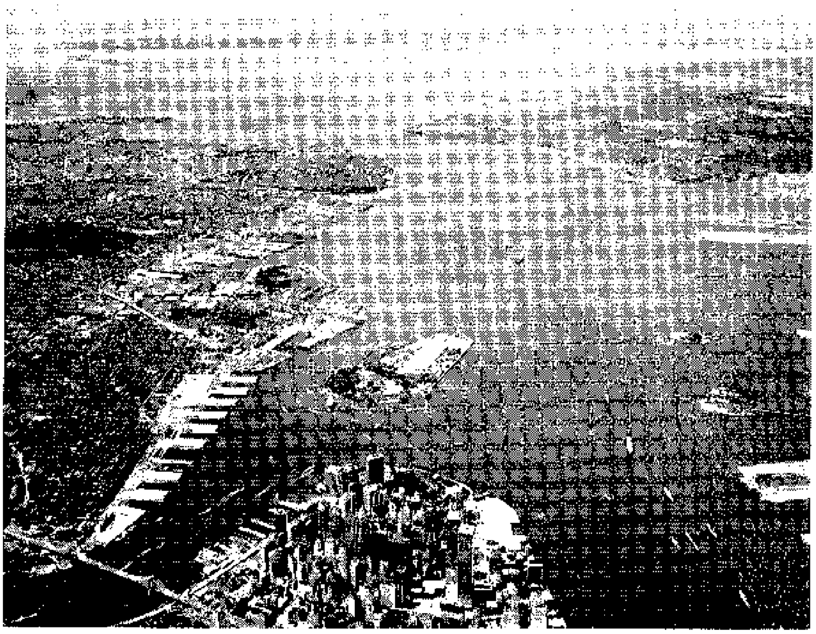
*Proceedings*

# The Significance of Atmospheric Pollutant Loading to the New York–New Jersey Harbor Estuary and Watershed



Michael P. Weinstein, Ph.D., Kim E. Kosko, Lisa S. Young, and Thomas J. Belton, Editors
and
Bruce J. Brownawell, Ph.D. and Stuart J. Nagourney, Roundtable Facilitators

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NEW JERSEY MARINE SCIENCES CONSORTIUM
Sea Grant New Jersey
MONMOUTH UNIVERSITY

# Preface

Bruce J. Brownawell, Ph.D.

Atmospheric deposition has long been recognized as an important source of nutrient, metal, and semi-volatile organic contaminants to soils and surface waters. But for potentially toxic forms, there has been a lack of long-term funding to quantitatively assess receptors at risk. Unlike acid rain studies where national and state sponsored atmospheric deposition monitoring programs have been successful in advancing scientific understanding and in shaping policy and regulations related to air emissions of nitrogen and sulfur, monitoring for airborne trace metal and organic contaminants have not enjoyed the same degree of success.

Similarly, research on these compounds, much of which has been generated or in part inspired by Drs. Steven Eisenreich and John Reinfelder, both of Rutgers University, has demonstrated the difficulty in designing programs to effectively address management questions (e.g., identifying contaminant sources and integrated fluxes to watersheds). Some of the challenges addressed at this Workshop included: trace level analyses that requires experienced laboratories to conduct the sampling and the analysis; the sometimes dramatic spatial variability (more so than for nutrients) that emphasizes the need for monitoring network approaches; and the need to simultaneously monitor multiple media to estimate gaseous fluxes of semi-volatile organics, and perhaps metals like mercury. New Jersey, and other partners from the region, have adopted a systematic network approach for assessing atmospheric deposition. The presentations and discussions at the Workshop highlighted the approaches being used, important results to date, and began to address ways that the data from this effort might be used now and in the future. I attended because I was interested in the learning more about the specifics of this "first of its kind" effort, and to hear about results from the individual studies.

The papers that make up these Proceedings best summarize the major goals and findings from the New Jersey atmospheric deposition study. I would like to share several impressions as I was introduced for the first time to the scope of the program. Perhaps more important than the scale of the project, and the questions that can now be addressed by the high frequency synoptic sampling occurring at an impressive array of sites distributed strategically around the New Jersey and the New York/New Jersey Harbor, is the close collaboration and mutual support between State Agencies, their laboratories, the *New Jersey Sea Grant College Program (NJSGCP)* and the University-based researchers that are doing much of the deposition work. This close relationship between the existing, air-quality-based air toxics monitoring program run by the New Jersey Department of Environmental Protection (NJDEP), *NJSGCP*-NJDEP co-funded atmospheric deposition research, and university-based scientists appears to facilitate the deposition program; together they serve to enhance the interpretation and future design of the study. The scientific ties that have developed between personnel from the Department and university researchers, an unfortunately rare event in my experience, will benefit New Jersey's citizenry as the academic community will become more involved in environmental management decisions, and hopefully will ensure a longer life for this model "marriage" between monitoring and research.

The structure of the New Jersey monitoring network not only allows for obvious and important management questions to be addressed but will most certainly lead to unanticipated findings and creation of new management questions. For example, the "first-ever" measurements of the estrogenic compound nonylphenol in atmospheric samples would not likely have been made if Dr. Eisenreich's laboratory was conducting this work on a solely contractual basis, in a mode that did not include the support of graduate students and post- doctoral research associates. Their *NJSGCP*-funded finding that Harbor waters were a sources of nonylphenol to the atmosphere could not have been made convincingly if the spatial array of sampling stations and associated meteorological data did not exist. The focus of Dr. Sybil Seitzinger's *NJSGCP*-NJDEP co-funded research on nitrogen speciation in atmospheric deposition and the bioavailability of those forms of nitrogen is likely to lead to changes in the way that we think about how to best manage nitrogen loadings into our watersheds. Finally, the Workshop itself and this *Proceeding* could not have been possible without co-funding provided by the *NJSGCP* and the NJDEP.

The potential benefits of having "cutting edge" researchers provide the best possible data are obvious. It is having a system whereby researchers have both the access to sufficient funding and an effective mechanism to communicate their ideas and expertise with government that sets this program apart and will likely lead to more effective management decisions in the future.

*Dr. Brownawell is an Associate Professor at the State University of New York, Stony Brook.*

# Foreword

Thomas J. Belton and Stuart J. Nagourney

Understanding the effects of air deposition and other non-point source pollution, including contaminant composition and magnitude of potential loads, is critical to scientists and policy makers for formulating watershed-based management strategies and regional solutions to environmental issues. The USEPA and most states have recognized that multi-media approaches to environmental assessment and management are best when dealing with contaminants that may be transported through both media. These commitments are reflected in recent revisions to both the Clean Water Act and the Clean Air Act, especially the latter's Great Waters Program.

The New Jersey Atmospheric Deposition Network (NJADN) provides us with an approach and a potentially important tool for evaluating time-space variations in concentrations of air contaminant loads to receiving waters in the state. The air-water deposition data will be critical to the development of status and trends information for watershed-based environmental management. It also allows an exploration of deposition and exposure scenarios, as well as providing a basis for characterizing multi-media sources and source strengths, including aspects of sub-regional, regional and long-range transport.

This workshop was developed by the NJDEP's Division of Science and Technology, and organized by the New Jersey Marine Sciences Consortium to review existing air-water data with emphasis on current research in and around the New York-New Jersey Harbor Estuary. A *specific* strategy of the work-shop was to recommend ways to incorporate the data into science-based management strategies. Key objectives were to: a) explore the feasibility for incorporating air components into the watershed management process; b) devise characterization and assessment tools to drive the process; and c) identify the order of these steps and the appropriate endpoints for the process.

From the perspective of environmental practitioners, we would like to understand how to:

- Use air data in a regulatory framework;
- Best design a permanent monitoring network;
- Coordinate efforts among regulatory agencies; and
- Best focus research to assist in regulatory decision-making.

A number of questions were posed during the afternoon roundtable discussion:

- What is the state of our current knowledge regarding the significance of air-borne pollutants and their impacts on coastal waters?
- What are the substantive gaps in our knowledge concerning the aquatic effects of airborne pollutants?
- What pollutants are of primary concern, in order of priority and why?
- For which pollutants do we need additional data, in order of priority?
- Do the air contaminants of concern lend themselves to multi-media modeling?
- What are the potential sources for the various pollutants — local, regional, and national — and the associated regulatory and management framework that can be applied to controlling them?
- Are there sufficient data available of suitable quality to incorporate into the TMDL development process and other water quality management programs?

A summary of the panel discussion is included as part of this *Proceedings*. As a result of this effort, and many other concurrent activities, we hope to extract best management practices and a framework for adaptive management to allow us to be more circumspect in how we monitor environmental contaminants.

*Mr. Belton and Mr. Nagourney are Research Scientists in the Division of Science, Research, and Technology within the New Jersey Department of Environmental Protection.*

# Contents

# Atmospheric Deposition of Organic Contaminants to the Hudson River Harbor Estuary and Coastal New Jersey: The New Jersey Atmospheric Deposition Network

Steven J. Eisenreich, Ph.D.
Rutgers, The State University

## Introduction

Wet deposition via rain and snow, dry deposition of fine/coarse particles, and gaseous air-water exchange are the major atmospheric pathways for persistent organic pollutant (POP) input to the Great Waters such as the Great Lakes, Chesapeake Bay, and the Hudson-River Harbor Estuary. The Integrated Atmospheric Deposition Network (IADN) operating in the Great Lakes and the Chesapeake Bay Atmospheric Deposition Study (CBADS) operating in Chesapeake Bay were designed to capture the *regional* atmospheric signal, and thus sites were located in background areas away from local sources. However, many urban/industrial centers are located on or near coastal estuaries (e.g., Hudson River Estuary and New York Bight) and the Great Lakes. Emissions of pollutants into the urban atmosphere are reflected in elevated local and regional pollutant concentrations and localized intense atmospheric deposition that is *not* observed in the regional signal. The southern basin of Lake Michigan and northern Chesapeake Bay, as two such locations, are subject to contamination by air pollutants such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), mercury (Hg) and other trace metals because of its proximity to industrialized and urbanized Chicago, IL and Baltimore, MD, respectively. Concentrations of PCBs and PAHs are significantly elevated in Chicago and coastal Lake Michigan and in the air over Chesapeake Bay near Baltimore as compared to the regional signal. Higher atmospheric concentrations of pollutants are ultimately reflected in increased precipitation and dry particle fluxes of contaminants to the lake/estuarine waters as well as enhanced air-water exchange fluxes of organic compounds such as PCBs and PAHs. Of course, the role of mobilized in-place pollutants, discharges from wastewater treatment facilities, and upstream river flow to overall water concentrations and loads must be evaluated to determine the relative importance of the atmospheric pathway. Processes of wet and dry deposition and air-water exchange of atmospheric pollutants reflect loading to the water surface directly. This is especially important for aquatic systems that have large surface areas relative to watershed areas (e.g., Great Lakes; coastal seas). Also, water bodies may be sources of contaminants to the local and regional atmosphere representing losses to the water column and inputs to the local atmosphere. This has been demonstrated in the New York /New Jersey Harbor Estuary for PCBs and nonylphenols. However, many aquatic systems have large watershed to lake/estuary areas emphasizing the importance of atmospheric deposition to the watershed (forest, grasslands, crops, paved areas, and wetlands) and the subsequent leakage of deposited contaminants to the downstream water body (Fig.1).

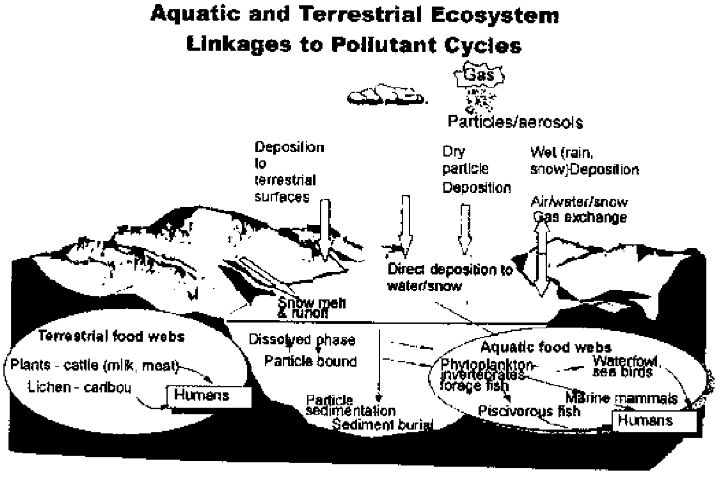
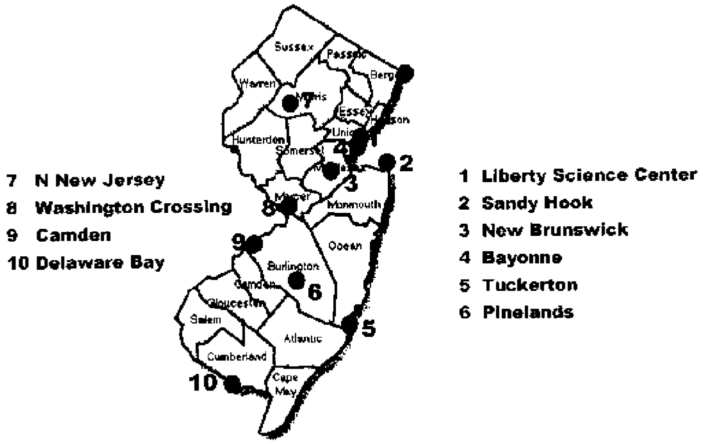


Fig. 1 — Aquatic and Terrestrial Ecosystem Linkages to Pollutant Cycles

Most lakes and estuaries in the mid-Atlantic States have large watershed/water area ratios emphasizing the potential importance of atmospheric pollutant loading to the watershed and subsequent release to rivers, lakes and estuaries.

## New Jersey Atmospheric Deposition Network

Atmospheric deposition of many organic and inorganic contaminants to aquatic and terrestrial systems in the Mid-Atlantic States is potentially important relative to other source pathways. Experience in the North American Great Lakes and in the Chesapeake Bay show that atmospheric deposition of toxic chemicals and metals represents an important, and frequently, the dominant source of contaminants to these systems. The New Jersey Atmospheric Deposition Network (NJADN) was established in October 1997: 1) to support the atmospheric deposition component of the New York Harbor Estuary Program; 2) to support the Statewide Watershed Management Framework and the National Environmental Performance Partnership System (NEPPS) for New Jersey; 3) to assess the magnitude of toxic chemical deposition throughout the State; and 4) to assess in-state versus out-of-state sources of air toxic deposition. The NJADN design is based on the well-developed experience in the Great Lakes and Chesapeake Bay, and is a collaborative effort of Rutgers University, the New Jersey Department of Environmental Protection (NJDEP), the Hudson River Foundation, and the *New Jersey Sea Grant College Program* (NJSGCP). The NJADN is a *research and monitoring* network designed to provide scientific input to the management of the various affected aquatic and terrestrial resources. Atmospheric research and monitoring stations were established at three locations proximate to the Hudson River Estuary (HRE) (Fig. 2).



S.J. Eisenreich, PI Rutgers University
Funded by NJDEP, HRF, NJSG/NOAA

**Fig. 2** — NJ Atmospheric Deposition Network

The first site was established at the Rutgers Gardens Meteorological Station in August 1997 in a suburban area outside of New Brunswick, New Jersey (NB) about 1.5 km both from US Highway 1 and the New Jersey Turnpike. The second site was established at Sandy Hook, NJ in February 1998 on a sandy reef serving as the border between Raritan Bay-Hudson River Harbor Estuary, and the Atlantic Ocean (marine/coastal). The third site was established at the Liberty Science Center (LSC) in Jersey City, NJ in July 1998 in the heart of the urban/industrial complex, on the Hudson River and opposite Manhattan and the Statue of Liberty (urban-industrial). Now sites are operating at sites in the Pinelands, Camden, Washington Crossing, Cape May, Tuckerton and in NW New Jersey as well as at a satellite station in Bayonne.

Each site contains a high volume air sampler for organic compounds equipped with filters and polyurethane foam (PUF) adsorbent operating at a flow rate of 0.5 m$^3$min$^{-1}$. At each site, 24-hour integrated air samples were collected every 6 or 9 days for the first year. The sampling frequency is now once in 12 days to match other long term monitoring programs (e.g., IADN) and to respond to funding limitations. Rainfall is collected over 12 to

24 days using precipitation collectors with 0.21 $m^2$ stainless steel surfaces and attached glass columns filled with resin (XAD-2). Additionally, intensive sampling has been conducted on Raritan Bay/Hudson River and the lower HRE since summer 1998. Both low volume and high volume collectors are also used to assess atmospheric total suspended particulate concentrations (TSP). Meteorological data and transport back trajectories are assessed for each site. The data focus on the signals of atmospheric concentrations and deposition of a group of target organic compounds (PCBs, PAHs, pesticides, nonylphenols; dioxins/furans) estimated for the sites most applicable to the Harbor Estuary: New Brunswick, Sandy Hook and Liberty Science Center.

## Results of the NJADN in the NY-NJ Harbor Estuary Area

The processes typically involved in the estimation of atmospheric deposition of organic compounds are shown schematically in Fig. 3.

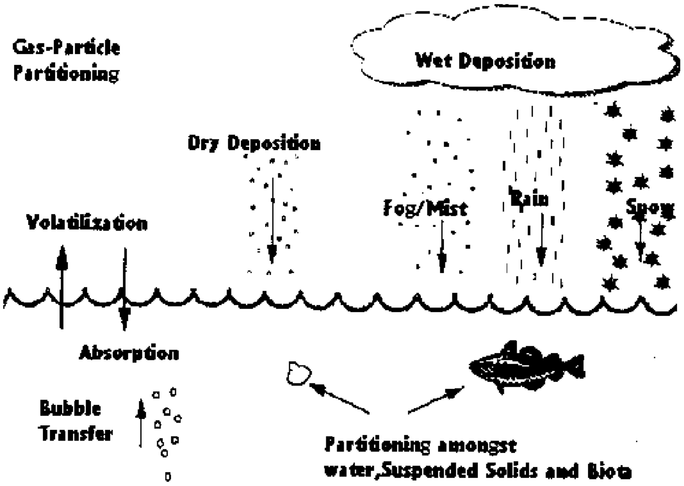


**Fig. 3** — Air-Water Exchange Processes (from Vlahos, Mackay, Eisenreich and Hornbuckle, 1996).

Concentrations of organic chemicals in rain, when multiplied by the amount of rainfall yield wet deposition fluxes. Wet deposition fluxes also include the contribution by snow. Likewise, organic chemical concentrations in the atmospheric particulate phase when multiplied by the appropriate deposition velocity (i.e., atmospheric removal efficiency), yield dry particle depositional fluxes. The product of the air concentration of the gas-phase chemicals and a mass transfer coefficient yields the flux of organic chemical due to gaseous absorption. Deposition by fog or mist is not considered, as are net air-water exchange fluxes. Table 1 lists the preliminary mean concentrations of PCBs, selected chlorinated pesticides, PAHs and PCDDs/Fs in the atmospheric gas and particle phases and rain at New Brunswick, Sandy Hook and Liberty Science Center from the NJADN. The concentration data will be used to estimate temporal and spatial deposition of target chemicals to the HRE.

## Acknowledgments

The NJADN, as a partnership of federal, state and private funding sources, is arguably the most aggressive and comprehensive research and monitoring network currently in the world. Certainly much of the credit for this endeavor must go to the leadership and futuristic thinking provided by D. Suszkowski (HRF), Commissioner Robert C. Shinn and L. McGeorge (NJDEP) and M. Weinstein (*New Jersey Sea Grant College Program*). In the coming years, this research and monitoring program will address key questions about the role of the atmosphere in delivering organic and inorganic contaminants, assist in managing aquatic and terrestrial resources, and identify sources of atmospheric contaminants.

**Table 1** — Concentrations of PCBs, Chlorinated Pesticides, PAHs and PCDDs/Fs in the atmospheric gas and particle phases and rain at New Brunswick, Sandy Hook and Liberty Science Center from the NJADN.

| **Organic Species** | | **NB** | | | **SH** | | | **LSC** | |
|---|---|---|---|---|---|---|---|---|---|
| | **Gas pg/m$^3$** | **Part Pg/m$^3$** | **Rain pg/L** | **Gas pg/m$^3$** | **Part pg/m$^3$** | **Rain pg/L** | **Gas pg/m$^3$** | **Part pg/m$^3$** | **Rain pg/L** |
| | | | | | | | | | |
| Σ-PCBs[a] | 530 | 20 | 2300 | 440 | 12 | 1400 | 960 | 58 | 3000 |
| Σ-[b] Chlordane | 100 | 7 | 690 | 98 | 5 | 500 | 61 | 10 | 100 |
| Trans- Chlordane | 40 | 3 | 230 | 40 | 2 | 170 | 26 | 5 | 40 |
| Cis- Chlordane | 35 | 2 | 230 | 33 | 1 | 170 | 21 | 3 | 30 |
| Trans-Nonachlor | 23 | 2 | 150 | 22 | 1 | 90 | 13 | 2 | 10 |
| 4,4 -DDT | 27 | 9 | 190 | 18 | 3 | 210 | 13 | 3 | — |
| 4, 4 -DDE | 236 | 17 | 410 | 62 | 2 | 80 | 21 | 2 | — |
| HCB | 113 | 1 | 80 | 125 | 1 | 150 | 55 | 0.3 | — |
| PHEN | 8900 | 160 | 28000 | 4800 | 83 | 24000 | 15000 | 330 | 72000 |
| PYRENE | 690 | 140 | 19000 | 410 | 70 | 19000 | 1600 | 400 | 40000 |
| B[b,k] FLUOR | 12 | 320 | 27000 | 3 | 120 | 32000 | 5 | 600 | 40000 |
| B [a] P | 37 | 88 | 8000 | 2 | 33 | 9000 | 5 | 200 | 16000 |
| $\Sigma CL_{4\text{-}8}$ DD/Fs[c] | | 1400 | | | 830 | | | 880 | |
| $\Sigma CL_{2\text{-}8}$ DD/s[c] | | 5160 | | | 2310 | | | 2430 | |
| $\Sigma CL_{2\text{-}8}$ DF s[c] | | 670 | | | 2570 | | | 2320 | |

a-sum of PCB congeners; b-sum of cis&trans chlordane and cis&trans nonachlor
c-chlorinated dioxins and furans; sum of gas + particulate

Appendix 2 (*see* page 44) of this document includes scientific publications already in place describing the role of the atmosphere primarily in the New York–New Jersey Harbor Estuary. The NJADN research team includes C. Gigliotti, P. Brunciak, E. Nelson, D. Van Ry, T. Glenn, J. Dachs, L. Totten, R. Lohmann, and S. Yan. Without their hard work and dedication, the NJADN could not have been implemented. Y. Gao and J. Reinfelder of Rutgers University are collaborators on several of these projects. The NJADN has been funded in part by the Hudson River Foundation (D. Suszkowski), the *New Jersey Sea Grant College Program* (NOAA, M. Weinstein), the New Jersey Department of Environmental Protection (S. Nagourney), and the New Jersey Agricultural Experiment Station.

# Atmospheric Deposition of Mercury to the New York–New Jersey Harbor Estuary and Watershed

John R. Reinfelder, Ph.D.
Department of Environmental Sciences
Rutgers, The State University

Mercury (Hg) is of environmental concern in aquatic ecosystems due to the toxicity of the mercury metabolite known as monomethylmercury ($CH_3Hg$). In this form, Hg may accumulate to toxic levels in aquatic biota, birds, and mammals (including humans) that consume fish and shellfish. Mercury methylation, as the formation of methylmercury from inorganic Hg is known, is mainly controlled by the activity of anaerobic bacteria and by a number of water quality parameters, as well as by the supply of reactive forms of mercury (largely HgII) to the water body and the formation and loss of metallic mercury, Hg°. Since atmospheric deposition is the major source of Hg to many surface waters, other variables being equal, increased atmospheric deposition should result in increased methylmercury concentrations in fish. Many environmental and biological factors affect the accumulation of methylmercury in aquatic food webs resulting in different patterns of methylmercury bioaccumulation in different waters subject to similar inputs from the atmosphere. Variations in the deposition of Hg can be used as a proxy for trends in Hg bioaccumulation and to quantify the extent that bioaccumulation is likely to respond to controls of industrial and other human activity-related inputs of Hg to the atmosphere.

## The Importance of the Atmosphere as a Source of Mercury to Aquatic Systems

Atmospheric deposition dominates the inputs of mercury to many natural waters, but is complicated by the long residence time of mercury such that atmospheric inputs from both long-range and local sources can be important (Fig. 1).

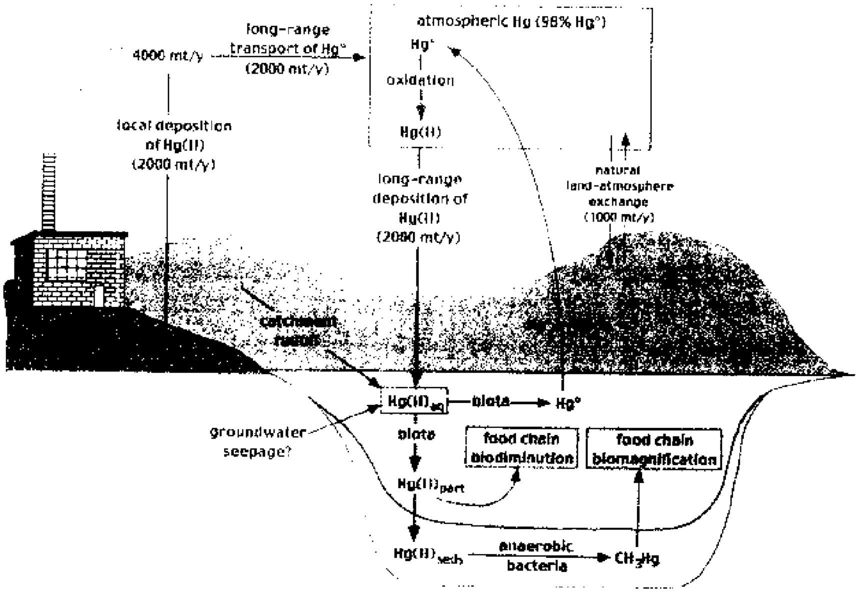


**Fig. 1** — Atmospheric and Aquatic Cycling of Mercury Including Global Annual Atmospheric Emission and Deposition Rates (mt = 1 metric ton = 1,000 kg) Based on Estimates from Mason et al., 1994. Ocean-Atmosphere Exchange of 2,000 mt/y, Not Shown

The atmospheric concentration of Hg has tripled over the past 150 years as a result of industrial activities, primarily power generation and waste incineration, which, worldwide, currently contribute about 4000 metric tons of Hg to the atmosphere each year. Half of the Hg emitted by human activities is in the oxidized ionic form Hg(II) and half is metallic mercury (Hg°). Hg(II) has a short atmospheric residence time (1 week) and is deposited regionally, but Hg°, which has a low aqueous solubility and is converted by oxidation to Hg(II) relatively slowly, has a residence time in the atmosphere of about 1 year. Thus, unlike other metals that are emitted primarily in ionic form, Hg is subject to long range transport and atmospheric deposition far from sources. The atmospheric deposition of Hg to aquatic systems is reflected in the accumulation of Hg by water, sediments, and fish. Thus, in water bodies that are not subject to other Hg loadings (from point or non-point sources), trends in Hg deposition are recorded in lake and wetland sediments, largely as inputs from the atmosphere. The accumulation of Hg in sediments has been studied at a number of remote and rural sites in North America, Europe, and Asia and found a useful tool for assessing spatial and historic trends in atmospheric Hg deposition. It is also important to study accumulation of Hg in sediments because the sediment concentration is an important factor correlated with Hg concentrations in fish. The increase in Hg accumulation in remote water bodies over the past two decades suggests that global Hg contamination is on the rise. However, regional patterns of Hg emissions and deposition can overwhelm the global signal (e.g., reduced emissions from regional sources are thought to have contributed to declining Hg accumulation in Minnesota and Wisconsin lakes despite increasing accumulation trends in remote lakes). While source emission studies show that anthropogenic Hg emissions in North America have increased significantly over the past 150 years, Hg accumulation in many parts of the U.S. have declined since the 1970s as a result of the elimination of point sources and the implementation of environmental controls in power generation and waste incineration facilities.

## Mercury in New Jersey's Atmosphere and Surface Waters

New Jersey surface waters receive Hg from atmospheric deposition, land runoff, and the resuspension of contaminated sediments. Hg inputs to surface waters therefore vary depending on proximity to urban/industrial development, watershed area, and inputs from specific point or non-point sources such as the runoff of inorganic and organic Hg pesticides from agricultural lands in certain parts of the state. There are few data on the atmospheric concentrations and deposition of Hg in New Jersey, but preliminary data on rain concentrations and wet deposition are available from the New Jersey Atmospheric Deposition Network (NJADN). Total Hg concentrations in rain and wet deposition fluxes in New Jersey are comparable with values from the Chesapeake Bay and the upper midwestern U.S., and are shown in the table below.

| Site | Concentration[1] (pM) | Wet Deposition (μg m$^{-2}$ y$^{-1}$) | Reference |
|---|---|---|---|
| New Brunswick NJ | 41 | 13.0 | Reinfelder unpub. |
| Jersey City NJ | 51 | 9.7 | Reinfelder unpub. |
| New Lisbon NJ (Pinelands) | 38 | 8.1 | Reinfelder unpub. |
| Camden NJ | 40 | 13.4 | Reinfelder unpub. |
| Sandy Hook NJ | 20 | — | Y. Gao, pers. comm. |
| Chesapeake Bay | 62 | 21.0 | Mason et al. 1997 |
| Baltimore MD | — | 35.0 | Mason et al. 1997 |
| Lake Champlain NY | 32 | 7.9 | Rea and Keller 1996 |
| Lake Michigan | 48 | 8.3 | Hoyer et al. 1995 |
| Little Rock Lake WI | 30 | 8.7 | Fitzgerald et al. 1991 |
| Upper Midwest | — | 7.4 | Glass and Sorensen 1999 |

[1] New Jersey concentrations are medians of 3 to 10 samples collected from Nov. 14, 1999 to Mar. 27 2000. Camden data are from a single sample collected in Mar. 2000.

Interestingly, these data show lower wet deposition rates of Hg in the relatively rural New Jersey Pinelands than other more urban/industrial locations, which suggests that local, intrastate sources can be important. While wet deposition typically accounts for 80–90% of total Hg deposition, dry deposition can be important in some urban areas. Dry deposition includes the deposition of particulate and gaseous forms of Hg(II) and Hg°.

Quantification of these terms as part of the NJADN will help constrain estimates of dry Hg deposition in New Jersey. Once deposited, the cycling of Hg is expected to vary widely among different lakes and wetlands in New Jersey which include kettle lakes, reservoirs, acid lakes in the Pinelands, and highly productive freshwater wetlands and marine estuaries. The importance of water body-specific chemical factors to Hg bioaccumulation is illustrated by the high Hg concentrations in fish from acidic Pinelands lakes which are far from urban/industrial sources of Hg, but are among the highest in the state and often (70%) exceed the US FDA action threshold of 1‰ by weight in edible tissues. Variation in the inputs and cycling of Hg in New Jersey surface waters are also reflected in Hg concentrations in lake and wetland sediments. Such trends have been observed in sediment Hg concentrations from three lakes in northeastern New Jersey which show an increasing gradient in Hg loadings with an increased proportion of urban/industrial-urban/residential land use in the watershed (M. Ayers, USGS, pers. comm.). The relationship between Hg accumulation in sediments and atmospheric deposition is complicated, however, by the contribution of Hg from runoff. Runoff carries Hg accumulated in the watershed as a result of wet and dry atmospheric deposition as well as a minor amount of Hg from natural and anthropogenic terrestrial sources. A study of seven small midwestern lakes found that Hg accumulation rates in lake sediments increased in proportion to the relative size of the watershed drainage area compared with lake surface area and that 20 to 40% of Hg accumulation in the lakes came from the release of atmospheric Hg in drainage basin soils. This study involved lakes whose watershed drainage area:lake surface area ratios ranged from 1.5 to 6. For coastal estuaries with watershed drainage area:water body surface area ratios of 10 to 100, the indirect contribution of atmospheric Hg via watershed runoff could be very large. The midwest lakes study found that 25% of the Hg deposited on the land was transported to the lakes. The value of the "watershed runoff efficiency" for large coastal watersheds is unknown, but could be critical to the evaluation of the impact of atmospheric deposition of Hg to New Jersey coastal waters.

## Information Needs to Evaluate the Importance of Atmospheric Mercury Deposition in the NY/NJ Harbor Estuary

In order to construct a balanced budget of Hg inputs to the NY/NJ Harbor Estuary, inputs from atmospheric deposition as well as other sources need to be quantified. As described above, inputs from the atmosphere include direct wet and dry Hg deposition to the estuary as well as runoff of land Hg derived from the leaching of atmospheric Hg in drainage basin soils. Other inputs may include point source release and groundwater seepage. In order to estimate the budget of inorganic Hg in a coastal system, Hg accumulation rates in estuarine sediments should be quantified. From both an environmental cycling and management point of view, estuarine sediments are the receptors of inorganic Hg in coastal waters since it is in the sediments where inorganic Hg is converted to its biomagnified form, methylmercury, and it is there that historic and modern trends in Hg accumulation and atmospheric deposition are recorded. The addition of Hg to the water column from sediment resuspension is not a source (or sink) of Hg in the system unless such resuspension is linked to the movement of tidal or other currents that results in the net loss of such materials. However, the biologically catalyzed conversion of Hg(II) to $Hg^{\circ}$ and the subsequent evolution of $Hg^{\circ}$ to the atmosphere is a loss of inorganic Hg that could reduce the ecological impact of atmospheric and other inputs.

## Use of Existing and Future Data to Develop Science-based Management Tools

Present and future studies of the atmospheric deposition of Hg should produce useful information for environmental managers who must assess the quality of coastal waters and recommend plans for their improvement. Studies of atmospheric Hg deposition, coupled with meteorological information, will enable scientists and regulators to identify important local and regional sources and to assess efforts to control them. Estimates of the atmospheric contribution of Hg to coastal estuaries will provide essential input to models designed to predict the impacts of current and future Hg emissions by linking Hg inputs to coastal waters with Hg methylation and food web bioaccumulation.

# Atmospheric Deposition of Trace Elements to the New York-New Jersey Harbor-Bight

Yuan Gao, Ph.D.
Institute of Marine and Coastal Sciences
Rutgers, The State University

Marine pollution research has long been concerned with understanding the budgets and processes associated with pollution-derived chemicals in coastal waters and sediments. Research in this area originally focused on the most obvious input fluxes, which were contributed by rivers and streams, sewage outfalls, dumping, etc. Over the past 20 years, however, it has become apparent that atmospheric deposition of contaminants is also an important pathway for chemicals entering the coastal environment, such as the Mediterranean Sea, the Baltic Sea, the North Sea, the China Sea, and many coastal regions of North America. The atmospheric pathway has provided geochemically and ecologically important inputs of contaminants to those coastal waters. In fact, in many areas atmospheric inputs of certain trace substances exceed those from more commonly investigated sources.

In general terms, there are two major processes that remove airborne particles from the atmosphere, dry deposition by aerosol particle settling and wet deposition by rainfall scavenging of airborne particles. The relative importance of these two processes depends on many factors, air concentrations, aerosol particle size, rainfall rates, etc., which vary in space and time. For substances that also exist as gases, dry deposition should be considered as well. The earliest findings regarding the importance of atmospheric deposition as a major pollutant pathway in the United States appeared in the early 1970s. Research conducted in the Great Lakes provided evidence that the input of several trace metals to Lake Michigan appeared to be primarily from air pollution fallout from Chicago. In addition, the atmospheric deposition of lead into a 12,000 km$^2$ area of the Southern California Bight accounted for about 45% of the pollutant lead input, with the remaining 55% from waste water, river runoff, etc. In response to the growing awareness of the importance of atmospheric deposition, several large investigations of atmospheric deposition of pollutants to the United States East Coast bays and estuaries close to industrial and population centers were recently conducted. Among them was the Chesapeake Bay Atmospheric Deposition Study (CBAD), a multi-year, multi-institutional experiment that focused on estimating the atmospheric deposition of organic contaminants and selected trace metals to the surface water of Chesapeake Bay. Based on data collected from two sites in Year 1 of CBAD, scientists from University of Delaware, Drs. Thomas Church and Joe Scudlark, concluded that atmospheric deposition provided quantitatively important inputs of potentially toxic metals, including lead, zinc, cadmium, and arsenic, to the Chesapeake Bay. Because many pollution-derived elements are typically present in fine particulate matter, their wet/dry apportionment suggests that the contribution of wet removal by precipitation may be greater for these enriched elements over the Chesapeake Bay. On the other hand, results obtained by Dr. Ken Rahn at the University of Rhode Island from a four-year study of sources of atmospheric contamination at West Point indicated that dry deposition of most trace elements at this site exceeded wet deposition. Their results suggest that any comprehensive study of total atmospheric deposition in the Lower Hudson Valley must include an aerosol dry deposition component. The West Point study suggests that atmospheric fluxes are dominated by dry deposition of larger particles for areas close or immediately downwind from emission sources. Clearly, both atmospheric dry deposition and wet deposition are important for characterizing the magnitude of atmospheric loading of pollutants of interest. These studies have also suggested that air emissions of potentially toxic chemicals in urban/industrial centers enhance the atmospheric deposition fluxes to coastal waters. This phenomenon is particularly evident in estuaries, bays, and enclosed water bodies adjacent to large cities and industrial areas, such as the New York-New Jersey Harbor Estuary.

In the Harbor Estuary, elevated levels of trace metals such as mercury and cadmium in saltwater fish have been observed in the water column. Conspicuous algae blooms due to excessive nitrogen, a nutrient, have also occurred in the Harbor Estuary and New York Bight. These chemicals are delivered to coastal waters by direct point sources, but they can also be attributed to non-point sources, such as atmospheric deposition. Until recently, quantitative assessments of these contaminants entering the New York-New Jersey estuary waters through the atmospheric pathway were lacking. The contribution of atmospheric deposition to the total load of pollutants in coastal waters of the region is not well understood, including the processes that dominate the atmospheric transfer of pollutants across the air-coastal sea interface. New data are crucial for characterizing regional pollutant mass balances and for understanding bioaccumulation of pollutants in marine food webs.

To quantify the contaminant loads from atmospheric deposition to the Harbor Estuary and to evaluate the role of atmospheric deposition in the region, atmospheric measurements of inorganic substances were initiated in this area in the fall of 1997 and have been carried out since then, with joint funding from the *New Jersey Sea Grant College Program* and the Hudson River Foundation. Additional funding was provided in early summer 1999 from the New Jersey Department of Environmental Protection. The specific objectives of this research were to establish temporal and spatial patterns of trace elements, mercury, and nitrogen in the ambient air over the Harbor Estuary and Bight and to investigate the role of atmospheric deposition in delivering these chemicals to New York-New Jersey coastal waters.

Atmospheric pollutant measurements were conducted at three locations: Sandy Hook, New Brunswick, and the Liberty Science Center (Fig. 1), targeting lead, cadmium, zinc, chromium, and copper. Sample collection focused on ambient fine suspended particles of 2.5 µm (PM 2.5) in diameter or smaller, since these very small aerosol particles can easily penetrate into human lungs and be responsible for certain diseases. Precipitation sample collection was primarily carried out at the Sandy Hook site.

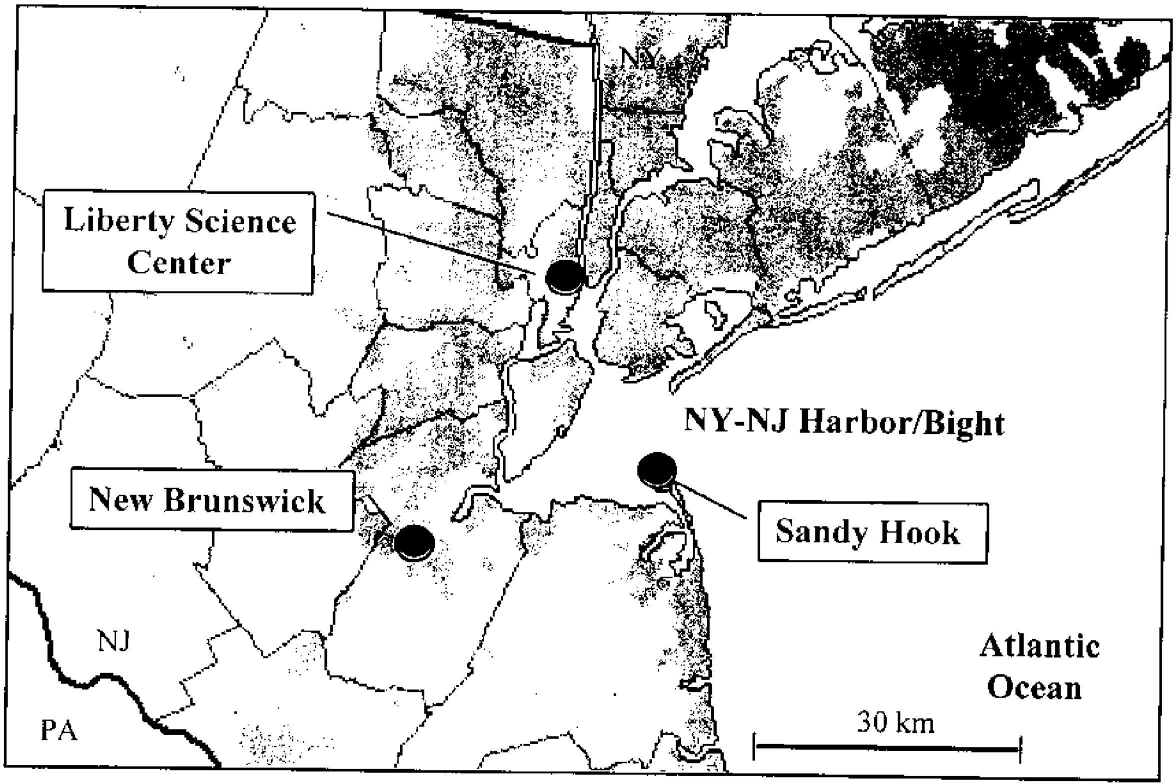


**Fig. 1** — Sampling Sites (Figure courtesy of Eric Nelson and Steven Eisenreich, modified from *The National Atlas, USGS.*)

Sample analyses for trace metals were conducted at Rutgers University's Institute of Marine and Coastal Sciences.

Preliminary results from this study indicate that the highest ambient levels of selected trace metals were found at the Liberty Science Center site relative to the other two locations (Fig. 2).

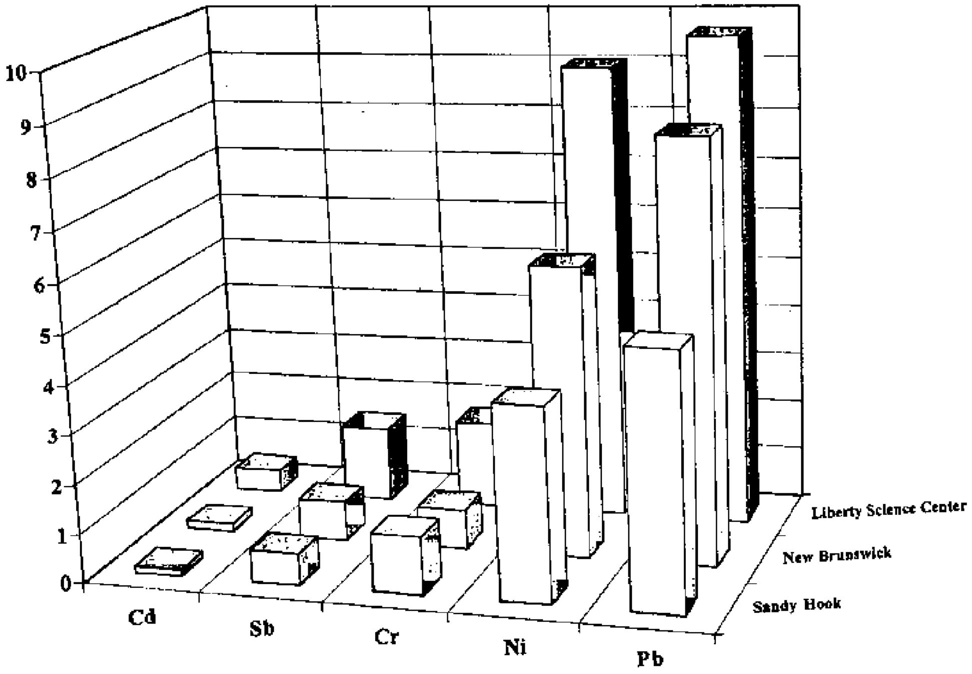


**Fig. 2** — Comparison of Selected Trace Metals in the Ambient Air (ng/m3).

A one-year measurement record indicated that the daily concentrations of these trace elements changed dramatically and that the seasonal patterns also varied from one element to another (Fig. 3).

Most of the target elements were highly enriched in very fine suspended particles in the ambient air. Based on these *in situ* measurements and atmospheric deposition model calculations, the atmospheric fluxes of selected trace elements to the Harbor Estuary were similar or higher compared to atmospheric fluxes at other sites along the east coast. To strengthen the current research program, measurements of atmospheric pollutants should be continued in order to establish long-term records in the region. Additionally, the new results should be analyzed in detail and integrated with other new data generated in this region. The atmospheric deposition results should also be incorporated into the Harbor Estuary chemical fate and mass balance models for better quantification of contaminant loads to the estuary.

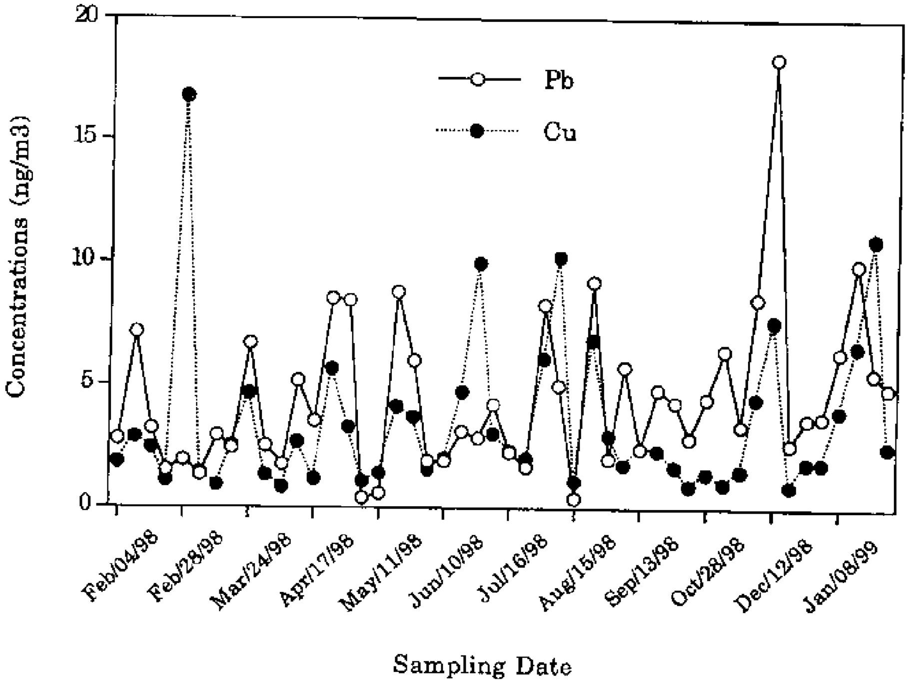


**Fig. 3** — Seasonal Variation of Trace Elements Associated with Fine Particulate Matter at Sandy Hook (1998-1999).

# Atmospheric Deposition of Nitrogen to Coastal Ecosystems

Dr. Sybil P. Seitzinger and Dr. Monica A. Mazurek
Institute of Marine and Coastal Sciences
Rutgers, The State University

The overabundance of nutrients, especially nitrogen, is causing environmental damage on all of the nation's coasts, according to a recent report from the National Academy of Sciences (www.nap.edu/books/0309069483). Nitrogen inputs to coastal ecosystems originate from many sources, including runoff from agricultural lands, sewage treatment plants, urban runoff, and natural inputs (Fig. 1).

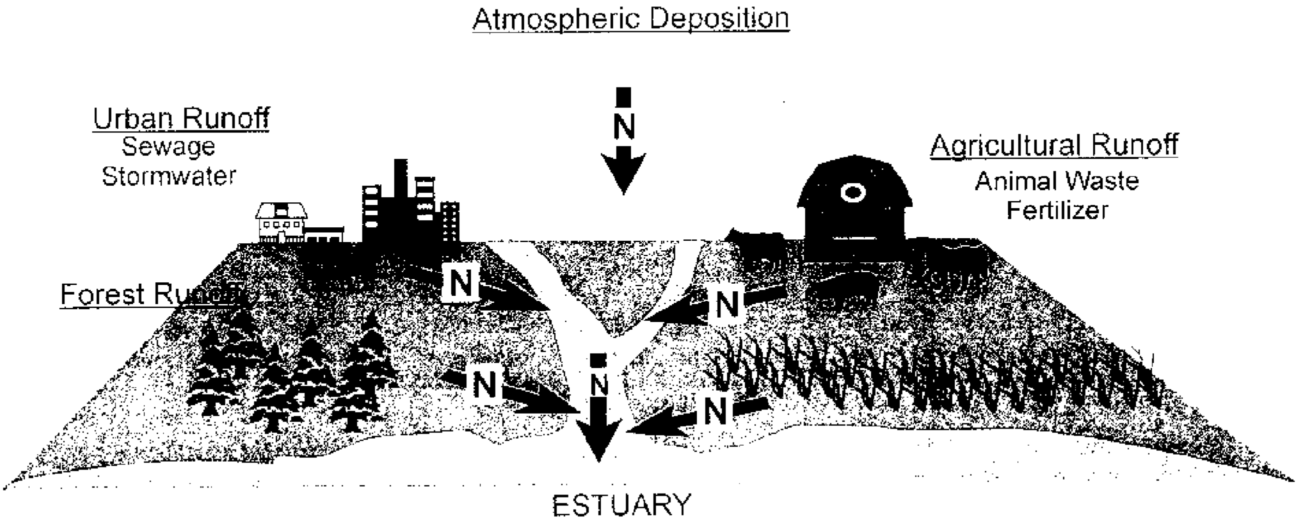


**Fig. 1** — N Inputs to Estuaries Originate from Many Sources

Atmospheric deposition (e.g., rainwater and dry deposition) also is an important source of nitrogen to coastal ecosystems. Dr. Seitzinger and colleagues in a number of national and international workgroups are examining the contribution of atmospheric deposition to N loading to over 40 estuaries along the eastern and Gulf coasts of the U.S. (NOAA Atmospheric Deposition Workgroup; Scientific Committee on Problems in the Environment Nitrogen Project). While the results of those workgroups are still being finalized, initial analyses indicate that atmospheric deposition can account for between 5% to over 50% of the N inputs to the watersheds. A preliminary analysis of N inputs to Barnegat Bay, for example, indicates that over 75% of the N inputs are from atmospheric deposition (Seitzinger and Sanders 1999). Clearly, controlling coastal pollution requires controlling sources of atmospheric nitrogen.

However, not all nitrogen is the same. One of the difficulties facing scientists and managers in relating atmospheric nitrogen deposition to coastal eutrophication is that nitrogen occurs in many forms and not all forms contribute equally to eutrophication. Nitrogen, for example, occurs in both inorganic and organic forms. Inorganic nitrogen (ammonia and nitrate) is known to be rapidly used by algae and to contribute to coastal eutrophication. Almost 40% of the inorganic nitrogen load to Barnegat Bay is estimated to be from atmospheric deposition (Fig. 2). However, organic nitrogen is often a major component of nitrogen inputs, including rainwater N, and little is know about its sources or its contribution to eutrophication. Preliminary estimates by

Seitzinger and colleagues suggest that rainwater accounts for over a quarter of organic nitrogen loading to Barnegat Bay.

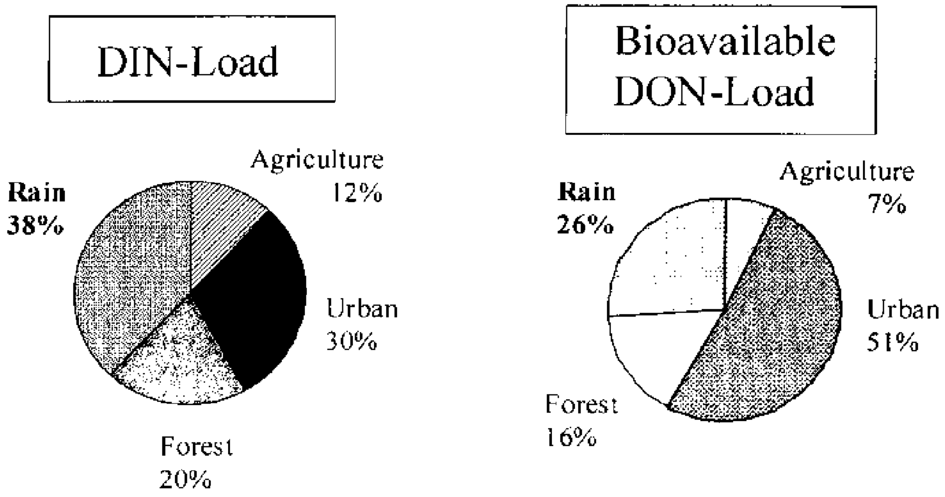


**Fig. 2** — N-Loads to Barnegat Bay from the Watershed and Direct Atmospheric Deposition (preliminary estimates).

The three major categories of nitrogen in atmospheric deposition are nitrate and ammonium (i.e., inorganic nitrogen) and organic nitrogen. A considerable amount is known about the magnitude and sources of inorganic nitrogen in rainwater. Over 80% of the nitrate in atmospheric deposition globally is anthropogenic in origin, primarily from the combustion of fossil fuels (Table 1). Approximately 75% of the ammonium is anthropogenic in origin, primarily from animal waste and biomass burning. However, almost nothing is known about the source of organic nitrogen in rainwater, including how much of it is from anthropogenic sources and thus how much might be controllable by changes in management practices.

**Table 1** — Sources of N in Atmospheric Deposition (global estimates from Galloway et al. 1995)

| | Amount (Tg N/y) | Major Sources |
|---|---|---|
| **$NO_3$** Anthropogenic | 22 | Combustion fossil fuels |
| Natural | 5 | Microbial, biomass burning |
| **$NH_4$** Anthropogenic | 39 | Animal waste, biomass burning |
| Natural | 13 | Volatilization, wild animal waste, biomass burning |
| **DON** Anthropogenic | ?? | ?? |
| Natural | ?? | ?? |

Another major challenge facing scientists and managers with respect to atmospheric deposition is that the sources of nitrogen to the atmospheric that are ultimately deposited in a watersheds and that thus can enter the estuary, are emitted to the atmosphere from hundreds of miles (kilometers) outside of the watershed. NOAA scientist, Dr. Robin Dennis, has been modeling and mapping airsheds for nitrate and ammonium for many estuaries throughout the eastern and Gulf coasts of the U.S. His analyses indicate that nitrate deposited to the Barnegat Bay watershed, for example, can originate from as far north as Canada, as far west as Ohio, and as far south as Virginia. This presents a particularly difficult challenge for managers in controlling the large inputs of N to Barnegat Bay from the atmosphere. However, because almost nothing is known about the sources of organic nitrogen in atmospheric deposition, we have essentially no information on where organic nitrogen deposited in the Barnegat Bay watershed originates.

With funding from NJ Sea Grant, New Jersey DEP, and the National Science Foundation, Dr. Seitzinger and Dr. Monica Mazurek are quantifying atmospheric deposition of inorganic and organic nitrogen over an annual cycle in the New Brunswick area. Samples collected during the summer of 1999 show that organic nitrogen often comprises 20% to 30% of the total nitrogen in rainwater (Fig. 3). They are developing novel analytical techniques to chemically characterize the organic nitrogen which will help in the identification of the sources (e.g., natural, anthropogenic and photochemical) of organic nitrogen in atmospheric deposition. Furthermore, they are conducting experiments to examine the effect of this nitrogen on estuarine eutrophication. Results indicate that rainwater organic nitrogen can stimulate both bacteria and phytoplankton production in Barnegat Bay water, and that the organic nitrogen in rainwater may influence the phytoplankton species composition (Fig. 4) (Seitzinger and Sanders, 1999).

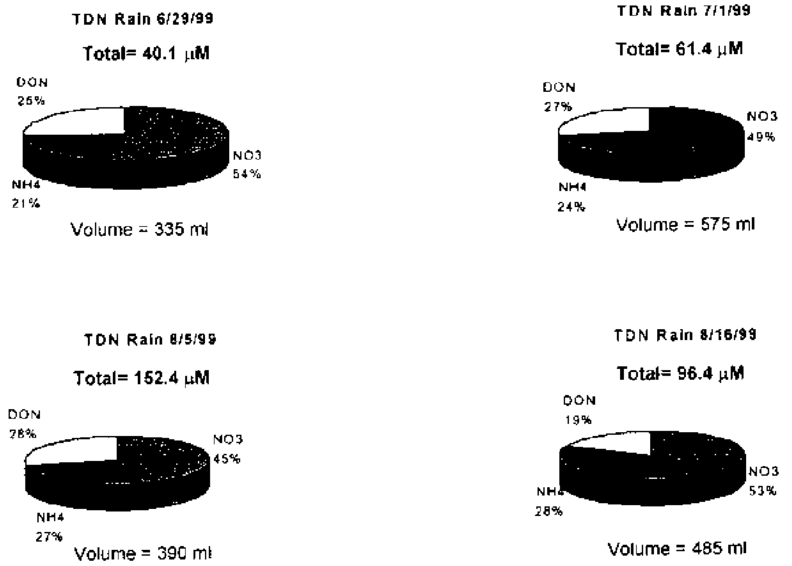
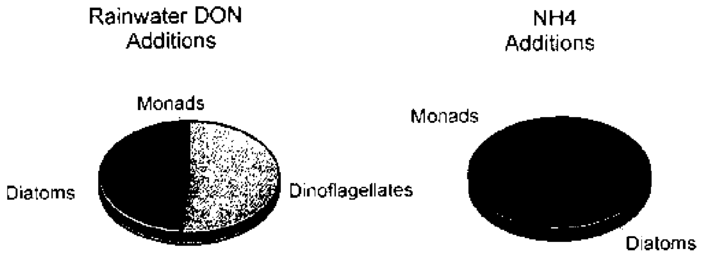


**Fig. 3** — New Brunswick NJ Summer 1999 Precipitation TDN Composition



(from Seitzinger and Sanders 1999)

**Fig. 4** — Rainwater Dissolved Organic N Effects Phytoplankton Species Composition

Currently, Dr. Seitzinger and colleagues are incorporating the results of their work on nutrient loading from atmospheric deposition as well as from agricultural and urban sources with inorganic and organic nitrogen bioavailability into the first land use/nutrient loading model that will explicitly include a more detailed modeling of the forms and amounts of nitrogen inputs to estuaries (Fig. 5). Barnegat Bay will be the first system in their analysis. This model also will be applied to a range of watersheds throughout the east coast of the U.S. to gain a regional perspective. Tools such as these will be made readily available to environmental managers so that they can more accurately assess the consequences of various development and nutrient management scenarios on coastal eutrophication, including management scenarios that may need to extend to states many hundreds of kilometers away to reduce atmospheric nitrogen deposition.

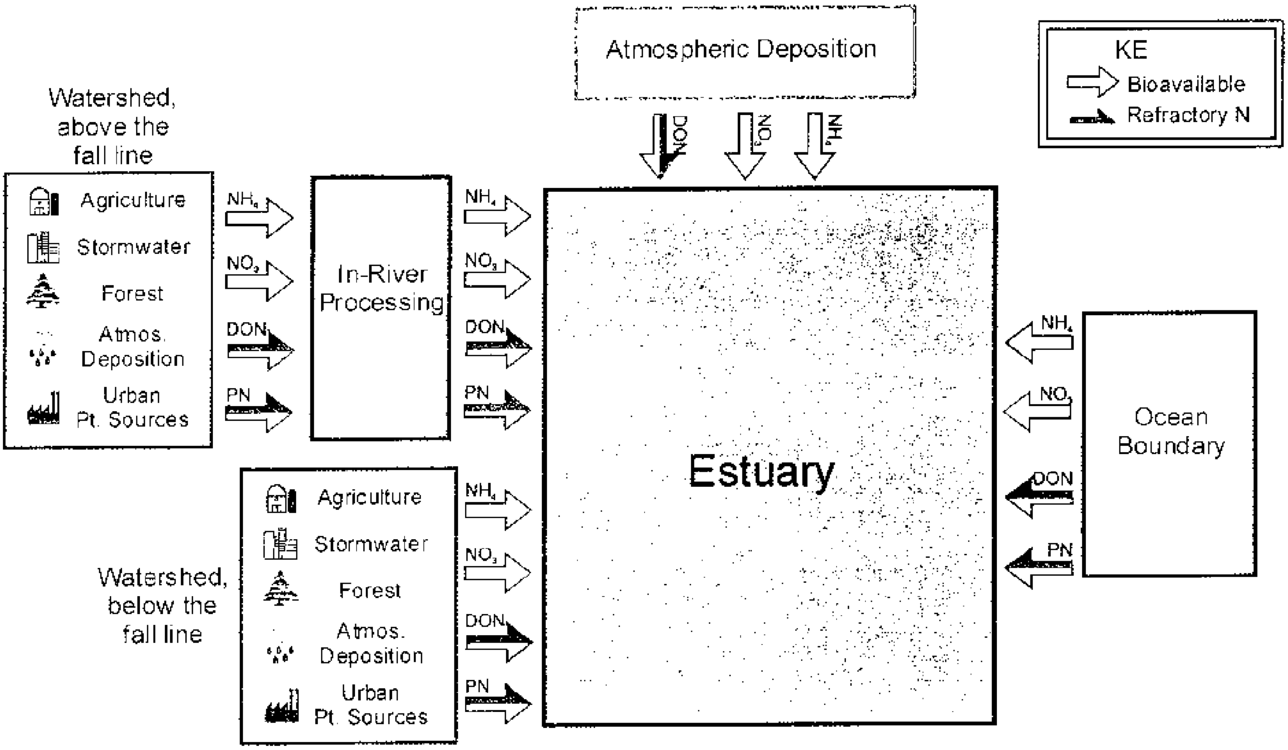


**Fig. 5** — Next Step for Watershed N Management – Bioavailable Nitrogen Model

For more information on the research activities being performed by Dr. Seitzinger and her team at the Institute of Marine and Coastal Sciences, visit: http://marine.rutgers.edu/NPC

# Round Table Discussion Executive Summary

Thomas J. Belton, Joel Pecchioli and Stuart J. Nagourney

## Introduction

The purpose of the Workshop Round Table Discussion was twofold: to review existing air-water data with emphasis on the New York-New Jersey Harbor region and to discuss ways to incorporate air-water data into science-based management strategies. The interaction among scientists, regulatory community members, stakeholders and the general public would hopefully raise awareness of assumptions underlying monitoring approaches, policy issues, data utility and limitations to the data gathering process. An important goal from a regulatory standpoint was how to transition research methodology and the data collected in an academic, peer-review forum into useful tools for regulatory programs. Specifically, the New Jersey Department of Environmental Protection (NJDEP) and United States Environmental Protection Agency (USEPA) are interested in developing environmental indicators as an underpinning to science-based regulatory management (e.g., NJDEP's National Environmental Performance Partnership [NEPPS] with USEPA) as well as tools for long-term status-and-trends monitoring/assessment.

From the perspective of environmental practitioners we wanted to understand how to:

- Use these data in a regulatory framework;
- Develop new *science-based* management policy;
- Establish the need (if necessary) for a permanent monitoring network;
- Use the air-water data in multimedia models;
- Explore mechanisms for all regulatory agencies (i.e., air and water programs) to coordinate their efforts; and
- Understand how we direct future research to assist in regulatory decision-making.

The format of the Round Table was for facilitators to pose a series of challenge questions to the panel members and to encourage participation from the audience. The questions posed to the panel, a summary of responses and an edited transcript of the full discussion follows. Hopefully the output of this effort will lead to recommendations for best management practices and a framework for adaptive regulatory management.

## Summary of Responses to Challenge Questions

### 1. Are the right contaminants being studied; are there additional contaminants that should be studied?

- Yes, information on appropriate chemicals is being collected.
- Many contaminants are present in the environment, most in several media.
- "Emerging" chemicals of potential concern and interest include Malathion, surfactants (nonylphenol), flame-retardants, whiteners, and fragrance compounds.

## 2. How should the management community prioritize what needs to be done and allocate funding accordingly?

- About a dozen chemicals are on a list identified within the New York-New Jersey Harbor Estuary Program, Comprehensive Conservation and Management Plan (CCMP) for Total Maximum Daily Load (TMDL) calculations to support waste load allocations for point sources.
- There is also a list of contaminants for air emissions that require future management decisions.
- Pollutants that are human health risks and exist at concentrations of concern in more than one media should have priority.
- A waterbody can serve as a source of the pollutant to the atmosphere (e.g., nonylphenol in the Hudson River).
- Primary questions that should be addressed:
  What are the problems associated with a particular pollutant?
  Are there exceedances of regulatory levels in seafood, water and/or sediments?
  Are there ecological effects?
  Are there human health effects?
  Are there economic considerations (relative to the costs of addressing the various pollutants of concern)?
  Is a particular contaminant already regulated as an air pollutant?
  Can anything more be done?

## 3. How do we establish a framework to assess the absolute and relative loadings of the contaminants under study, due to direct atmospheric deposition and indirectly via non-point source runoff?

- Need to make better use of Geographic Information System (GIS) tools, and fate/transport modeling.
- Need to understand the contribution from dry deposition utilizing empirical data.
- Need to understand the role of particles, both large and small, to deposition impacts.
- Mercury (Hg) – direct atmospheric deposition loadings are relatively small, but indirect loadings as a result of runoff from land areas may be large.
- Nitrogen – both direct and indirect loadings from atmospheric deposition are important.
- PCBs - ~20-30% of loadings could be from direct atmospheric deposition.
- PAHs – direct atmospheric deposition could be the dominant source, accounting for >50% of loadings.

## 4. What are the major sources of uncertainty in the data; can the magnitude of this uncertainty be reduced?

- Need quantitative understanding of dry deposition
- Recommend funding be provided to conduct air/water studies, at the watershed level.
- Variability in precipitation intensity can effect loadings by 50-100%; dry deposition may vary by 100-200%.
- The magnitude and variability in other (non-atmospheric deposition) sources is unknown.
- Mercury uncertainty in direct atmospheric deposition is ~50%
- PCBs, PAHs, pesticides – uncertainty ~ 20%, but is ~100% when considering variability in precipitation and dry deposition.

## 5. How does the magnitude of this uncertainty (100% +/- a factor of 2) affect the interpretation and use of these data by the regulatory/management community?

- The relative magnitudes of the loadings due to the various types of sources are important, especially as it effects the uncertainty in modeling activities.
- Need to know the uncertainties, and then can employ a "weight of evidence" approach.
- Understanding the variability in water quality data is important (e.g., storm events may be significant contributing factors)?
- The amount of uncertainty complicates developing specific strategies for use by local/municipal officials in regulating specific point-source emitters.
- We must consider the impacts of stormwater from extreme events such as Hurricane Floyd.
- Researchers and regulators need to better understand the mechanisms for input of pollutants and source-receptor relationships.
- Need to know indirect loadings/runoff from land areas; watershed retention efficiencies.

## 6. What type of data assessment should be undertaken?

- GIS-based landscape approaches (looking at current/historical land use/land cover) for air sources.
- Evaluation of National and State Emission Inventories, National Toxics Inventory.
- Runoff and watershed retention efficiencies.
- Trace metal fingerprinting to identify sources.
- Linking dry deposition and meteorological conditions.

## 7. Why are TMDLs a key endpoint for some of the data?

- TMDLs supply a mechanism to limit NPDES permitted sources to waterbodies.
- Through the Clean Air Act's Great Waters Program they also allow a regulatory overlap with air emission sources and SPDES permit controls if links are found between the two media.
- Hydrological transport models are being developed for the Harbor Estuary Program as tools for the States to support the TMDL development process (that allows inputs from air, sediment loads and bioaccumulation).

## 8. What do we know about the sources of the contaminants?

- National and State Emission Inventories, and the National Toxics Inventory are of very poor quality and specificity relative to the needs in atmospheric deposition.
- The atmospheric "lifetime" for most organic chemicals is 2-4 weeks, so the impact of *long-range* sources is important.
- Mercury – there is a large worldwide reservoir and long-range transport is usually more important than local sources.
- Dioxins are "recycled" through air/water systems (i.e., historical contaminants) and not present due to current primary emitters.

## 9. Do the air contaminants of concern lend themselves to multi-media modeling?

- Yes, but we need to consider temporal scales in setting deposition parameters.
- The air data must be integrated with water-based models so that TMDLs can be derived.

### 10. What kind of monitoring should be done in the future; do the data support the establishment of a permanent monitoring network?

- Coordination with national air efforts is needed.
- For regional atmospheric deposition trends analysis at least two NJDEP air contaminants monitoring sites are planned.
- Possibly use mobile sampling platforms to supplement the data from fixed sites.
- Research is needed to supplement "routine" monitoring programs.
- Each pollutant must be addressed individually and perhaps differently.

### 11. How can the existing data be used to develop future data collection needs?

- Existing NJADN data are from research-level monitoring; they are not "standard" and are very expensive to obtain.
- States may study approaches and contaminants of concern from NJADN to identify chemical targets and sampling locations for future regulatory monitoring networks.

### 12. Does this entail permanent sites or special studies?

- Both.
- Permanent sites for long-term trends analysis are needed.
- Also need special purpose studies to address specific issues.

### 13. Are inventories or source profiles more pressing needs than additional monitoring?

- Flexibility is needed: priorities will vary with each pollutant of concern.

# Atmospheric Deposition Workshop

## Edited Round Table Transcript[1]

Monmouth University
West Long Branch, NJ
April 13, 2000

Panel:
**MR. STUART NAGOURNEY**, NJDEP
**DR. BRUCE BROWNAWELL**, SUNY, Stony Brook
**DR. MICHAEL P. WEINSTEIN**, NJMSC, *New Jersey Sea Grant College Program*
**MR. WILLIAM BAKER**, Senior Air Advisor/Policy Advisor, EPA Region II
**MS. JENNIFER DiLORENZO**, Bureau Chief, Watershed Management, NJ DEP
**MS. JOANN HELD**, Chief, Air Quality Evaluation, NJDEP
**DR. SYBIL P. SEITZINGER**, IMSC
**DR. STEVEN J. EISENREICH**, Rutgers University
**DR. JOHN R. REINFELDER**, Rutgers University
**MR. THOMAS BELTON**, NJ DEP

**MR. NAGOURNEY:** What we are going to try to do this afternoon is establish a dialogue between the researchers and some of the regulated community that will be using data produced by the research community. I would like to introduce my co-facilitator, Dr. Bruce Brownawell from the State University of New York at Stony Brook. In addition to the researchers you met this morning the afternoon discussion panel also includes Ms. Joánn Held, who is the Chief of Air Quality Evaluation for the New Jersey DEP. Ms. Jennifer DiLorenzo, who is in charge of the Watershed Management Program for NJ DEP Dr. Bill Baker, who is the Senior Air Advisor/ Policy Advisor for USEPA Region II. In your handouts you have a list of challenge questions and some specific issues that we have developed for consideration this afternoon. We will first pose those questions to the panel, and then ask for your input. We have approximately two and a half hours allocated for this discussion period. We want to spend as much time as possible in developing a dialogue. The key goal of this effort is, how can we develop a partnership for identifying issues that are not yet fully addressed on the research side? And then, how do we use that information to help the people in the regulatory community make the key policy judgments and decisions that we are charged to make. We are trying to forge a real partnership here between the regulatory community and the research community, and as many of my colleagues often tell me, whenever we start with the research program typically the way it works is that we decide it is a good idea to do some research, so we contract to do that, we collect some data, and then about three years down the road after the project has been completed we then decide what are we going to do with the data we have collected. EPA is critical of that approach, as they rightfully should be. We are at a point in this project where we have a tremendous amount of state-of-the-art, interesting information coming out. Now the challenge for all of us, both on the research side and the regulatory side, is

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[1] Original Roundtable Discussion transcript prepared by State Shorthand Reporting Service, a professional reporting service located in Allenhurst, NJ. Edited by the New Jersey Marine Sciences Consortium (NJMSC). Any errors, omissions, or misrepresentations of the original transcript are wholly those of the NJMSC.

to come to some understanding of how these data are going to be used. And that is not an easy task, but I think we have some of the right people here to at least begin the process. With that as the framework, I am going to turn this over to Dr. Bruce Brownawell, who is going to lead the first part of the panel discussion.

**DR. BROWNAWELL:** I have learned a lot in this morning's technical session and what we would like to do is to make sure that we all learned as much as we can about the perspectives of the scientific community and the needs and perspectives of everybody else that is interested in this important topic. I learned last week, when I was going over the draft of challenge questions, that there is a tremendous need for understanding the types of data that are being generated here. We have only narrowed down slightly some of those questions that were being asked. So we have quite an ambitious program today, and hopefully we will get through most of it. It is the quality of this discussion that will make this a useful and educational experience. The first discussion topic, which is sort of a catchall, is called "state of the knowledge". But I want to sort of focus in on two questions that seem to be on top of everyone's mind. First, are we studying the right contaminants? And if we wanted to spend more money, where would we spend that money? And, if unfortunately, as things tend to happen, and we need to spend less money, how do we prioritize what we need to do? My perspective is, if you ask a panel of 10 research scientists, what the priorities should be, you will probably receive 10 different research priorities. And so, instead of asking a scientist *per se* what they think the most important contaminants are, I thought we could focus the discussion on the question: How do we prioritize? What criteria should the management community be using to determine where the highest priorities should go? Also, in addition to the contaminants that we heard about today, are there others that the panel or people in the audience think are priorities that we need to start worrying about, that we have some preliminary information about? Or, that people are looking at in other places and are finding out to be important? Secondly, one of the things that Dr. Seitzinger did a good job of talking about today was how big the nutrient, specifically nitrogen pie is to the overall loadings, but the other speakers did not do quite as much in terms of talking about how big their respective pie slices are in terms of the atmospheric loadings. So I would like to get a little bit of perspective on what we know now about how big the size of those atmospheric pie slices are for the other contaminants. And then finally: When we are talking about atmospheric loadings, when we are thinking about semi-volatile compounds like many of the organic contaminants Dr. Eisenreich talked about this morning, or mercury that Dr. Reinfelder discussed, how do we think about this pie diagram? How do we establish a framework to assess relative loadings? That is an important question that people need to come to terms with. So let us go back and start with: How do we prioritize contaminants of concern? I made a list this morning of items I thought one might talk about, and I would like to get the panels' and the audience's perspective on the question: What are the criteria for prioritizing the contaminants of concern? Certainly there are management drivers in terms of, approaching or exceeding regulatory levels in seafood, or in sediments, or in water. We know about other ecological effects. We certainly should be thinking of how big a piece of the pie the atmospheric deposition is. If the atmospheric deposition is a tenth of a percent of the total loadings, maybe we do not need to spend a million dollars determining how big it is. If we already know the loading estimates quite well, we might decide not to spend as much money on a given contaminant. One argument might be made that if the loadings or if the sources are long-range atmospheric transport that maybe we do not need so much local high spatial variability in sampling. Finally, we might want to be spending money on monitoring contaminants for which we have implemented some expensive management strategy to control that contaminant to see how well the control strategy has been working, i.e., to see if the money has been spent well. The panel could first address: 1) whether we are measuring the right things, and 2) where should we be putting our priorities in this fixed, if there is a fixed, pool of money for measuring the deposition of contaminants?

**MR. BAKER:** I guess it depends on what perspective you are coming from. The perspective that the three invited panel members are coming from presumably is that of regulators, and therefore, I guess, we are physically separated from the academic community. I hope we are not that separated! Presumably, the people in the academic community want to answer some of these questions to get at the truth of the matter. We have a more practical approach to things and we are looking for answers to develop regulations. So I would start by seeing if there a problem with a particular pollutant of concern. Now, I am an air person not a water person, so I can not tell you how to get at that particular issue. But maybe some of the water people can say how they determine whether or not a particular contaminant is of concern from a health standpoint or from an ecological standpoint. I think that is the initial question that has to be answered before you get at prioritization. Is there in fact a problem?

**MS. DiLORENZO:** From a regulatory perspective it might be good for the scientists to be aware of the constraints and issues that the Department of Environmental Protection has to answer. For example, we are required to do total maximum daily loads (TMDL) for the toxic components in the Harbor that have been identified as concerns by the Harbor Estuary Program. We are also required to do TMDLs for nutrients. Those are our priorities because we have a time frame through a memorandum of agreement with the EPA to do those TMDLs by, say, 2007. We would like to do it faster than that and if some of your research activities can be in accordance with that goal it would be very helpful. We ultimately have to implement TMDLs on the people, industries and dischargers. And the better the data we have for the atmospheric deposition component, the better our modeling efforts are going to be.

**MS. HELD:** I guess, the first question is: What are the contaminants of concern? And Ms. DiLorenzo says she has a list for her area and that is a good thing. The next question then is: Is everything on that list what we need to know for all New Jersey, or are there certain contaminants for other parts of the state that we need to address? And I do not know that answer either. I would approach it as a question: How do you figure out what the key contaminants of concern are? I think that is something that the experts in water quality and biology are places where I would go to for that answer. And I would ask them what is causing problems in the water and then those are the ones to work on. I do not think that every little bit of air pollution that falls in the water is going to cause a problem. We need to focus on the right compounds. And I think that by addressing some of these questions, we would go in the right direction. And knowing my management, I think they would like people to come to them and say this is a concern and that we are ready to hear the next part of the story, which is identifying the sources. But they need a nice concise explanation of the problem.

**DR. BROWNAWELL:** Dr. Eisenreich and Dr. Seitzinger, you have both been on numerous planning committees where you have designed programs like this. From your experiences, how do you think the management community should be developing prioritization for how they spend their funds?

**DR. SEITZINGER:** I think that it is stated very clearly: First of all you need to figure out what compound is causing a problem. If a given compound is not causing a problem, then maybe it has a lower priority. It does not mean that it does not need to be looked at because it might be something that in the future will cause problems that we are not aware of at the current time. What you have listed there as number one is basically ecological facts. I guess I would say that is a priority. That is the priority for setting the priority. What has the most effect? Most negative effect?

**DR. BROWNAWELL:** That sets the stage, but then the next question is how do you deal with more than one pie? We have pies in terms of atmospheric loading, you also have a pie in terms of dollars. We heard that we have somewhere on the order of 30 contaminants or classes of contaminants that are of concern in the Harbor Estuary. Do we spend the same amount of money for all of them? Of course, some of the analyses are more expensive than others. But in terms of sampling effort or regional coverage how would you ask the management committee to decide how much should be spent in one effort versus another effort? Right now they are spending effort on most of what has been identified. How do we prioritize?

**DR. SEITZINGER:** I think you have kind of hit it on the head again, which is you look at what is causing the major problems in the environment. And then you also have to look at what is the relative cost of addressing each of them. And do some balancing between those two.

**MR. NICHOLAS DeGRAVE:** Another way to look at this perhaps is to think about it in terms of management, what you call management drivers. What are the management drivers? Is it contaminated sediments?

**DR. BROWNAWELL:** How big is the management driver?

**MR. DeGRAVE:** Well, what are they and can they be prioritized? Or do they all have equal weight? Is it eutrophication? Is it health effects as a consequence of bio-accumulation of persistent contaminants? What are the management drivers and do they all have equal weight?

**MS. HELD:** Could I say something about that? I think that is a good point and if within our department we would be competing actually. Some folks are most concerned about water quality, especially if it is a drinking water supply, for example. And they would be concerned about whether or not you are degrading water quality. Whereas, others might be more concerned about sediments because when you have to dredge them, it is going to be present problems. And others would be more concerned with the biological effects on organisms . So we are all coming at it from different directions and we are going to have resolve problems, I guess. A pollutant that has all those problems, may end up being the one that gets the priority.

**MR. BAKER:** And I will add a fourth one. As you learned today not only will water bodies be receptor for pollutants but they can also be sources of the pollutants. So we in the air pollution community might be concerned because the water body itself is actually serving as a source.

**MR. MARK WATSON:** I think for everyone in this room that it is the ecological effects and health effects that we are really most concerned about. But when we are talking about where we focus our efforts and how we can use the information that we get out of the studies to really impact policy, we can not leave out the economic factors too. Because when we are dealing with policy makers some of them may be driven by ecological concerns or health concerns but others are going to be driven strictly by economic concerns. So while we are looking at this from a scientific standpoint we also need to look at; e.g., what impact mercury has on fishing tourism, and the fishing business, and acid rain on the forestry industry, and ozone on tourism as it relates to haze, and make sure that because we are in the science field that we do not leave out those other factors, which can really be the driving force behind getting regulations in place.

**DR. BROWNAWELL:** I guess one of the questions we wanted to make sure we asked today was whether there are contaminants that are not currently a part of the network that people in this room should be thinking about that might be on the horizon in terms of future monitoring efforts. I thought maybe I would start the question with Dr. Eisenreich to see if he has a perspective on things that have not been included today that he would like to see addressed.

**DR. EISENREICH:** One of the things you have to realize for a system like this is that every chemical that exists is in the system at some concentration. It is being discharged either through the air, the water, the waste treatment facilities, the rivers. And I mean, virtually every chemical. The lists that have been prepared in the past that drive both air and water toxic measurement programs, monitoring, modeling, and research, all fit into a set of criteria. They are persistent or they are transformation products or toxic and persistent. If the chemical is toxic, it is automatically on the list. If it is bio-accumulative even if it does not have known toxicity, it is automatically on the list. If it is a large volume production chemical that is known to be released into the environment but perhaps not even measured in the system, it probably will make the list. If there are chemicals that have been reported to be present even though there is no known toxicological effect, of those kinds of chemicals but somebody has suggested that maybe their sheer presence is of concern, for environmental human ecological health relationships or socioeconomic political type considerations, they can make the list. But I think that what Dr. Brownawell is referring to are this category of, what we call, emerging chemicals. New chemicals that are used in agriculture today that were not used 15 years ago, and are they a problem in this system or other systems? I was asked yesterday whether we intend on measuring Malathion. Well, I will tell you that up until the recent Nile virus story in New York City, Malathion was never an issue in this part of the country. Except with respect to some homes, of course, maybe it can be. But if they are going to use widespread spraying of Malathion as a pesticide, you know Malathion is reasonably toxic in environmental systems. So Malathion might make the list. Surfactants, degradation products of surfactants; e.g., nonyphenols, are very present and very prominent in their concentrations and loadings in the New York/New Jersey Harbor Estuary. They are bio-accumulative, and potentially toxic to aquatic species and humans. They are persistent, bio-accumulative, toxic chemicals. I mean, this is a type of compound that is not getting a lot of attention but it is either being discharged or produced in very large quantities in urban industrial centers. Most of it coming from waste water treatment discharges. So here is a new class of chemicals with respect to our considerations. All sorts of flame retardants, compounds that are used as whiteners in home and commercial applications, which are known to exhibit downstream aquatic toxicity. There are new and interesting thoughts about fragrance compounds which are reactive in humans and perhaps organisms as well. And large quantities of these materials are discharged with almost nothing known about their aquatic toxicology. These are all sorts of categories and my point is if there is a compound that is produced and used, it will escape into the environment. It will be in this particular environment as well. The lists have to be separated into manageable, somewhat routine monitoring, historical-type considerations. So, what other compounds are present in the air and water environment that we might be concerned about and there should be efforts to detect them, to lay out the framework of the problem? But it is a very difficult task to prioritize all chemicals that may be on the list that we should be measuring. It would be an endless list.

**MR. THOMAS BELTON:** I think it is important for us to know what else is out there that could be a problem. But to keep this pragmatic we, as managers, have a list of about a dozen contaminants that we have to do TMDLs on. Mr. Baker and Ms. Held have a series of air contaminants that they manage. What we are driving at today and trying to get a handle on, is how we prioritize these contaminants? Just to give you an example of what we faced in the Harbor Estuary's Toxics Committee, there is a list that has three categories; water, biota and sediment. To get on the list of concern, you had to violate some standard, some criterion. Some of these criteria are pretty straightforward. The water has a quality standard that you exceeded. For biota they typically use Food and Drug Administration tolerances, which are not risk-based. They are based on economic concerns such as how much impact can a fishery sustain? But in reality they do not manage to the level that would be protective of human health. Yet if they violated an FDA criterion, they are on the list. But, if you wanted to use a water quality model to protect fish, you would probably have to go lower than the FDA concentration to protect what lives in the water. Similarly with sediments there are no sediment criteria. The EPA is working on them. The Canadians have some criteria that some American managers use when we attempt to look at sediments, and there are a number of sediment based criteria that are site-specific, which are risk-based, that hazardous waste mangers use to govern some kind of a cleanup. But we had people from NOAA and the Corps of Engineers come into our community and talk about NOELS and LOELS and no adverse affect levels as possible interim criteria that we would use to evaluate the process. So when we are talking about prioritization, those are the kinds of things that we as manager need, because what we are trying to do (for instance, with the modeling activities) is create a model for the Harbor that will address both sediments and water quality issues. They both have different endpoints based on what you are measuring. And the air, obviously, can result in some of these contaminants making their way into the water, but then we would have to manage from what I heard today some of these contaminants based on how volatile they are, how chlorinated they are. Are they more available or less available, and more or less bio-accumulative? These considerations may play into our decisions on going after one chemical in advance of going after another. Those are the kinds of things that our committee struggled with. How does (today's) panel feel about that?

**DR. BROWNAWELL:** I would like to get back to the Malathion question, I have been looking into it a little, but for a different reason. It may have some importance in terms of atmospheric deposition and effects but people should realize that in the marine environment it did not last for two days. So we are not talking about a persistent chemical, not it is particularly bio-accumulative, and it does not end up in sediments. So if there are effects there are going to be near shore or near-discharge effects that would have them be transported out to deeper water through some other biological vector, disease or something else. To put the panelists on the spot, and based on what you know about atmospheric deposition, what do you think the single most important contaminant is, if you had to measure one contaminant in terms of atmospheric deposition?

**DR. SEITZINGER:** One inorganic contaminant?

**DR. BROWNAWELL:** Any contaminant. We do not know the organic ones.

I would like to ask each of you if there is a pie that you could draw for the Harbor Estuary system; how big a piece of the total pie is the atmospheric deposition component? Some of you are going to have a complex answer in terms of the net exchange, so why do not I start with Dr. Reinfelder.

**DR. REINFELDER:** With regard to mercury?

**DR. BROWNAWELL:** Well, mercury is the most important so, of course.

**DR. REINFELDER:** As I illustrated this morning the atmospheric deposition has to be a big piece of the pie for mercury because of the large reservoir and the long-range transport mechanism that the atmosphere represents. Contrast that with other metals that do not persist in the atmosphere— lead, copper, zinc, which are scavenged out rather quickly. So I would say relative to other metals of concern like zinc and copper and silver perhaps, that atmospheric deposition of mercury is going to be the most important on the trace metal side. And it is going to be a substantial piece of the pie, but the big uncertainty comes with estimating the runoff component.

**DR. BROWNAWELL:** And how you account for that?

**DR. REINFELDER:** And how you account for that, yes.

**DR. BROWNAWELL:** But do you think mercury — the direct atmospheric deposition of mercury is five percent, 20 percent, 50 percent or ......

**DR. REINFELDER:** Direct to the surface of the water?

**DR. BROWNAWELL:** Yes.

**DR. REINFELDER:** A very small piece of the pie, because of the surface area of the Harbor-Estuary. Contrast that with Chesapeake Bay which has a very large surface area. Then the direct atmospheric deposition of mercury starts to become a bigger piece of the pie. But we have a smaller estuary, apportionately smaller direct atmospheric deposition. But I think the indirect atmospheric deposition for mercury is going to be a big driver of that piece of the pie.

**DR. BROWNAWELL:** Dr. Seitzinger you spent a bit of time on that today.

**DR. SEITZINGER:** Yes, I think that you asked us to address the New Jersey/New York Harbor area. But, I would like to address my comments to New Jersey coastal waters in general. I think that in terms of nitrogen deposition that in the upper area of the New York/New Jersey Harbor watershed, that atmospheric deposition is a very important source of nitrogen. If you are looking at the Harbor as a whole, there are sources from the Metropolitan area itself that are much larger than the atmospheric deposition component. However, if we look at other coastal areas of New Jersey, for example, Barnegat Bay, and very likely the other small bays along the entire coast, that clearly atmospheric deposition is major component of the nitrogen coming into these systems and leading to eutrophication of those systems. We just completed a data synthesis effort for Barnegat Bay, for example, and tried to summarize some of the eutrophication problems there that can be documented with existing data. But clearly, atmospheric deposition of nitrogen is a major source to a lot of coastal New Jersey. Not only direct deposition on the water itself, but deposition on the watershed with subsequent transport through the river, and possibly groundwater to the bays themselves. And it is also not an insignificant component of nitrogen input into Delaware Bay as well, to sort of complete the New Jersey picture for coastal areas.

**DR. EISENREICH:** Well, let me address it. We have tried to do this exercise for the two classes of compounds, 1) PCBs and 2) for a variety of polycyclic aromatic hydrocarbons. I must caution that the data are based on summertime measurements only. But it looks as though as much as 30 percent of the PCBs input, let us say, to Raritan Bay could be coming from direct atmospheric deposition. Maybe it will turn out to be 20 percent, or 15 percent but understanding that there are significant surface loads of PCBs into that system from the upper Hudson River, the Raritan, Passaic Rivers, etc., this is actually a surprisingly large number to us. We will see how accurate it is as we perform more sophisticated interpretations of the data. In contrast, for many of the PAHs we are arriving at the conclusion that the atmosphere could easily be the dominant source. Because of the relatively low loads of PAHs that are coming in from the upper Hudson River and the river borne transport in general, the atmosphere is likely to be a very important source, greater than 50 percent of the total for that system.

**DR. BROWNAWELL:** In terms of how managers use input numbers, how would you give it to them in a way that is useful?

**DR. EISENREICH:** Well, what we intend to do is to give them the input side of the air/water exchange. The gas absorption side. That is an input. And then in terms of the water body effect itself, we will estimate that output.

**DR. BROWNAWELL:** That explains your graph today. I did not understand it. Now, I understand it. That is why it was a small number.

**DR. EISENREICH:** So it can be — obviously, there is gaseous deposition into the bay and gaseous volatilization from the bay. But from a mass budget point of view, you need to separate out those components.

**MS. ZOE ZELMAN:** Since it seems to be common in your opinions that air deposition is a significant contribution to contamination in the Harbor, has there been modeling that shows how close to the source, like, mercury is ? Is it suspended in the air for two miles from the source? Or it is coming from Ohio? Or is it because of the incinerators in Linden? Why hasn't it all gone out to sea?

**DR. REINFELDER:** There was one study showing transport of mercury on fine aerosols from copper smelters in central Canada to lakes in central upstate New York. Those kinds of aerosols have a one-week residence time. So depending on meteorology it could be transported quite a distance. And the other side is the gas-phase, for mercury there is a large gas-phase emission of elemental mercury that can be transported around the globe, because it has a one-year residence time.

**MS. ZELMAN:** You are saying that 50 percent is coming from the air and we can not identify the source, it is going to be very difficult to eliminate this load to the environment.

**DR. REINFELDER:** Right. I think the 50 percent was not for mercury. In terms of a regulatory point of view, yes, you want to identify the sources; e.g., are there local sources feeding atmospheric deposition of mercury to the New York/New Jersey Harbor? I think network data will speak to that in terms of comparing Pineland sites, which tend to have no proximal sources or very few, to sites in more urban, industrialized areas. But even the Pinelands will be impacted by regional sources from Pennsylvania, for example.

**MS. ZELMAN:** It will travel that distance?

**DR. REINFELDER:** Oh, yes, for mercury.

**DR. EISENREICH:** Just a comment on that: The atmospheric lifetime of many of the organic compounds can be as long as two to four weeks. That means they can go around the world several times. It also means that volatilization of a chemical in Mexico can make it to New York in three days, well within its atmospheric lifetime. That is how chemicals get incorporated into the Arctic ecosystem. Long-range transport of these chemicals is not a difficulty.

**DR. REINFELDER:** It is dropping continuously. Throughout that lifetime it is being resupplied and it is being scavenged.

**MR. BELTON:** To build on that notion, from the perspective of prioritization and managing it was pointed out that some of the contaminants tend to absorb to large particulates and fall close to sources. Can we narrow down the list to go after those to try to do what Mr. Baker wants to do; i.e., look for local regional sources that we can manage as opposed to things we can not manage? Is it possible to use the data to do that more directly?

**DR. REINFELDER:** For mercury the current data will not address that, because we are not sampling large particles, which are very difficult to sample.

**MR. BELTON:** Could you talk about other trace elements?

**DR. REINFELDER:** I do not believe Dr. Gao is doing any large particle sampling. I do not know that for a fact.

**MR. BELTON:** Certain things that Dr. Gao described associated with chromium and copper seem to apply

**DR. REINFELDER:** For particles?

**MR. BELTON:** Right. Yes. Fine particles.

**DR. EISENREICH:** I think there may be a misconception here. The same chemicals that are on small particles are also on large particles.

**DR. REINFELDER:** Yes. Everything is everywhere.

**DR. EISENREICH:** You could do it at different concentrations but it is the same.

**MR. BELTON:** Yes. I understand. But from the perspective of large particulates falling close to the sources, do we use that as an indicator to look for localized sources?

**DR. BROWNAWELL:** Not necessarily, because if you have higher deposition velocities near cities it can focus the deposition near there.

**MR. BAKER:** I do not think I said that we should just look at local sources. I would agree with what Dr. Eisenreich said, I mean, if you have particulates coming out of a source, you are going to have both coarse and fine particles and you going to have contaminants absorbed on both. One thing that we may want to consider is: Is a particular contaminant being regulated because it is problem within the air? But if it is already being regulated for other reasons, that may put it at a lower priority than something that is not a high priority for air regulation; e.g. if it is causing a water problem.

**DR. BROWNAWELL:** We are going to be talking about variability and how to use the data a little bit later on.

**MS. CARTER:** I just have two comments. We have been talking about this for a while and we are clearly struggling a little bit. We are trying to prioritize some of these issues. One thing that can be said is that the up and coming tool for integration is GIS. Results can be prepared in such a way that they are linked to appropriate locational information, because at some point all these things come together as a system. Things move through the system and they end up as different sources and sinks. So my basic two comments are as a researchers we really want to be doing two things, perhaps not only doing a lot of fate and transport modeling, but also doing some corresponding things like fugacity modeling, where we are not really looking at individual transport but we are actually trying to get where things move and into which compartments they end up residing in. For example, what is the exchange between the air and water? By doing this, you end up understanding in a larger sense, in a management sense, where things are going to end up over time. And I think then you can start looking for problems to help you prioritize things in the media in which things are going to end up. So if you can actually encourage future research that also included some fugacity kinds of work running tandem with other kinds of modeling work, I think that would help the managers determine long-term strategies. And then also develop things so that they can move into GIS format. We have to start comparing this to a lot of the health data and some of the other data. Those are my main comments because I think we are struggling.

**MR. NAGOURNEY:** I just wanted to comment on Ms. Carter's suggestion about fugacity models. The USEPA in Washington is providing resources to develop a New Jersey based fugacity model that Dr. Eisenreich is going to be leading. So that aspect of the situation is going to be addressed, we hope.

**DR. GEORGOPOULOS:** There are some words that when I hear them, like, fugacity or kreiging or whatever, I have to make a comment. We spend so much time talking about time scales of transport, the system that involves air and watersheds, is very dynamic. Fugacity models involve a dynamic limit that does not involve time. Essentially they are volatile, they are available for infinite time; we have to be very careful whenever we try to use a simple model just because it is simple for regulatory purposes. Models are very good in giving us a sense of limits. But for this particular type of system where we have interactions at time scales of a few days, there are tools that your geographic information system approach of integrating information from different data bases, different media that Ms. Carter mentioned, is very powerful and we cannot avoid going in that direction eventually. USEPA has put significant amounts of effort in developing a national toxics inventory. All the states have been involved in this, particularly for primary emission of PAHs, and mercury compounds, and we have to start using these data to check this inventory against reality. Are we missing major components in this data base? I think we have to start looking at the whole picture, the informational sources, informational transport dynamics, informational deposition. We are at a good juncture in time when all these things start to happen. The technology is there. It is under development. But we have to start thinking in terms of the tools of GIS, original modeling of the National Emission Inventory, of the National Toxics Inventory, of the State Emission Inventory. As mentioned, there is mercury coming in to the estuary in principle, and I am not saying that in principle it represents reality. In principle there are tools that would allow one to link deposition with the sources, the primary sources of mercury. As Dr. Reinfelder mentioned the fact that we have a rural site would give us some chance to watch an evaluation of both models and inventories that are available for this purpose.

**DR. DENNIS SUSZKOWSKI:** I have a question for Dr. Eisenreich. On your estimates in Raritan Bay, for PCBs. Are you saying that of the total PCBs in Raritan Bay, 20 percent are coming directly from the air to the water, or within the entire watershed that drains into Raritan Bay?

**DR. EISENREICH:** Directly.

**DR. SUSZKOWSKI:** Directly. Wow!

**DR. BROWNAWELL:** I am going to turn the discussion over now to a trained facilitator. I am usually the guy that stirs the pot. So I am going to turn it over to Mr. Nagourney.

**MR. NAGOURNEY:** Thanks, Dr. Brownawell. We can come back to some of these issues later in the afternoon but I wanted to turn for a few moments to data variability. And I want to approach this from a couple of different perspectives. To ask the panel, the researchers, and also the regulators: What are the major sources of uncertainty? In his presentation this morning Dr. Eisenreich identified several of them. Are there different sources of uncertainty for different classes of parameters? That is the first question I would like to pose. Do we truly understand the magnitude of the uncertainty that exists, and how can we communicate that from the researchers to the data users? Is it possible to put a true sort of global air term on atmospheric measurements? And to the regulators, the question is: How would you interpret data that might be ten plus or minus 400, if those indeed are the data that are available? So let me pose these questions to the researchers first and then we will turn to the regulators and ask these same questions. Also, we have a fourth point to talk about and that is: Are there things we can do from a research perspective to minimize those uncertainties? Is there research that we can do to support "tighter" numbers?

**DR. EISENREICH:** Let me start, and let the others think about it a little bit. We have done a lot of work over the years on all these classes of compounds that I have described involving the combination of sampling and analytical uncertainty. We now think that is down to about plus or minus 20 percent for PCBs, and PAHs, and whatever. And that is probably about as good as we can do, plus or minus 20 percent. But that is not going to be the limitation. That is not what is going to be what drives the uncertainty in the flux or the loading estimate. For wet deposition, it also will be for precipitation intensity; i.e., what is the precipitation volume over time? But more importantly what is the variability of precipitation over the water body or watershed over that time same period. It is not going to be the same in a larger watershed versus a small one. So that is going to add perhaps 50 or 100 percent uncertainty to the flux. If you go to something like dry particle deposition, whether it is small, or medium, or large size particles in the distribution of the chemicals on those particles, and how deposition velocities vary with meteorological conditions, day versus night, and various types of convective and system-wide weather systems, seabreezes or non-seabreeze effects. Those deposition velocities are easily going to be plus or minus 100 or 200 percent. When you begin packaging this together you have, of course, uncertainties that are not additive. They must in fact must be propagated and weighted. It is not unexpected that the best loading numbers that we could conceive generating are plus or minus 100 percent for PCBs, PAHs, and normal chlorinated pesticides.

**DR. SEITZINGER:** I think there is also considerable uncertainty in the nitrogen deposition. It is maybe not as great as it is for some of the toxic organic compounds. Some of the same factors will come into play, as Dr. Eisenreich mentioned. In addition, I think that what we have to consider for the uncertainties in atmospheric contribution of nitrogen to coastal waters is the removal of some of the nitrogen in the watersheds before it gets to the coastal waters. So basically a process is going on within the watershed that is altering the total amount of nitrogen that gets to the coastal waters. In addition we need to understand the retention factors for the different nitrogen compounds as well as different nitrogen sources. There is considerable uncertainty in the magnitude of sources other than atmospheric deposition. While I showed those bar graphs for our best estimates of the various sources of nitrogen to those 15 different watersheds, all of those sources have uncertainty associated with them. If you consider multiple, propagated, uncertainties, they can be fairly large. I think one of the important things to be doing are studies on a watershed scale, choose a watershed that is of a manageable size in the state to try and focus efforts on getting very good quantification of the various nitrogen sources in that watershed. Compare them to the atmospheric deposition component and do some very good process studies or use some appropriate techniques to try and understand the relative retention of those different sources within the watershed, and therefore be ultimately able to resolve the various sources to coastal waters.

**DR. REINFELDER:** With regard to mercury, we can probably do pretty well on estimating a direct wet deposition number, which in most cases, is the total atmospheric deposition. So I think we are going to be pretty good at getting a total atmospheric deposition number for mercury, maybe plus or minus 50 percent. However, the natural variability in the rainfall that Dr. Eisenreich mentioned will be a big factor in the uncertainty estimates. I would reiterate that natural variability is going to be a large part of the uncertainty. As Dr. Seitzinger pointed out, watershed retention efficiencies which right now have infinite uncertainty associated with them, are a key factor. We can get good deposition numbers, but what is actually delivered to a given estuary is a big uncertainty right now.

**MR. NAGOURNEY:** So let us turn to the regulatory community for a moment and let us assume that the best we can do is plus or minus 100 percent for certain parameters. Is that of any use to you? What are you going to do with those numbers? You have to develop TMDLs. You have to develop toxic inventories. You have a whole bunch of state-of-the-art data that is plus or minus 100 percent.

**DR. EISENREICH:** Maybe it would be better to say plus or minus a factor of two.

**MS. HELD:** I think the relative numbers are what is really important. For example, if you give me the wet deposition estimate for mercury— even if you do not look at the runoff and the dry deposition values the mercury number is a big piece of the pie. And the other estimates that are missing make it an even bigger piece of the pie. You do not know the total picture. But that is enough for me to figure out what to do. So I think that the relative contributions of atmospheric deposition compared to the other parts of the pie might be one of the things that will be helpful to us, and will help us to skirt a little bit of the uncertainty issues.

**MS. DiLORENZO:** At this point, New Jersey DEP is hopeful that we can use as much of the atmospheric deposition data in our TMDLs as possible. I am not a modeler so I am not sure how much the variability would be incorporated into the modeling efforts. We have a number of different models that we are using and one of the model evaluation groups would have to say what is appropriate data-wise. Relatively speaking, for each of the components loading to a particular water body, we are going to have to assign responsibility to dischargers. So having a good number for the atmospheric deposition will allow us to look to those sources from the air and implement some regulatory action. And I will turn to the PVSC, and say this is your contribution. You are going to have to reduce your nitrogen load by $x$-amount, and then I am going to have to go to the municipal officials, the local government and say this is your storm water component and you are going to have to do these best management practices to reduce the nitrogen loading. So I think relatively we can do some work but again with respect to the models and what is legally defensible in court, I would have to have the model evaluation group tell me that.

**MR. BELTON:** It is an observation. When it comes to data uncertainty and regulatory implementation, my experience, which is experience on the ground, is that the best "weight of evidence" is often used. Right now some of the models that we are using employ literature values, which come from publications, some of which are current, some of which are old. Coefficients for models come from literature values that have uncertainties associated with them. We make judgment calls on how good the information is relevant to how old the data are. Those are the same calls that you make when you try to evaluate in your laboratory whether you want to use it or not. Plus or minus 100 percent, I have used data like those to make decisions in the past. I was responsible for fishing advisory in the State of New Jersey. And I had 30 and 40 fish to analyze when the population of fish were in the millions. But what we had was consistent concentrations of PCBs and dioxins in almost every fish we looked at. There is a Food and Drug Administration level which was not-risk based but rather based on something that I could hang a hat on. And in working with people in other states that we shared waters with, we came up with an approach which was reasonable, rational, and we placed it into a model that we used. So I do not tend to be frightened by uncertainties. I would rather know the uncertainties and state what they are. I am very happy to hear Dr. Eisenreich and Dr. Reinfelder make these comments, so that I am aware of this. So that when somebody criticizes us for an action, we can state that we are aware of those uncertainties and there is a "weight of evidence" that supports our approach.

**MR. ROBERT NYMAN:** I wanted to reiterate what Ms. Held said about some of the relative importance in the variability. If you are saying that the load is only five percent of the total load plus or minus 50% or whatever — well, if it is five percent plus or minus five or ten, that is not so bad. But if you are saying that it is 50 percent plus or minus the same, then it is a much bigger deal. The other point is that, I am not sure that people really mention it often, the water loadings also vary obviously, there are error bars around those estimates as well. I am not sure that we can say that they vary by a factor of two as well. We are looking to compare a lot of this information or incorporate it into the CARP data that are being collected. I do not know what the variability is going to be on that as well. Who knows? Maybe we will have better numbers for the air than for the water.

**MR. ERIC VOWINKEL:** One thing that concerns me is that the Metropolitan area is probably the most intensely utilized region in the United States, or one of the most. And if you are going to find contaminants, this is where you are going to find them. So I would suggest the more contaminants we look at the more we are going to learn. And I like to look at the bigger picture rather than looking at some of the smaller lists of contaminants we are looking at. So some of the emerging contaminants that Dr. Brownawell mentioned earlier is something we should look at. And if there are people out there that can fund these existing air sampling platforms to do some of these emerging contaminants, I think it would be the way to go. Another thing I would like to reiterate is, as part of the piece of the pie question. One thing that USGS is doing is some storm sampling. And as far as contaminants are concerned Hurricane Floyd probably pushed through the system large magnitudes of contaminants, PCBs, PAHs, mercury, the whole works, in a short period of time, in a week's period of time, and all our estimates of loads from our rivers are usually done during low flow events. And it is not really taking into account that large pulse of contaminants that are being moved through the system. I think we should take that into account when we make our estimates for total piece of the pie. I think we should work together to try to work out those numbers.

**MR. NAGOURNEY:** Let me ask the panel one more question. Given there are certain inputs to the uncertainty that we can not control, there are obviously other uncertainties that we may be able to control. Dr. Eisenreich mentioned this morning the idea or issue of dry deposition and the fact that we really do not have as good a handle on the dry side of the atmospheric input as we do on the wet side. Is there any sense of trying to put greater emphasis on narrowing that uncertainty in the effort to try to get more usable data also on the regulatory side? Are there ways we can look towards trying to narrow that uncertainty that make sense economically in terms of cost-benefit? Or do we simply accept the uncertainties the way they are and try to deal with them?

**DR. EISENREICH:** I mentioned in my presentation this morning that we are funded by USEPA in Washington to do just that for the Harbor Estuary. A colleague of mine, Dr. Tom Holson at Clarkson University, and I worked together both in Baltimore and in Chicago. We have worked on developing new technologies for measuring and assessing the role of different particle sizes. And one goal was to develop the technology to adequately sample big particles, and then chemically determine their content. Then apply estimates to get at the actual dry deposition. We are doing it three different ways, particle size, distributions, a new technology in assessing dry particle deposition to water surfaces, and also designing aerodynamically suitable dry deposition plates. The essence is that we are going to deploy these devices in selected campaigns at the Liberty Science Center and at Sandy Hook starting in the fall and for the next 18 months after that. We should be able to get a handle for the first time both on the relative importance of big particles versus small particles, but also to get a much better estimate of the dry deposition of those large versus small particles for the chemicals that we are tracing. And we are tracing the list that I showed this morning as well as 15 trace elements.

**DR. MICHAEL WEINSTEIN:** Given what I have heard, and what I have been reading about, and what we have been funding I believe the numbers will hold up insofar as the atmosphere is contributing a substantial portion; i.e., slice of that pie. Whether it be 20 percent, greater than 50 percent and with the uncertainties wrapped around it. I have an engineering question from the standpoint also of what I have heard and what other people have talked about. For those identifiable sources to the atmosphere, are the BMPs now as costly, more costly, about the same as they are, let us say, at the end of the pipe for various other means of source control? The idea being is it much more cost effective to cleanup a third of the pie versus attacking the two-thirds, the bottom line being getting below the water quality criteria? Is there an engineer here that might be able to address that? I would like to know the answer to that and it is something that I can take up with a different community.

**MS. HELD:** I cannot answer that question but I think that is something that I have just been thinking about when Ms. DiLorenzo suggested that we apportion the responsibility among several groups depending on the proportion of their contribution. In the air program we do not do things that way. We look and say, okay, there is this contribution, this one, this one, this one, what is the most cost effective approach for reducing them? Each pollutant is going to have a different answer. But you would look around at all of them and say, well, if we just go to this one and maybe there is infrastructure money or something available, well let us do that instead of getting everybody else to do something that is really extreme and untested or something. So I think for each pollutant there maybe a different answer and it would be nice if there is the flexibility with TMDLs to do that kind of thing.

**MS. DiLORENZO:** There is flexibility in the TMDLs in terms of trade-offs. If something is more cost-effective to do in one segment of the regulated community, then the others contribute to that. So there are trade-offs to get the biggest bang for your buck.

**MR. BAKER:** This gets back to the question of data variability. This is probably the ideal way of doing it but once you get away from the assumption that we have a problem in this water body and here is a source over here that is contributing to the problem. And once you ask the question well how much does that source contribute to what I am measuring here at this water body? Then you get into all these questions of variability and what is happening. You have to understand the mechanism. What we do in air a lot is we assume we have a problem, we have a source, and if we reduce the emissions from the source that we are going to be impacting the problem without necessarily fully understanding that relationship. And we can do that but the more you try to do a really good cost effective solution to a problem, the more you have to understand and the more the variability comes into play.

**DR. SUSZKOWSKI:** I just want to go back, I think the previous two speakers addressed your point, Dr. Weinstein. Again, I think the key is to put the atmospheric component in to context of everything that is affecting the estuary, and then you see what you have got. And what makes the most sense. I would like to just go back to the numbers. If you guys could promise to get numbers within 100 percent, I think a lot of us would be very, very happy. I was sitting over here very delighted.

**DR. EISENREICH:** You are the only one in the room.

**DR. SUSZKOWSKI:** Within our CARP program we have gone through the exercise of trying to construct those pie charts for all the contaminants we worried about, and we have not been too concerned about nitrogen and some of the metals that we can construct the pie charts on. Well, there are not the ones that we are most worried about. We do not even think we are close to be being within an order of magnitude of estimating where these things are coming from by source loading. So I would just like to say I would like to be able to hold your feet to the fire on that estimate of being within 100 percent.

**DR. EISENREICH:** I thought you were making an argument we could relax a little bit. I guess not.

**MR. NAGOURNEY:** Let me move onto the next topic, which Dr. Brownawell will facilitate, which is applications of data. Before I hand it over to Dr. Brownawell, I will have to turn to my colleague Mr. Belton to sort of frame the issue on TMDLs. Why are we interested in this? Why TMDLS are a key endpoint for some of the data? And then we will have a discussion which Dr. Brownawell will lead for a few minutes before the break on exactly what are some of the applications of this information.

**MR. BELTON:** I have been asked to kind of put this in focus. I am not sure if I totally understand it myself but... We are going to have to generate a multimedia model. We are going to have to have some kind of modeling tool which is going to fold in sources including ambient concentrations into a predictive model. The predictive model that we are looking at right now will be developed for the Harbor-wide area, which includes that whole green area I showed you on the slide this morning. That model will have a receiving water component. It will have a storm water component. It will have a sediment suspension and re-suspension component. It will have a food chain component as well. Now the air data would normally be built into these models, as I understand it some of these receiving water models already have factors built in assuming that there is some net flux of air contaminants into the system. What we really want to do is take the data and put that into some localized, real-time modeling predictions. Some of the things that I heard today have intrigued me. There are two approaches to doing this model. I know in the Chesapeake Bay region they developed a model which took the air component and the water component and they built what is essentially a spatial model. They took air sheds and broke them up into spatial segments and overlaid them on top of the receiving waters, which allows you, theoretically, to predict where things will move from your air into the watershed, and then through receiving waters. I am not sure how doable that is but that is generally the spatial model that they set up. One of the questions: Can we just take some of the air data that we are generating here and put them into the preexisting models as monthly means and get the kind of information that we need? Or do we need to really build a spatial model that will be able to distribute this information? Initially, my feeling was we may not have to develop a spatial model but then I heard some of the information that Dr. Reinfelder presented today about the mercury data, which showed that in some studies on receiving waters based on catchment basins, that this may not be a wise approach. And my comment is: If you just take the air data and you do not factor in the particles falling on the ground, with those contaminants removed at a certain level, or possibly changed before they get into the water, the model may not work. You might have to really deal with looking at what happens once the air gets on the surface of the water versus the land, and what happens as it gets turned into storm water. So those were some of my thoughts when I posed the data needs for TMDLs. Do we just take the air data and stick it into preexisting models? Or do we have to do something to the data?

**DR. BROWNAWELL:** We will try to answer that in a little bit and see what our panelists and our audience think about some of these issues. And there are a lot of data being collected in this program and there is an awful lot of information wrapped into the data. So the thought for the audience is try to get a feeling for what kind of information we are going to be able to get out of it in terms of sources directly into the atmosphere as well as non-point sources in terms of runoff into the basin. Whether we are talking watershed, or we are talking runoff from the parking lots and street, and streets are very important for many of the metals and PAHs. How do we get our arms around those thoughts? What do we know right now? And what could we be doing with the data? And finally, is there anything that we could be measuring that we have not included yet that might allow us to get more information about sources for people that are trying to control those sources? So I guess what I would like to start with is: We saw a number of examples today of how you get some information about sources. Dr. Eisenreich talked about the fact that with the dibenzo-dioxins we are seeing lot of what looks like recycled compounds suggesting that you are not necessarily going after primary emitters to get your arms around the problem for dioxins. But there are also data from all these programs related to wind direction, perhaps to trajectory analysis, New Jersey has this broad network. And so I guess I would like to turn it over to the speakers to get a perspective of what kind of information they expect to get out of this discussion. The first question I ask: When measuring concentrations in the air based on a given program, what are we going to be able to expect to know about what the source of the individual contaminants are?

**DR. REINFELDER:** Maybe I should start with identifying sources.

**DR. BROWNAWELL:** You are taking individual measurements and what is it we are learning about the sources and what can we expect to know after a couple of years of monitoring about the sources that might be controllable or not controllable for various metals and mercury especially?

**DR. REINFELDER:** One thing that I did not discuss and has not really come up in terms of identifying sources of atmospheric metals and mercury is the use of the trace metal fingerprint that we are getting from my work and Dr. Gao's work, to identify specific sources, be they fossil fuel, coal or oil, incineration, etc. There have been studies linking specific trace element fingerprints to specific sources. That is one avenue that we will be pursuing that will help in that regard. And also linking dry deposition to meteorological conditions; similar to what Dr. Eisenreich presented in terms of back trajectories of air masses. This has been done successfully with mercury in dust, for example. I keep going back to this New York State study because it shows clearly that when the wind is out of the south, you get a lower mercury input than when it comes from the northwest, which is coming from the copper smelters in Canada. And that is how they identified that particular source. So I think a combination of trace metal fingerprinting and meteorological back tracking will help in the identification of sources.

**DR. BROWNAWELL:** From examination of the data so far my interpretation of what you showed today and you probably said this, is that it does not appear that the local sources of mercury are controlling the normal concentrations. Is that correct?

**DR. REINFELDER:** I think that the largest fraction of the wet deposition I am measuring is not from local sources. But there seems to be local differences among the sites in terms of concentrations of mercury in rain and the deposition fluxes that I have calculated so far. Those are not the major fraction of the mercury that I am seeing, but that is a qualified statement right now.

**DR. BROWNAWELL:** Is there anything else that we could be measuring in terms of rare earths or anything that would give us more information than we are presently getting in terms of source identification?

**DR. REINFELDER:** We are not measuring rare earths but we are measuring antimony as a tracer of some specific sources. You can use combinations of zinc, copper, cadmium to identify some of these sources. So we are measuring most of the metals that we need, to do this kind of analysis. Getting back to what Mr. Belton said earlier: how do you deal with spatial variability in the model? Can you just plug in a number and go? Of course, not! And the spatial variability has two components. I think there is going to be some variability in the direct deposition between sites even within the state, and, of course, what you talked about, the catchment area size, add spatial variability to those numbers. And for mercury, as I have emphasized that what we really need to get a handle on is the efficiency of the transport of terrestrially deposited mercury to the water body of interest.

**MS. HELD:** May I say something about the catchment issue? We also have looked at it more from a modeling perspective; i.e., what the runoff would be and we went through the literature and said here is an equation, we will use it. This equation and those parameters there is a lot of uncertainty in those parameters and that might be something we should go back and look at right now. What is in there and what needs to be measured? A lot of it though is more not what was falling from the sky, but what kinds of soils you have, what kinds of vegetation you have, and those sorts of parameters. You probably need to be collecting that information, and getting that model ready so when the deposition numbers are all there, you can combine them.

**DR. REINFELDER:** I am not sure we have information to get that number. I mean they had a 25 percent number in the Midwest study, if it fell on the land 25 percent of it would end up in the nearby lake. Can we apply that number in New Jersey, really that is an open question as far as I am concerned.

**MS. HELD:** It would vary around the state too.

**MR. BELTON:** At the NYSERTA Conference last year they talked about forest cover, and from the perspective of nitrogen and acid rain binding up certain contaminants. Based on what was said earlier, doing a geographic approach, if you knew what the land cover was, and add that to your catchment basin, maybe you could look at it that way as well.

**DR. BROWNAWELL:** I am going to come back to this indirect runoff estimation in a few minutes. So we will come back to this issue.

**DR. EISENREICH:** Use different scales and different regimes for thinking about sources. Dr. Georgopoulos would tell us correctly that if you have information on emission inventories and link that as a driver of atmospheric transport, ultimately putting that information into a deposition model, you can then relate concentrations in the atmosphere at a point, as well as deposition, back to the source. Thus, you can apportion the sources. For some things like mercury it is thought that we have a pretty good handle on what the emission inventory looks like in the United States. They used to think we had a pretty good emission inventory on dioxins and furans too. The emission transport deposition models throughout the United States accurately reproduce the pattern of high deposition, low deposition, high concentrations, low concentrations. It just that the model output underestimates the deposition by a factor of 5 to 10. And there are sources of dioxins that are missing, but the model framework seems to work. That is very, very encouraging because somewhere along the line you have to gain confidence that the model itself accurately reproduces reality to the extent that we understand it. Now we turn our attention to the chemicals that we are measuring here most of the time. Obviously we can relate in a very simple sort of way high concentration days to wind direction, low concentration days to wind direction. Major episodic influences, as well as back trajectories. But for something like PCBs this is a banned chemical. There really is no good emission inventory for PCBs, although, there are now really trying to build one again. Most of the PCBs are remobilized from existing reservoirs for which emission inventories do not yet exist. Of course, they do not. I mean we know precisely where all the PCBs that were produced and used in the United States in the last 65 years are. They are distributed everywhere across the vegetation and soils of North America, the waters of the North Atlantic, and a little bit moved up to the Arctic. We know exactly where it all is. So this is one where new strategies about developing emission inventories is very important. But in the meantime you really have to quantify the source or source areas. First you understand what is driving atmospheric concentrations and then you try to back that off in terms of identifying important source areas, maybe even source types. For something like polycyclic aromatic hydrocarbons however, we know that a vast majority are derived from combustion sources, although evaporative sources may be important in this region as well. And there you have the opportunity not only for measuring individual tracers that are more heavily loaded to some sources or the other, but also to apply new sophisticated statistical techniques to get at source identification. So we are presently undertaking the task of using positive matrix factorization, a very powerful modification of existing principle component analyses, with the 36 compounds that we have been measuring at the various sites particularly in this region to identify what is contributing to the atmospheric concentrations of PAHs in that region. How much comes from diesel trucks? How much comes from gasoline powered motor vehicles? How much has come from oil refineries or oil combustion? How much is coming from natural gas combustion? How much may be coming from other sources we not familiar with at the moment? And we are confident that the power of the technique is such, and we have enough measurements of individual compounds in enough samples, that we will be able to estimate the relative source contribution to the PAHs that exist in this region. And so there is a whole variety of techniques that can be applied and the success of any one of them really depends on the properties of the chemicals, where they come from, where they are residing, and their production history. If there is good emission inventories, use Dr. Georgopoulos' approach and take those emission inventories and run with it, because I think they will very accurately reproduce what we will measure in the field. In the absence of them, you have to do any thing you can to narrow down source directions, source areas, source types in order to get back to that all important point that if the atmospheric deposition is important for a water body or a terrestrial regime, you have to go about the effort of identifying the sources. Now you may in fact be identifying the sources, but for example, if the major source of PCBs is fugitive evaporation from Pennsylvania, I think you have to throw up your arms and pretty much move onto the next chemical.

**MS. HELD:** No, we will sue them.

**DR. EISENREICH:** But if 20 percent contribution to local PCBs is coming from volatilization out of the lower Hudson River Estuary and an additional 20 percent is coming from degassing from the very substantial degassing that occurs in municipal landfills, then now you have real targets. Clean up the Hudson River for PCBs. Well, that is happening. And do something about the way in which we degass these landfills.

**DR. BROWNAWELL:** I would like to open it up for some comments or questions, or, you know maybe what people would like to know about sources. What you would like to see in terms of outcomes of data?

**DR. SUSZKOWSKI:** I think the kind of analysis that Dr. Eisenreich made is something that we are hoping will continue, not only some of the broader scale modeling that we are doing under CARP, but by putting together a couple of scales of models. A broader scale model to quickly get at the macro sources. Are we mainly concerned about air, or are we mainly concerned about POTWs? Try and focus our attention in the right arena and then go after those sources in a variety of ways. I think what we have heard a lot about today is the notion of flexibility in the way one attacks all of these problems. And I think what we are learning is that there is no right way, rather, there are a variety of ways and you have to just pick the right one, or be lucky enough to pick the right one to get the job done. The other thing I wanted to comment about too, we talked about emerging contaminants, and I think it ties into this discussion. It is nice to plan programs and we are all going to come away from this meeting recommending that we do more research. I mean, it is just natural — I am sure that is what is going to come out of this. What we do not do a good job on a day-to-day basis with though is working the regulatory side of things with the science. And when money becomes available it is very difficult to channel it into the kinds of research that we are hearing about and I am sure will be touted as wonderful kinds of things to do. I think that is a real challenge in making sure that those resources are available to do the kinds of what I will call, "ugly monitoring" that one needs to do to at some of the sources to stay ahead of the curve. I think we have a unique experience here in this region with the opportunity to get a little bit ahead on some issues, or maybe not. I guess from my perspective we are ahead a little bit of some other estuaries but having that money available somehow to insure that we can look at those emerging chemicals, that we can use new techniques is, I think, very important to the successes that we are going to need for ultimate contaminant reduction in the region.

**DR. BROWNAWELL:** I am going to jump to the next topic which is one that has always interested me and that is related to how do we estimate the atmospheric deposition of some of the metal and particle reactive organic contaminants that fall on the watershed. And in this case, our biggest problems with metals and potentially toxic organic contaminants is in our urban estuaries where we have tremendous economically important management decisions facing us. It is not your normal watershed. We have got a lot of concrete and asphalt. So when we do our TMDLs and we get the results from our CARP study and we find out sewage treatment plants are a major source or a significant source of PAHs, let us say, to New York Harbor, do we go and just blame some Sewerage Commission? Or when are we going to be able to say what the ultimate source of these contaminants are? What do we know now and what should we be doing in order to assess the indirect atmospheric deposition, especially into our urban estuaries? There has been a lot of work done, as Dr. Seitzinger suggested today, with nutrients especially nitrate in a variety of watersheds. Often times, far from man's influence. We have a lot of big advantages in how you study nitrate retention because it is a soluble nutrient that more or less follows the rain water. Whereas, if you are looking at something particle reactive like PCBs or PAHs or mercury, you can expect a large lag in terms of retention characteristics, and that might be an oversimplification in some cases. We also do not have the same sort of watershed in the urban environment. So I guess, maybe I would like to go around the table and see what people think and what the audience thinks about: What do you think we know now? Are we going to know any more? What is it that we need to do to better assess how much, let us say, what is in the CSOs? Or how much is in sewage effluent that is actually coming from the atmosphere?

**DR. EISENREICH:** A few years ago we were working in a workshop context about the importance of the watershed delivery of chemicals in the Chesapeake Bay via the Susquehanna River. We understood from the monitoring work that — I have to get the number right — I think it was like a kilogram per day of PCBs traveled from the Susquehanna River into the Chesapeake Bay at the mouth of the river. And so if we took into account what we thought to be atmospheric concentrations of PCBs distributed over the watershed, which exceeds the surface area of the Bay by 64 times, and estimated with what little knowledge we had about how forested areas really remove and cleanse the atmosphere of this class of chemicals, we calculated that a leakage rate of 0.01 percent of the estimated atmospheric deposition would account for all of the PCBs we saw in the Susquehanna going into Chesapeake Bay, which is one of the biggest sources to the system. Now I do not think anybody actually went back to test it, but one of the things I have suggested to NJDEP and also to some USEPA people from New Jersey is that we ought to isolate two small lakes with small watersheds or manageable sized watersheds. One in the northern part of the state and one in the southern part of the state. And really identify specific chemicals of interest, one or two, probably a nutrient, a metal, an organic, or something. And identify the relative importance of this atmospheric delivery to the watershed that gets into the system. I think it can be modeled based on the nature of the science. But we have no idea whether it is correct. No idea whatsoever. And it is very important that we understand these, I call them leakage rates, Dr. Brownawell what did you call it?

**DR. BROWNAWELL:** Retention factors?.

**DR. REINFELDER:** Retention factors, I am not sure.

**DR. EISENREICH:** Other efficiency samples?

**DR. REINFELDER:** Efficiency samples, export?

**DR. EISENREICH:** There we go. Export Efficiencies for the watersheds. You know, these numbers in the 10 or 20 percent range are really large numbers. This is very impressive. For lead, we know from studies over the last 20 years that the number is down around one percent or less. But we do not have very much information on the organic side. But it is very clear that we need to find this out because one can imagine transport of polluted air masses, ozone and $NO_X$ and all the precursors and PCBs and PAHs moving out the I-95 corridor or coming from Philadelphia and Camden across the Pinelands. There is no question that sensitive parts of New Jersey are being impacted by this polluted air mass. But we have not really undertaken the task of trying to understand the magnitude of the issue. That is, cleansing the atmosphere. The reverse side of it is, what proportion of that material actually gets mobilized into the flowing streams that make it to Barnegat Bay, for example? We have already estimated on the back of the envelop that all of the contamination of organics in Barnegat Bay can be accounted for by this sort of atmosphere-terrestrial capture leakage into the water and then dripping out into the Bay. It can account for all of the contamination in the system. Whether or not it really does that, I do not know. But that information really needs to be determined. This is a very important management question too, about the health of the ecosystem. It is interesting on one hand to put out fish advisories for consumption of certain types of fish based on chemical contamination in Barnegat Bay, when there are no sources in the watershed of that material. I mean, what do you do? From a management point of view and a regulatory point of view, you are out of luck. Unless it is really an atmospheric source, and you deal directly with the atmospheric side.

**DR. BROWNAWELL:** If for no other reason that you have decreased recharge when you pave a watershed, there has to be less retention in the urban environment. And to me that is a major question in what that retention is in highly urbanized environments and that is where the automobiles are, if we are interested in PAHs or maybe dioxins, or for example, some of the metals.

**DR. REINFELDER:** It could be a short-circuiting effect. Just to add, I agree with Dr. Eisenreich's assessment that it would be nice to take some relatively reasonably sized lake-watershed system to make this kind of an assessment in New Jersey. So we would have some efficiencies to work with at least. A couple of thoughts with regard to both organic contaminants and mercury. Is revolatilization during the time that mercury is there, one of loss factors? It is not only retention compared to something like lead where it sticks to the particles. Mercury also sticks to the particles but it also can be reduced and volatilized, and the same goes for other organic contaminants. Your question about mercury entry into the water and waste water treatment facilities is an interesting one that I have not even contemplated could be a recycling term for mercury in terms of simulating microbial reduction of $Hg^{+2}$ to $Hg^0$ that would then be volatilized during the treatment process. But that is just a very off-the-cuff hypothesis right now.

**DR. BROWNAWELL:** Presumably, if we believe the data from storm sewers and CSOs and could model the drainage, it is an accessible problem almost based on existing data. But it is not one that I think has been looked at very carefully.

**DR. REINFELDER:** I think back to studies finding silver as a nice tracer and being retained in waste water and water treatment, and I do not know of similar data for mercury that would be very useful.

**DR. EISENREICH:** The City of Detroit has done a several million dollars study, trying to evaluate the contribution of urban runoff reaching the treatment facilities. And the reason for it is that concentrations and loadings from the major Metropolitan Detroit waste water treatment facility were violating all sorts of standards. It was by far and away the biggest source of PCBs and mercury to the Detroit River and Lake Erie. I mean it was a very big source. So they have gone through various experiments trying to connect the atmosphere to deposition on paved surfaces, and then runoff, and what contribution that came to. What they arrived at is it represented less than 10 percent of the total. So they are rather confused at the present moment, five-million dollars later! Less than 5 or 10 percent of the loading of mercury and PCBs! There was also copper, cadmium and lead involved, but those two mercury and PCBs, less than 5 to 10 percent of mercury and PCBs loads coming out the other end of the waste water treatment facility could be accounted for by urban runoff in the Metro Detroit area, this big rain filter.

**DR. BROWNAWELL:** My guess would be PAHs would be the biggest potential.

**DR. EISENREICH:** Well, I thought mercury and PCBs would be important myself and we were just wrong.

**DR. BROWNAWELL:** I would like to open it up to our other panelists. What you would like to see in terms of uses of the data?

**MS. DiLORENZO:** I like the idea that Dr. Eisenreich mentioned about trying this kind of work on one or two lakes in the state, north and south, and why don't you give us a proposal and we will see what we can do?

**MR. BELTON:** That is a good idea.

**MS. DiLORENZO:** It is a very good idea.

**MR. BELTON:** That is something that we had a meeting with Dr. Eisenreich and panelists on a while back and discussed this specific issue, and we think it is something worth looking into.

**DR. SUSZKOWSKI:** I just might to add that scientists have been looking at a lot of the reservoir systems by collecting and dating cores and looking at PAHs and PCBs and a variety of other things and coming up with some interesting estimates.

**DR. REINFELDER:** And I understand they are going to be doing mercury as well?

**DR. BROWNAWELL:** Mr. Baker, do you want to add anything? Any other comments or questions?

**MR. CHARLES APP:** We have very similar problems with PCBs in particular in the Delaware Estuary and that is one of the reasons I am here because I want to hear what was going on in this area. I can not help but think that across the country there are workshops, just like this one, going through the same process and asking a lot of the same questions, if not exactly the same questions. It sure would be nice if there was some kind of coordinated, focused, national research effort to get at these issues. We are not the only ones that have these problems. And I think, just speaking from our experience and in our region in trying to deal with these kinds of issues, we never have even 1/10th the resources that we need to do the job. So we cut corners. We try to beg, borrow and steal wherever we can get a little bit of funding, but we still end up not having enough to really do what we would like to do. Maybe there is a need to elevate this discussion to another level so it does get the kind of attention and resources that these kinds of issues deserve. Right now, it is just not getting what it deserves in my opinion.

**DR. EISENREICH:** My USEPA colleagues can tell you that this is already in place through USEPA's National Estuarine Reserve Program and the connection to the Great Waters Program. They have already been meeting and exchanging information and Great Waters has been distributing money nationwide, San Francisco Bay, and Tampa Bay, and Galveston Bay, and other estuary systems to evaluate needs. I think the emphasis has largely been on mercury and nitrogen, but to some inorganics as well. So they are indeed already linking up and are linked up. Maybe it is just trying to identify where they are in USEPA with respect to this.

**MR. APP:** I am an office Director in the region and I have three national estuary program studies in my office. There is some truth to what you say, Dr. Eisenreich, that people are talking about it, but I know for a fact that it is just scratching the surface.

**DR. EISENREICH:** I know that too.

**MR. APP:** And it is a little bit frustrating at times to see that we are really not doing nearly as much as we ought to be doing and have the capability to do. It all goes back to the resources that are available, and what the real priorities are. Somehow the word needs to get to the right people, so the resources are put in the right places.

**DR. EISENREICH:** I agree with you.

**MR. WATSON:** Along those lines I am about to issue a program opportunity notice in a couple weeks to integrate a lot of this information that is out there on acid deposition, on nitrogen, on mercury, on fine particles, and it is three-quarters of a million dollars. It is not enough to do everything but it is trying to get the information that is out there and get people to start sharing it more. Even though our focus, of course, is really on benefits specific to New York State there is an awful lot of work going on here and nationally that can be shared in both directions. I have to talk to Dr. Suszkowski because we are funding some of the same sorts of projects in the same state. You are working with people in New York State and we need to find ways to try to get our limited resources together in a timely manner. We all have our peculiar funding cycles and, you know, if I have a grant with a due date in June but the EPA is not going to have their money available until October, it messes up everyone's approach and somehow we have to sort of think about how we can be a little more flexible in getting people to work together.

**MR. NAGOURNEY:** What I would now like to do is to spend the remaining time talking about data management. What I want to focus on is really two points that were on your handout that we really have not addressed. We have a research effort here in terms of the atmospheric deposition network in New Jersey that is a three-year project and we are maybe halfway along that path at this point. There is going to come a point where that funding is going to run out, and then we have to think about what happens after that. Do we continue to monitor the way we have gone along but on a more routine basis? For what parameters? In what locations? How do we integrate the research effort that Dr. Eisenreich had begun into a monitoring situation? And how should that monitoring situation should be structured? On the other hand maybe a routine monitoring network is not what we need. Maybe we should think about a series of special studies, more research oriented to examine specific issues? So given that any point in time we are going to have limited resources what is the best way to apply them in the future to collecting data to address the issues? I want to first put that to the panel in terms of how they see things evolving in a two- to five-year time frame from a programmatic perspective? And then ask for the audience's input as to the best ways that we could spend our resources.

**DR. EISENREICH:** Let me say first that our experience with the integrated atmospheric deposition network in the Great Lakes Region says that the greatest benefit from that program is the atmospheric trend analysis. It has five sites spread over a very large region, and they use the data to estimate deposition. But where it has been most applicable is in looking at the long-term trends of chemicals that vary seasonally, let us say, in the entire region. And those trend analyses have been very important in documenting technology shifts, and improvements in environmental status and trends, etc. To some extent, I think it would be advisable in the long term to isolate one or two sites in New Jersey, or even one site that would take care of that issue of long-term trends. Are things getting better? Are things getting worse? And also using it in a sampling framework to address other questions on a somewhat more intermittent basis perhaps.

**DR. REINFELDER:** This is for the future?

**MR. NAGOURNEY:** Yes. As we are sitting here we have got resources to put into atmospheric deposition studies in the future, *x*-number of dollars. What would you do with it? Would you establish, like Dr. Eisenreich said, a status and trends network? Would you like to see the money used for other purposes or combinations thereof?

**DR. REINFELDER:** Probably a combination would be the best. I think it would be very useful to maintain a long-term collection site. I know in terms of mercury, Dr. William Fitzgerald has been a great proponent of a monitoring network for mercury. And certainly in this region in between New York and Pennsylvania we should have at least one site for looking at mercury. But probably the entire network should not be maintained indefinitely beyond a reasonable time-frame and that resources should be put into the specific areas that we have talked about. The catchment issues, looking at the source identification issues a little bit more carefully in terms of: Can we fingerprint the atmospheric deposition that we are measuring? And again, refining the models is really going to be a big effort. You are going to get to a point where more measurements are not really going to help you and you are going to have to really make decisions in a modeling framework. Some research probably needs to go into that as well.

**MR. NAGOURNEY:** My colleagues on the regulatory side of the house.

**MS. HELD:** I would agree that you definitely need to maintain one or more sites for trends, especially for those pollutants with a TMDL where source reductions are required. You want to see how we are doing. I would think some kind of monitoring to see how successful you have been would be an important component. And perhaps we can look regionally at a network so that if we only have one or two in New Jersey but there are a couple close by in other states, we can still get a pretty good regional picture. And we should think about that when we are identifying sites. I know this focus today has been on estuaries but I think more in terms of where the people are, so if you are trying to choose sites that you are going to keep going, Camden, New Brunswick, Elizabeth and Chester are good candidates. We are going to do some extensive air toxics monitoring there and the data that you are collecting at those sites already is complementary. Those would be great sites in my mind. But no matter where you choose them, if there is a complementary data set that obviously enhances the site and makes it even more useful, those are the ones I would choose. I also like the idea of being able to go out for special purpose studies. There is still so much we will not know at the end of this three, or four, or five years that you are going to need the capability to fill in gaps, to be prepared to address new pollutants. Those would be the places where I would place emphasis.

**MR. BAKER:** There actually may be some good news in this area. There are two trends that are going on in air monitoring and while we are not directly funding deposition modeling out of the normal Air Grant that the Department gets, we are redirecting the money that we give the Department, which is fairly substantial, for the monitoring network. This is done in two ways which I think will help and maybe even help keep some of the stations operative; 1) we have a PM fine standard coming down the line and there is a lot of money that is going in to establishing a network to monitor for PM fines. And some of those stations will actually be doing speciation, which will give us information that will help here; and 2) air toxics are starting to get increased attention. And there was actually some extra money made available this year to fund stations in four, I think, it actually became five major metropolitan areas to do a rather detailed air toxic monitoring study. Unfortunately, New York/New Jersey was not one of them. But there will be money available for some smaller studies in other areas and there will be money going into, I am sure, New Jersey for that. This money should continue into the future. So like I said, it may not be as bleak a picture as you may have painted it initially.

**DR. BROWNAWELL:** I would like to make query Dr. Eisenreich. I heard one maybe more permanent air stations are in place, and I would argue that you would want to have at least two stations for contaminants that have significant urban sources. I would think you would want to have one non-urban as well as one urban, and to try to rely on a non-urban monitoring station that was out of your control in another state, history has told us, both ancient and recent, that it is not always possible to rely on inter-comparisons for some of these trace contaminants, including putting the data into models. It is not as good as people think it is in terms of inter-comparisons between laboratories and programs. I would think to get the most use of the data, you would want at least two stations. Would you agree with that, Dr. Eisenreich?

**DR. EISENREICH:** I agree. Three would be better.

**DR. BROWNAWELL:** Of course.

**DR. EISENREICH:** But of course to check those three you need three more. In fact you need to build a buoy in the harbor, a platform and put it on top....

**MR. SCOTT DOUGLAS:** First I would like to thank the researchers for coming in today and sharing their work. This kind of work is critical for those of us who are dealing with Port activities. The contamination in the Harbor has been a significant issue and a stumbling block for Port development, and for the maritime and economic growth of the Port region. I guess in that light I would like to say that it is very important for us who are working on maritime policy that if we are going to be talking about funding, continued funding on these projects that we need to make sure that we keep it in context for the economy. Where are these particular impacts, where are these particular loadings, and how do they tie back into the economy, are important to keep in mind. We need to also be able to show that as a result of the money spent on monitoring, and that we are going to spend on source reduction, that we are actually getting somewhere. I think that is very important. The Port Authority has mentioned that they want information from the CARP program to be able to go down to Washington to ask for money for source control. The reason they want to do that is because it is tied to the cost of dredging. They can do that through the Water Resources Development Act. That is the funding mechanism to continue to monitor. So the monitoring program needs to be able to tie back to that dredge material economic component. That is something to keep in mind as you develop any kind of long-term monitoring. I think the other element that I would like everyone to be thinking about is, how the various impacts, the various sources, the various loadings, the various contaminants of concern are tied together? And any strategy that is undertaken to reduce sources is looked at in terms of its overall context. Because sometimes putting a lot of effort into a source reduction in one area can either remove resources from another area, which may be of equal impact or equal effect on the environment. Or it can actually take resources away from a very serious area and put them into an area that is not so serious, because we think we understand that one better. So I would just encourage everyone to, as they are working really hard in this very complex area, before they wrap things up— to back up and just look at it from 20,000 feet in the air— and to just make sure that we are doing, and what we are recommending, make sense in the overall picture.

**DR. EISENREICH:** Just one more statement, if I might. As we gain more atmospheric data in the southern part of the state, it is very clear that there is a very, very pronounced north/south gradient in everything. And so that clearly has to be thought about in terms of long-term monitoring.

**DR. WEINSTEIN:** New Jersey Sea Grant has a process, we have an infrastructure through the Sea Grant Advisory Board that would dictate whether or not this Sea Grant funded work continues from the standpoint of relevancy to the State of New Jersey. And I do not think I am going out on a very large limb to say it is very likely do so. So I will offer through the Sea Grant Advisory Board upon which Mr. Belton sits, and the USEPA sits, and the Corps of Engineers sits, and Dr. Suszkowski sits as a Board of Trustee member, that we will in the future be soliciting proposals. As long as those proposals meet the rigorous technical quality criteria that we establish for them through a different group, the Scientific Advisory Committee, that we will see this work continue. I make the same offer, we have had great success leveraging Sea Grant and NJDEP dollars. I am hoping we will continue to do that with Hudson River Foundation, with New York Sea Grant eventually, and the USEPA and others. So I keep that on the table. We will contribute to a source pool of funds as long as the relevancy and technical quality is there.

**MR. NAGOURNEY:** Let me pose this question to those USEPA people who remain: We have been only slightly successful in making our argument to Washington about funding research in New Jersey on atmospheric deposition. We have got this $100,000 which has been pending for three years, Dr. Eisenreich is that correct?

**DR. EISENREICH:** We have not gotten it yet.

**MR. NAGOURNEY:** Yes, we have not. Although we have been promised this now for some time. Is there any way that any members of the audience could suggest that we try to regionalize this approach, if we are going forward with some sort of permanent monitoring effort? Going to USEPA, obviously, ends at the Delaware Bay. And we have Delaware and Maryland and other USEPA regions to think about. Is there a way to approach this problem from a regional perspective, indeed it is a regional issue, that we could develop a plan that could span more than one USEPA region and perhaps give us some more leverage on negotiating the funds we need to address this issue? Let me turn to my Region III colleague here for a comment.

**MR. APP:** I think it is a very valid comment. It is a very valid comment and clearly if you have a broader base of support, and in this case it would be two USEPA Regions with multiple states, you know those kinds of proposals are looked on more favorably. And they do stand a much better chance of getting funded. So I think there is the opportunity there, and as I said before, we have a lot of the same problems and a lot of the same needs. It would make sense to me that we take a look at that.

**MR. NAGOURNEY:** I think what is an appropriate outcome, at least on this issue, is to try to come to some consensus on a regional basis with various players contributing to a long-term management plan on this issue. To say once these data are obtained and the current research effort ends this is what we are going to do, and this is why we are going to do it, and here is where new (or existing) sites are going to be, and here is the information that is going to be derived, and here is who is going to benefit. That approach seems to be a good way to go about it.

**MR. APP:** I agree with you. I guess that coming out of this meeting we ought to talk about how we make that happen now going into the future. You know, maybe Mr. Nyman and I, and some other folks here, can address that and see what we come up with.

**MS. DiLORENZO:** I just wanted to mention that the State has made a significant contribution to the TMDL effort by dedicating the corporate business tax to watershed management and we have expanded our water quality sampling stations in our whole network. So it would only be fair for the USEPA to step in and be a player and develop the long-term monitoring for the air stations like we have done for the water quality stations. And just a note to the researchers, I do not know whether this is something you might want to look at but look at the data that we have for our water quality stations in relation to your air monitoring stations and see if there is any relationship there.

**DR. SUSZKOWSKI:** Mr. Scott Douglas provided a clue. What you are really talking about is how do you get money to do the things that you want to do. And it helps to have a hook and what has been a hook for a lot of the work that has gone on has been the dredge material problem. Now I do not want to suggest we continue to have dredge material problems, but if states want to do something there are things they can do. On the New York side there has been active interest in the Hudson River Estuary Management Program, which is a just a state program. And there is some discussion now of having that program being a line item in the budget that would allow, we hope, a long-term monitoring fund to be established as well to do some of these things. I think that the idea of having cross regional or USEPA regional monitoring is really a great idea, and I think the way to continue those things is to kind of merge and update the things like the CCMPs for the Delaware and Harbor Estuary Program. We have a monitoring plan in place. It could be revised. I mean, it is on the books. It is just waiting for somebody to come in with funding. And we have continued to explore funding to get these various indicators and we always come up short. And one of the things that I would hope that New Jersey might consider because where we see money is in settlement agreements, some litigation, or other action. Although New Jersey takes in money from enforcement as I understand it, it goes into the General Fund and is not readily accessible. I would very much look towards those sorts of enforcement initiatives to start a fund to make these things happen because I think monitoring is not going to continue into the future. It just does not happen. We do not really have any examples anywhere that I am aware of in the country unless there is some established pot of money for continuing monitoring over the long haul. So I would say there is very little hope of our good intentions making that happen here, but I do think there are some opportunities. The one thing that we really did not talk about is there are different kinds of monitoring. As Dr. Eisenreich mentioned, you took actions and you want to see how well things are going as a result of those actions. Are things getting better? Are things getting worse? That is one way of approaching it. But we have also talked a lot about monitoring that goes into our conceptual and mathematical models. It is not just trend monitoring but collecting data that you are using to build conceptual "models" into the future and testing them and so on. I think that is where we have to look a little bit more carefully as to the research role, the monitoring role, the outreach and the variety of things to get done. And if it is done in a context of accomplishing a specific project, whether it be cleaning up dredge material or something where you have that hook, it makes things much more manageable, and I think more reasonable in order to get funds. But I think it is an administrative problem more than a science problem.

**DR. WEINSTEIN:** Someone asked me earlier how we are going to disseminate this information. It is clear that this is being taped and it is going to be edited, and we will spend some time putting together an executive summary from the tape, which along with the articles that our researchers will be providing will be published as your handout says as a *New Jersey ShoreLines* special publication. My comment to you is that each of these journeys begins with a small step and Sea Grant will underwrite the costs with whatever remains from this grant (to host this conference) and other sources of discretionary money that I have. But I think you have already seen that this is going to be a valuable discussion document plus the summary articles and the funds that are forthcoming for the copies that I can create. And I ask anyone who is willing to step forward, to make that happen. We will also put this material up on our website.

**MR. BELTON:** I would like to ask a technical question. We are discussing environmental impacts and environmental management. We are talking about whether we need to establish a long-term monitoring network; from a State perspective and even from a regional perspective that is an interesting consideration. We heard that you might be able to get away with establishing one or two sites throughout the state and I know I posed this question before to you, Dr. Eisenreich, about the length of time, the duration that you would sample, and would you sample differently based on what your goals are? If you are looking for long-term transport as opposed to regional signals, you might want to have one or two stations that you sample frequently as opposed to a diffuse group of stations which you would sample on a long-term basis. I would like to address Ms. Held on the point she made, about four sites in the state, Camden, New Brunswick, Elizabeth and Chester as areas that we are thinking about doing more long-term monitoring in the future. How often are we going to be sampling those sites? What are the study objectives? And do you see a way to take what Dr. Eisenreich has created as a New Jersey atmospheric deposition network and rolling that into the larger scheme with some minor modifications?

**MS. HELD:** Well, I know that as far as how frequently we are planning to sample, I think there are hoping to do it once every six days. I know that Mr. Peterman was designing the network at the request of the Governor. There is a lot of interest in it. He looked at where we had deposition monitors going or about to start up and felt that piggybacking would be very, very helpful to us. We could get a lot more bang for the buck at those sites. And we are sort of counting on getting some metals data from the particulate sampling, at least in the short term. So that is sort of the dry deposition side, the particles and the gases. And we have not thought about the wet deposition part but that certainly is another important factor for certain pollutants. So as we move forward with getting that set up — I do not know whether we could get more money for that. We do not have enough money to do what they asked us to do as it is. There is also a plan to have equipment that can move around the state for special purpose sampling, either a trailer or some other kind of mobile platform. One that could go to different parts of the state for anywhere from three weeks to a year and sample for these pollutants.

**MR. BELTON:** You would sample on a six day basis and would you be sampling for the same contaminants of concern that Dr. Eisenreich and Dr. Reinfelder are looking at now?

**MS. HELD:** At the fixed sites we would be sampling volatile organics, a lot of aldehyde type things, a bunch of semi-volatiles, probably not dioxins because we can not afford it. And then the metals, if they are not already monitoring for metals, we would do some metals. And then mercury because that is a different method. So a big suite of pollutants is what we are looking at.

**MR. BELTON:** One last question. Are you aware if Pennsylvania and New York have similar networks or similar monitoring activities planned in the future?

**MS. HELD:** New York State had a lot of air toxics monitoring going on for quite a few years spread around the state. I do not know how much is still there now but there was a time where they couldn't get money for anything but air toxics monitors. I do not know what the existing network is like now. Other New England States also have networks going, some on a long-term basis and some on a campaign basis. Vermont did monitoring at several cities in their state but on a short-term basis, but a couple of sites are continuing.

**MR. BELTON:** What about Region III in Pennsylvania, Delaware and Maryland? Do you know if they have networks setup?

**MS. HELD:** I have not discussed what they do.

**MR. BELTON:** I am just thinking of this in terms of a regional approach.

**MS. HELD:** Yes.

**MR. BELTON:** It would make more sense if they had something on the ground that they could build.

**MR. BAKER:** As I said there is going to be more toxic monitoring done throughout the nation.

**MR. NAGOURNEY:** Any other comments from the panel or the audience?

**MS. HELD:** Since we are on the environmental management thing I do not know where you are going with the rest of discussion, but having spent the last few years on the National Environmental Performance Partnership System and trying to think about environmental management, it seems to me there are many steps that should be followed, and what we have heard today are bits and pieces of stuff. Two points I would like to make, one is I think of pollutants as children. They are each special. They have to be approached individually.

**DR. REINFELDER:** You are not supposed to favor one child over the other.

**MS. HELD:** Some need more help than others. But each is special and we can try and develop a broad approach, but for each pollutant there is going to be different twists and turns. But I also think it would be very helpful with all these bits and pieces that we have that you pull it all together in the form of what is in the water, is it bad? What does the source pie chart look like? For the air deposition part can you do source apportionment from what you know, can you use emission inventory information to figure out what the sources are? Then develop your reduction plan from modeling efforts. Maybe use the modeling to see if it is going to work. And then with the long-term monitoring you can see if you made any progress. I think you have all those steps and we should probably lay them out for each of these important pollutants that we are talking about or pollutant groups, and find out where the gaps are. Because for some of these pollutants we have gaps in that list, and for others maybe we are starting to fill them in pretty well. I would love to see that sort of logical progression now that we are getting so much information.

**MR. NAGOURNEY:** I think what we probably can do is have that discussion at least amongst ourselves and put this on a piece of paper and then distribute it. I think that would be a valuable tool for us to have, because there are people that want to be here like Mr. Peterman in Air Monitoring, who should be here, and Mr. Elston who should involved in this discussion. So we need to involve them as well. What I would like to do sort of as an outcome of this workshop is to think about convening another session. I do not know quite how this would work. But to talk about the issue of next steps. And try and involve a couple of USEPA Regions, maybe try to get USEPA in Washington involved if that is appropriate. Try to bring in Sea Grant, and Hudson River Foundation, maybe our dredging office in New Jersey, and other players to see what we do long term on this issue that makes sense. And I think here in terms of where we put our stations and what we ask them to look at. That I think, would be a valuable outcome of this effort. So what I will try to do as sort of a program manager at least for the network is to try to facilitate that aspect and to identify the players, see if we can get them together in a relatively short time frame to start that discussion. And then see based upon the comments that are derived from that discussion, see how we approach the mechanistic piece of who we approach for funding, how do we do that?

**DR. EISENREICH:** I would like to just make a concluding comment. We have been throwing the term monitoring around rather loosely. This is not monitoring. Measuring dioxins, furans, PCBs, chlorinated pesticides, at multiple sites on a high frequency basis at trace levels in the atmosphere is not monitoring. This is really more research monitoring. I think it is one of the reasons, of course, why there is really very few of these kinds of major efforts because it is so difficult. It is so expensive. It requires lots of instrumentation and talented young people and tremendous care with respect to doing this in the field. We call it routine and we work our hardest to make it routine, but it is not routine. This is not for everybody. But it is becoming much more so as time goes along. And I think what the people in the Great Lakes have missed in their groundbreaking network, that we have tried to capture in New Jersey, and hopefully will remain part of the message is that these kinds of efforts are really monitoring and research networks. The monitoring part can provide an infrastructure of background data, background information and leads to framing appropriate questions. But all atmospheric questions cannot be answered by having a routine monitoring network. It must involve research, campaigns in the field to support models, to look for long-term data — you can never really address properly air/water exchange in the Harbor unless you go to the Harbor, get a boat, and you know you do not do this in the context of a routine monitoring network, although it would be very nice to do that. But I wanted to make the distinction that this kind of monitoring is not like measuring phosphorus in a river system draining into a lake. This is much more sophisticated and sort of on the edge than that kind of activity. But it is these kinds of networks that really provide the infrastructure and basic information to address the questions; that can also be attacked then very, very clearly by having a specific type of campaign, a specific type of statistical type analysis, a specific modeling network. Dr. Georgopoulos is very interested, for example, in taking the PCB data out of the New Jersey atmospheric deposition network and trying to back out what the emission inventory must in fact be and where. Where are the emission strengths? Where are the clean systems? Where is the bad system? And how can we from a larger perspective, translate that nationally. Because this occurs everywhere. And so even just a data-rich system obtained in a monitoring sense really can be the formation of a major research area to get emission inventories. Where you cannot get them using the standard type of going to source, measuring the appropriate thing. So I wanted to just emphasize that research and monitoring are really part and parcel of the same question. And in the Great Lakes I think they have essentially lost the research side, and I hope that does not happen in the mid-Atlantic states.

**DR. WEINSTEIN:** We have another success story. It does not quite exactly fit what Dr. Eisenreich just said but it is related. It shows how you can leverage dollars. We funded a three-year project to develop a new hydrodynamic model and that model was being used to predict the fate of chlorine and its by-products in coastal outfalls. Now to calibrate the model required a rather large monitoring data set and I had a hard time, because I was told I was having a hard time by the Scientific Advisory Committee, funding that portion of it. But we were able to work out a deal, a partnership with nine coastal sewerage authorities, who funded that portion of the work. And together hopefully we will have a better assessment tool in the long term. And again, they funded approximately 25 percent of the total budget.

**DR. BROWNAWELL:** I guess we are getting ready to wrap up here. Mr. Nagourney I would like to thank the panelists and the audience for participating so much. I would like to make just one comment to follow up on Dr. Eisenreich's point that a lot of these management questions, to address them well requires research level participation. I am very pleased after being here today that New Jersey on the atmospheric side has done a very good job to provide a model for how this could work. And I just hope that New York and New Jersey can learn from this model to address some of the other large problems that are facing the New York Harbor Metropolitan area. I would like to thank everybody for an excellent afternoon.

**DR. WEINSTEIN:** I will say the same thing on behalf of Sea Grant and on behalf of the Consortium, and with our DEP colleagues, I think today was very fruitful and worthwhile. And now we will have the proof of the pudding in the *Proceedings* of this effort. Thank you all for attending. **(Session is concluded.)**

## In Attendance

Charles App – USEPA Region III
Arthur Baehr – U.S. Geological Survey
William Baker – USEPA
George Bakum – Tosco Refining, L.P.
Kirk Barrett – Rutgers University, MERI
Carol Bellizzi – USEPA
Thomas Belton – NJDEP
Jenn Bonin – US Geological Society
Bruce Brownawell – SUNY at Stony Book
Gary Buchanan – NJDEP
Gail Carter – NJDEP/DSRT
Kevin Civerolo – NYS Dept.of Environmental Conservation
Jennifer DiLorenzo – NJDEP
Scott Douglas – NJ Maritime Resources
Steven Eisenreich – Rutgers University
Mary Downes Gastrich – NJDEP
Ellen Falvo – Monmouth County Health Dept.
Anne Marie Fournier – Monmouth County Health Dept.
Yuan Gao – Rutgers University
Panos Georgopoulos – Rutgers Unversity, EOHSI
Cari Gigliotti – Rutgers University
Joann Held – NJDEP
Roland Hemmet – USEPA
Nancy Immesberger – NJDEP
Peter Jones – NYS Dept.of Environmental Conservation
Robert Kelly – USEPA
Barbara Kieffer – NJMSC
Zoe Kilman – USEPA, HEP
Lingard Knutson – Port Authority of NY/NJ
Kim Kosko – NJMSC
Carl Lawrence – Tetra Tech
Catherine Libertz – USEPA Region III
Jenny Liming – NJMSC
Judy Lows – NJDEP
Yeleno Maumova – Rutgers University
Leslie McGeorge – NJDEP
Edward McGrath – Rutgers University
Ascam Mirza – NYS Dept. of Environmental Conservation
Stuart Nagourney – NJDEP
Eric Nelson – Rutgers University
Robert Nicholson – US Geological Society
Robert Nyman – USEPA
Joel Pecchiloi – NJDEP
Helen Rancan – NJDEP, DWM
Imtiez Rangivale – Rutgers Unversity
John Reinfelder – Rutgers University
Dave Rosenblatt – NJDCP
Jinyoung Shin – Rutgers University
Kim Simpson – Monmouth County Health Dept.
Gopal Sistla – NYS Dept. of Environmental Conservation
Peter Sugarman – NJDEP, Geological Survey
Qing Sun – Rutgers University, EOHSI
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Daryl Van Ry – Rutgers University
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Mark Watson – NYERDA
Michael P. Weinstein – NJMSC
Tim Wilson – US Geological Society
Rick Winfeld – HydroQual
Shu Yan – Rutgers Unversity
Lisa Young – NJMSC
Rudy Zsolway – NJDEP

# Appendix I:

## Atmospheric Deposition Non-point Source Projects Cofunded by the *New Jersey Sea Grant College Program* in Partnership with NJDEP/NJDOT Maritime Resources

*Air-Sea Exchange of PCBs and PAHs in New Jersey Coastal Waters*
Principal Investigator: Dr. Steven J. Eisenreich
Department of Environmental Sciences, Cook College, Rutgers University
Initiation: 3/1/97 Completion: 2/28/99

*Atmospheric Deposition of Nitrogen and Trace Metals to the NY/NJ Harbor Estuary*
Principal Investigator: Dr. Yuan Gao
Institute of Marine and Coastal Sciences, Rutgers University
Initiation: 3/1/97 Completion: 2/28/99

*Atmospheric Deposition Deposition to Barnegat Bay*
Principal Investigator: Dr. Yuan Gao
Institute of Marine and Coastal Sciences, Rutgers University
Initiation: 3/1/98 Completion: 2/28/00

*Model Development and Chemical Characterization of Bioavailable Nitrogen Loading to Coastal Lagoon Ecosytems*
Principal Investigators: Dr. Sybil Seitzinger and Dr. Monica Mazurek
Institute of Marine and Coastal Sciences, Rutgers University
Initiation: 3/01/01 Completion: 02/28/02

*Monitoring of PCB Air Emmissions in Sites Receiving Stabilized Harbor Sediment*
Principal Investigators: Dr. George Korfiatis and Dr. Steve Eisenreich
Stevev Institute of Technology, Institute of Marine and Coastal Sciences,
Initiation: 2/99 Completion: 11/02

*Shiptime for Air-Water Exchange Measurements in the NY-NJ Harbor Estuary*
Principal Investigator: Dr. Steve Eisenreich
Institute of Marine and Coastal Sciences, Rutgers University
Initiation: 3/1/98 Completion: 2/28/99

# Appendix 2:

# Related Research Articles Published To-Date Supported by *New Jersey Sea Grant College Program* Funding

Baker, J.I., R.A. Hites, and S.J. Eisenreich. 2000. PCDD/Fs in the Great Lakes air and water and in the New Jersey coastal atmosphere. A Report to the New Jersey Department of Environmental Protection and the Hudson River Foundation.

Boethling, R.S., D. Calamari, C. Cowan-Ellsberrt, and S.J. Eisenreich et al. 1999. Evaluation of persistence and long-range transport of organic chemicals in the environment. *In* G.M. Klecka and D. Mackay, editors. Summary of the SETAC Pellston Workshop. SETAC Press: Pensacola, FL.

Castro, M.S., C. Driscoll, T.E Jordan, W. Reay, S. Seitzinger, R. Styles, W. Boynton, J. Cable. In Press. Assessment of the contribution made by atmospheric nitrogen deposition to the total nitrogen load to thirty-four estuaries on the Atlantic and Gulf coasts of the United States. *In* R. Valigura, editor. Atmospheric Nitrogen Deposition in Coastal Watersheds. AGU Books: Washington, D. C.

Dachs, J., D.A. Van Ry, and S.J. Eisenreich. 1999. Occurrence of estrogenic nonylphenols in urban and coastal atmospheres. Environ. Sci. Tech. 33(15):2676-2679.

Dachs, J. and S.J. Eisenreich. 2000. Adsorption onto aerosol soot carbon dominates gas-particle partitioning of PAHs. Environ. Sci. Tech. In Review.

Dachs, J. and S.J. Eisenreich. 1999. On the adsorption and partitioning of organic compounds onto/into fractal sorbents. Environ. Sci. Tech. In Review.

Dachs, J., S.J. Eisenreich, J.E. Baker, F.-C. Ko, and J.D. Jeremiason. 1999. Coupling of phytoplankton uptake and air-water exchange of persistent organic pollutants. Environ. Sci. Tech. 33(20):3653-3660.

Dachs, J., S.J. Eisenreich, and R.M. Hoff. 2000. Influence of eutrophication on air-water exchange, vertical fluxes and phytoplankton concentrations of POPs. Environ. Sci. Tech. 34(6):1095-1102.

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Eisenreich, S.J., P.A. Brunciak, J. Dachs, T. Glenn, C. Lavorgna, E.D. Nelson, L.A. Totten, and D. Van Ry. 2000. Persistent organic pollutants in the coastal atmosphere of the Mid-Atlantic states-USA. *In* R. Lipnick and D. Mackay, editors. Persistent Bioaccumlative Toxic Chemicals. ACS Symposium Book Series: Washington, D.C.

Gigliotti, C., J. Dachs, E.D. Nelson, P.C. Brunciak, and S.J. Eisenreich. In Press. Temporal and spatial trends of polycyclic aromatic hydrocarbons in the New Jersey/Hudson River Estuary coastal atmosphere. Environ. Sci. Tech.

Lohmann, R., Nelson E.D., S.J. Eisenreich, and K.C. Jones. 1999. Air-water exchange of PCDD/Fs in the Raritan Bay / Hudson River Estuary. Organohalogen Compounds 43:193-198.

Lohmann, R., E.D Nelson, S.J. Eisenreich, and K.C. Jones. In Press. Evidence for dynamic air-water exchange of PCDD/Fs: a study in the Raritan Bay/Hudson River Estuary, USA. Environ. Sci. Tech. 34.

Macdonald, R., S.J. Eisenreich, T.F. Bidleman, J. Dachs, J. Pacyna, K.C. Jones, R. Bailey, D. Swackhamer, and D. Muir. 2000. Case studies on persistence and long range transport of persistent organic pollutants. *In* G.M. Klecka and D. Mackay, editors. Evaluation of Persistence and Long-range Transport of Organic Chemicals in the Environment. SETAC Press: Pensacola, FL.

Nelson E.D. and S.J. Eisenreich. 1999. Trends and dynamics of chlordanes in the coastal atmosphere of the Mid-Atlantic United States. Organohalogen Compounds 41:391-394.

Paerl, H.W., W.R. Boynton, R.L Dennis, C.T. Driscoll, H.S. Greening, J.N. Kremer, N. N. Rabalais, S. P. Seitzinger. In Press. Atmospheric deposition of nitrogen in coastal waters: biogeochemical and ecological implications. *In* R. Valigura, editor. Atmospheric Nitrogen Deposition in Coastal Watersheds. AGU Books: Washington, D.C.

Seitzinger, S. P. and R. W. Sanders. 1999. Atmospheric inputs of dissolved organic nitrogen stimulate estuarine bacteria and phytoplankton. Limnol. Oceanogr. 44: 721-730.

Seitzinger, S.P. and R.W. Sanders. 1997. Biologically reactive dissolved organic nitrogen inputs from rivers to estuaries. Mar. Ecol. Progr. Ser. 159:1-12.

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Van Ry, D. A., Dachs, J., Gigliotti, C. L., Brunciak, P., Nelson, E. D. and S.J. Eisenreich. In Press. Atmospheric seasonal trends and environmental fate of alkylphenols in the lower Hudson River Estuary. Environ. Sci. Tech.

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