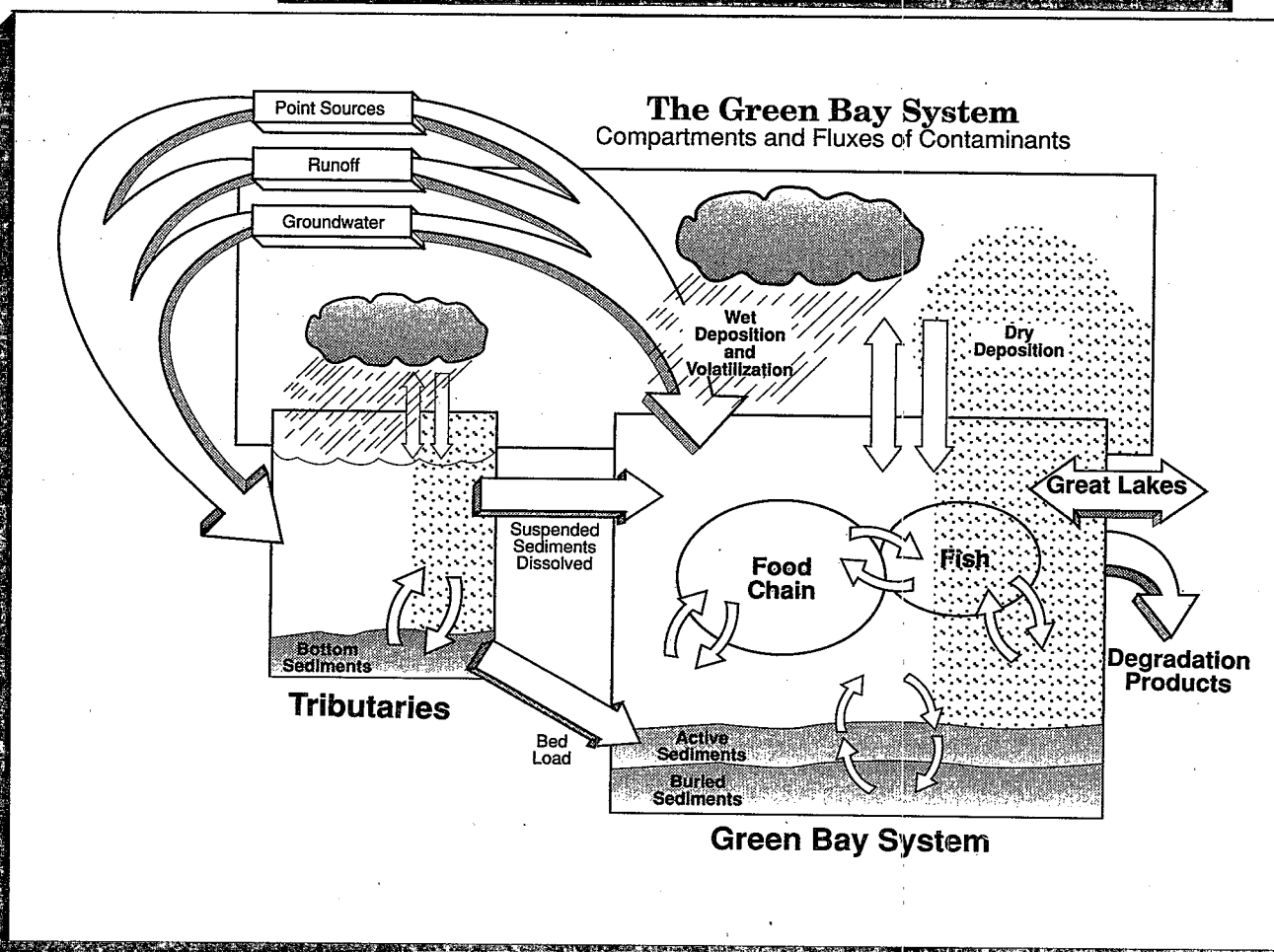




# The Green Bay Mass Balance Project

## An Advanced Analytical Model For Environmental Management

GREAT LAKES/NATIONAL ESTUARY PROGRAM TECHNOLOGY TRANSFER SERIES



### Summary

The Green Bay Mass Balance Study is a pilot project to evaluate the feasibility of mass balance modeling for toxic substances as a basic planning and management tool in restoring Great Lakes Water Quality. If proven, the methodologies employed in the Green Bay Model offer an accurate process for pollution control and remedial action plans. Engineers and policy makers will be able to employ lake- and basin-wide simulations to test the costs

and benefits of alternative policies with greater confidence than any current process.

The Green Bay Mass Balance Study will be of most interest to National Estuary Program participants involved in scientific applications, to the Technical Advisory Committees, and to those managers and staff who are designing long-term monitoring strategies.



## Introduction

Since the first Great Lakes Water Quality Agreement was signed in 1978, the Great Lakes National Program Office has worked to restore proper functioning of the Great Lakes ecosystem. While early work focused almost exclusively on reducing eutrophication by controlling nutrient inputs, more recent efforts have expanded to try to understand and control inputs of toxic contaminants. Techniques used early in the program that resulted in effective nutrient control methods may, with modification, be useful in managing toxic contamination.

When scientists began to focus on the major causes of eutrophication in the 1960s, they constructed basic input-output models of the Great Lakes to determine the most immediate (and cost-effective) measures to address the problem. Those analyses highlighted the need to control phosphorus discharges to the Lakes. Resulting control actions included banning phosphorus-based detergents, modifying industrial and municipal sewage treatment plant operations, and improving soil conservation practices by farmers in the watershed, all of which reduced phosphorus discharges. Such controls have already resulted in marked improvements in the Great Lakes' ecological health, especially in Lake Erie. Signs of improvement include, for example, revitalized fish communities.

Further studies have shown that a similar input-output methodology may be applicable to toxic pollutants, although the analytical and modelling processes are more complex. When studying pollution control technologies, a model — or series of models — would account for the flows of the most important toxics through the Great Lakes, from when they enter the lakes to when they leave. This input-output scheme, based on the principle of conservation of mass, is referred to as Mass Balance Modelling.

Scientists and policy-makers hope to use the technique to evaluate alternative strategies for controlling toxic contamination in the Great Lakes. This fact sheet, prepared by EPA's Office of Marine and Estuarine Protection and the Great Lakes National Program Office, describes the Green Bay Mass Balance study. Other fact sheets in this series address the overall management framework for the Great Lakes Water Quality Agreement, and the multi-state (and international) fish monitoring program for measuring the presence of toxic chemicals in commercial and recreational fish species. An earlier fact sheet covers the Great Lakes National Program Office load management strategy for phosphorus.

## Study Objectives

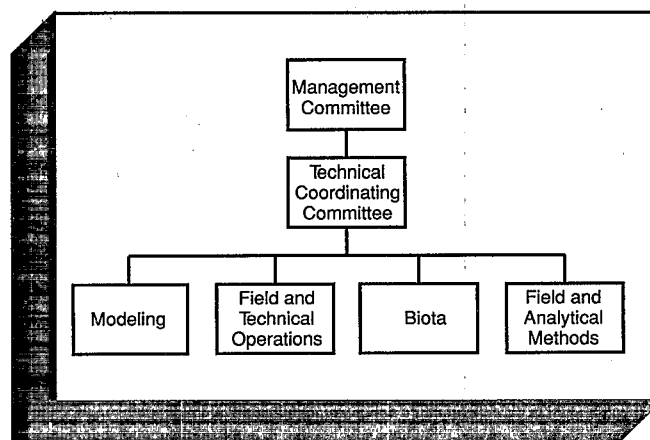
The Green Bay Mass Balance Study was begun to test the feasibility of using a mass balance approach to

assess the sources and effects of toxic pollutants which are spreading throughout the Great Lakes food chain. Specific objectives include:

- Assessing the technical and economic feasibility of the Mass Balance approach for use in the management of pollutant loading and impacts on Great Lakes ecosystems;
- Calibrating the Mass Balance model for sources, transport routes and fates of pollutants in the Great Lakes ecosystems in general;
- Identifying the major sources of pollutants entering the Green Bay ecosystem and ranking their relative significance; and
- Demonstrating methods and priorities for further studies of toxic pollutants in the Great Lakes.

Four chemicals and chemical groups representative of major classes of toxic compounds were selected for the Mass Balance Study. They are: PCBs (and related compounds), dieldrin (a pesticide), cadmium, and lead. By including the entire family of PCB chemicals, the study will actually measure 209 chemicals, over 80 of which are currently found in detectable quantities.

Inputs of these chemicals have been measured in all of the major surface water tributaries flowing into Green



Bay, in point sources, in wet and dry precipitation and in groundwater. The goal of the Green Bay Mass Balance Study is to predict the concentrations of these four chemicals in walleye pike, brown trout, and carp (the defined end points of the study's food chain) to an acceptable level of accuracy, at an affordable cost. Once a mass balance budget has been established for each pollutant of concern, it should be possible to simulate the long-term effects on Great Lakes water quality by mathematical modeling.

The basic mass balance model can be reduced to the following formula:

$$\text{Input} + \text{Generation} - \text{Accumulation} - \text{Consumption} = \text{Output}$$

Enters  
through  
system  
boundaries

Produced  
within  
system

Stored  
within  
system

Transformed or  
degraded  
within system

Exits  
to  
outside

To meet the study goal for accurate prediction of toxic pollutants in the fish at the end of the food chain, study planners estimate that data collection and analysis procedures must be accurate to within  $\pm 20\%$  of actual mean values for major sources and "compartments" of pollutants. In the world of ecological research, these are very stringent requirements.

The study began in 1986, with preliminary monitoring and planning, and is scheduled to be completed in 1991. The bulk of the data sampling was performed during 1989 and 1990.

The Study's annual funding in Fiscal Years 1989 and 1990, provided by GLNPO, was \$1.1 million, with minor additional contributions from the other participating agencies.

## Lessons Learned

If successful, the Green Bay Mass Balance Study can provide the International Joint Commission with a new range of scientifically validated analysis and planning tools for managing pollutant loads throughout the Great Lakes. While the scope and cost of the Green Bay Study are beyond the means of other areas just getting involved in the National Estuary Program, there are important lessons to be learned from the Green Bay Mass Balance Study:

- There are major advantages to be gained from organizing a method for coordinating a variety of individual scientific projects (most of which will be carried out by academic interests, whether there is

an estuary program or not). By working with local academic, scientific, and environmental consulting groups to identify major ecosystem issues in the estuary, by defining basic data standards for all interested researchers, and by establishing a common database, accessible to all interested researchers, a Management Conference can encourage the development of a considerable body of scientific and technical information with long-term potential utility for policy research and estuary management.

- There are a variety of new environmental management tools like the Green Bay Mass Balance Model which are being developed and assessed. Technical Advisory Committees need to monitor these projects to identify those new technologies that could make contributions to the local management program on two different levels:
  - the discovery of important new estuary management "facts" that need to be incorporated in planning and management strategies (e.g., hydrilla promotes the rapid restoration of many estuarine areas); or
  - new models or simulations that can be adapted at low cost to the management needs of the local estuary.

For further information on the Green Bay Mass Balance Study, contact the Great Lakes National Program Office (312/353-3503) or the Office of Marine and Estuarine Protection, Technical Support Division (202/475-7102).

