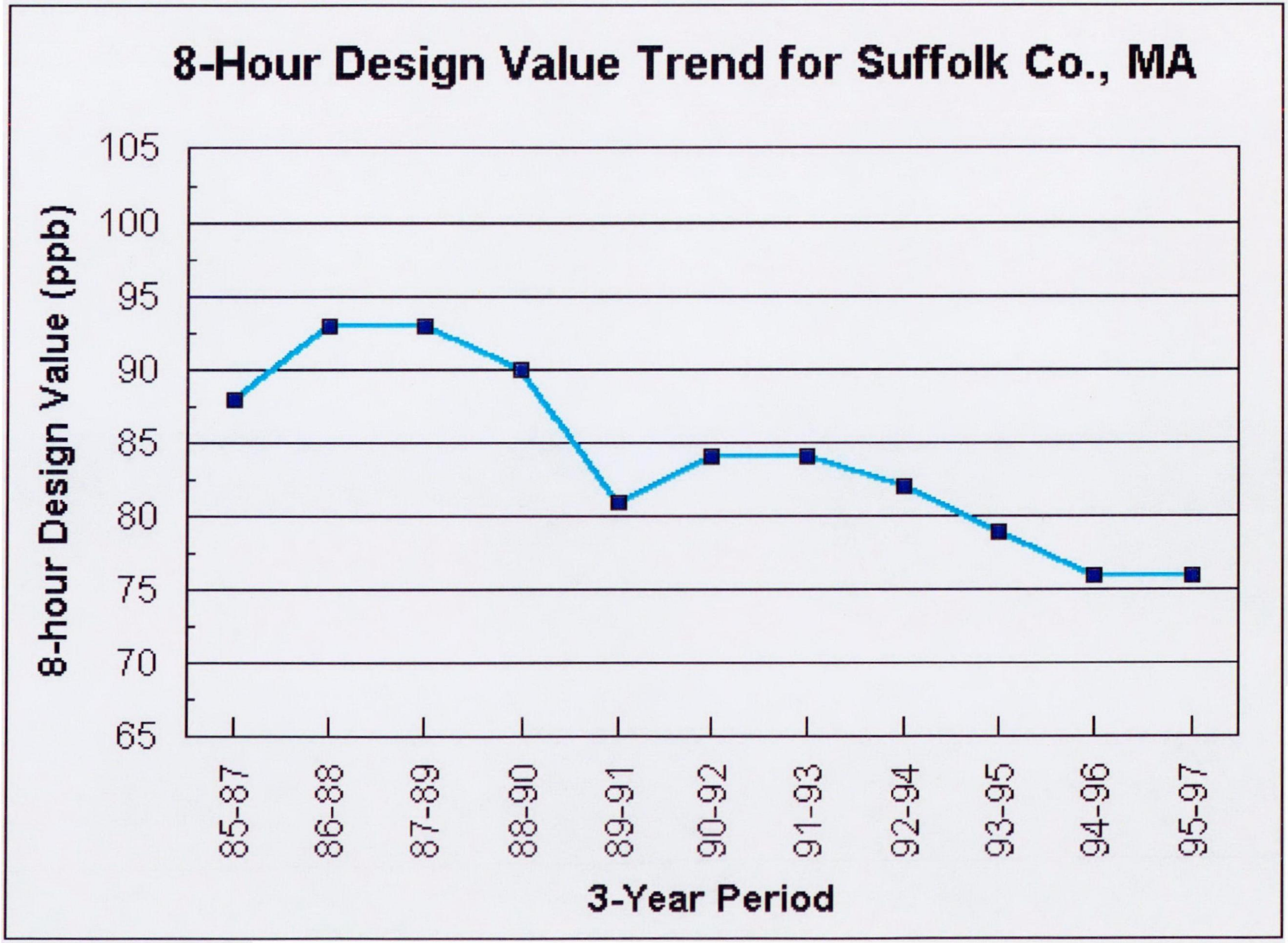

8-Hour Design Value Trend for Kennebec Co., ME
8-hour Design Value (ppb)
105
100
95
90
85
80
75
70
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

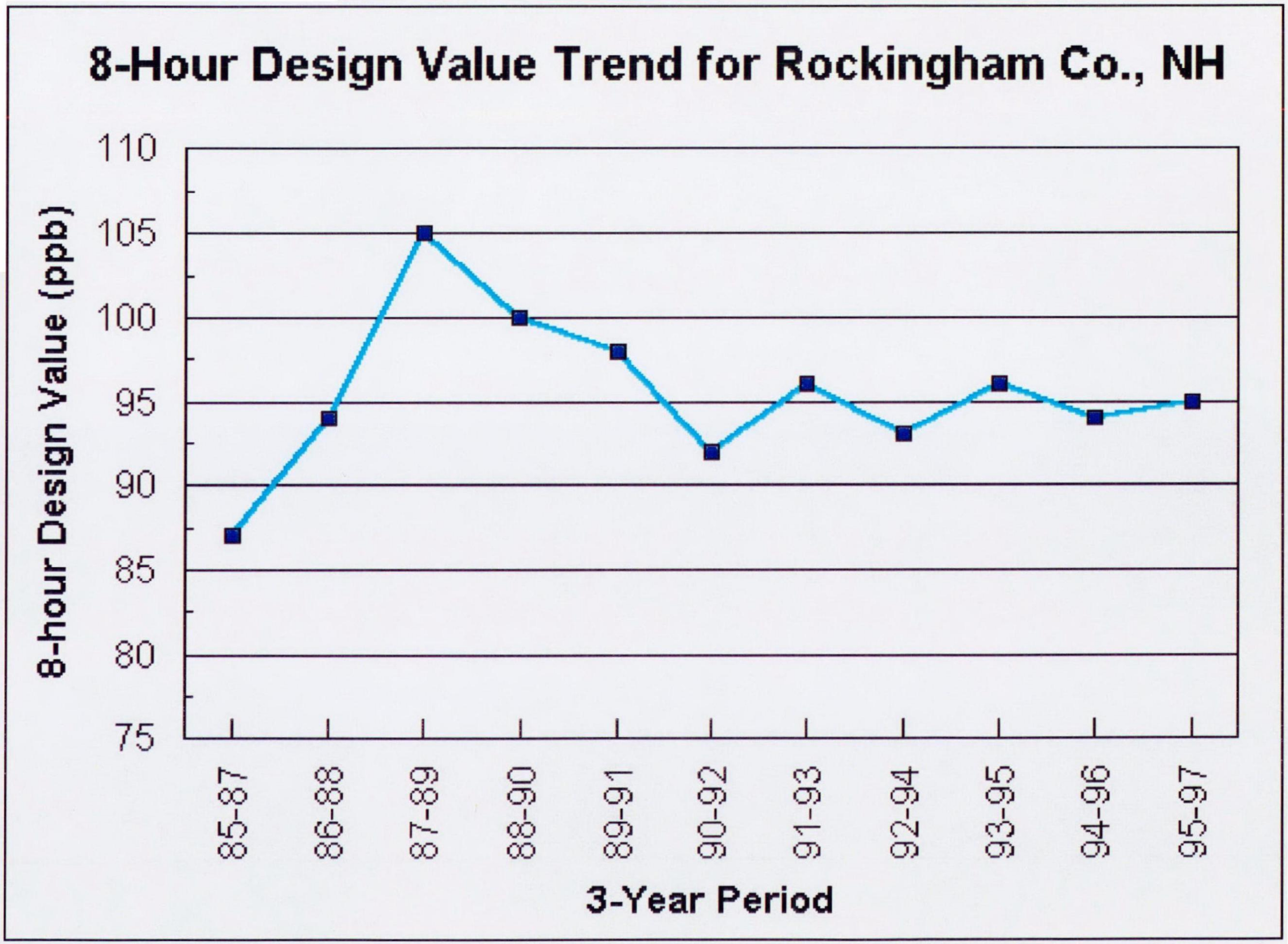

8-Hour Design Value Trend for Knox Co., ME
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

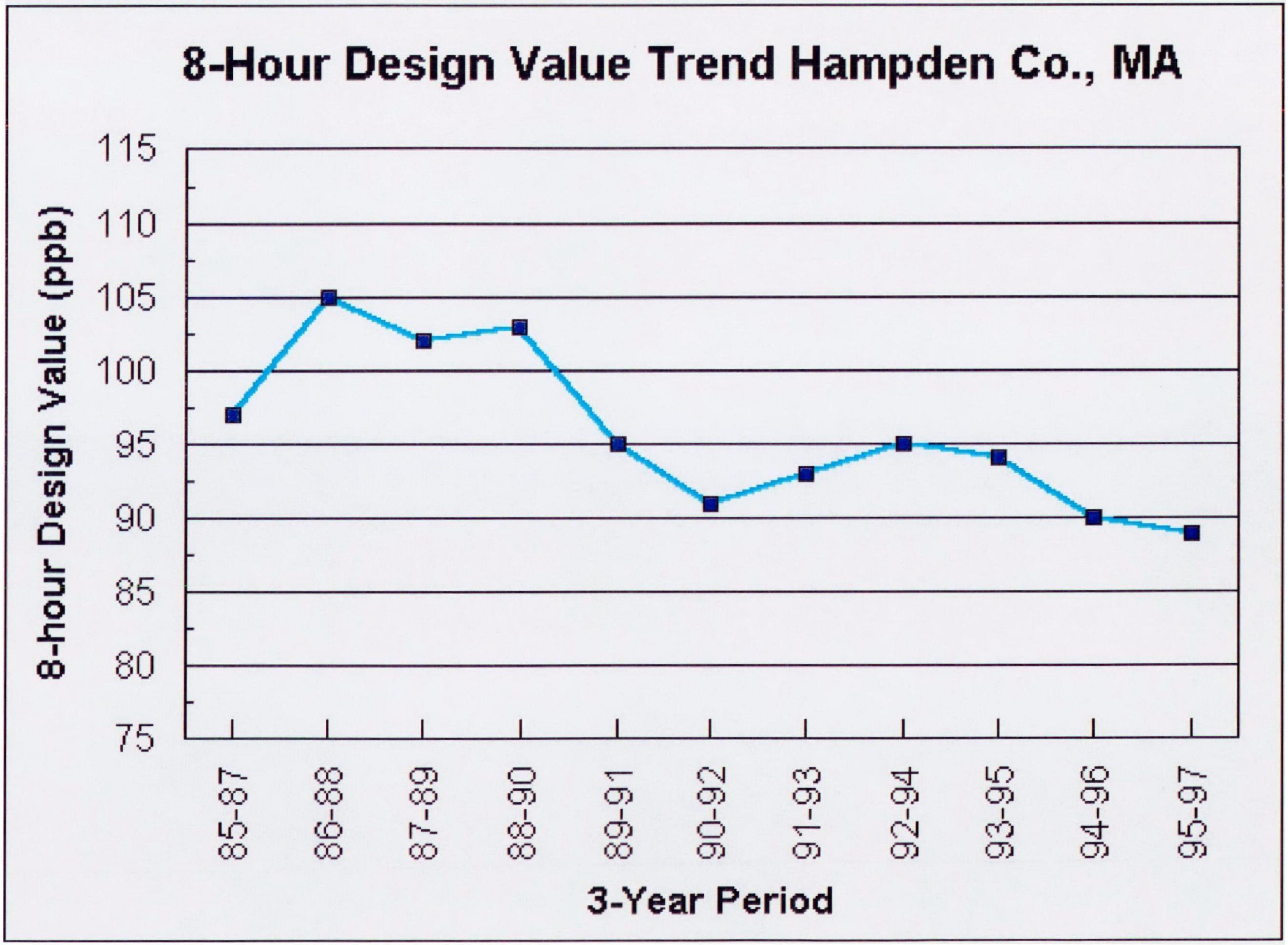

8-Hour Design Value Trend for York Co., ME
8-hour Design Value (ppb)
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

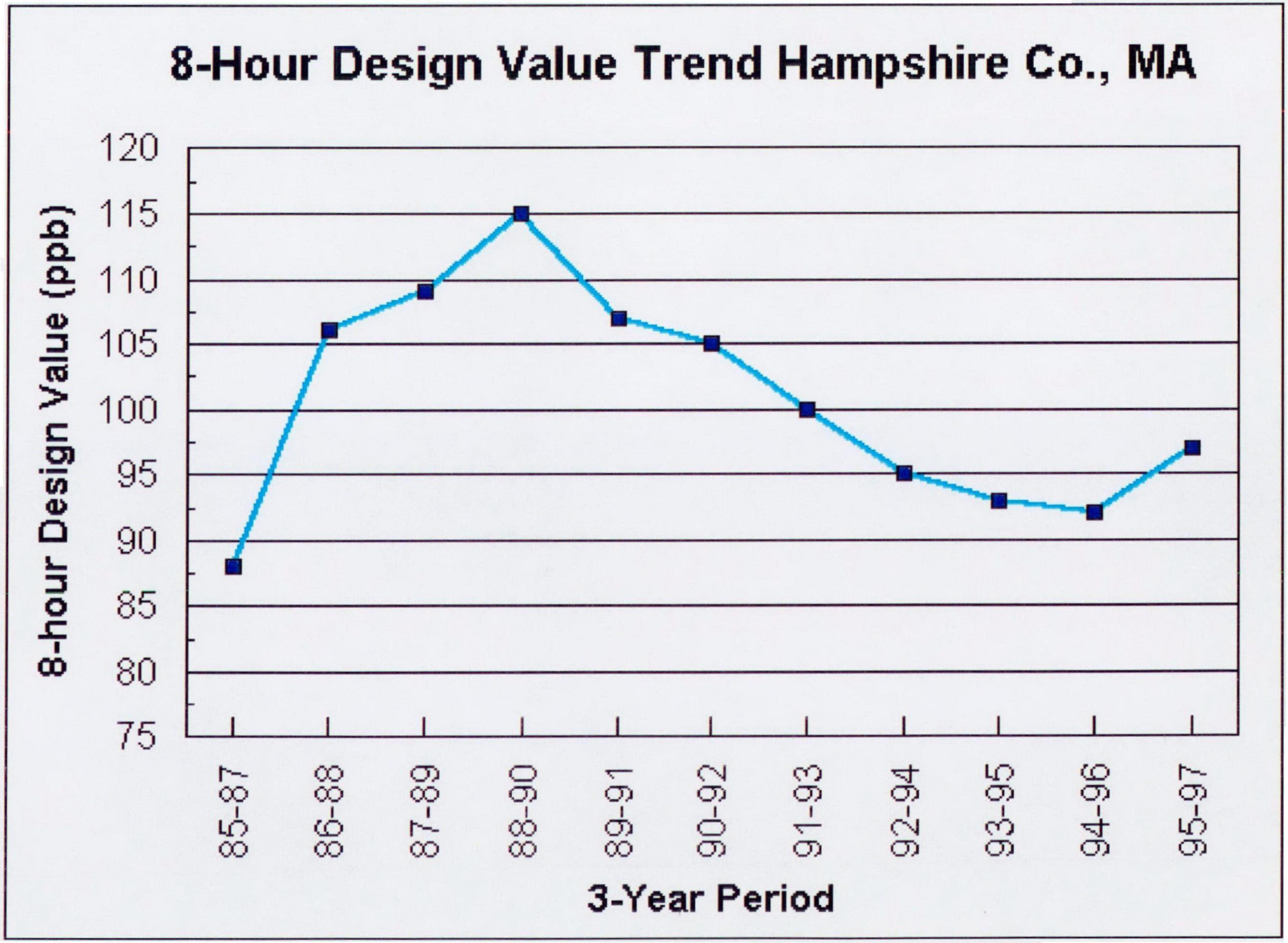

8-Hour Design Value Trend Essex Co., MA
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

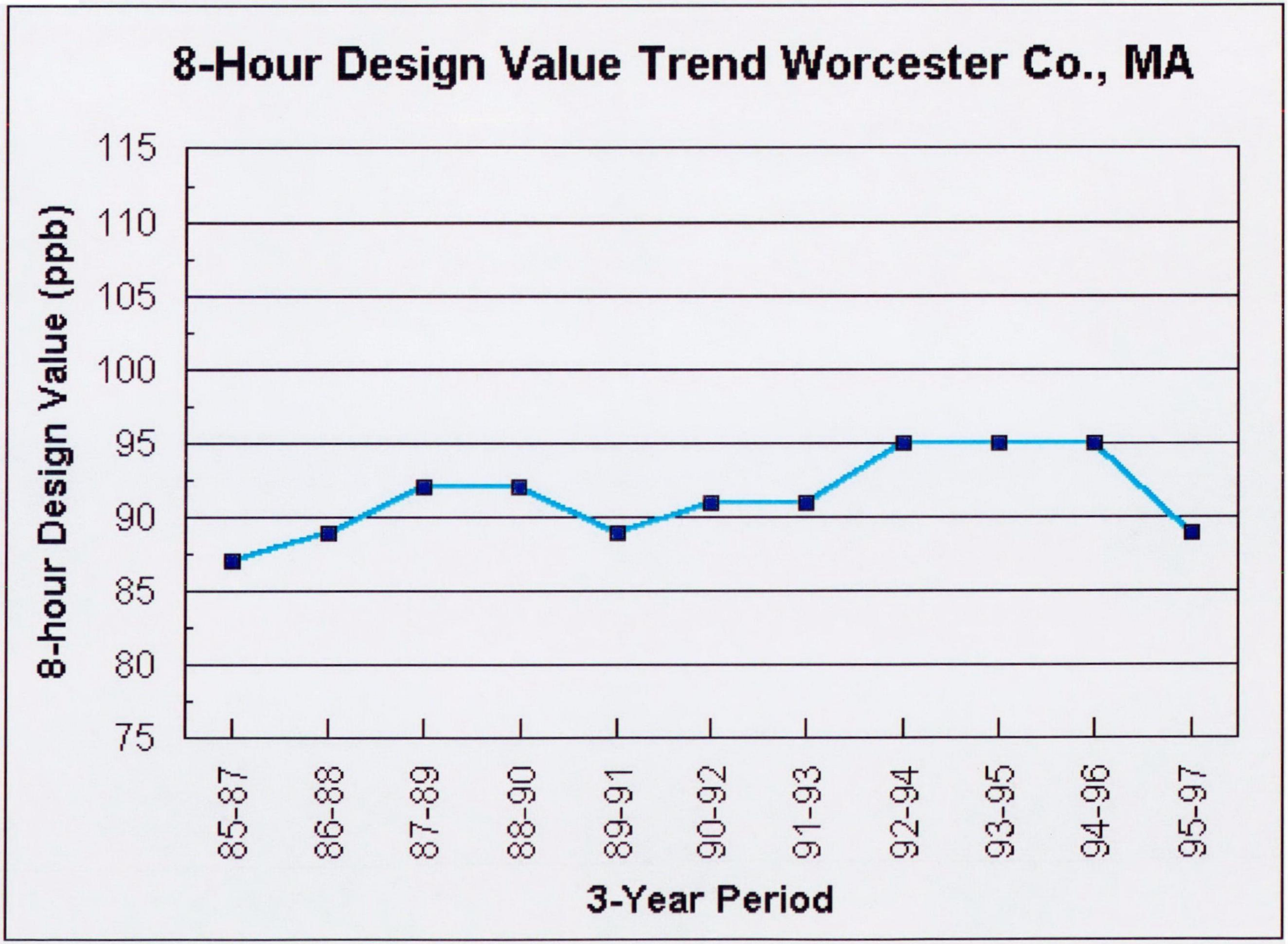

8-Hour Design Value Trend Middlesex Co., MA
8-hour Design Value (ppb)
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

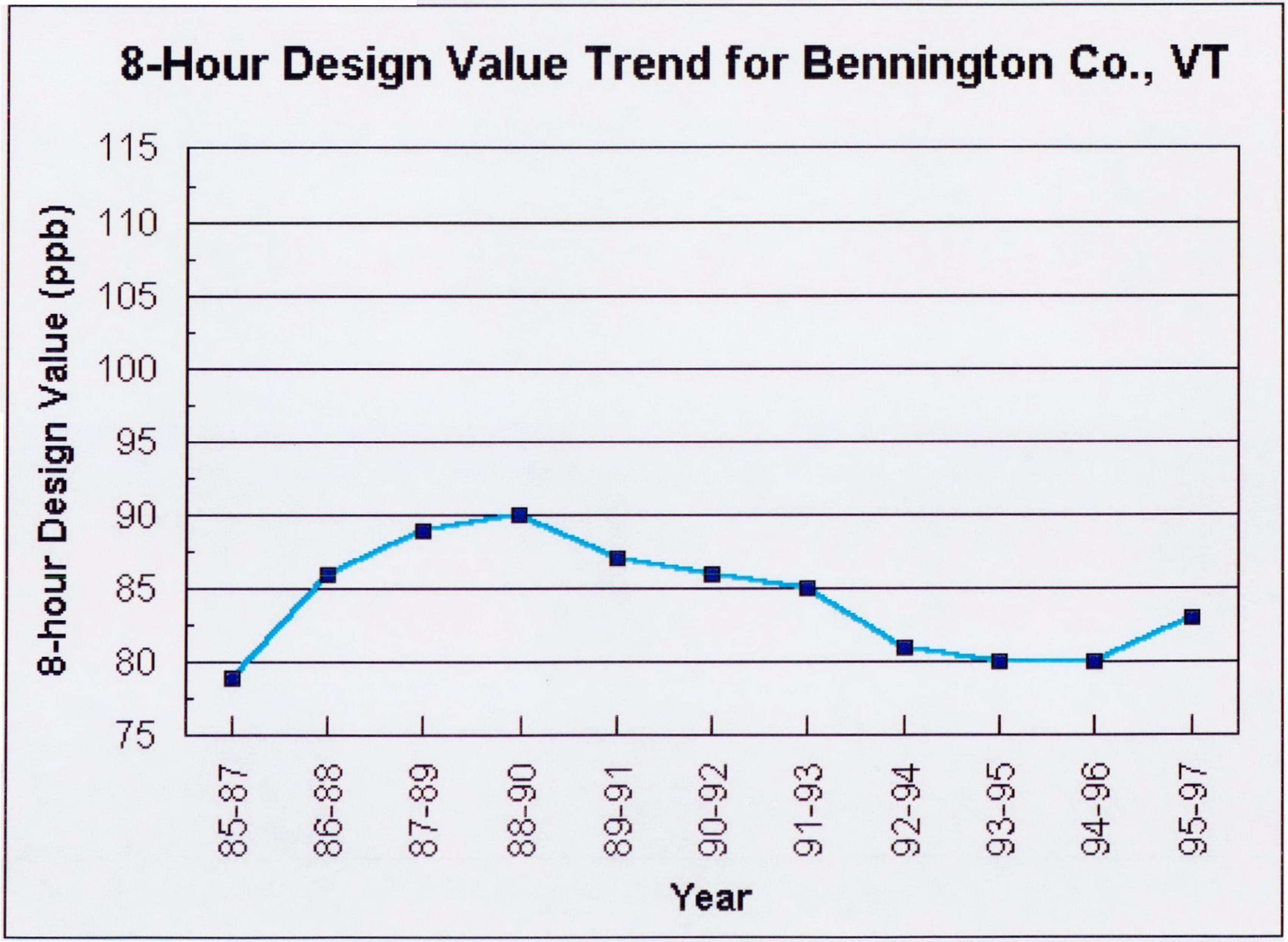

8-Hour Design Value Trend for Suffolk Co., MA
8-hour Design Value (ppb)
105
100
95
90
85
80
75
70
65
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

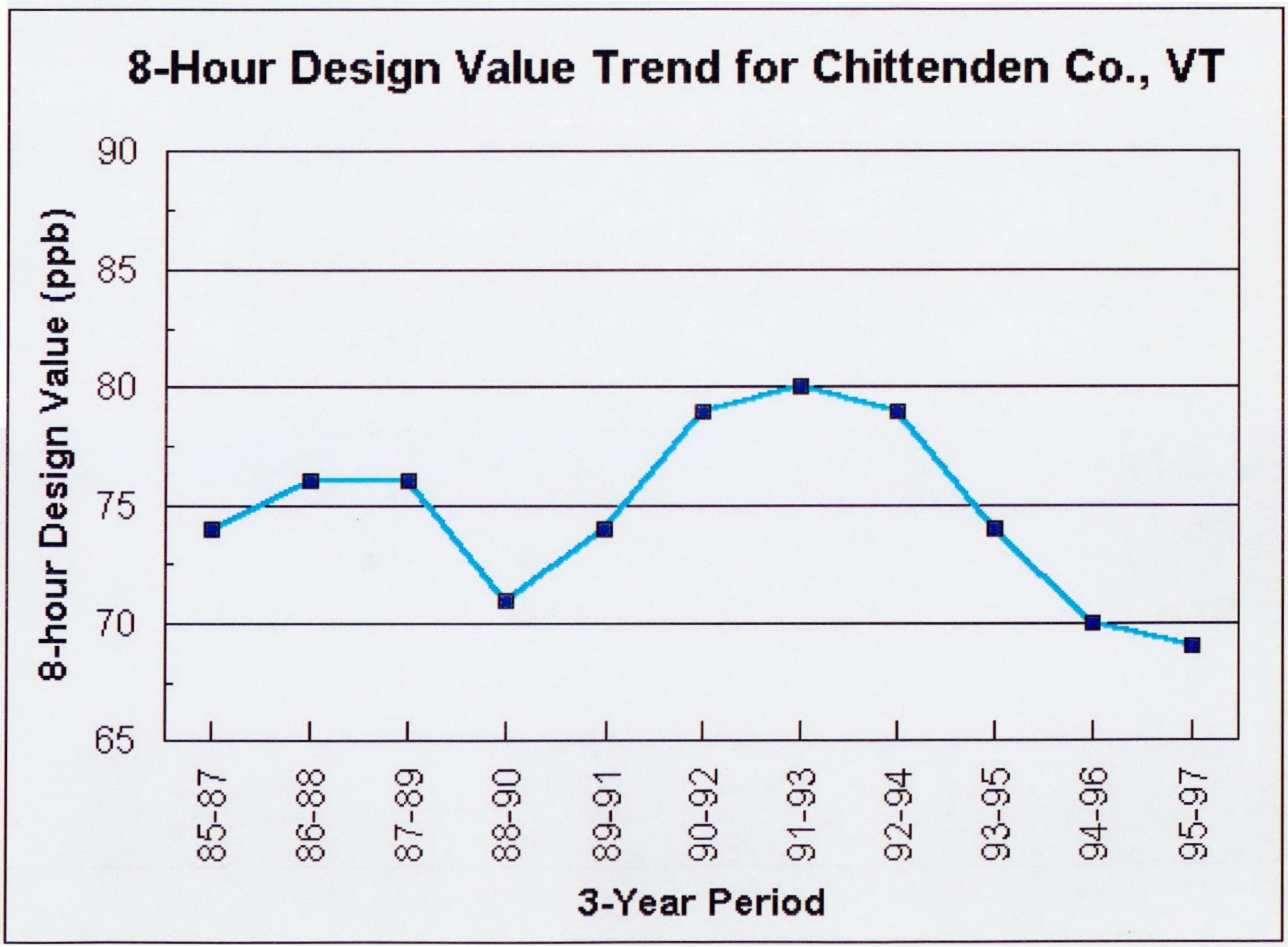

8-Hour Design Value Trend for Rockingham Co., NH
8-hour Design Value (ppb)
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

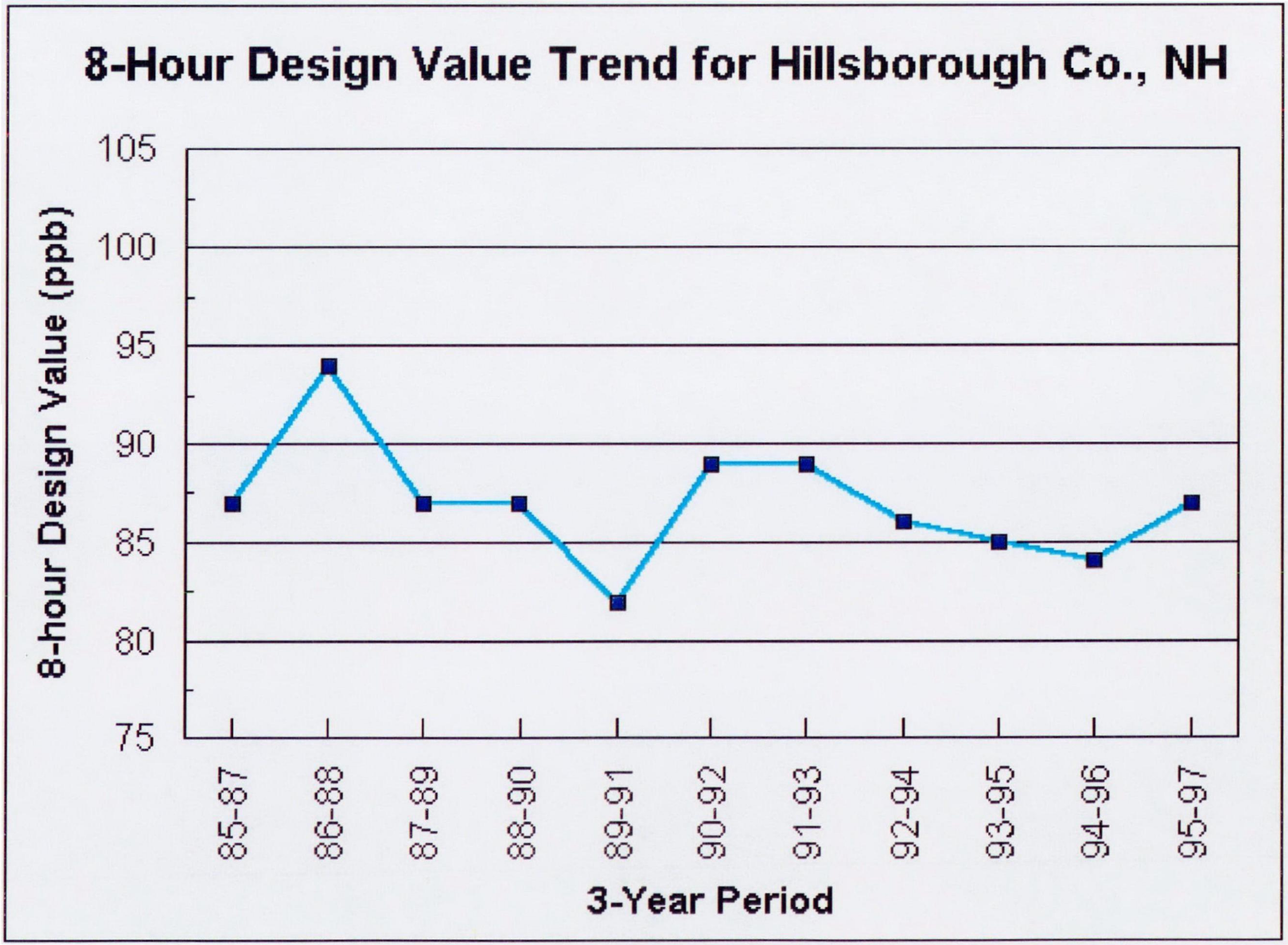

8-Hour Design Value Trend Hampden Co., MA
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

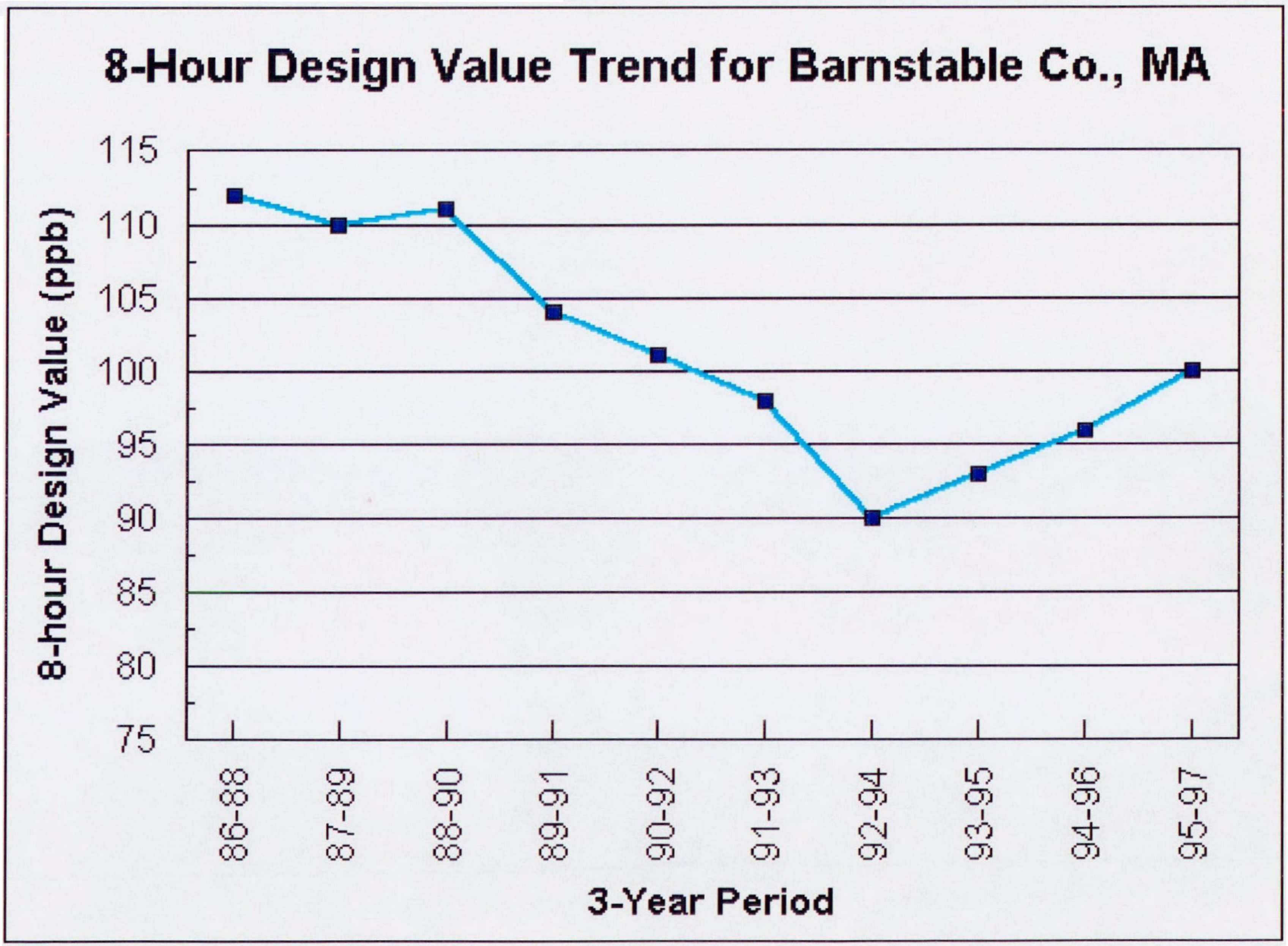

8-Hour Design Value Trend Hampshire Co., MA
8-hour Design Value (ppb)
120
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

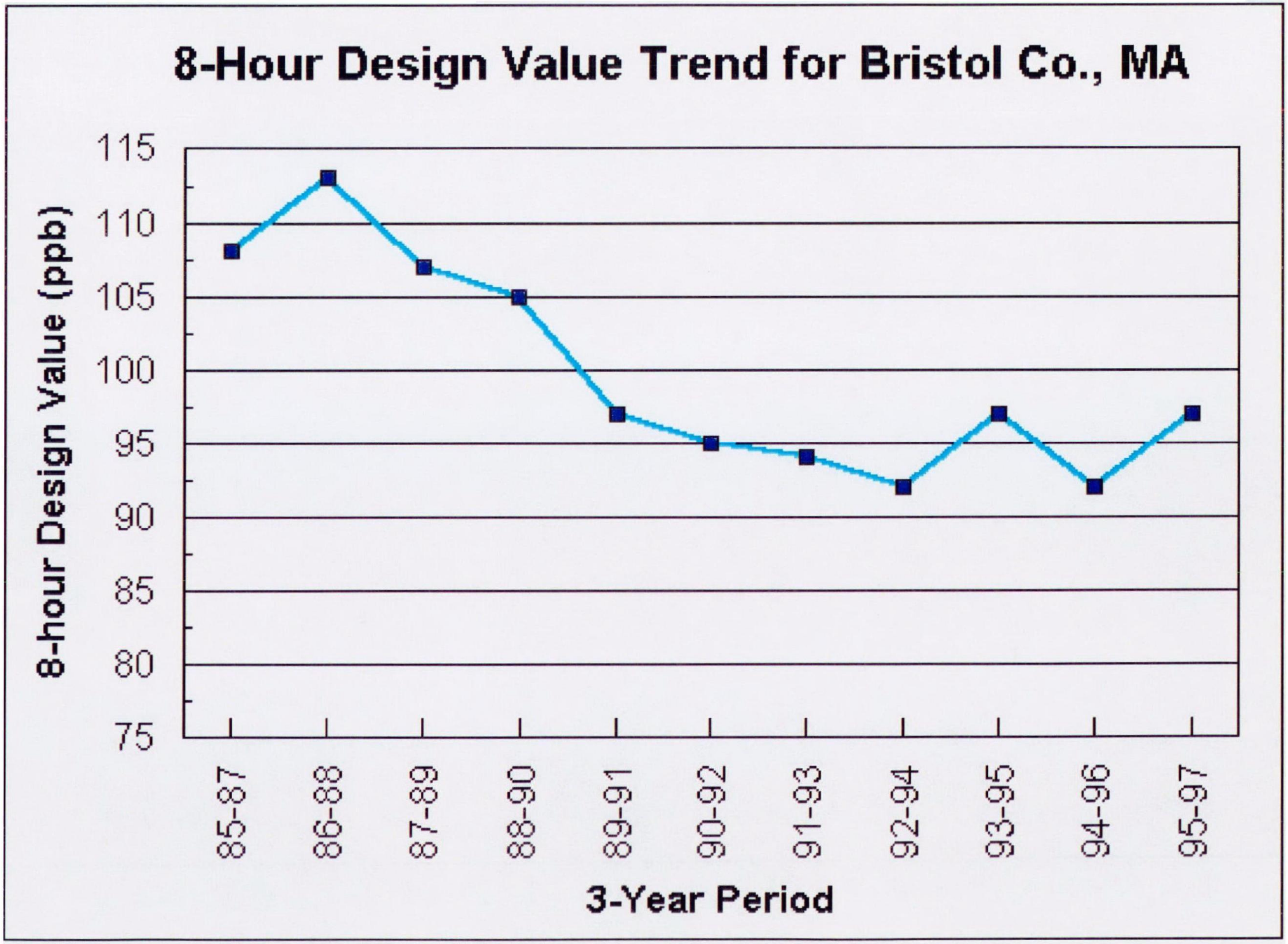

8-Hour Design Value Trend Worcester Co., MA
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

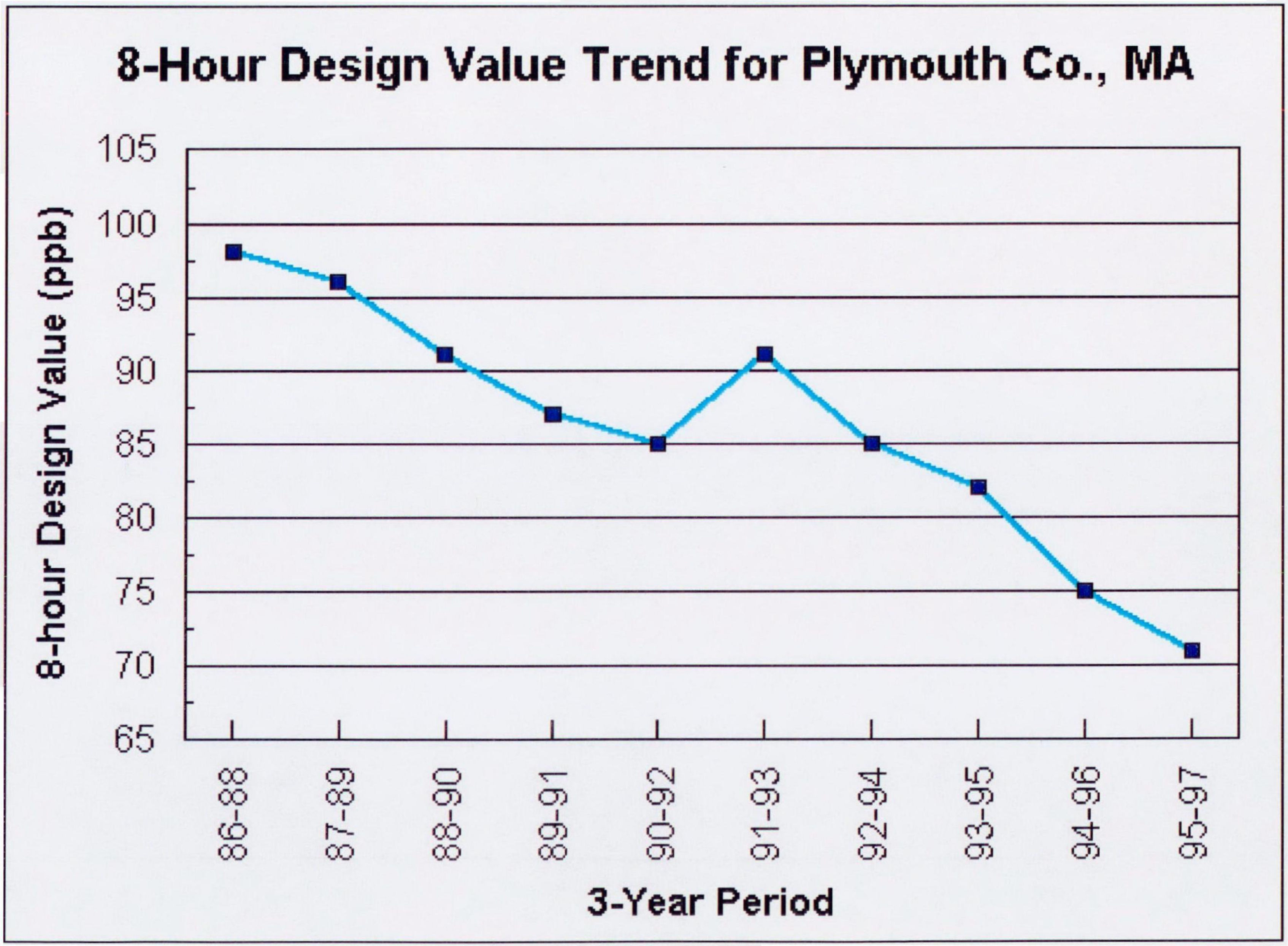

8-Hour Design Value Trend for Bennington Co., VT
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
Year

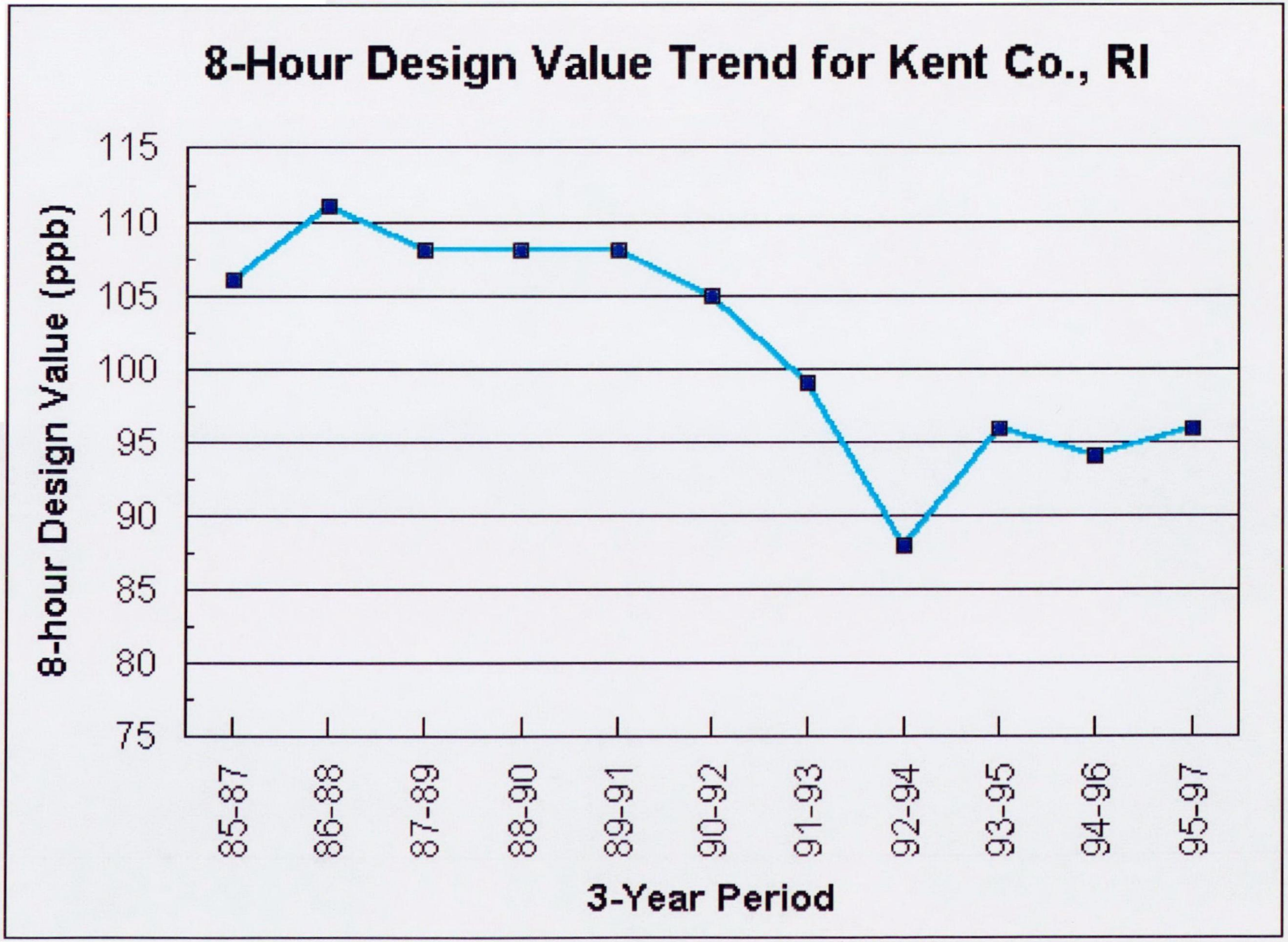

8-Hour Design Value Trend for Chittenden Co., VT
8-hour Design Value (ppb)
90
85
80
75
70
65
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

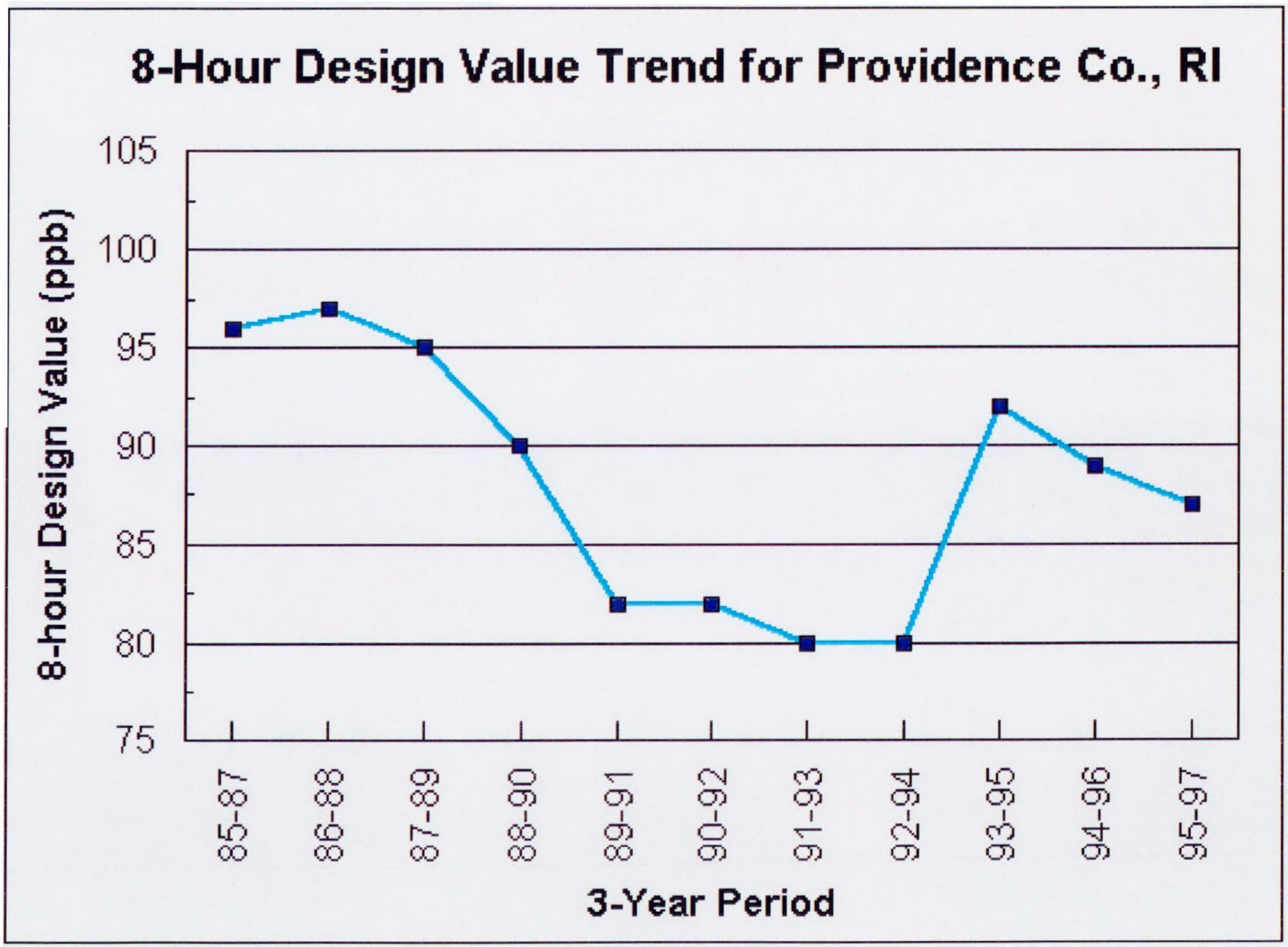

8-Hour Design Value Trend for Hillsborough Co., NH
8-hour Design Value (ppb)
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period


8-Hour Design Value Trend for Barnstable Co., MA
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

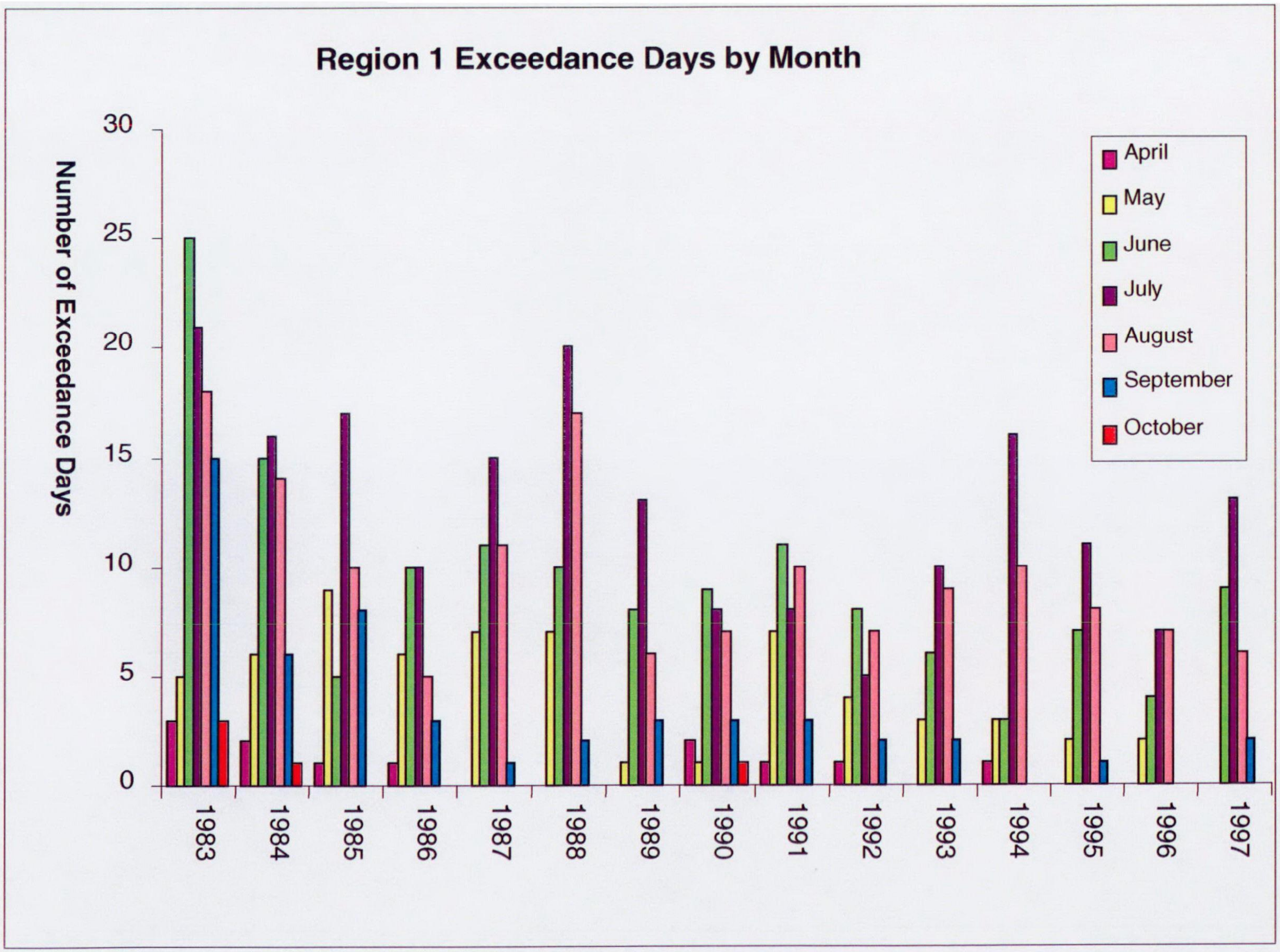

8-Hour Design Value Trend for Bristol Co., MA
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

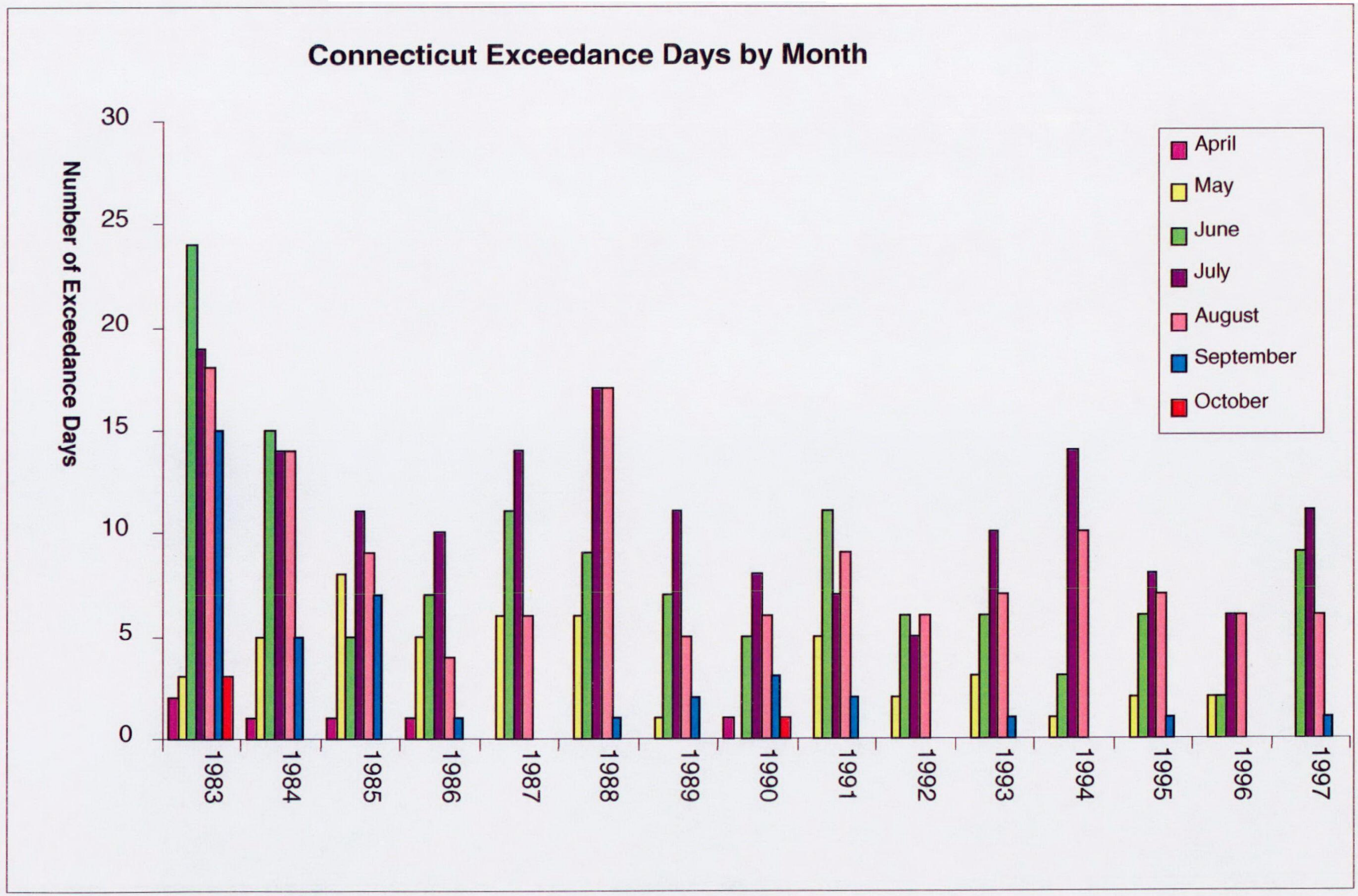

8-Hour Design Value Trend for Plymouth Co., MA
8-hour Design Value (ppb)
105
100
95
90
85
80
75
70
65
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

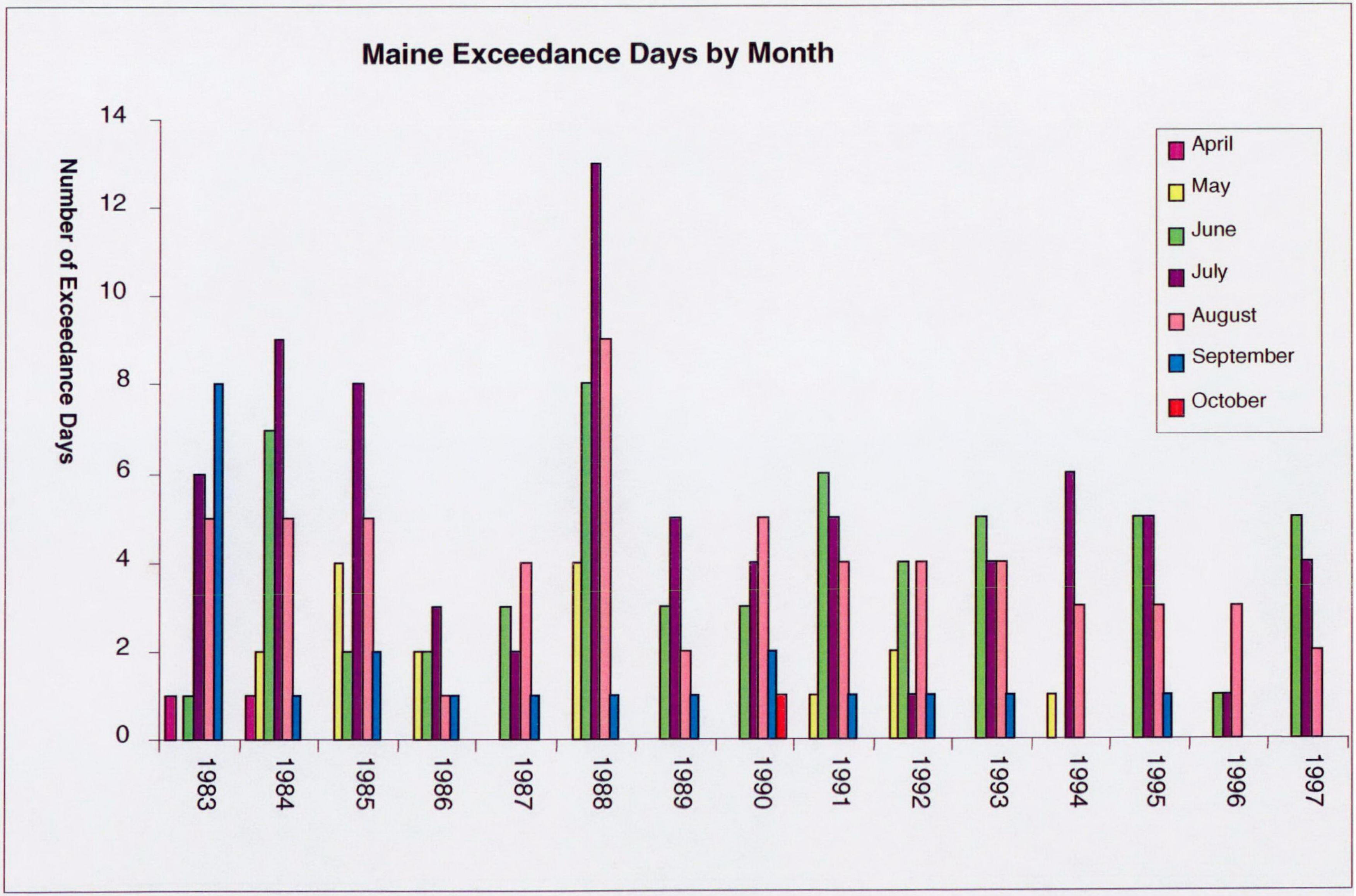

8-Hour Design Value Trend for Kent Co., RI
8-hour Design Value (ppb)
115
110
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

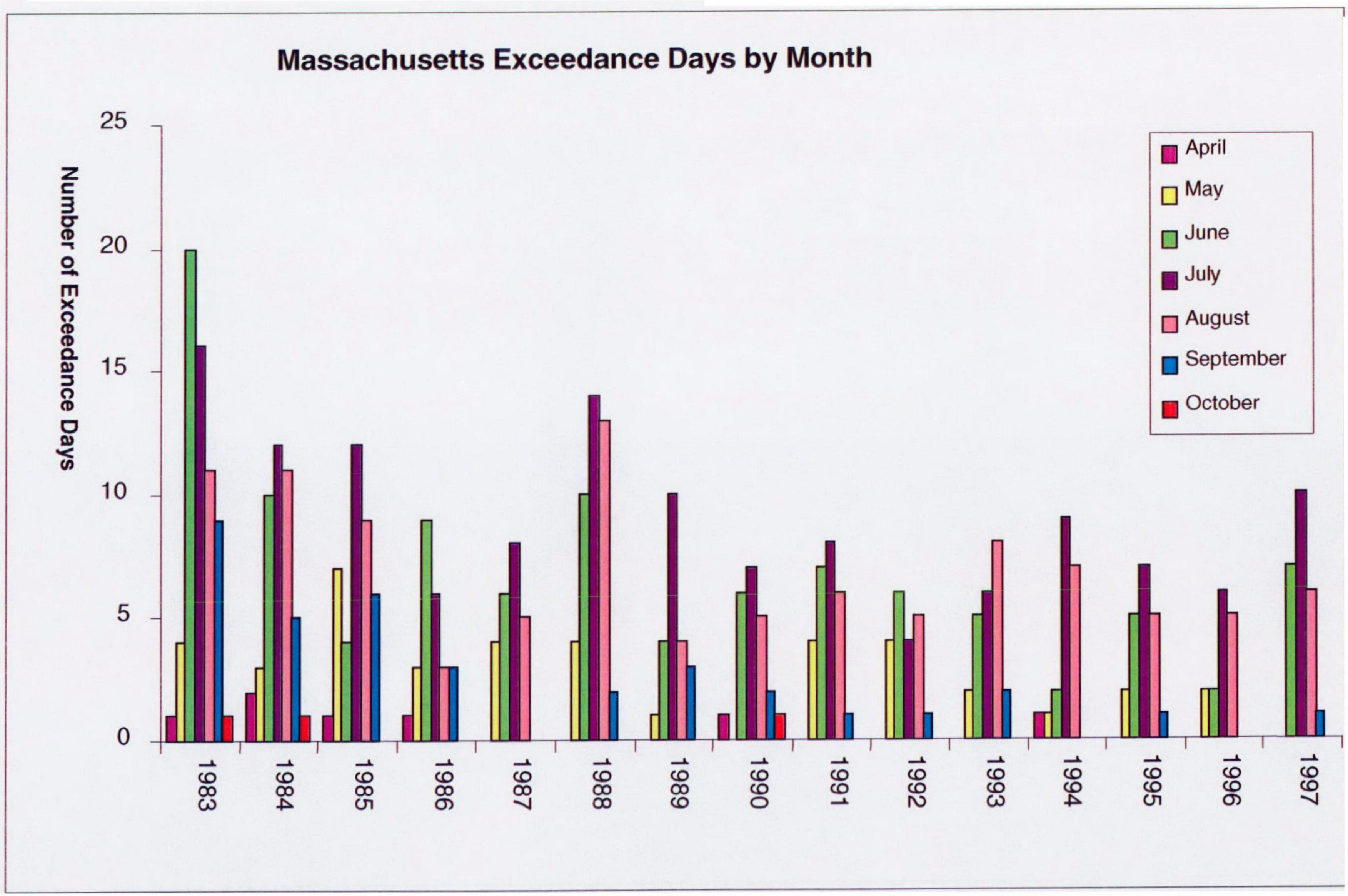

8-Hour Design Value Trend for Providence Co., RI
8-hour Design Value (ppb)
105
100
95
90
85
80
75
85-87
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
3-Year Period

# Appendix F
## Exceedance Day by Month

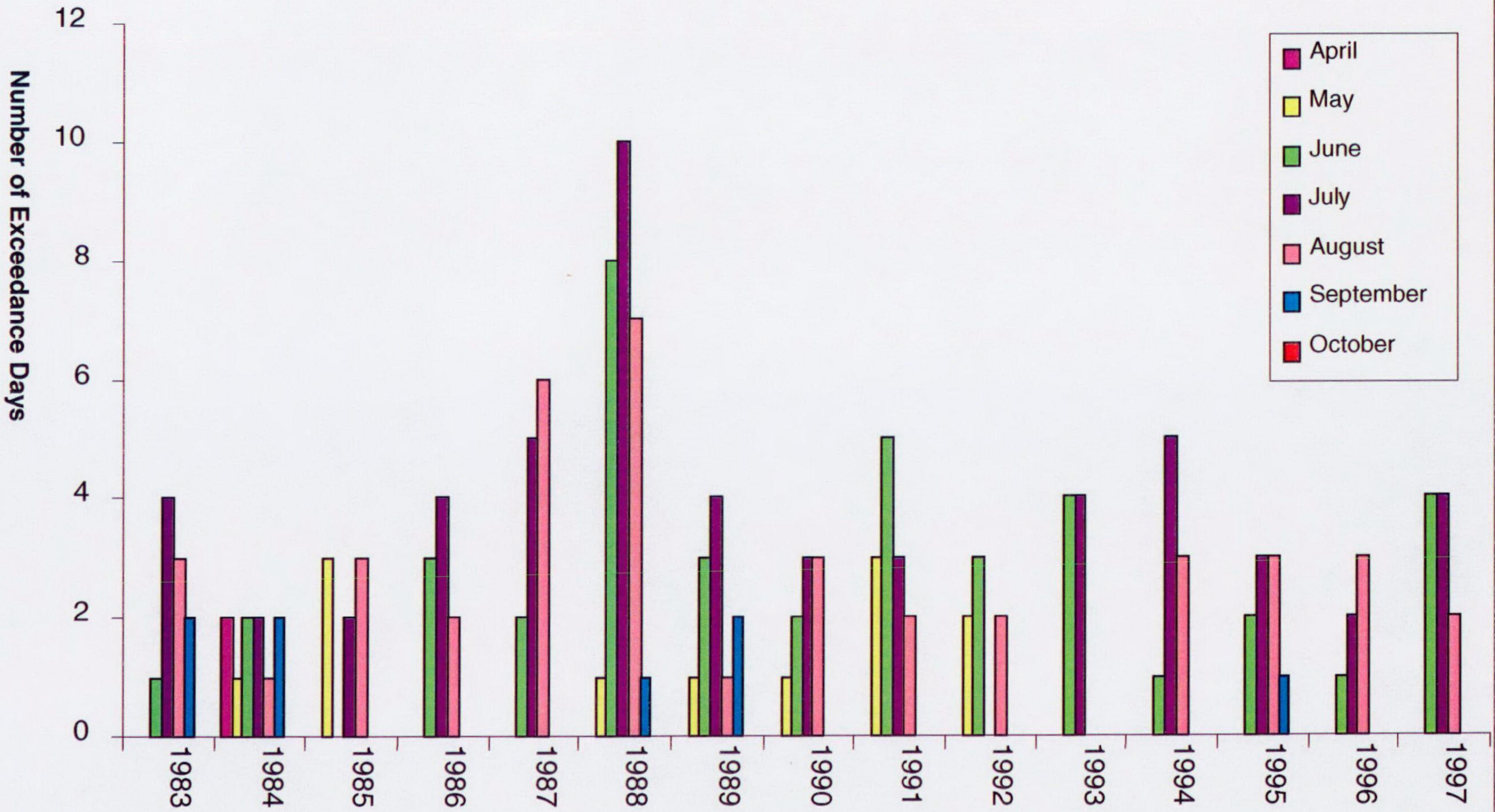


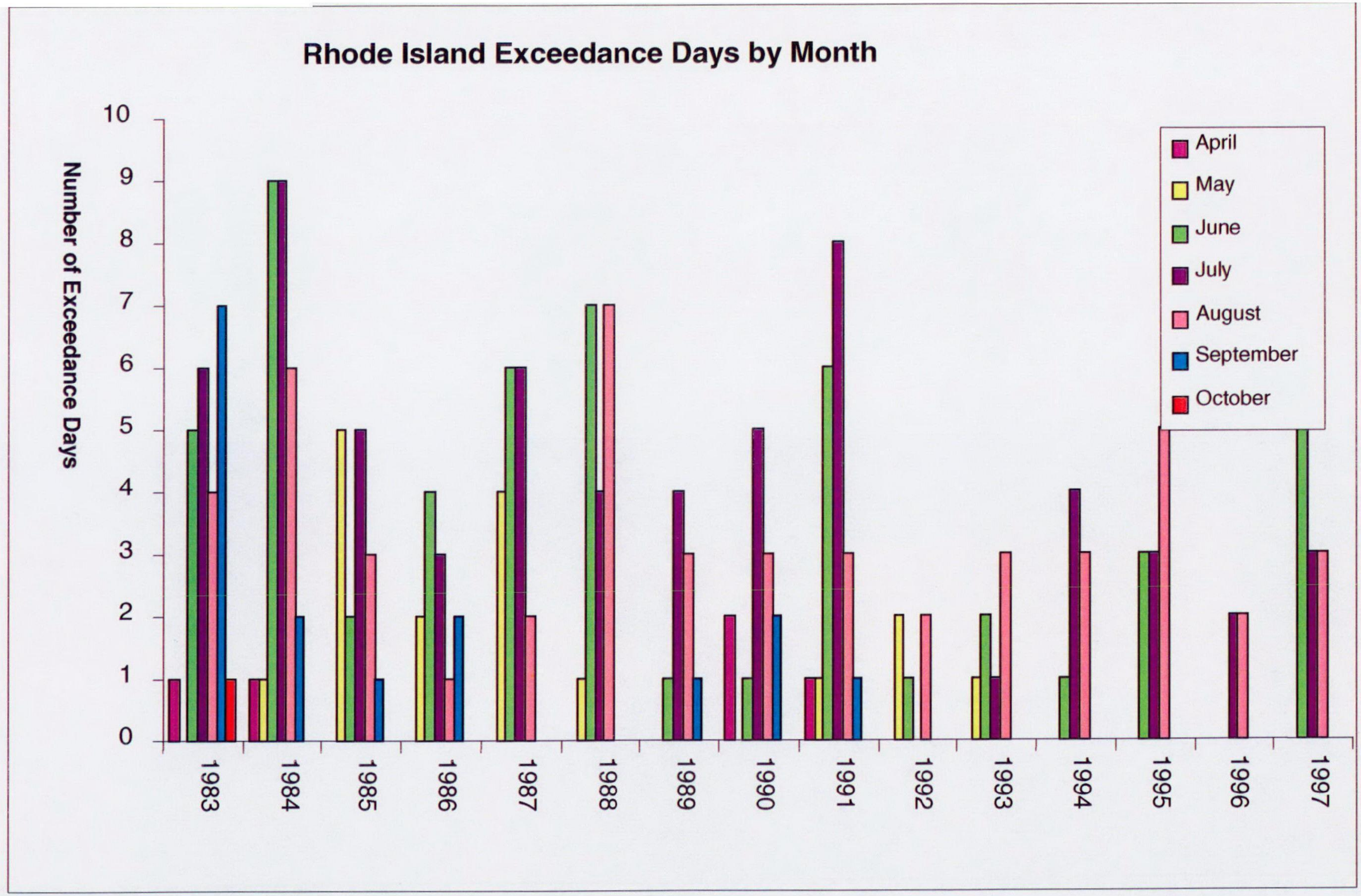

Connecticut Exceedance Days by Month
Number of Exceedance Days
0
5
10
15
20
25
30
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
April
May
June
July
August
September
October


Maine Exceedance Days by Month
Number of Exceedance Days
0
2
4
6
8
10
12
14
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
April
May
June
July
August
September
October

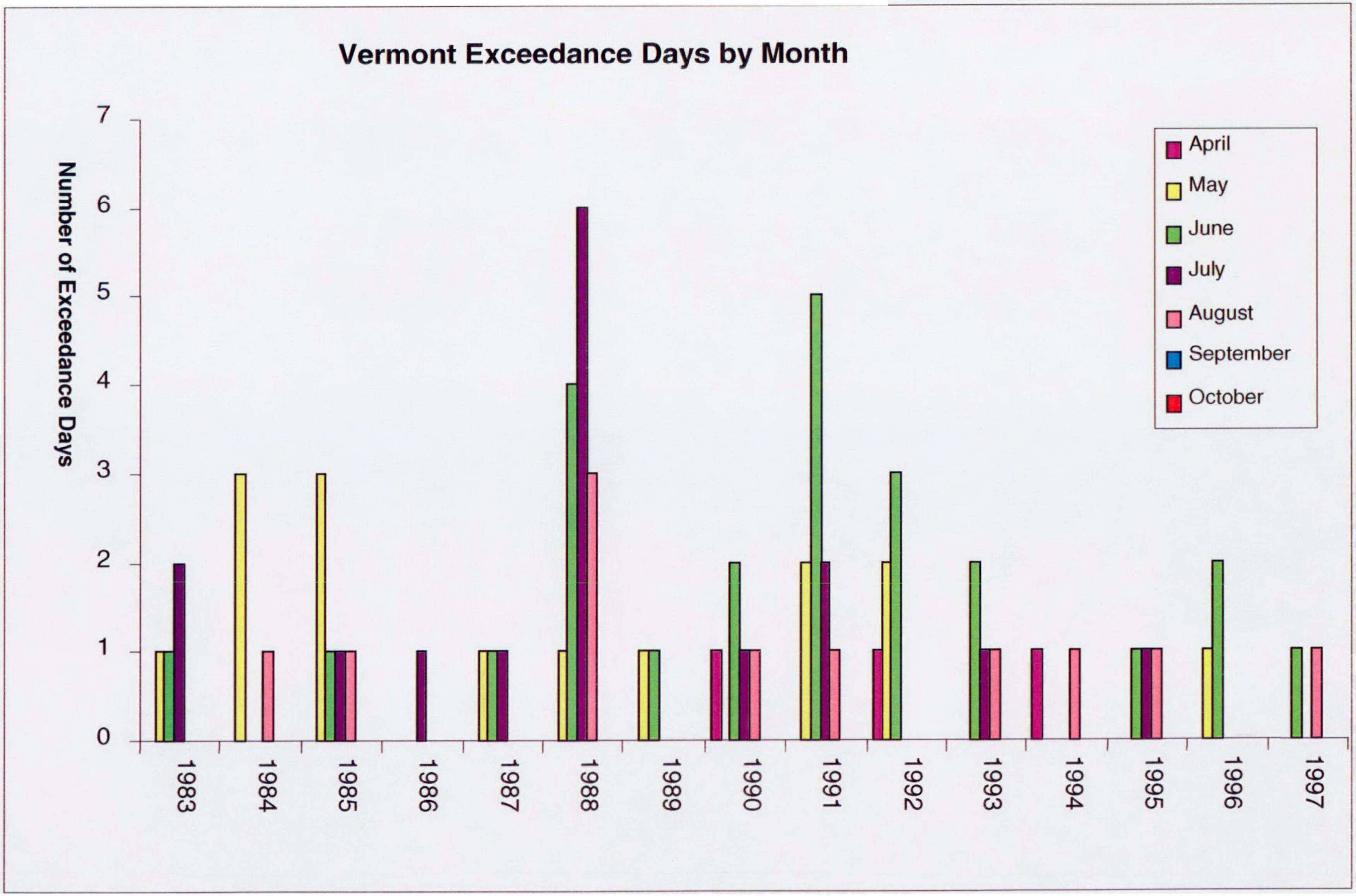

Massachusetts Exceedance Days by Month
Number of Exceedance Days
0
5
10
15
20
25
April
May
June
July
August
September
October
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

**New Hampshire Exceedance Days by Month**

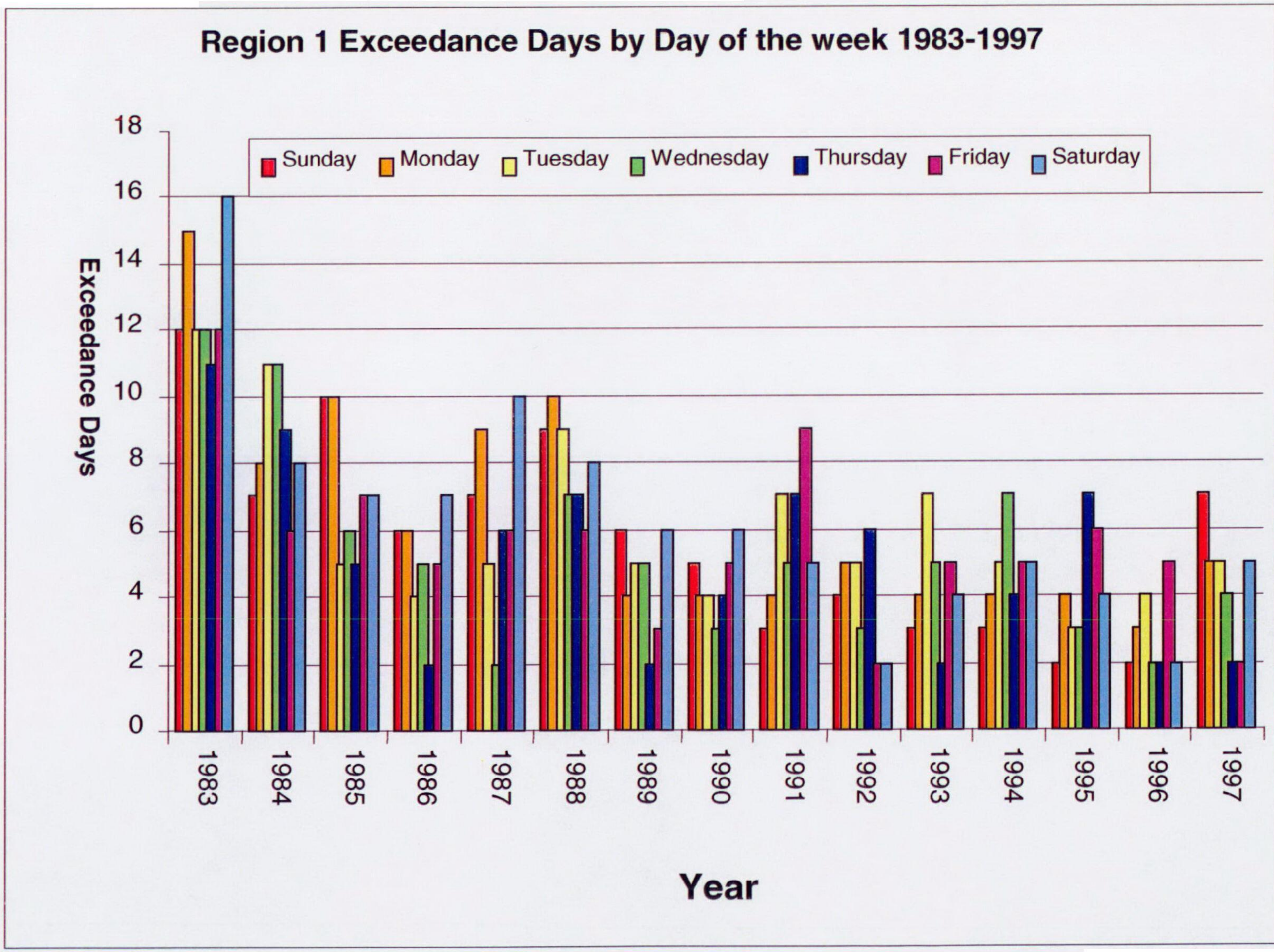


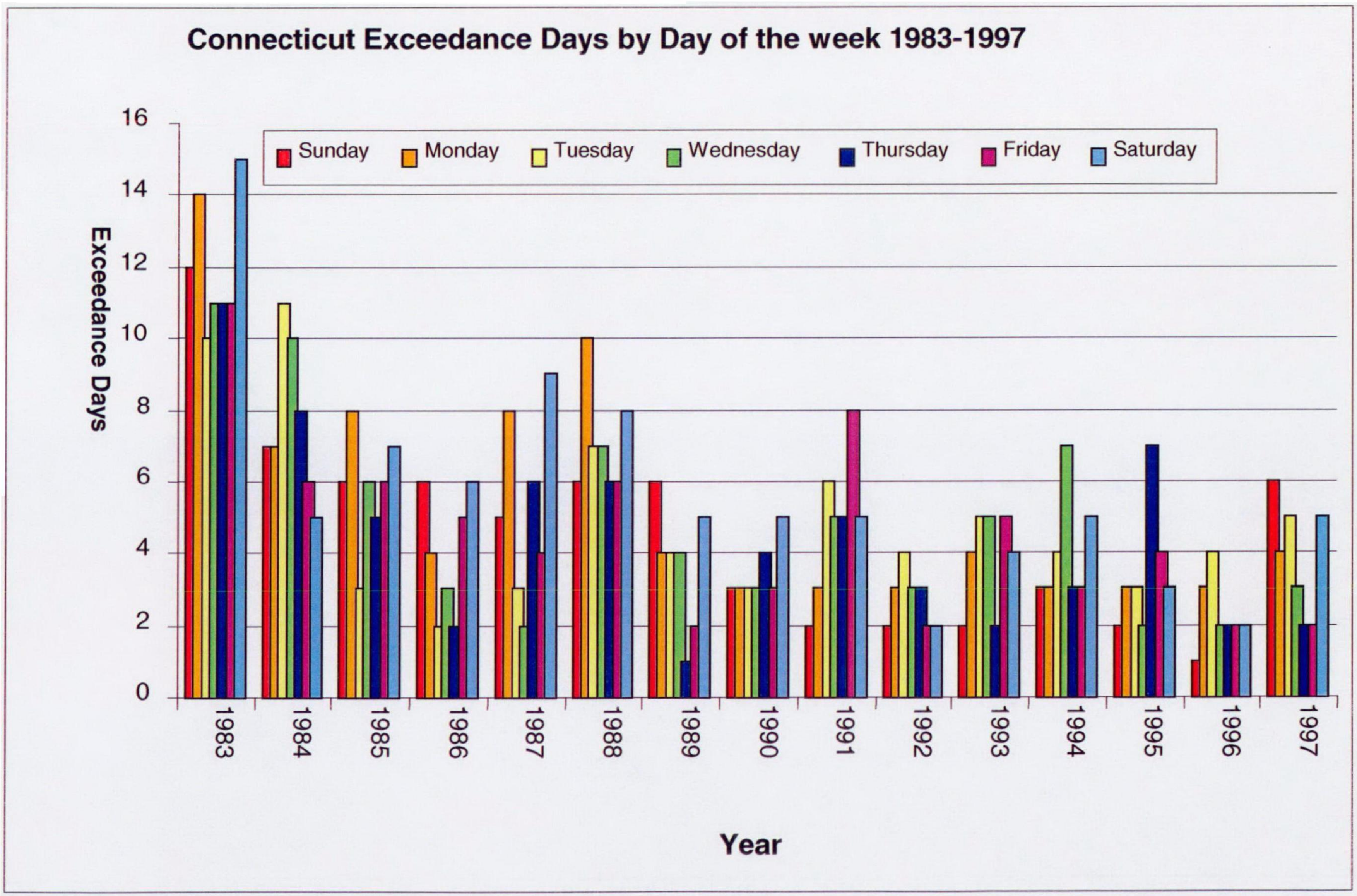


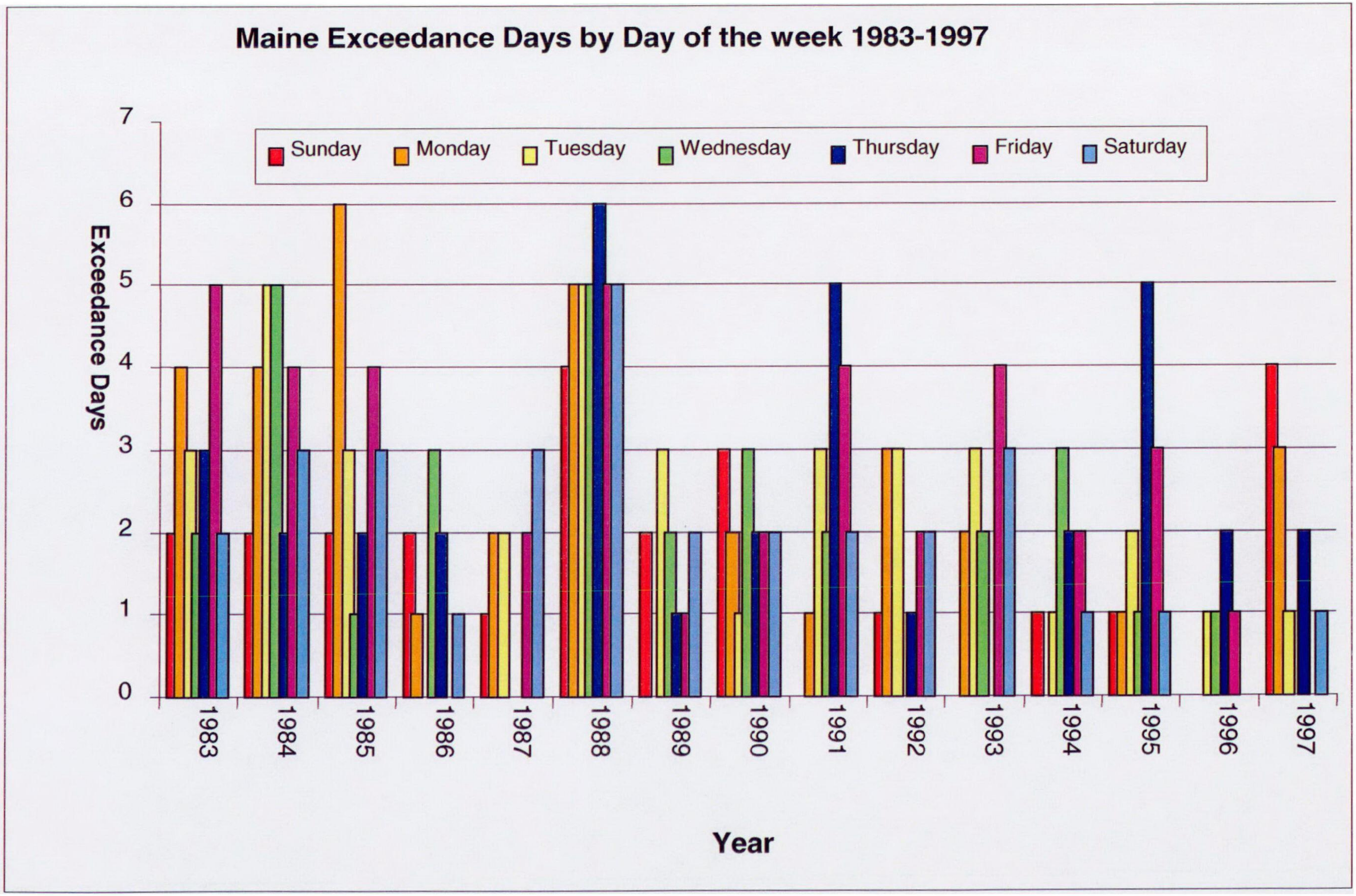
Rhode Island Exceedance Days by Month
Number of Exceedance Days
0
1
2
3
4
5
6
7
8
9
10
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
April
May
June
July
August
September
October

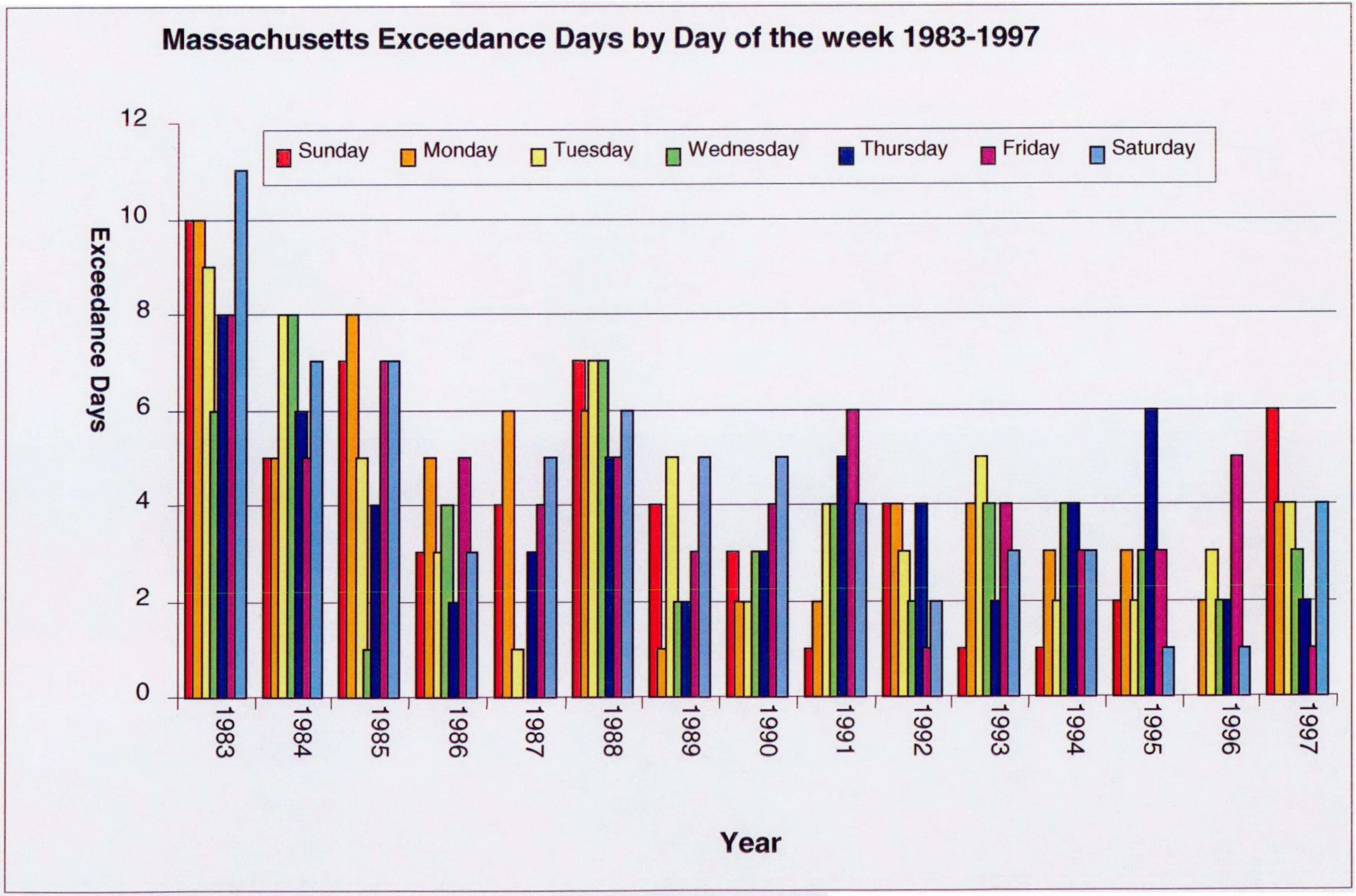

Vermont Exceedance Days by Month
Number of Exceedance Days
0
1
2
3
4
5
6
7
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
April
May
June
July
August
September
October

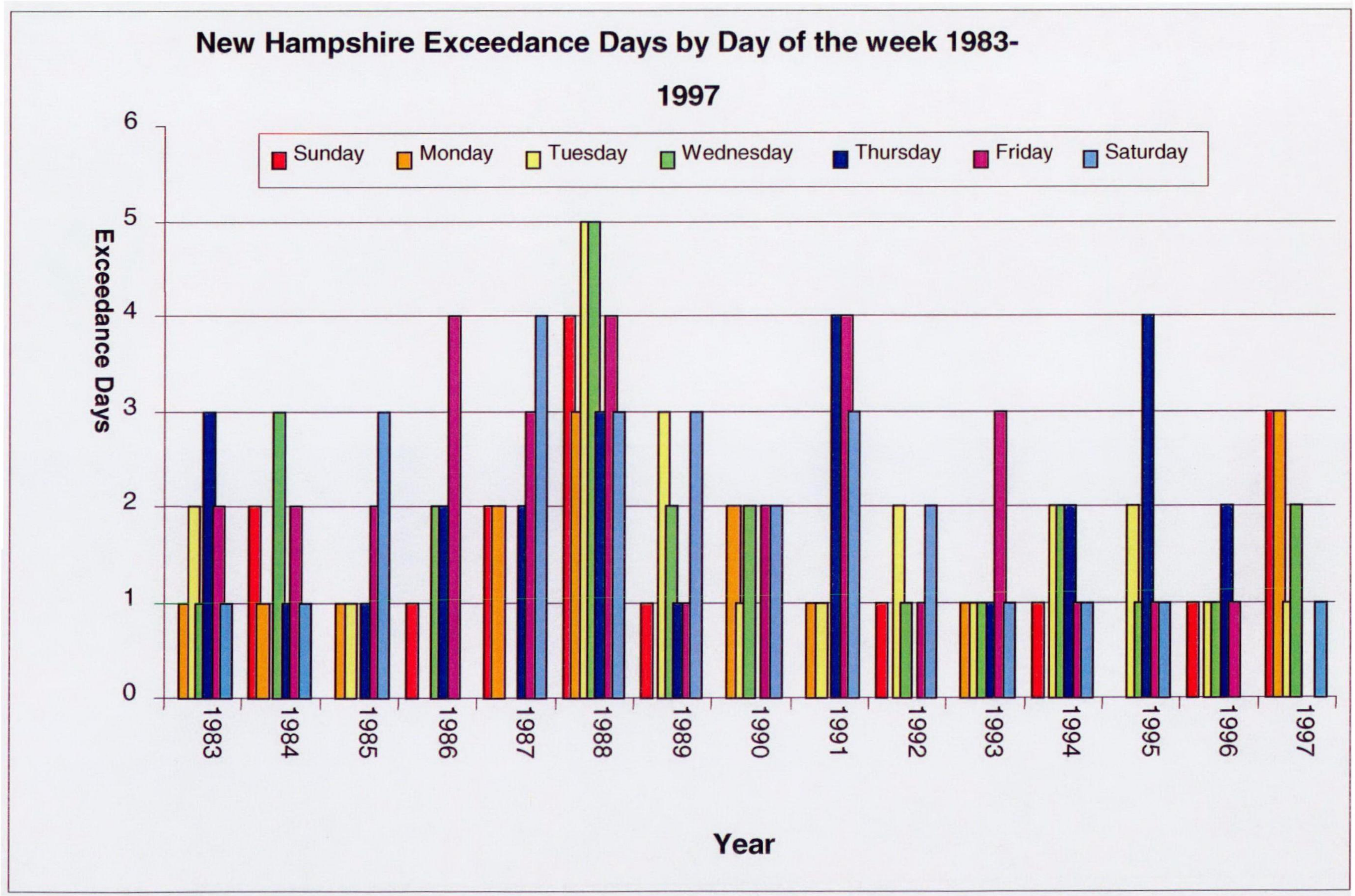
# Appendix G
## Exceedance Day by day of the week

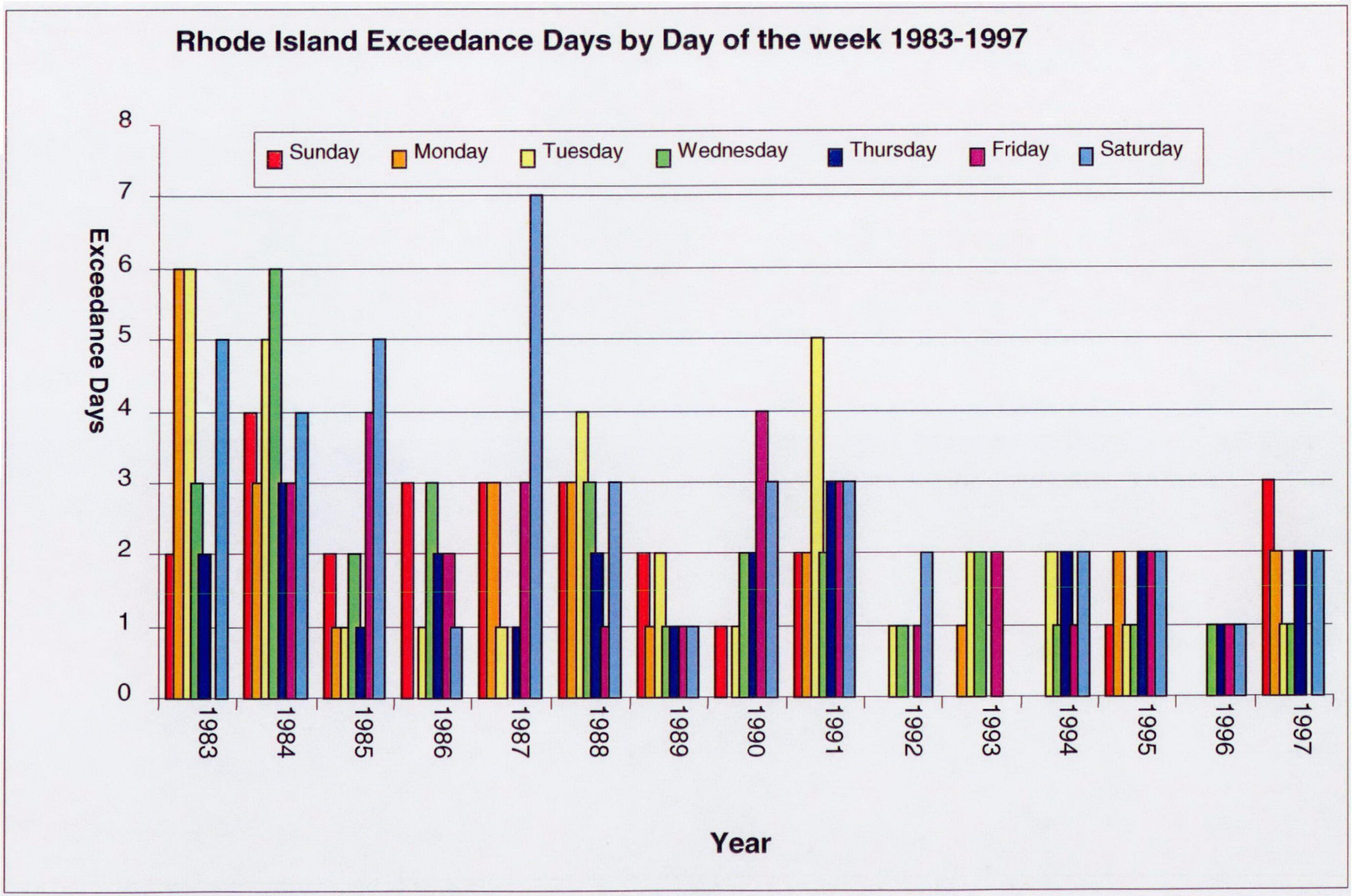


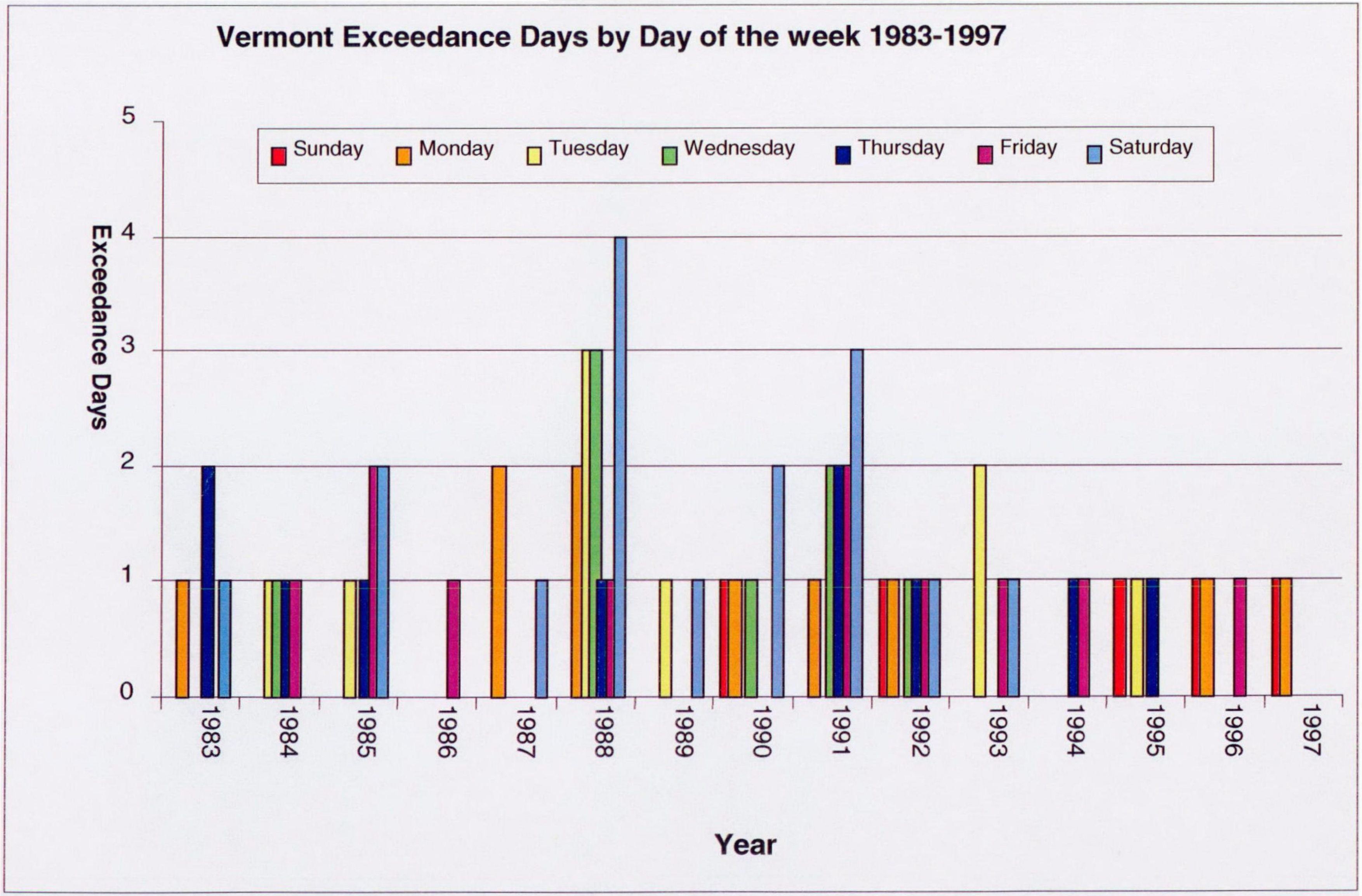

Connecticut Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
2
4
6
8
10
12
14
16
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year


Maine Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
1
2
3
4
5
6
7
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year


Massachusetts Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
2
4
6
8
10
12
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year

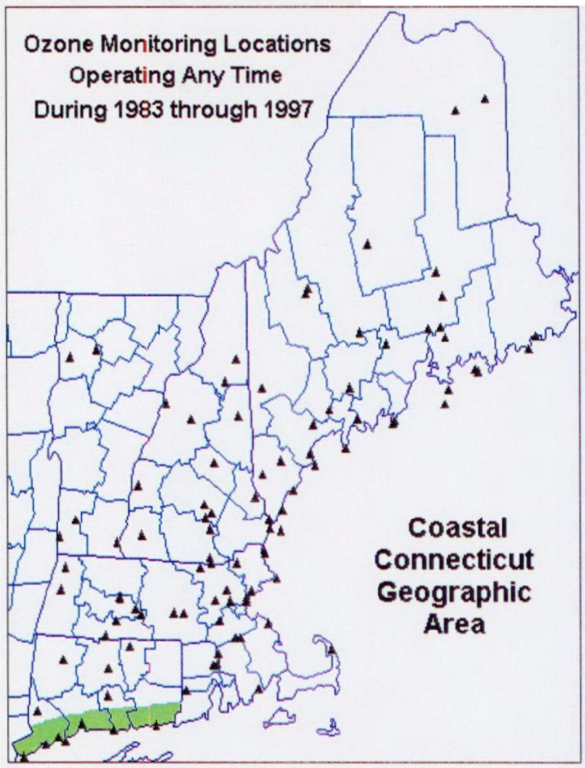

New Hampshire Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
1
2
3
4
5
6
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year

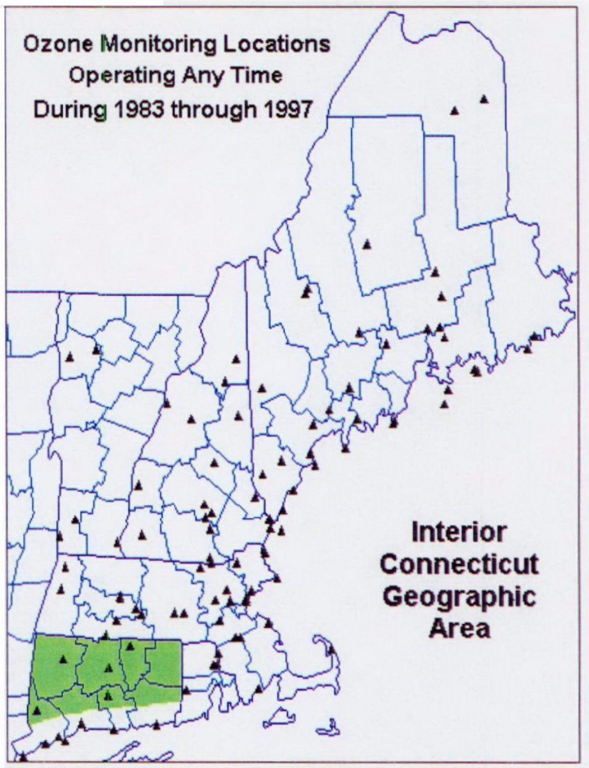

Rhode Island Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
1
2
3
4
5
6
7
8
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year

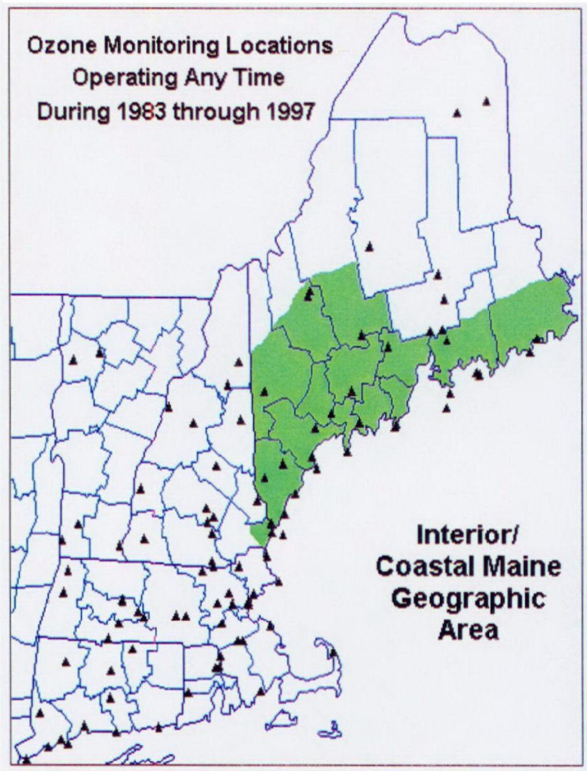


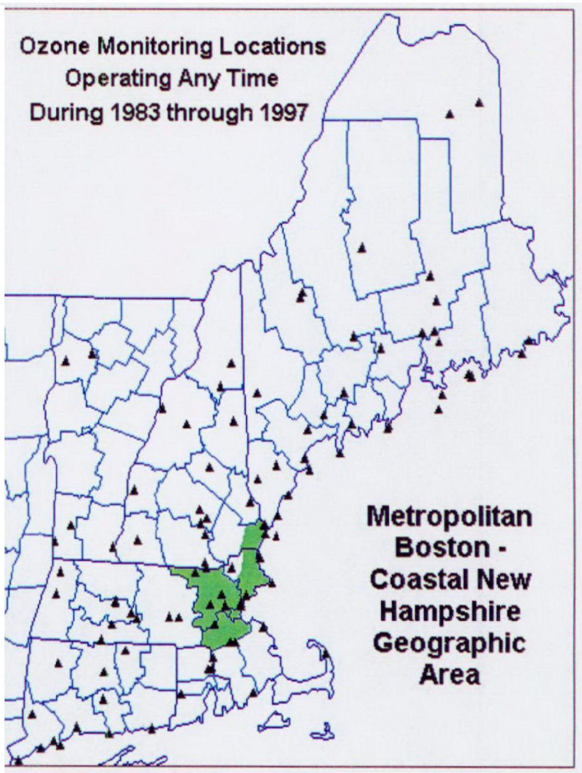
Vertermont Exceedance Days by Day of the week 1983-1997
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Exceedance Days
0
1
2
3
4
5
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year

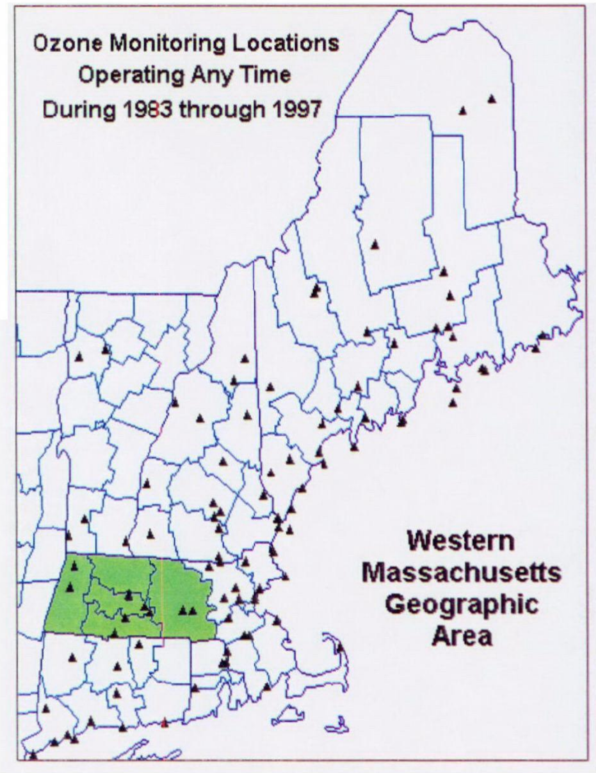
# Appendix H
# Geographical Area Maps

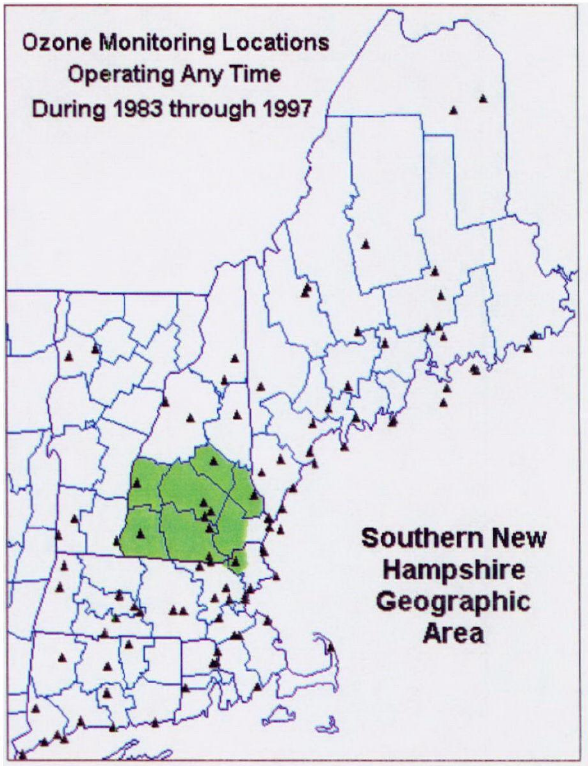


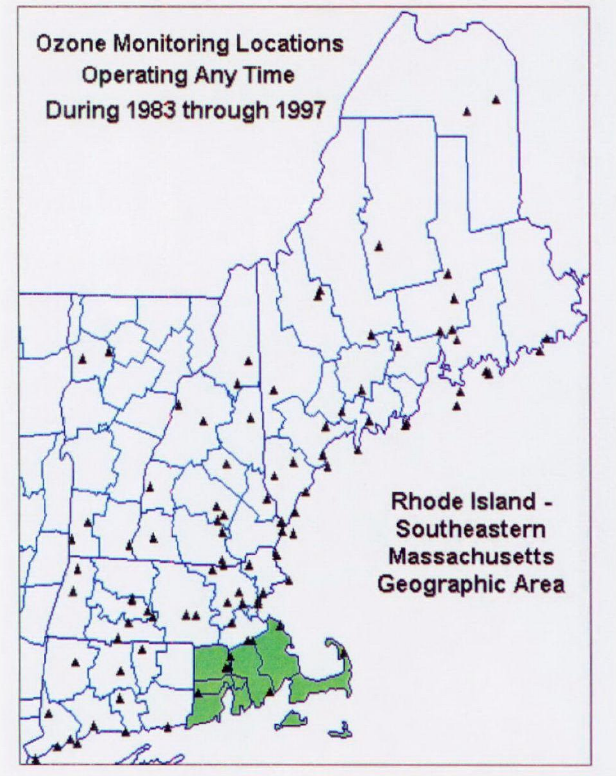




Ozone Monitoring Locations
Operating Any Time
During 1983 through 1997
Western
Massachusetts
Geographic
Area


Ozone Monitoring Locations
Operating Any Time
During 1983 through 1997
Southern New
Hampshire
Geographic
Area


Ozone Monitoring Locations
Operating Any Time
During 1983 through 1997
Rhode Island -
Southeastern
Massachusetts
Geographic Area

# Appendix I
## Tabulated Exceedance Day Data by State

Tables 1-7. Each table includes data covering the fifteen-year period 1983-1997. The number of monitors in operation for each geographical area is shown as changing the number of monitors could influence the number of days where ozone exceeded the standard. Temperature data from seven meteorological sites are displayed. The temperature cut off was chosen such that a reasonable chance for an exceedance existed in the 1980's when the air temperature for that region was as listed in the table. Exceedance days are those where at least one site in the given geographical area exceeds the standard.

**Table 1. Region 1**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 40 | 39 | 41 | 39 | 44 | 43 | 48 | 50 | 53 | 58 | 58 | 63 | 65 | 66 | 62 |
| # of 1-hour exceedance days | 65 | 43 | 30 | 17 | 30 | 38 | 14 | 15 | 25 | 9 | 17 | 12 | 13 | 5 | 13 |
| # of 8-hour exceedance days | 90 | 60 | 50 | 35 | 45 | 56 | 31 | 31 | 40 | 27 | 30 | 33 | 29 | 20 | 30 |
| # of days with T>85 ®F from 7 Region 1 sites | 66 | 45 | 34 | 33 | 41 | 52 | 35 | 48 | 61 | 31 | 53 | 60 | 60 | 37 | 37 |

**Table 2. Connecticut**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 13 | 13 | 14 | 13 |
| # of 1-hour exceedance days | 61 | 37 | 22 | 11 | 27 | 34 | 13 | 13 | 24 | 8 | 15 | 9 | 13 | 4 | 13 |
| # of 8-hour exceedance days | 84 | 54 | 41 | 28 | 37 | 50 | 26 | 24 | 34 | 19 | 27 | 28 | 24 | 16 | 27 |
| # of days with T> 85 ®F at Bridgeport | 33 | 23 | 8 | 16 | 21 | 35 | 17 | 23 | 35 | 10 | 34 | 32 | 29 | 8 | 19 |
| # of days with T> 85 ®F at Bradley AP | 58 | 37 | 25 | 27 | 38 | 47 | 32 | 42 | 56 | 20 | 44 | 42 | 51 | 26 | 32 |

**Table 3. Maine**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 6 | 6 | 8 | 9 | 10 | 9 | 11 | 11 | 13 | 16 | 16 | 16 | 18 | 16 | 13 |
| # of 1-hour exceedance days | 10 | 12 | 6 | 2 | 5 | 19 | 4 | 5 | 7 | 2 | 4 | 1 | 4 | 0 | 3 |
| # of 8-hour exceedance days | 21 | 25 | 21 | 9 | 10 | 35 | 11 | 15 | 17 | 12 | 14 | 10 | 14 | 5 | 11 |
| # of days with T>85 ®F at Portland | 22 | 18 | 8 | 4 | 12 | 27 | 13 | 16 | 31 | 7 | 19 | 13 | 15 | 1 | 18 |

**Table 4. Massachusetts**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 15 | 14 | 14 | 11 | 14 | 15 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 16 |
| # of 1-hour exceedance days | 38 | 21 | 14 | 8 | 9 | 30 | 8 | 6 | 9 | 4 | 9 | 6 | 8 | 2 | 4 |
| # of 8-hour exceedance days | 62 | 44 | 39 | 25 | 23 | 43 | 22 | 22 | 26 | 20 | 23 | 20 | 20 | 15 | 24 |
| # of days with T> 85 ®F at Logan AP | 52 | 34 | 17 | 21 | 16 | 37 | 19 | 28 | 42 | 15 | 32 | 44 | 40 | 15 | 27 |
| # of days with T>85 ®F at Worcester AP | 34 | 13 | 4 | 5 | 15 | 35 | 12 | 8 | 16 | 4 | 12 | 11 | 12 | 2 | 8 |

**Table 5. New Hampshire**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 5 | 5 | 5 | 5 | 6 | 5 | 7 | 9 | 9 | 10 | 10 | 10 | 10 | 14 | 13 |
| # of 1-hour exceedance days | 4 | 2 | 2 | 3 | 4 | 13 | 2 | 2 | 4 | 0 | 3 | 1 | 3 | 0 | 1 |
| # of 8-hour exceedance days | 10 | 10 | 8 | 9 | 13 | 27 | 11 | 9 | 13 | 7 | 8 | 9 | 9 | 6 | 10 |
| # of days with T> 85 ®F at Concord | 47 | 20 | 25 | 15 | 27 | 38 | 23 | 34 | 38 | 20 | 36 | 34 | 44 | 22 | 30 |

**Table 6. Rhode Island**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| # of 1-hour exceedance days | 7 | 16 | 6 | 4 | 8 | 7 | 2 | 6 | 9 | 1 | 1 | 1 | 4 | 0 | 1 |
| # of 8-hour exceedance days | 24 | 28 | 16 | 12 | 18 | 19 | 9 | 13 | 20 | 5 | 7 | 8 | 11 | 4 | 11 |
| # of days with T> 85 ®F at Providence | 50 | 15 | 15 | 14 | 27 | 34 | 24 | 22 | 47 | 15 | 35 | 22 | 36 | 16 | 25 |

**Table 7. Vermont**

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of monitors | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 3 |
| # of 1-hour exceedance days | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| # of 8-hour exceedance days | 4 | 4 | 6 | 1 | 3 | 14 | 2 | 5 | 10 | 6 | 4 | 2 | 3 | 3 | 2 |