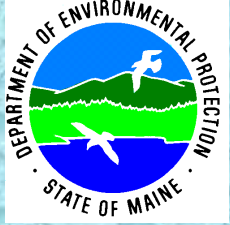
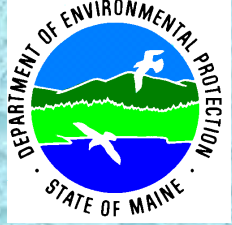


Casco Bay Deposition Study



In 1990, Casco Bay was designated an "estuary of national significance" and included in the U.S. Environmental Protection Agency's National Estuary Program, established in 1987 to protect nationally significant estuaries threatened by pollution, development or overuse. As a result of this designation, the Casco Bay Estuary Project (CBEP) was formed with the mission of preserving the ecological integrity of Casco Bay and ensuring compatible human uses of the Bay's resources through public stewardship and effective management.



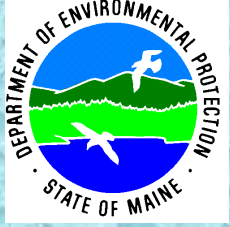
Casco Bay Estuary Project:

Collaborative interagency and citizen effort to develop a plan for managing the Casco Bay watershed

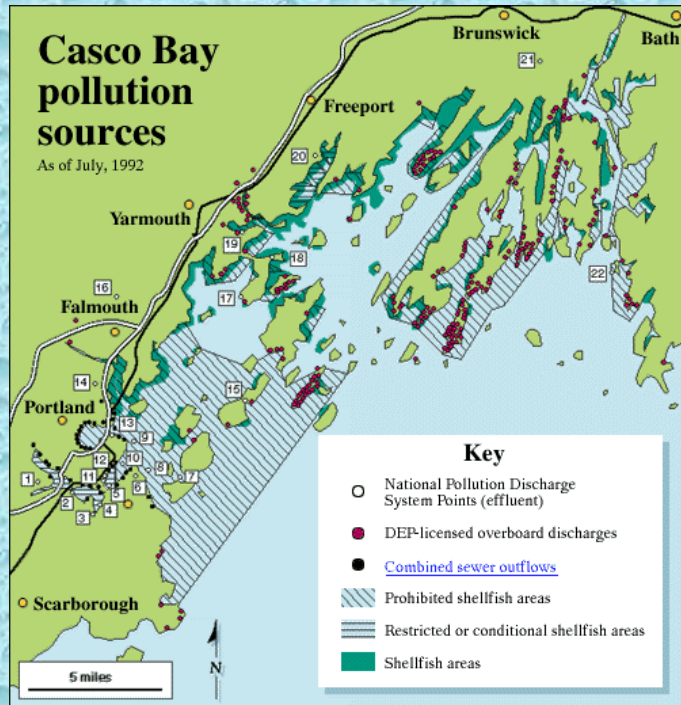
Casco Bay Plan - adopted 1996



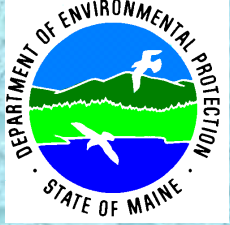
- ✓ protect wildlife habitat
- ✓ improve water quality
- ✓ reduce pollution from stormwater runoff and combined sewer overflows
- ✓ reduce toxic pollution
- ✓ protect and restore clamflats and swimming areas



Issues Identified by Casco Bay Plan:



- ✓ nuisance algal blooms from excess nitrogen causing mortality in shell fish and other marine animals
- ✓ elevated levels of Hg, Cd, PAH
- ✓ fish advisories due to elevated levels of methyl mercury in watershed fish



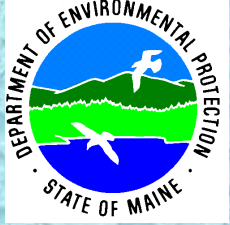
Air Deposition Study funded by Great Waters Program

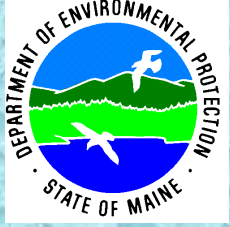
- ☞ Is air deposition a current source of pollution to the bay?
- ☞ What is the contribution of deposition to total pollution loading?
- ☞ What is the relationship of the estuary to regional patterns of air pollution?



Casco Bay Deposition Study Objectives:

1. Establish a long-term deposition monitoring site near Casco Bay (PAH, Nitrogen, Mercury, Acid Deposition, Fine Particulates)
2. Develop a relatively simple method to estimate atmospheric mass loading of “target” pollutants.

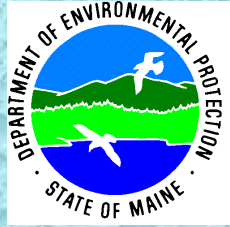




Air Deposition Study Team Members

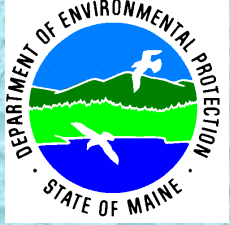
- **Maine DEP**
 - Cathy Richardson, Ellen Doering, Jeff Emery, Don Prince, Doug Saball, Andy Johnson - Advisory Committee
 - Don Prince - site operator
- **USEPA Region 1**
 - Diane Gould, Alan Van Arsdale, Jeri Weiss - Advisory Committee
- **Casco Bay Estuary Project**
 - Beverly Bayley-Smith - Grant Administrator, Advisory Committee
- Byard Mosher - Contractor for Data Analysis



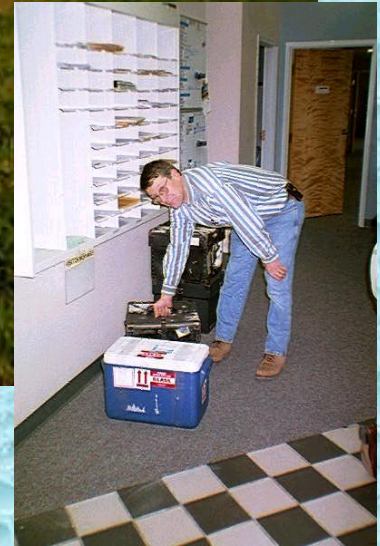


Location of Air Deposition Site: Wolfe's Neck Farm - Freeport, Maine

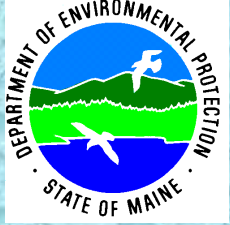




Collecting the MDN Sample

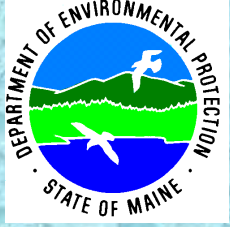


Sending it out for analysis



Site Configuration

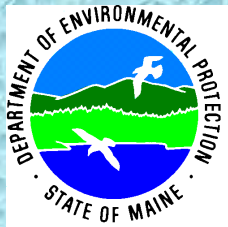
- Fine Aerosol Chemistry - **IMPROVE** Sampler
- Precipitation Ion Chemistry - **NADP** Sampler
- Mercury Deposition - **MDN** Sampler
- PAH Wet and Dry Deposition - UMass Lowell Sampler
- Meteorological Data - Recording rain gauge and wind speed / direction



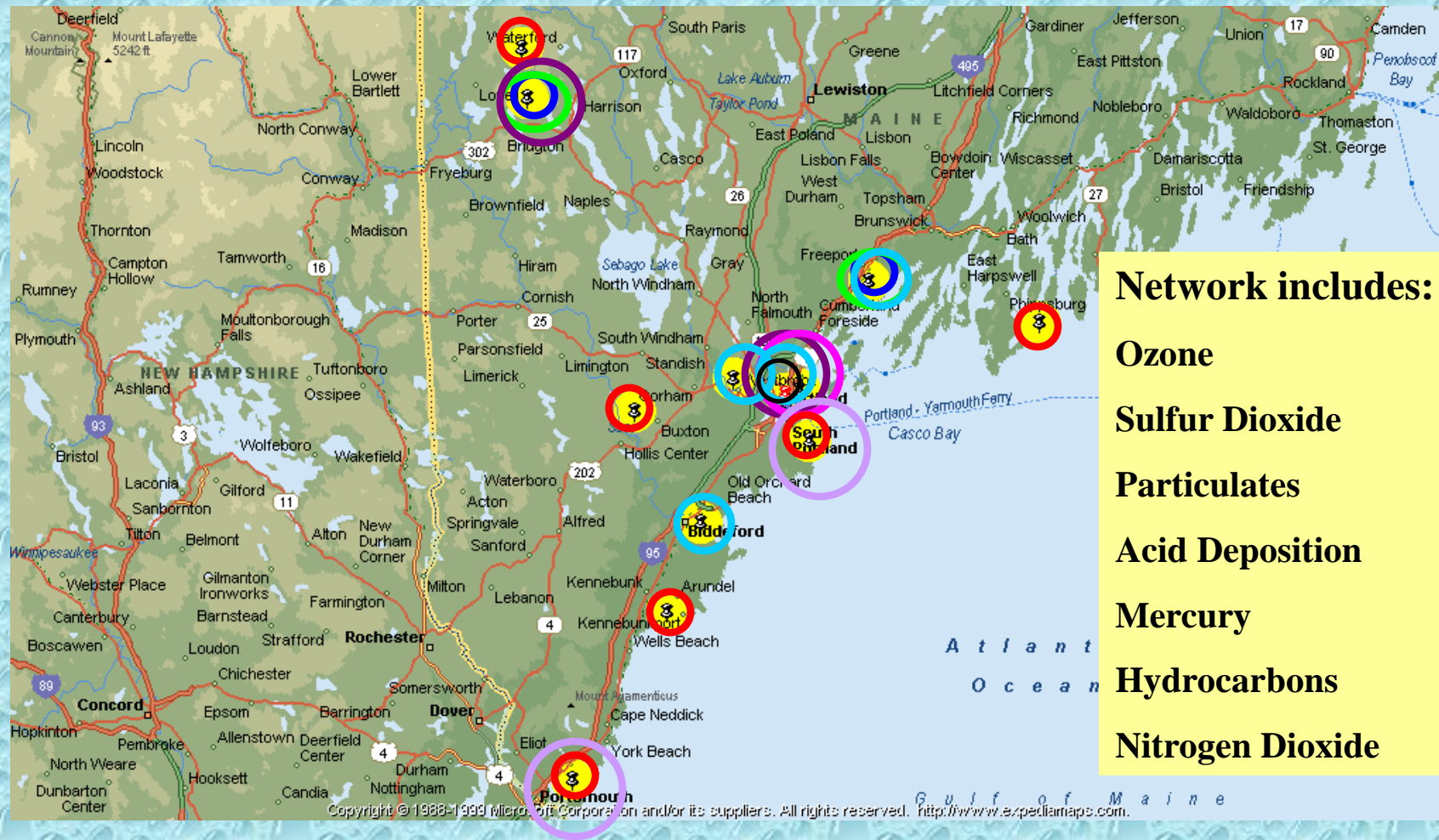
Sampling Frequency

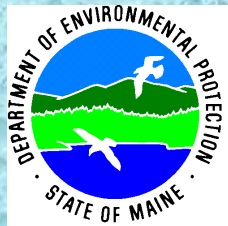
- Fine aerosol (IMPROVE)- SIP calendar, every 6th day
- Precipitation chemistry (NADP)- weekly integrated sampling (sampling bucket set up on Tuesday and removed the following Tuesday)
- Mercury deposition (MDN)- weekly integrated sampling (same as NADP)
- PAH deposition - weekly integrated sampling, one week/month for one year (same as NADP)
- Sampling began Jan-Feb 1998 and will continue for three years



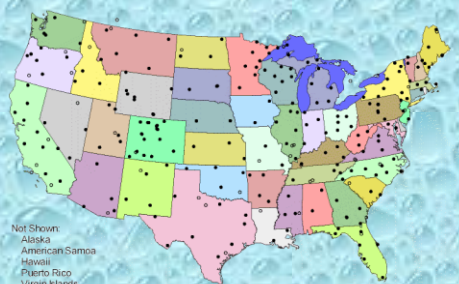


The Casco Bay deposition site is part of the MEDEP's Southern Maine Air Monitoring Network



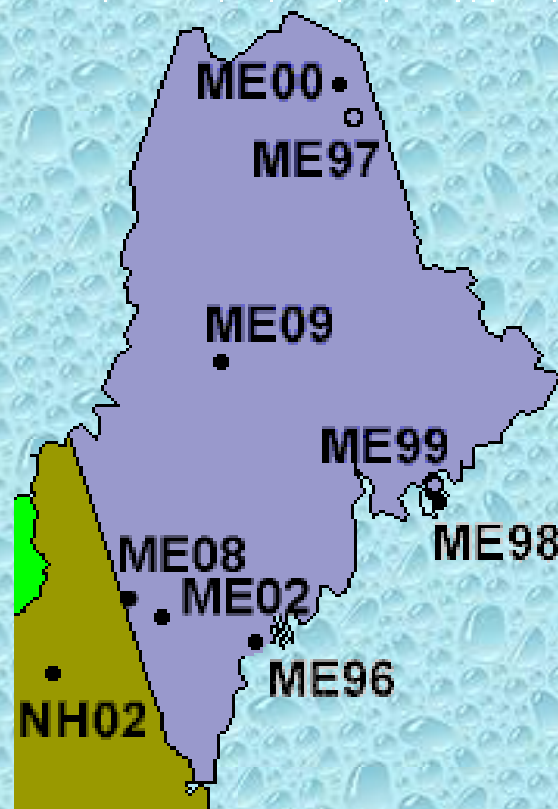


The deposition site is also part of the National Atmospheric Deposition Program - NADP

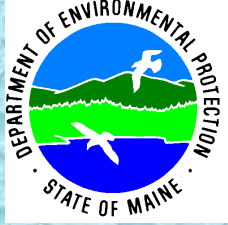


National Atmospheric Deposition Program

ME00:	Caribou
ME02:	Bridgton
ME08:	Gilead
ME09:	Greenville
ME96:	Freeport
ME98:	Acadia, McFarland Hill

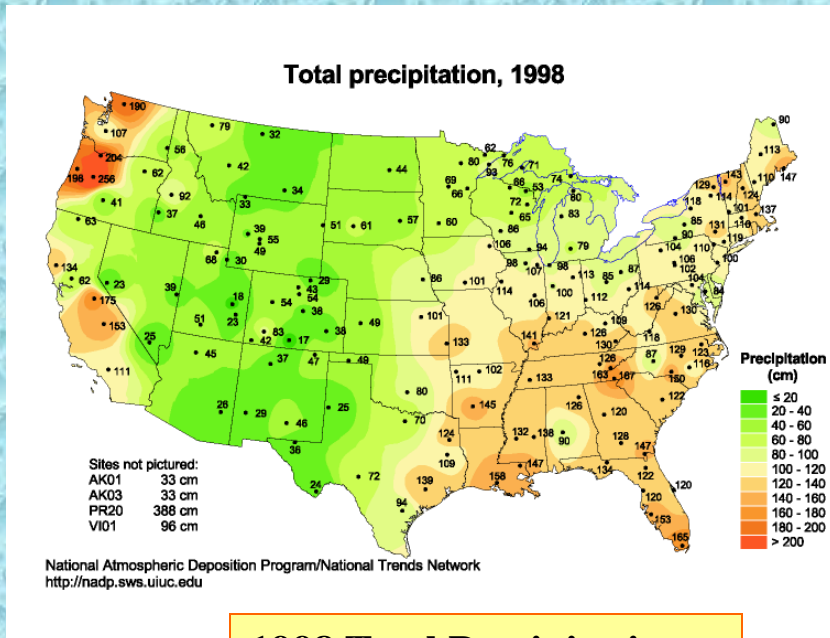


Inactive: 97 Presque Isle; 99 Acadia Paradise Hill

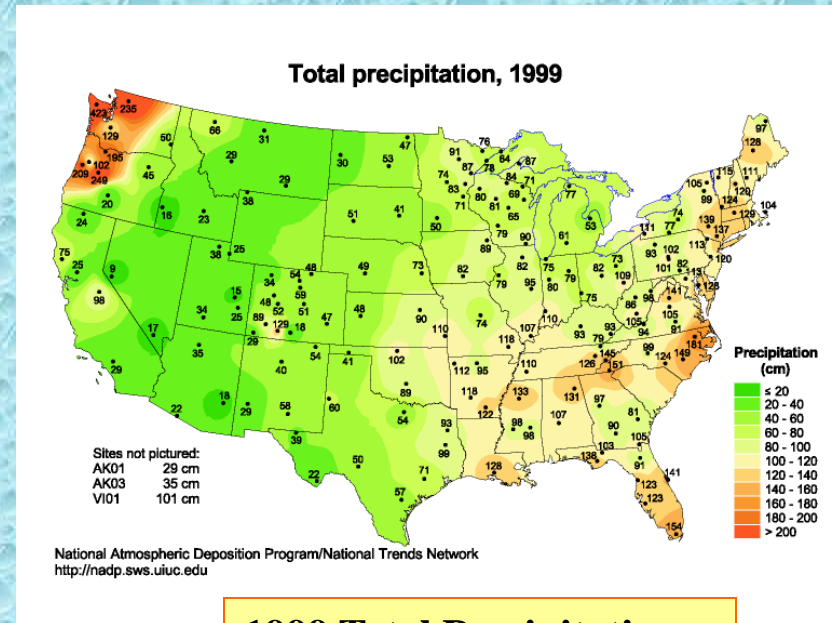


NADP precipitation isopleth maps.
The CBDP data is in the box adjacent to the corresponding map

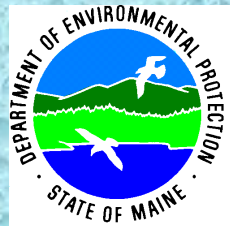
NADP



1998 Total Precipitation:
128.7 cm

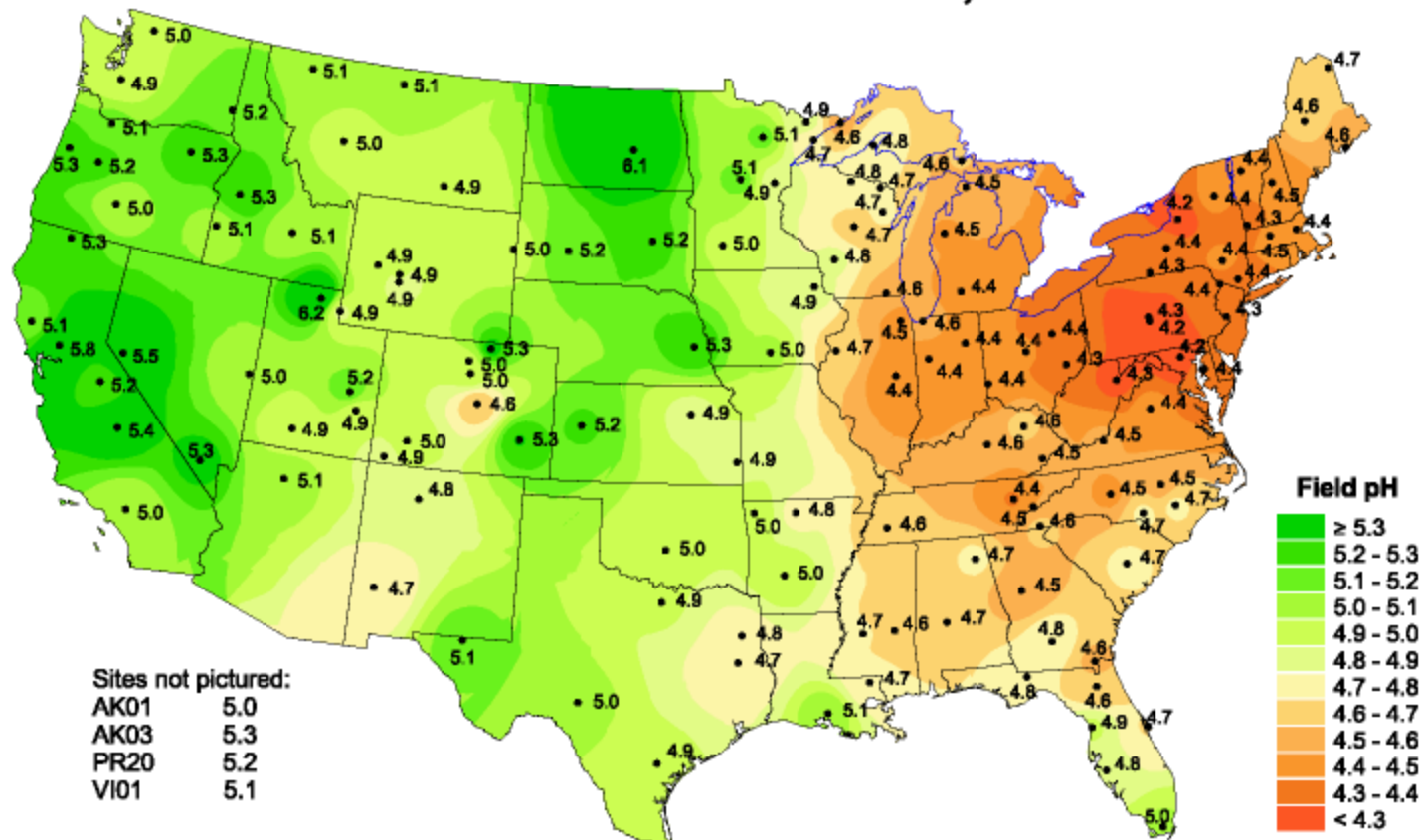


1999 Total Precipitation:
118.5 cm



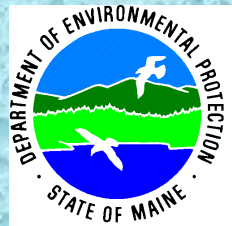
NADP

Hydrogen ion concentration as pH from measurements made at the field laboratories, 1998



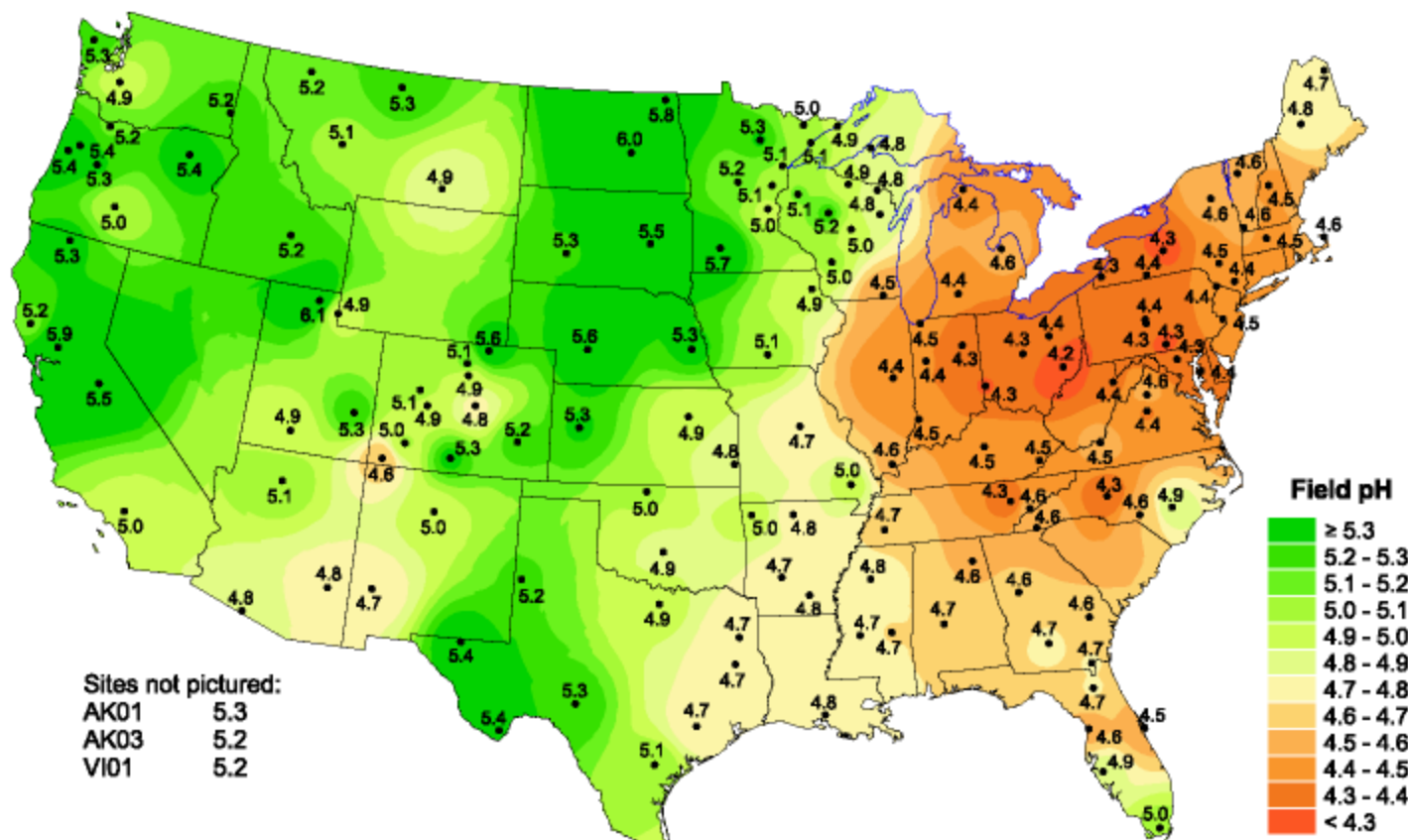
National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

1998 Annual Average pH:
4.62



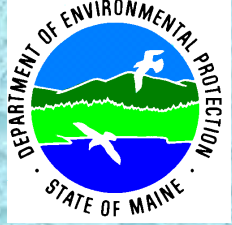
NADP

Hydrogen ion concentration as pH from measurements made at the field laboratories, 1999



National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

1999 Annual Average pH:
4.58



Deposition Trends

Precipitation chemistry dominated by sulfates and nitrates

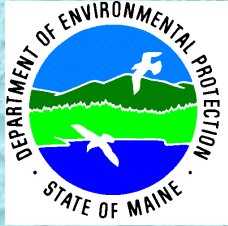


Coastal marine environment has significant influence on precipitation chemistry (sodium and chloride 42% of measured species)



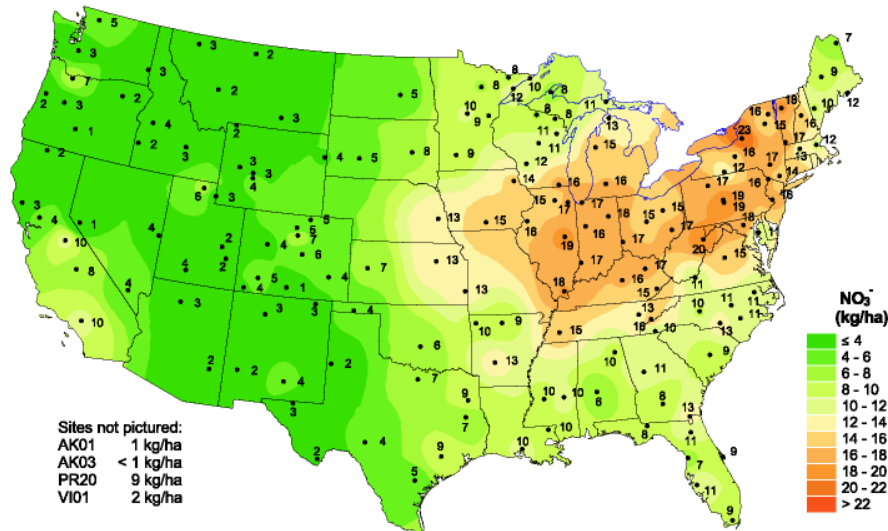
East / West and North / South variations in precipitation chemistry across the state (other pollutants like ozone show this kind of variation)

NADP



NADP

Estimated nitrate ion deposition, 1998



Sites not pictured:
AK01 1 kg/ha
AK03 < 1 kg/ha
PR20 9 kg/ha
VI01 2 kg/ha

National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

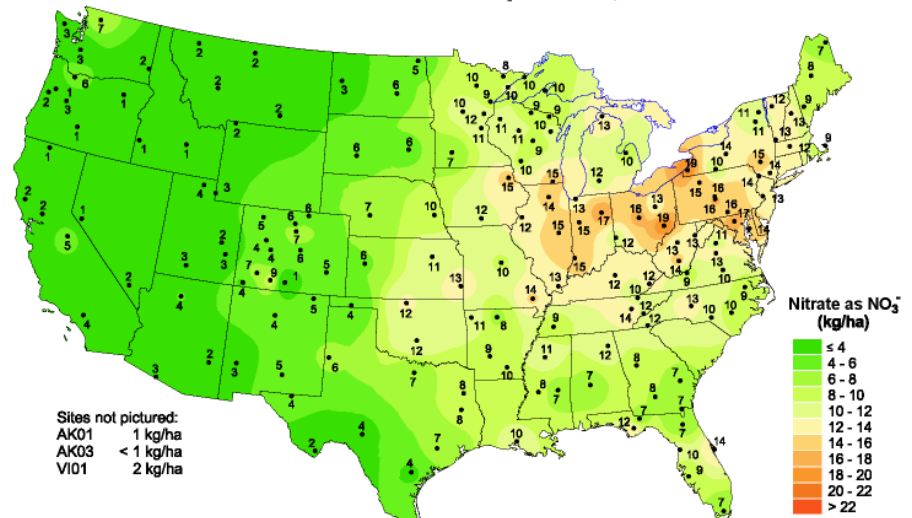
1998 Nitrate Annual Average:

10.91 kg/ha

Highest seasonal average in 1998:

Summer: 3.71 kg/ha

Estimated nitrate ion deposition, 1999



Sites not pictured:
AK01 1 kg/ha
AK03 < 1 kg/ha
VI01 2 kg/ha

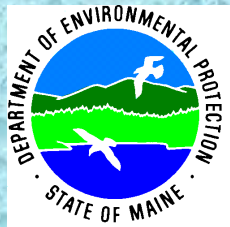
National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

1999 Nitrate Annual Average:

11.09 kg/ha

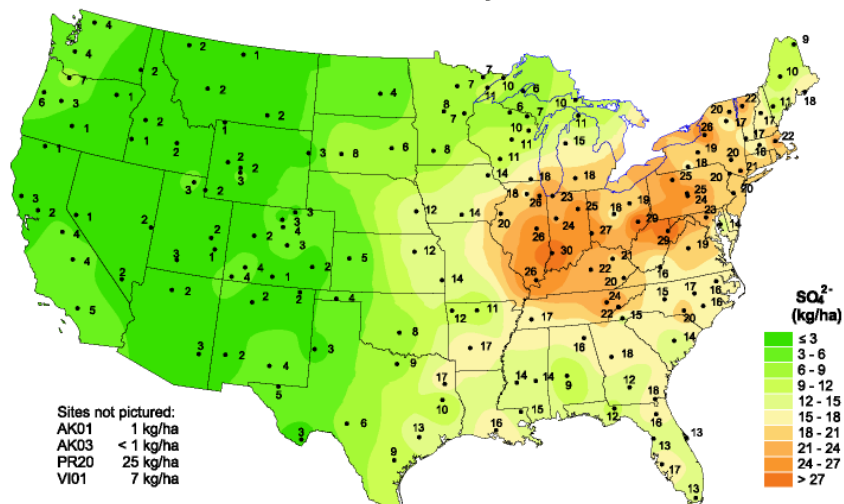
Highest seasonal average in 1999:

Winter: 3.32 kg/ha



NADP

Estimated sulfate ion deposition, 1998



National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

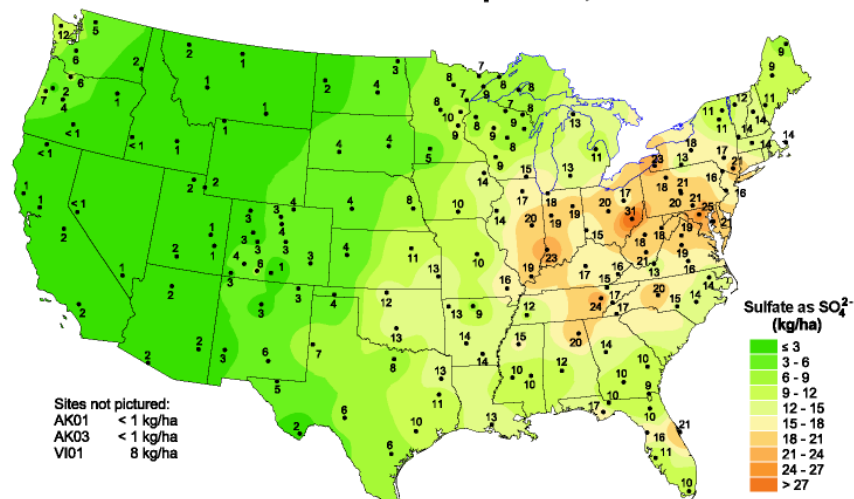
**1998 Sulfate Annual
Average:**

14.22 kg/ha

Highest Seasonal Average:

Summer - 6.24 kg/ha

Estimated sulfate ion deposition, 1999



National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

**1999 Sulfate Annual
Average:**

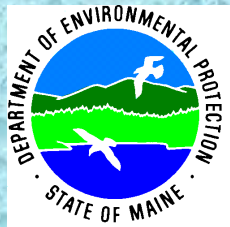
14.44 kg/ha

Highest Seasonal average:

Winter - 4.08 kg/ha

[illegible]

ME00:	Caribou
ME02:	Bridgton
ME09:	Greenville
ME96:	Freeport
ME98:	Acadia, McFarland Hill



MDN

✓ Fairly uniform annual concentration averages
(nannograms per liter or ng/l) across the state in 1998:

Greenville 5.87 ng/l

Bridgton 6.56 ng/l

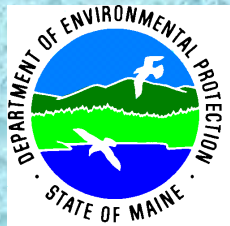
Freeport 7.78 ng/l

Acadia 6.06 ng/l

✓ Highest concentrations in summer months of
June, July and August

✓ In 1998 Freeport had the highest annual
deposition rate of 12.1 ug/m² (micrograms per meter
squared)

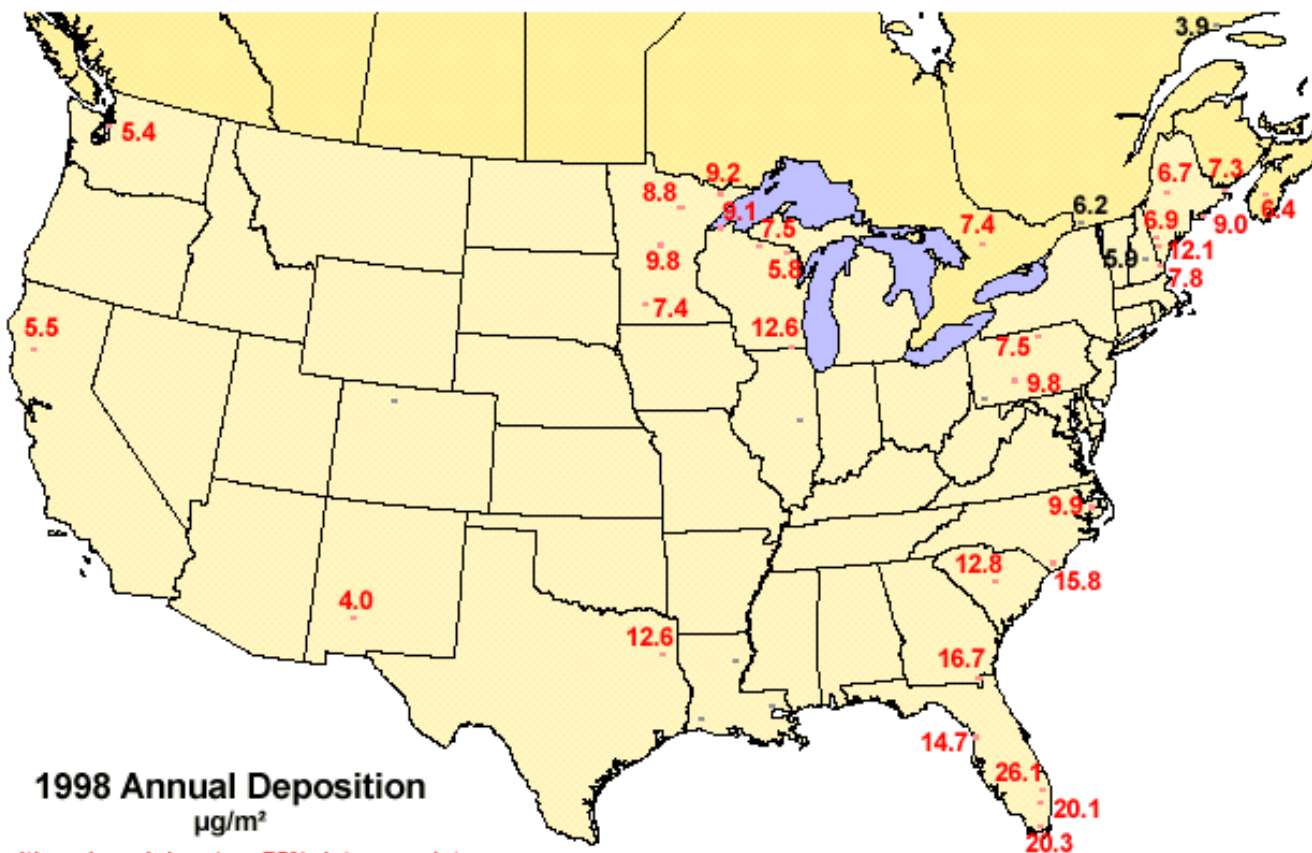
✓ More pollutant and acidity laden precipitation
tends to contain more mercury

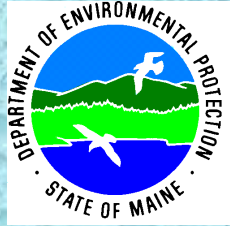


MDN

1998 Annual Deposition Values

National Atmospheric Deposition Program Mercury Deposition Network

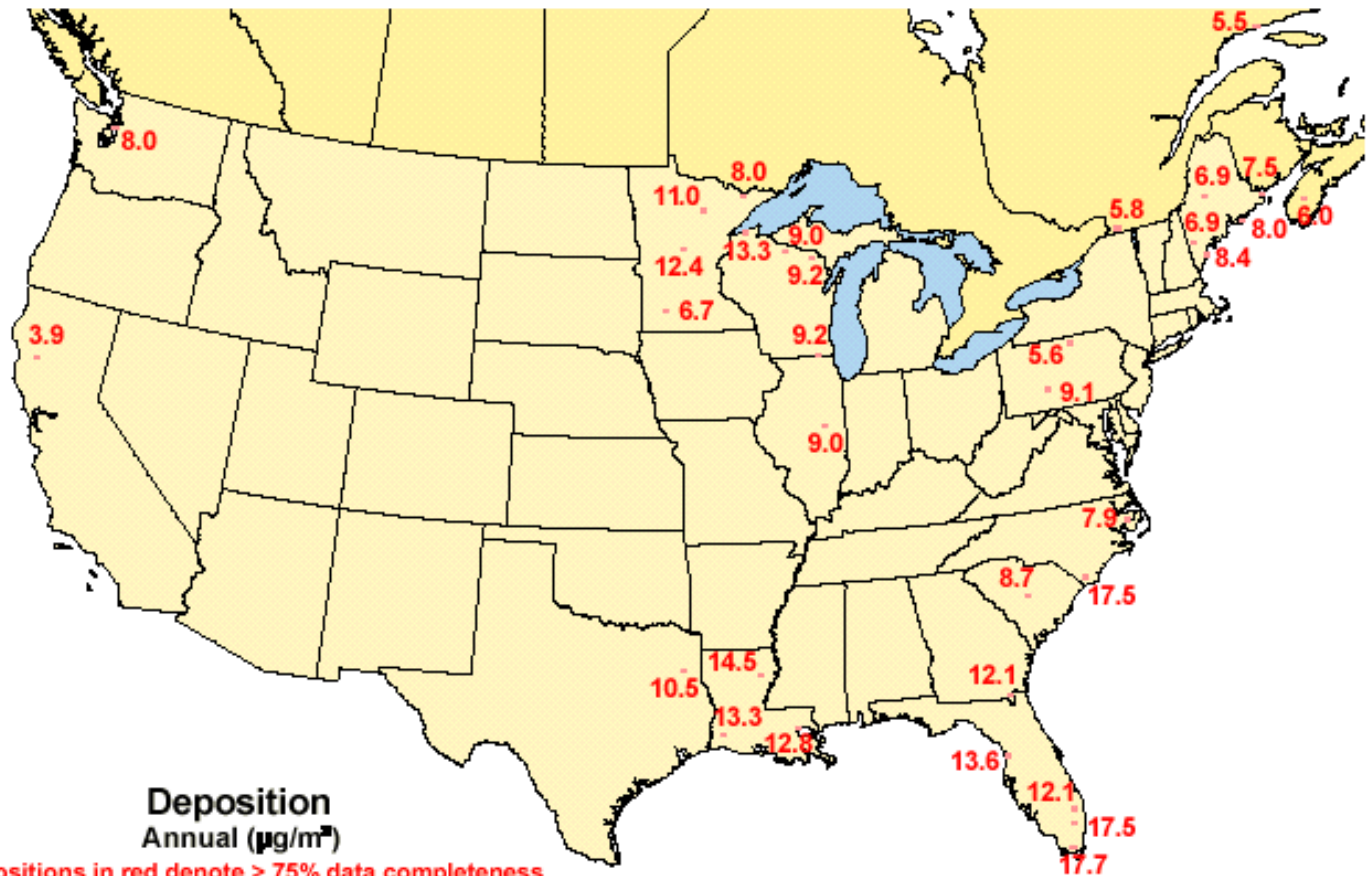


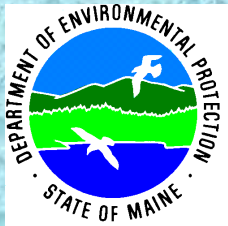


MDN

1999 Annual Deposition Values

MDN - 1999





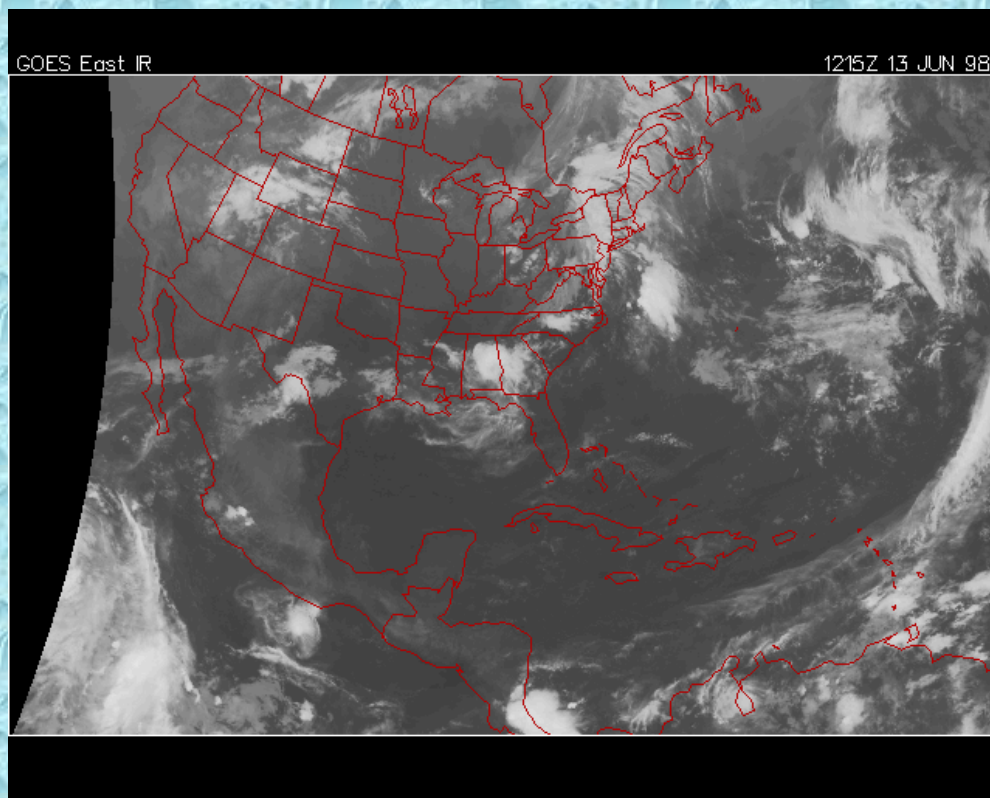
2.208 ug/m³ or 18% of the annual Mercury deposition occurred during the sampling period of 6/9/98 - 6/16/98.

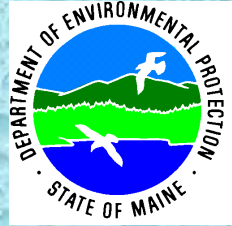


MDN

✓ June was 3rd wettest on record - 9.01 inches; 7 inches fell from 6/12 through 6/17

✓ On June 13th Freeport received 3.58 inches of rain

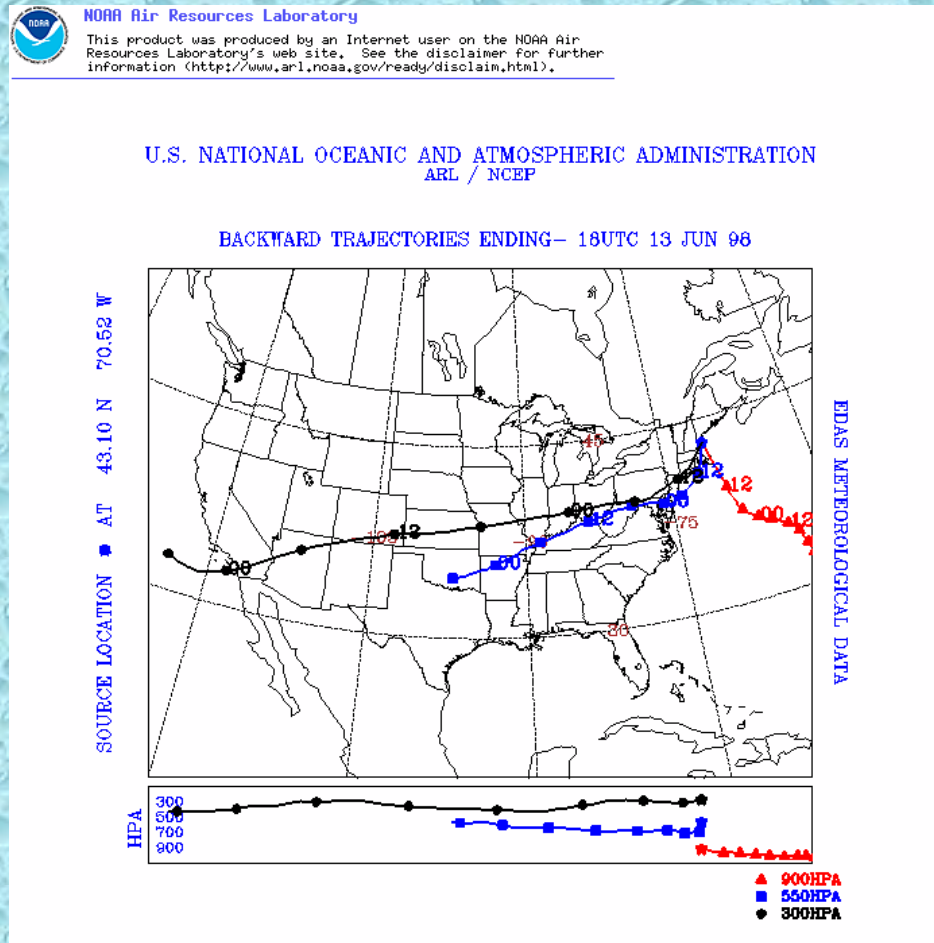




MDN

Trajectory map created by the READY HYSPLIT model. This is a back trajectory showing the origins of the system that produced so much rain.

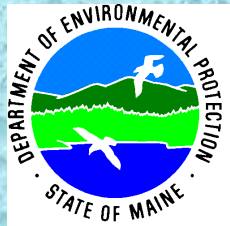
www.arl.noaa.gov/ready/hysplit4.html



Red = 1000 m

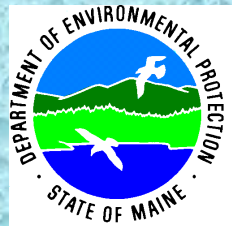
Blue = 5000 m

Black = 10000 m



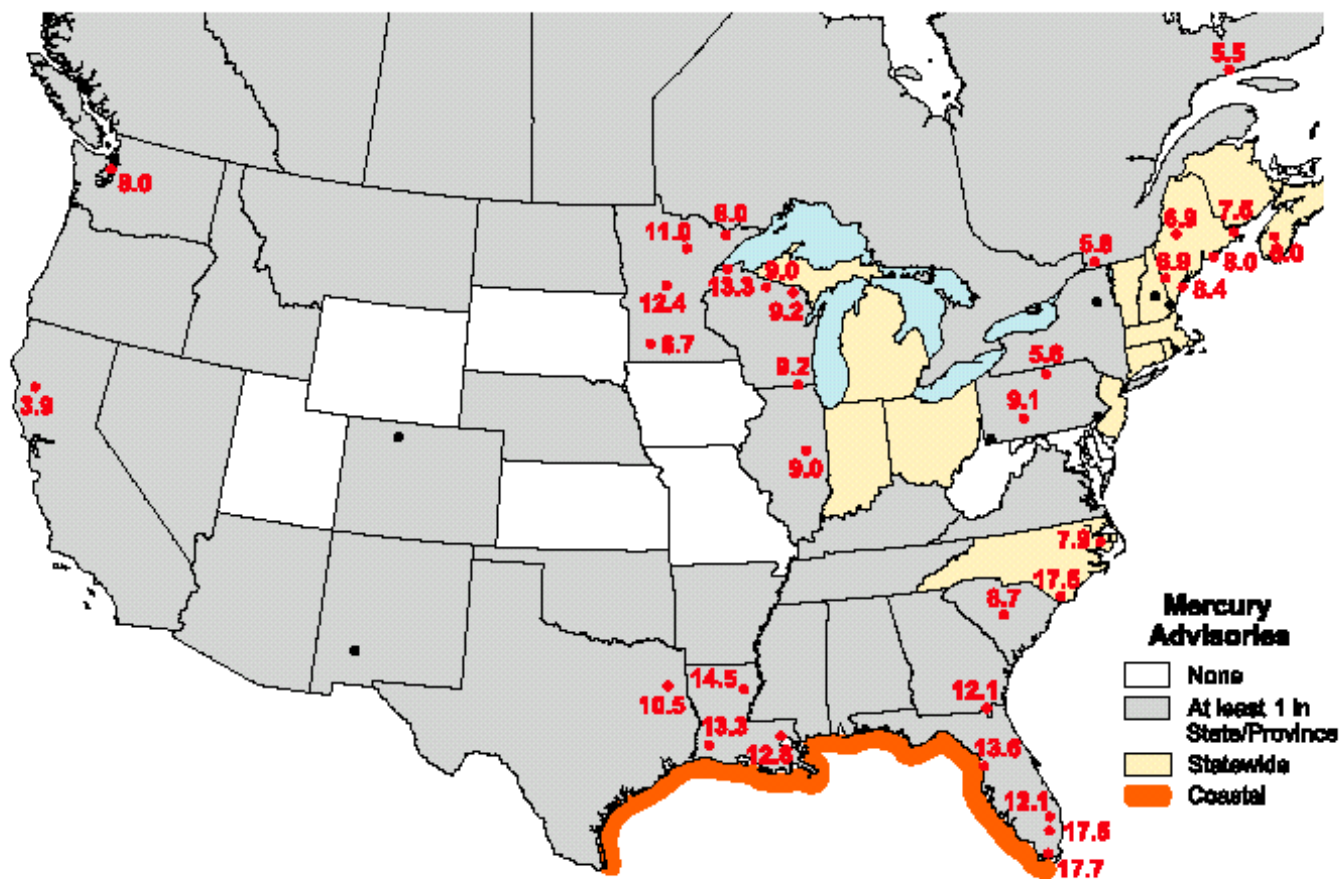
NADP data corresponding to the sampling period of June 9, 1998 to June 16, 1998 and compared to annual averages for 1998:

	June	1998
pH:	4.65	4.62
Na	149.98 mg/m2	775 mg/m2
Cl:	258.68 mg/m2	1305 mg/m2
NO3:	86.69 mg/m2	1090 mg/m2
SO4:	154.11 mg/m2	1422 mg/m2

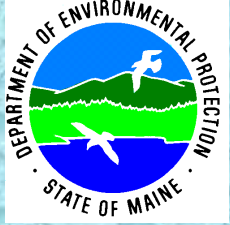


MDN

Map showing Mercury Advisories and corresponding 1999 data:



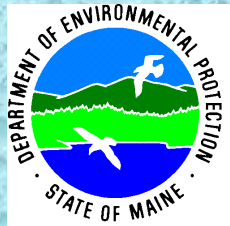
National Atmospheric Deposition Program/Mercury Deposition Network



IMPROVE

The CBDP is also a part of the Interagency Monitoring of Protected Visual Environments or IMPROVE network:

- ✓ USEPA and National Park Service
- ✓ Measures the composition of visibility impairing aerosols
- ✓ Help identify sources of impairment on individual site, regional, and national scales
- ✓ Document trends



IMPROVE

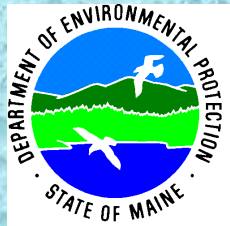


IMPROVE Modular Aerosol Sampler

Explanation of IMPROVE Sampling Modules:

- **Module A:** PM_{2.5} particles (0-2.5 μ m) on Teflon. These are analyzed by five methods:
 - gravimetric mass for PM_{2.5}
 - hybrid integrating plate/sphere method for optical absorption
 - Proton Elastic Scattering Analysis (PESA) for hydrogen
 - Proton Induced X-ray Emission (PIXE) for Na-Mn
 - X-Ray Fluorescence (XRF) for Fe-Pb
- **Module B:** PM_{2.5} particles (0-2.5 μ m) on nylon. A denuder before the nylon filter removes nitric acid vapors. These are analyzed by ion chromatography (IC) at Research Triangle Institute for nitrate (NO₃⁻), chloride (CL⁻), sulfate (SO₄²⁻), and nitrite (NO₂⁻).
- **Module C:** PM_{2.5} particles (0-2.5 μ m) on quartz. These are analyzed by at Desert Research Institute for carbon using the Thermal Optical Reflectance (TOR) combustion method. A secondary filter at selected sites is used to determine artifact. These are reported in 8 temperature categories.

IMPROVE composition at Freeport

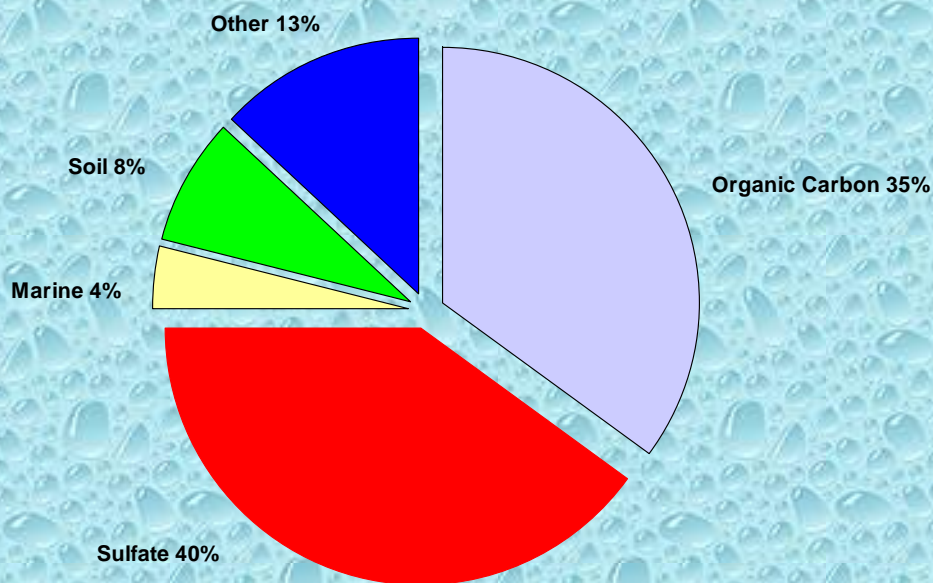


IMPROVE

Fine aerosol composition is dominated by pollutants from human activities

Levels of airborne pollutants at Freeport are generally lower than those found in urban areas such as Boston

Air mass trajectory analysis indicates that both regional and long range source regions influence pollutant levels in and around Casco Bay



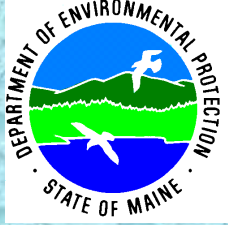
Aerosol Composition in Freeport, Maine



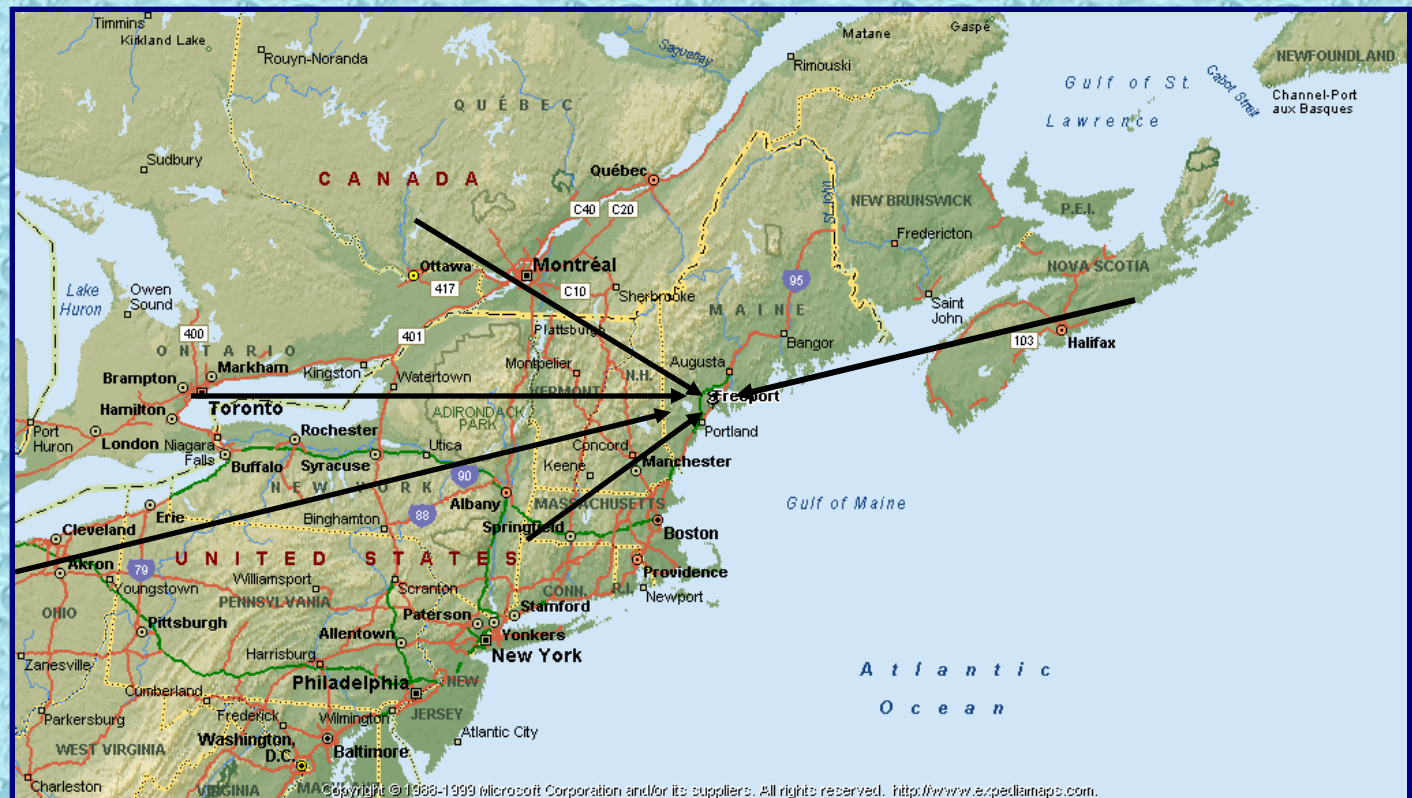
IMPROVE Caveats (Byard Mosher Data Report 9/27/00) :

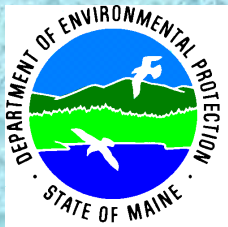


- 1. Fine Mass values may be suspect. Sum of Species values are much greater than the FM totals.**
- 2. Mercury values are suspect and much higher than values reported from other studies in the Northeast.**



Possible regional sources for IMPROVE aerosol pollutants - based on trajectories run by Byard Mosher





IMPROVE

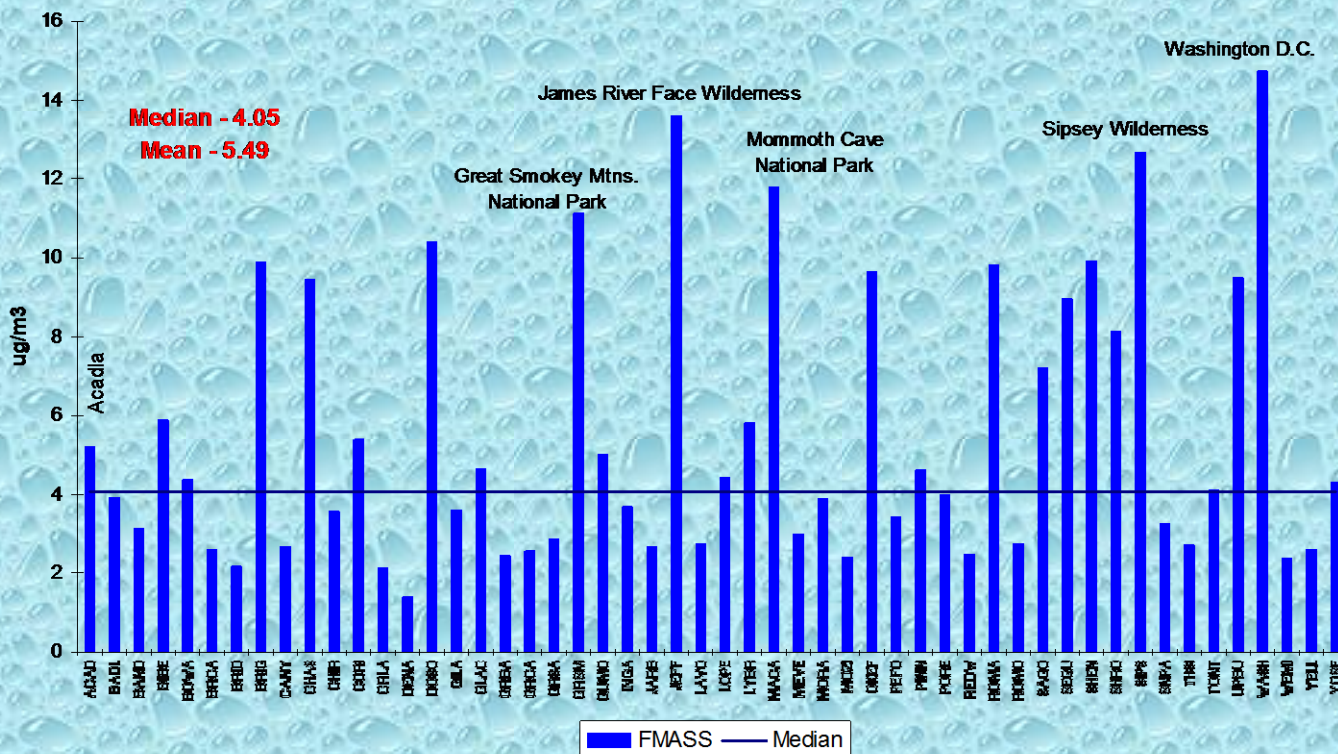
1/98 -6/99 CBDP
Fine Mass:

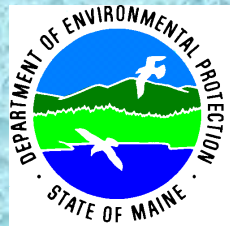
Median **3.5**

Mean **5.05**

Comparison of CBDP Fine Mass data to National data trends:

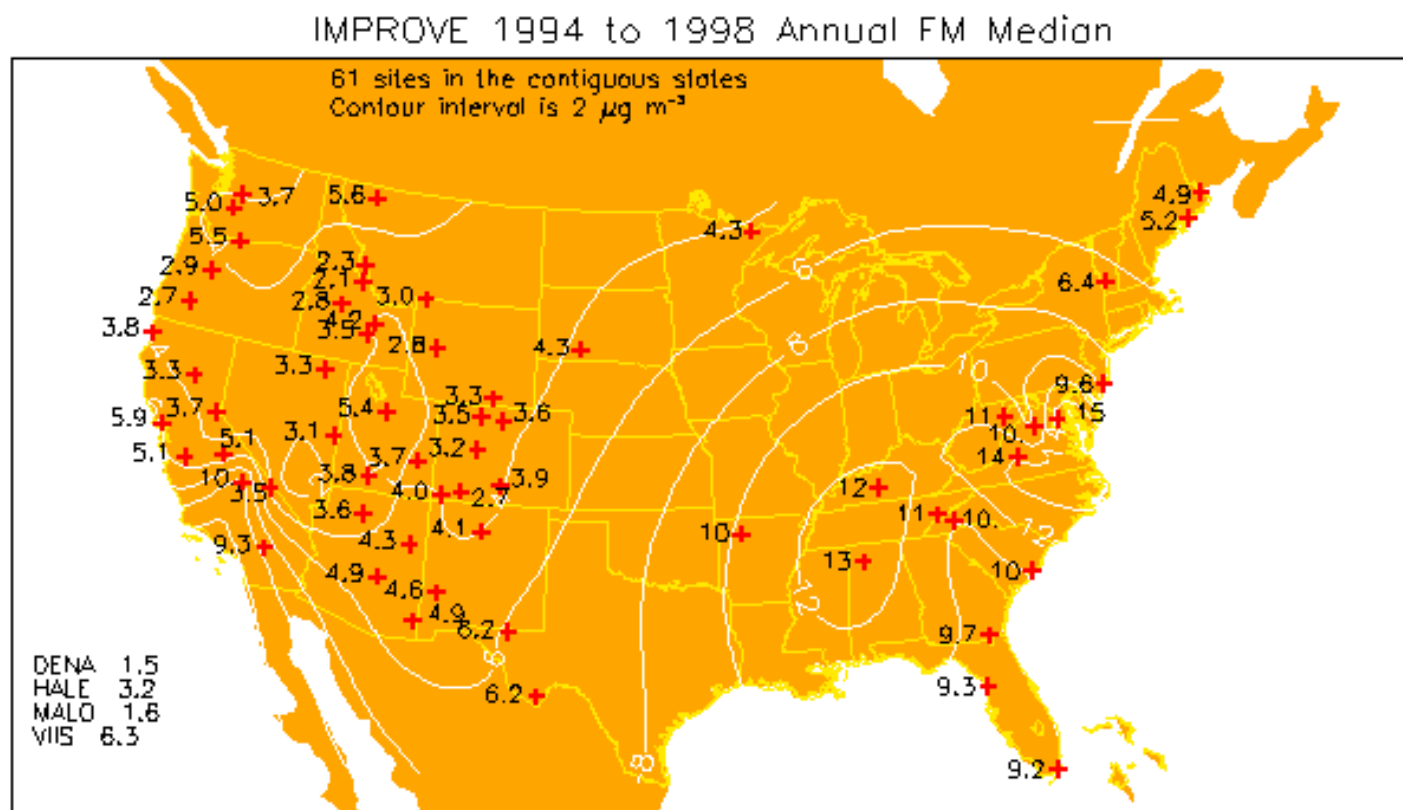
5-Year Annual Average 1995 - 1999
NPS Sites
Fine Mass



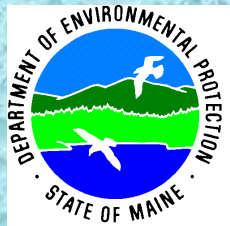


IMPROVE

IMPROVE Fine Mass isopleth map:



NPS ARD Fort Collins CO, Mon Aug 30 17:47:04 1999



PAH Monitoring Configuration

Dan S. Golomb and Eugene F. Barry
- Principal Investigators

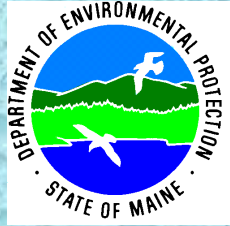
University of Massachusetts - Lowell



Figure 1. The UML wet/dry collector



Figure 2. The interior of the dry collector



PAH

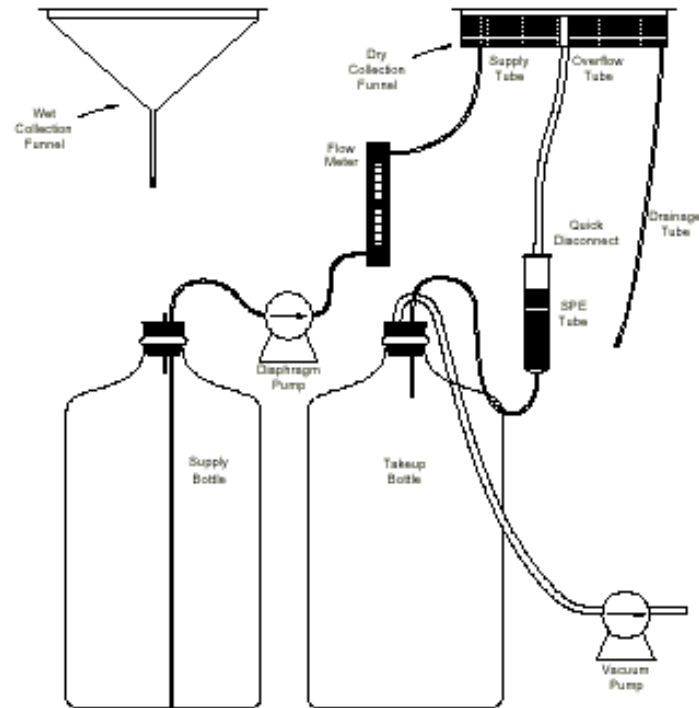
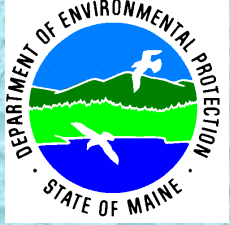


Figure 1. Schematic of UML wet/dry collector

Wet deposition runs into a funnel that drains into a temperature controlled, shielded collection flask. Dry deposition onto the surface of a funnel continually filled with purified water. The overflow (collection surface) is caught by the receiving flask. (Simulating the ocean surface)

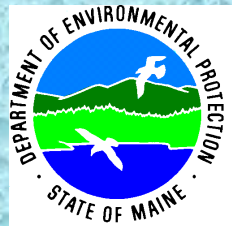


PAH



Figure 2. Photo of UML wet/dry collector

Photo of wet /dry PAH collector



PAH

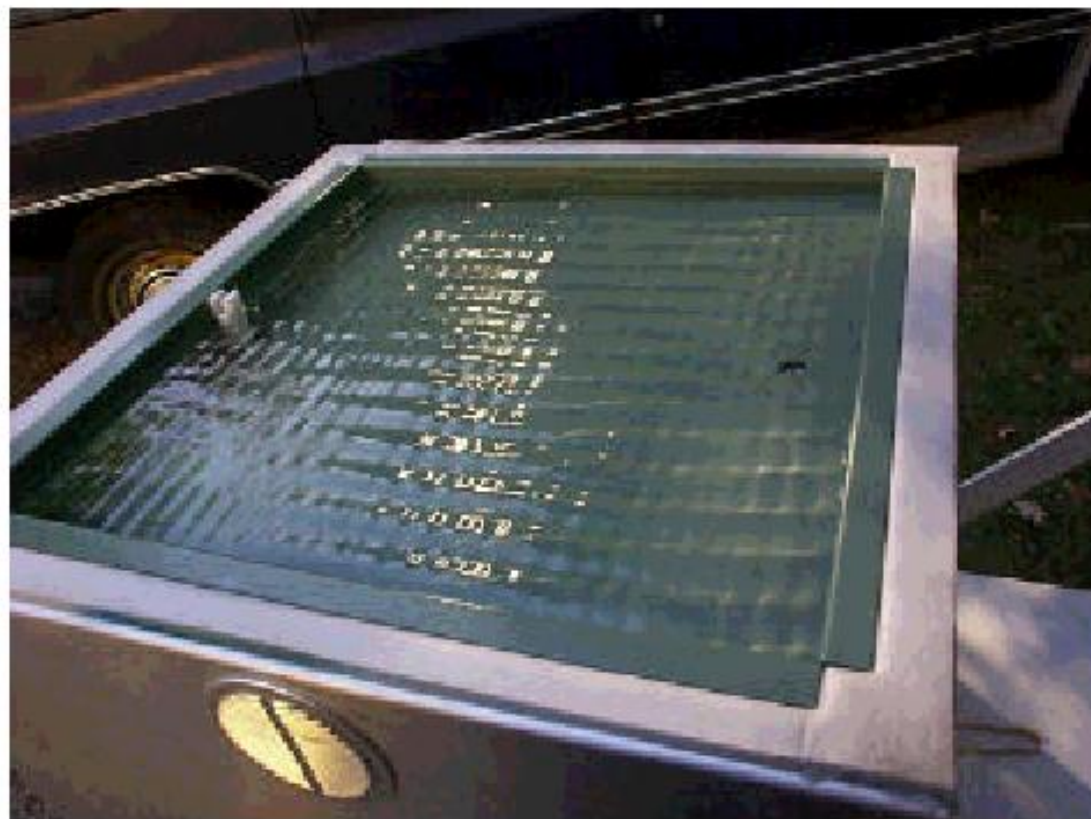


Figure 3. Top view of the dry collector

PAH Monitoring Summary:



- ✓ A modified precipitation collector designed by Dr. Dan Golomb (UMass-Lowell) was deployed at the Freeport site for one year
- ✓ 16 dry deposition and 12 wet deposition samples were collected between March 1998 and February 1999
- ✓ Dry PAH deposition at Freeport was lowest during the summer and highest during the winter months
- ✓ Dry deposition rates at more urban locations (Boston area) are much higher than those found at Freeport, suggesting that local emissions are a major source for PAHs in dry deposition
- ✓ There was no clear seasonal variation in wet deposition of PAHs at Freeport
- ✓ Precipitation amount does not appear to influence PAH concentrations in precipitation
- ✓ No definitive source(s) for the PAHs found in wet and dry deposition at Freeport could be identified

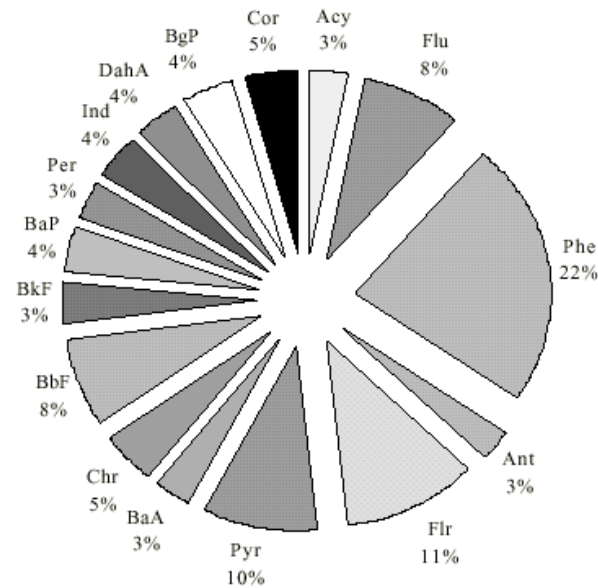
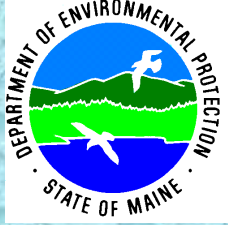


Figure 4. Average annual composition of PAH species in wet deposition

There was very little difference between the average annual composition of PAH species in the wet and dry deposition.

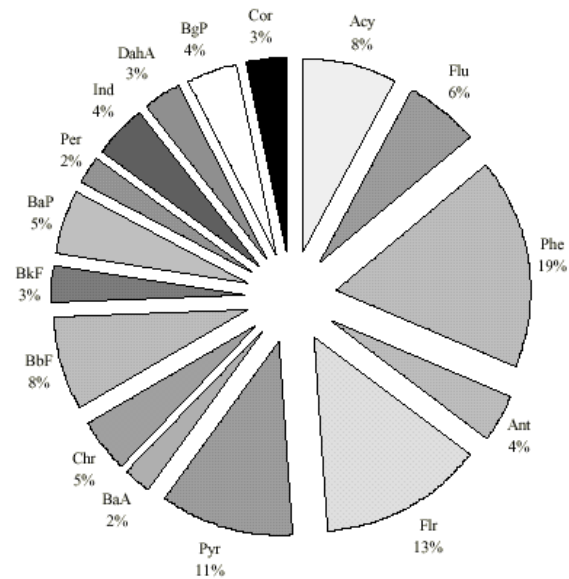
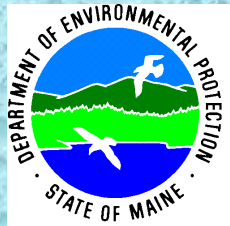


Figure 5. Average annual composition of PAH species in dry deposition



Summary of Preliminary Results from the Casco Bay Air Deposition Study

- **Coastal regions of Maine experience higher concentrations and deposition of pollutants compared with in-land sites.**
- **Both fine particle and precipitation chemistry at Freeport are dominated by man-made pollutants.**
- **The deposition of Nitrogen and Mercury to Casco Bay is significant and comparable in magnitude to point source inputs.**
- **Regional sources of airborne pollutants appear to be varied and complex. Both nearby sources such as metropolitan areas along the eastern seaboard and more distant sources, such as the industrialized Ohio River Valley, are important.**

