Chapter 22

Toward Cost Effective Planning and Management of Water Quality

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Water resources, especially those in urban areas near large rivers, lakes and estuaries, have serious management problems today. In the eastern and central parts of Canada and the United States, where the climate usually provides a dependable and adequate year-round precipitation, many of the problems are associated with both surface and ground water quality. The surface water quality problems today in this region are usually due to a combination of combined sewer overflows, non-point-source runoff from urban and rural land and river, lake, estuarine, and bay sediments contaminated with toxics such as polychlorinated biophenyls, PCBs, and various pesticides due to past uses. Ground water quality problems today result from past agricultural chemical overuse and leaching through municipal and industrial landfills, pipeline breaks, leaking underground storage tanks and septic tanks.

This is in contrast to the arid and semi-arid regions of the West and Southwest in the United States. The problems there are due largely to the leaching of farmland irrigation water, which contaminates downstream surface water with minerals, e.g. selenium and pesticides, and the overpumping of aquifers for both municipal and agricultural uses. Other factors, including evapotranspiration from crops and reservoirs, transbasin diversions and drought initiated low flow periods, also contribute to the problems.

Knowledge of, and response to, water quality problems in the eastern,

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more humid, region has evolved during the past three decades. The dominant focus during the 60's and 70's was on organic waste water from municipal and industrial point sources. Massive subsidies, in the form of construction grants, were provided by both the Canadian and US federal and provincial/state governments to municipalities to upgrade and/or expand waste water treatment plants. The result was a significant reduction in organic loadings and suspended solids to receiving waters and an increase in shell and fin fish populations in many locations. Some estuaries are still in decline.

By the early 80's there was new knowledge of deformed fish and fish-eating birds caused by low concentrations of toxic chemicals in the sediments and the water column of receiving waters. The bioaccumulations of toxic materials occurred in the aquatic food chain leading to unsafe body burdens in fish and birds. Advisory notices from state regulatory agencies not to eat many fish species and water fowl followed. Knowledge was gained also of the connection between upstream land use practices, both rural and urban, and downstream eutrophication and toxic contamination during the 80's.

The recent response to an improved understanding of surface and ground water pollution in this region has been significant and partially effective. Attempts to include the ecosystem philosophy in the studies of the Great Lakes problem areas initiated by the International Joint Commission have often been made. Most of the past investments were made according to technology-based rather than water-quality-based standards. The technology-based standards are effluent regulations set according to the treatment levels that can be met today by use of proven wastewater treatment equipment and processes. Water-quality-based standards, the alternative regulatory approach, have not been used much during this period. The difficulty of enforcement and the tendency for inequity among dischargers in different geographical locations have been cited as reasons for using technology-based standards (Viessman and Hammer., 1993). Wasteload allocations, the rationing of receiving water assimilative capacity, are examples of combining technology with water-quality-based standards. This regulatory policy has been used for those receiving waters already heavily polluted that could not be remediated through use of technology-based standards alone. Today, with a more complex set of pollution sources, including point, non-point, and in-place pollutants coming from both urban and rural sites throughout a watershed, as well as less money available, it may be wise to seek a new mix of technology and water-quality-based standards.

This chapter forms a progress report on recent water quality management efforts in a few areas of eastern North America. The ongoing Remedial Action Plan activity throughout the Great Lakes is indicated along with some recommendations for improvements in the analysis and planning process which include explicit consideration of cost-effectiveness. The planning and management status of one site on the Great Lakes, the Fox/Wolf River and Green Bay, Wisconsin is described in more detail. The role of stormwater and water quality

modelling in some specific cases is included. Conclusions are drawn and some recommendations given.

22.1 A Regional Example - Remedial Action Plans in the Great Lakes

The Remedial Action Plan effort in the Great Lakes has been chosen as an example to demonstrate the need for an improved analysis and planning process.

The International Joint Commission has broad responsibilities to advise Canada and the United States on common water problems along the border. Water quality is just one of the problems. The Great Lakes Water Quality Agreement, signed in 1972, revised and expanded in 1978 and amended in 1987, is the key document stimulating recent actions in water quality. Two important parts of the 1987 amendments are: the expanded incorporation of the ecosystem approach and the focus on severely polluted areas (Colburn et al., 1990). The Commission identified 43 locations, called them Areas Of Concern and directed that a plan for correction of the water quality problems at each site be prepared and implemented. The Areas Of Concern are shown in Figure 22.1.

The first plan completed in Canada was for Hamilton Harbour in Ontario in 1990. The first completed in the United States was for the Fox River/Southern Green Bay, Wisconsin in 1989. Since then, as more experience has been gained, the plan preparation process has been divided into three stages (Anonymous, 1989):

- 1) when definition of the problems has been completed;
- 2) when remedial and regulatory measures are selected; and
- 3) when monitoring indicates that the identified impaired uses have been restored.

To date, 34 stage 1 plans, as shown in Figure 22.1, have been written and are in various stages of review. Two, the Detroit River connecting channel and the Hamilton Harbour have recently been reviewed extensively (Steggles, 1992a) and (Steggles, 1992b). It is apparent that considerable progress has been made. Some general comments on both the strengths and weaknesses of the RAP process and outputs can be made. The strengths include:

- 1) Use of the ecosystem philosophy in preparation of the plan. This philosophy, to seek a broader understanding of the problem and include the land, water, air and all living systems, has helped most people to understand that the problems are complex and that they will not be solved easily or quickly.

Figure 22.1
43 Areas Of Concern identified in the Great Lakes Basin

- 2) Local participation in preparation of the plan. Most plans have been prepared with the guidance and advice of local citizens representing a wide range of interests and responsibilities. People involved are more likely to understand the problem and are more likely to have strong opinions, hopefully positive, about the plan and the need for implementation. Sometimes called stakeholders, these citizens often become the local leaders working toward implementation. Local participation, in addition to that by the province/state, will be a key to the successful development and implementation of the stage 2 plans.

The weaknesses, which apply more to the urban and industrial dominated Areas Of Concern with a number of impaired uses, include:

- 1) Use of the ecosystem concept. The vagueness of this term has contributed to the difficulty in preparation of some stage 1 reports. Many investigators define the ecosystem boundary for a particular Area Of Concern as the region containing evidence of impaired use. For those areas containing several use impairments, a number of ecosystem boundaries may exist. It is difficult to know what should be included and what should not.
- 2) Limited operational institutional analysis. Some of the plans do not contain sufficient information on how the existing institutions function in carrying out their missions. This problem is highlighted at border sites. It is especially apparent along the international border, e.g. no apparent coordination in the preparation of the St. Lawrence River (Cornwall, Ontario and Massena, New York) stage 1 plans. Difficulties have existed also at state boundaries, e.g. the Wisconsin/Michigan boundary, Menominee River area of concern.
- 3) Infrequent use of a core technical staff for the plan preparation. The people assigned to prepare the RAP are often obtained from the public agencies with regulatory responsibilities in the particular province or state. Many times specialists are assigned for shorter time periods to collect necessary information and write a related segment of the plan which one person, identified as the RAP coordinator, combines to complete the stage 1 plan. Opportunities for interdisciplinary ecosystem-based actions are severely limited by this approach. This problem will become more crucial during the stage 2 effort. Efforts are already underway to correct this problem at some sites beginning stage 2 efforts.

- 4) Inadequate determination of the relative importance of sources of materials of concern and the associated pathways and fates of those materials. The recent Green Bay mass balance is the primary example of a successful investigation of this type in the Great Lakes region. Even it was quite limited since it was directed primarily at PCBs which are located in the lower watershed containing 10% of the total land area. This weakness is more evident in the United States. A simple mass balance approach has been used in most complex Areas of Concern in Ontario.

22.2 Summary - Regional Example

It has been estimated that the remediation cost for the 43 Areas Of Concern ranges between US \$100 billion and US \$500 billion (Colburn et al., 1990). A large part of this cost would be for correction of the combined sewer systems and the contaminated sediments. The recent announcement by the Ontario government of plans to create the Ontario Clean Water Agency to spend CAD \$258 million and to seek a private sector contribution for a total of CAD \$400 million for investment during the next four years on water and sewage systems confirms the more likely level of investments (Anonymous, 1993a). The Clinton Administration has recently received a report endorsed by 114 mayors across the United States that "environmental problems have been addressed in a vacuum, without carefully examining their impacts on personal incomes, private property rights, the economy, productivity or national competitiveness" (Anonymous, 1993b). It is clearly not politically possible today, in either Canada or the United States, to seek the commitment of such an amount for these actions.

Today, in the early 1990s, there is a need to seek a change in past planning and management structure and style to stimulate improved priority setting in investments for improvements in environmental quality. Increased attention to the holistic approach and to the affected local communities is needed. The watershed is an important land area to consider, along with the jurisdictional boundaries of governments of general jurisdiction and regulatory agencies. An interdisciplinary planning effort, including special attention to cost-effectiveness, conducted on a continuous basis, is needed. The planning staff should be established to integrate economics, ecology, technology and institutions. The computer and various modelling efforts are important, but not central, parts of the effort. The institutional structure and its continuous functioning to seek cost-effective and implementable actions are central. The institutional arrangements necessary to establish and conduct a successful continuous regional planning effort should be carefully structured to account for existing political sensitivities. Two important parts of the planning effort needed, and often missing in today's activities, are a financial plan and a public information and education effort.

Evidence of such changes has already begun to emerge in both Canada and the United States. Efforts are underway in both Hamilton and Collingwood, Ontario to include the identification of alternatives and their associated costs in the stage 2 planning effort (Steggles, 1993). An experimental planning effort which includes a cost-effective analysis is underway as part of the clean-up activities in the Green Bay, Wisconsin watershed. Comments on all of the local activities to reduce the impaired uses at this site follow.

22.3 A Local Example - The Fox/Wolf River, Green Bay Watershed

A variety of planning efforts and physical improvements related to impairment of beneficial uses are ongoing in the Fox/Wolf River and Green Bay, Wisconsin watershed. The “bottom” of the watershed is the Fox River/Southern Green Bay Area Of Concern. It was noted earlier that this site was the first in the United States to receive approval for a stage 1 plan. Prepared before development of the three step process, it contains some information normally included in step 2. This example contains a brief description of the watershed followed by descriptions of several ongoing or recently completed activities related to abatement of the local water quality problems.

The Fox/Wolf River system drains an area of 6600 square miles (17,100 square kilometers) in northeastern Wisconsin, as shown in Figure 22.2. It is the dominant stream flowing into Green Bay, both in terms of water quantity and loads. Pollution problems have been documented for at least sixty years (Harris, H.J. et al., 1989) since the pulp and paper industry began to grow along the 39 mile reach downstream of Lake Winnebago which was created as part of the last glacial period about 20,000 years ago. This area has been very attractive to water-based industry since soon after settlement by European immigrants during the mid-nineteenth century. The location and elevation of Lake Winnebago made the lower river very desirable. It is located at a point in the watershed where 90% of the drainage area is upstream, thereby creating a natural flood control reservoir which assured a downstream flow regime with few low and high flows. It is also located over 150 feet above the level of Lake Michigan. Bed rock in the river is located such that most of the elevation drop occurs at seven locations, the site of rapids before any development. Each of the rapids served as the site for early industrial development.

Urban growth was linked to industrial growth, and water pollution followed. The growth continued through the years and by the end of World War II the river was being rapidly degraded. By the early 1970s many reaches of the river became anaerobic during the summer primarily from excessive pulp mill waste water and overloaded municipal sewage treatment plants. An investment of almost US \$400 million in municipal and industrial waste water treatment

Figure 22.2
Fox/Wolf River watershed.

plant improvements during the 1970s, along with industrial plant process changes and materials recovery, resulted in the reduction of over 90% of the biochemical oxygen demanding waste waters and suspended solids. No combined sewers existed in the drainage basin by then. They had been systematically eliminated over the decades of street improvements since the end of World War II. Fish began to reappear in the river and people began to buy and build homes on shoreland during the 1980's.

The algae blooms and sediment-laden storm water runoff continued to create periodic questions about a healthy river and bay. Then evidence of the contaminated fish and fish-eating birds appeared and a new phase of the river and bay cleanup began. That phase, involving awareness of the aquatic ecosystem and bioaccumulation of toxics in the food chain, is still on-going today. The interest in, and commitment to the Remedial Action Plan process emerged during the mid 1980s and still exists today. Evidence of the commitment may be found in each of the recent or ongoing activities directed to learning more about the degraded water and the land uses that cause the degradation. Evidence may also be found in the construction projects underway to reduce nonpoint source pollution in the East River Watershed and point source ammonia pollution from the Appleton and Green Bay sewage treatment plants. Comments on these recent activities follow.

22.3.1 Fox River/Southern Green Bay Remedial Action Plan Implementation

Efforts to implement the recommendations of the plan continue. All of the various activities reported in this local example could be reported under this subheading as evidence of implementation. However comments in this section will be restricted to those activities identified in the 1992 and 1993 work plans prepared by the plan implementation staff and recommended for adoption by the Public Advisory Committee (Harris, V.A., 1992). The lead agency for the effort is the Wisconsin Department of Natural Resources, WDNR. It has assigned the equivalent of three people, full time, to the Green Bay RAP for several years.

Local community leadership is provided by the Public Advisory Committee, appointed by the WDNR. This group is assisted by two citizen advisory committees, the Scientific and Technical Advisory Committee and the Public Education and Participation Committee. In total, about fifty local citizens, representing business, recreation, environment, state legislature and local government are active. The County Executive serves as chair of the Public Advisory Committee. Through his leadership, county government has allocated US \$25,000 per year for the past three years to the committee for implementation activities. Smaller amounts have been contributed by other public and private organizations and through Federal grants, to make a budget of approximately US \$50,000 (WDNR staff salaries have not been included in the budget). The 1993

budget is near US \$70,000 due to two grants received through WDNR efforts. Most of the extra money will be used for an educational display about the Area Of Concern in a new educational building located near the mouth of the Fox River.

Monthly meetings of the Public Advisory Committee, organized by the coordinator and assistants, serve as the community center of plan implementation. A wide range of activities are stimulated by these meetings. Many of the other projects described in this chapter are reported on at the meetings. In this way, perhaps several hundred local people are involved in plan-related activities.

It should be stated that broad, strong support for plan implementation does not exist either locally or in state government. Other issues, such as jobs, public safety, human health, education and, of course, taxes, are judged by most people to be much more important. The majority of people living in metropolitan Brown County have little knowledge of the Remedial Action Plan. A recent survey indicated that approximately 20% of the local population had some knowledge of the Remedial Action Plan (Baba et al., 1990). They may not seek more until plan implementation efforts begin to affect their own lives more directly. Public education continues to be a key part of the implementation effort.

22.3.2 Green Bay/Fox River Mass Balance

Early in December 1992, the US Environmental Protection Agency, Region 5, Great Lakes National Program Office, sponsored a two day conference to present the results of a major research effort to understand the pathways and fate of PCBs in the Fox River and Green Bay. It was generally known that PCBs had been used in the manufacture of carbonless paper and that this persistent toxic chemical compound existed in the waste sludge from two paper companies located on the shore of the river. The companies had used waste paper as their basic raw material for papermaking for decades. PCBs have been recognized for several years as a problem in the local aquatic ecosystem and fish advisories have been issued to warn people about the danger. Yet, there was no accurate knowledge of the quantity present, its location or its destination.

The conference revealed very important information (Wittman, 1992). Although most of the PCBs had originated from past manufacturing practices in the lower Fox River watershed, less than 1% of the chemical entering Green Bay today comes from point sources. The rest comes from bottom sediment deposits. Over 90% of the PCB laden bottom sediment is buried beneath cleaner sediment, so does not presently contribute to the active material in the water column. The risk of these deposits becoming active is linked to future flood events which may scour the cleaner sediment and expose the contaminants for transport downstream.

The mass balance investigation, which began over five years ago and cost in excess of US \$12 million, has provided important new information about

the local contaminated sediment. This information will certainly influence future management decisions about specific actions in the Area Of Concern and the rest of the watershed.

22.3.3 East River and Other Priority Watershed Projects

The East River watershed is an important part of metropolitan Brown County. The river drains approximately 150 square miles in Brown and Outagamie County, as shown in Figure 22.2, and enters the Fox River about one mile upstream of the mouth, in downtown Green Bay. The river carries about 10% of the total phosphorus and sediment that enters the Green Bay body of water so attention has been drawn to it for some time. It was identified as a Priority Watershed by the Wisconsin Department of Natural Resources in 1989. As such, rural land owners, primarily farmers, and municipalities were eligible to apply for special grants to pay for up to 80% of various management practices designed to reduce non point source pollution.

Priority projects typically take ten years to complete. The early years are used to conduct an inventory and to locate the primary problem areas with their associated land use practices. The remainder of the time is used to work with farmers, other land owners and municipalities to help them qualify for and construct the recommended management practices. Most problems are expected to be solved at the end of the ten year period. The program is voluntary and requires local cost sharing so education is an important part of the total effort. The budget for East River Priority Project is about US \$24 million. Of this amount, about US \$7 million (\$5.3 state share) is for rural projects and US \$17 million (\$7 million state share) is for urban projects.

Two other smaller projects in upstream, primarily rural, sub watersheds are also in progress. About US \$5 million total is budgeted for them. The need for funds to support more priority watersheds across the state far exceeds the supply. At the present rate of funding, it will be sometime in the mid 21st century before all watersheds in Wisconsin are served. An attempt last year by the legislature to provide more money to this program was vetoed by the Governor, reflecting the difficult times in raising enough revenue and the political reality of funding priorities.

22.3.4 East River Water Quality Demonstration Project

The US Department of Agriculture, Soil Conservation Service, is the lead agency sponsoring a water quality demonstration project in the East River watershed. Brown County and the University of Wisconsin also participate. Although conceptually and geographically related to the East River Priority Project, it has a separate budget, staff and goal. The goal is to demonstrate improved farming practices that will reduce discharges from agricultural

activities while maintaining and improving farm profitability. Improved planning in use of crop fertilizer to match particular crop needs, by use of soil tests, is one part of the project. This measure often reduces the runoff of excess nutrients which contribute to downstream eutrophication. Other parts of the project include energy efficiency improvements in dairy farm milking centers and in barnyard manure handling and disposal. All of these measures may increase net farm income. Extensive agricultural land runoff computer modeling has occurred as part of this effort. The models AGNPS, Agricultural NonPoint Source, SWRRB-WQ, Simulator for Water Resources in Rural Basins - Water Quality and EPIC-WQ, Erosion/Productivity Impact Calculator - Water Quality, were all used to gain more information. Most of the modelling efforts were conducted on land in the Bower Creek watershed, a subarea of the East River drainage basin, as shown in Figure 22.2.

22.3.5 Municipal Point Source Plant Expansion For Ammonia

There are also investments being made in municipal sewage treatment plants at this time. Construction is underway at the two largest publicly owned treatment works in the watershed, Appleton and Green Bay, to reduce discharge of ammonia and to reduce the carcinogenic formation of chloramine compounds due to effluent disinfection practices. The capital investment, based on orders issued by the Wisconsin Department of Natural Resources, is about US \$140 million. This amount includes a significant State subsidy in the form of both grants and low interest loans.

These improvements, scheduled for completion late in 1993, represent the dominant investment for water quality improvement in the watershed. Yet the impact of the investment in restoring impaired uses of the ecosystem is expected to be marginal. The ammonia concentration in the sewage effluent, which is presently lethal to some fish fry, will be significantly reduced, from an average of 8 parts per million (ppm) in 1990 to less than 1 ppm with the result of having more contaminated fish in the receiving waters that should not be eaten because of other substances, e.g. PCBs. The fish advisories will still exist and the better sewage effluent will not significantly affect the algae blooms or storm water surges including phosphorus and sediment in the water column.

The historical dominance of attention to point sources is beginning to be questioned as this information becomes available. Is it wise to invest funds in these pollution sources when: a) these investments will not solve the problem, and b) the societal return from other investments, particularly non point sources, may be much greater?

22.3.6 Contaminated Sediment Abatement Demonstration Project

The PCB contaminated sediment site on the shore of Little Lake Butte

des Mort in the Fox River, shown in Figure 22.2, is an important source of PCBs in the watershed. It is the most upstream site and is located at the downstream end of a small watershed, putting it at risk of being carried by storm runoff into the main river flow. It is also a small, highly concentrated deposit which may be easier to address than others. As a result, it was selected several years ago as the site of a sediment remediation demonstration project by the Wisconsin Department of Natural Resources. A report on alternative remedial practices, such as dredging and incineration, dredging and off-site disposal and no action, was prepared under contract by a consultant (Anonymous, 1992). The results were presented at a public meeting early in 1992. No decisions on a remedial action have been made yet but a broad based regional effort is underway to raise money to pay for it. An amount approaching US \$10 million, for the demonstration project, is expected to be needed. If the demonstration project is successful, it may set the stage for policy decisions that focus on other active sediment deposits. The stakes are high! An estimate of approximately US \$500 million, in 1988 dollars, was made in the 1989 Remedial Action Plan for dredging and treatment/disposal of PCB laden river sediment in the Fox River downstream of Lake Winnebago.

22.3.7 North East Wisconsin Waters For Tomorrow Project

The North East Wisconsin Waters For Tomorrow is a non profit corporation formed in 1990 to organize and sponsor a study for cost-effectiveness in the planning and management of the water resources of the Fox/Wolf watershed. The formation of the organization was stimulated by an increased awareness that the present set of government actions resulting in water pollution abatement was not providing society with the best use of the money invested. Disconnected attention to rural and urban pollution sources without the explicit accounting for the relative cost-effectiveness of the specific management practice contributions toward reaching a given water quality objective was identified as a major problem.

The entire watershed was identified as the primary land area to focus on in an investigation of this water resources management problem. The complex jurisdictional, cultural, environmental, political and economic features of the watershed led to the proposal that a small interdisciplinary team of specialists be formed to conduct a year long framework study. The goal was to integrate ecology, economics, technology and institutions to obtain new planning and management information on cost-effective practices to achieve a particular water quality goal. Contributions, both cash and in kind, were obtained from a wide range of public and private organizations including the Wisconsin Department of Natural Resources and the University of Wisconsin for the one year effort.

A three-person team, including a natural resources planner, a water

resources civil engineer and an aquatic biologist was recruited. The group, formed during late summer and early fall in 1992, has been assisted by local and national consultants. The investigation is being directed to three of the societal goals identified in the Remedial Action Plan for the Area Of Concern:

- 1) improved water quality
- 2) improved wetland habitat
- 3) improved water based recreation

The investigation includes consideration of present, 1990, and circa 2010, population and employment in the watershed. It also includes the present and some possible future levels of technology used in both urban and rural regions. The primary effort is directed to the water quality part of the investigation.

Point and nonpoint sources, urban and rural, contributions of phosphorus and suspended solids are being estimated. Using 1990 as the base year and the SWRRB-WQ agricultural land runoff simulation model, the contributions of phosphorus and suspended solids from various types of agricultural land use and forest land use are being estimated for each of the 41 sub-watersheds. Corrections for downstream transport are made to account for the spatial importance of the source. Urban contributions will be added according to the location in the watershed. Future loadings of phosphorus and suspended solids are estimated according to different assumptions of crop patterns and the degree of low-intensity sustainable agriculture predicted for use in a particular sub-basin.

This information will be analyzed to determine whether or not the estimated instream loadings meet existing or desired quality standards. The unit costs of various management practices, both point and non point, whether urban or rural, will be estimated based upon public information. Then, if the water quality associated with an assumed population level, employment mix and land use practices, is less than the assumed stream water quality standard, a least cost mix of actions, selected from throughout the watershed, urban and rural, will be identified. This set of calculations will be repeated for two or three water quality standards, providing information similar to that shown in Figure 22.3. These standards will include a number of measures such as the level of sediment and nutrient reduction, degree of natural habitat rehabilitation and level of water-based recreation. The information provided may be very useful to both the general public and decision makers. It may help them to make better decisions about the preferred level of improvements and the possible least-cost mix of actions to achieve them.

The results, scheduled for completion this next summer, are not expected to be definitive. Hopefully, they will demonstrate the value of the cost-effective analysis approach and stimulate continued efforts to provide better information for decision making.

Figure 22.3
Seeking an operational objective: a Green Bay example.

22.3.8 Summary: Local Example

There are clearly a number of activities related to the water quality problems of the Fox/Wolf River and Green Bay that have been recently completed or are in progress. Two different kinds of activities are identified: studies and capital investments in physical works. It may be useful to list them here along with the approximate public investment to gain a different perspective than was provided in the earlier discussions.

Studies

-Fox River/Southern Green Bay Remedial Action Plan	\$50,000/year
-Fox River/Green Bay Mass Balance	\$12 million over 5 years
-East River Water Quality Demo Project	\$2 million over 5 years
-Contaminated Sediment Abatement Demo	\$10 million over 3 years
-North East Wisconsin Waters For Tomorrow	\$300,000 for one year

Physical Works Capital Investments

-Priority Watershed Projects East River et al.	\$29 million over 10 years
-Municipal Point Source Ammonia Abatement	\$140 million over 3 years

Several questions naturally arise from a review of such a list. Has the money been invested wisely? What improvements could be made in making future investments in water quality improvement? How could the analysis and planning process be changed to provide better information to both the general public and decision makers? Some suggestions follow.

22.4 Suggested Improved Approach to Analysis and Planning

Improvements in the framework for analysis of, and planning for, management of water resources in estuaries, bays, sounds and their related upstream watersheds, can be achieved by using a more holistic approach. The approach is to integrate economics, ecology, technology and institutions within an investigation that produces more valuable information for decision making. Although more extensive writings on this subject have been reported elsewhere (Day et al., 1992, Bower et al., 1982), some comments on four key elements of the approach are presented here. The elements are: an operational objective, an investigation of the pollution sources, a cost-effective evaluation of the alternatives and an institutional structure and financial mechanism for continuous management.

22.4.1 An operational objective.

Many water resources planning efforts today begin with the preparation of goal and objective statements. Special care is needed to define an objective so that it can be used in a practical way to develop measures of progress. Often the stated objective is not operational, i.e. inadequate information is provided on how to meet the objective.

The Fox River/Southern Green Bay Remedial Action Plan may be used as an example. The primary goal is to attain a healthy and balanced aquatic ecosystem. One of the objectives to be met in seeking the goal is to reduce the PCB body burden in walleye pike. This objective is not operational since it does not include information on how to reduce the level. An operational objective is needed, i.e., what is the quantitative relationship between the walleye PCB body burden and the PCB load entering southern Green Bay from the Fox River? It is not enough to formulate objectives that relate to a particular aspect of seeking the goal. The objective must be defined in terms of those variables that operationally link to alternatives for corrective action. The changes needed are presented graphically in Figure 22.4. For consideration of reducing the PCB body burden in walleye pike, the operational corrective action is to reduce the amount of PCBs entering the water body from upstream. But the linkage between the body burden, value x in Figure 22.4, and the upstream loading, value y in Figure 22.4, is not a simple and direct relationship. It must be understood before proceeding with an effective analysis.

22.4.2 An investigation of pollution sources including projections.

Some stage 1 plans, especially those in the United States for Areas Of Concern with a number of impaired uses, do not contain adequate information on the relative importance of sources to enable the development of management strategies. Effective stage 2 planning in such complex ecosystems will be difficult without this information. Computer-based watershed simulations may provide useful approximations of suspended solids, phosphorus and other pollutants contributing to the impairments. The approximations can often be quite crude and still be valuable because insight can be gained from comparisons of the loadings among different sources and among different parts of the watershed.

22.4.3 A cost-effective evaluation of alternatives.

Most water resources problems today, especially those focusing on water quality, are addressed by technology-based regulatory standards. The identification and evaluation of alternatives seldom occur, other than in the consideration of specific unit processes for design of facilities such as a waste

Figure 22.4
Seeking an operational objective: a Green Bay example.

water treatment plant or in some nonpoint source remedial activities. Similarly, measures of cost-effectiveness are seldom used for complex problems such as those encountered in many Areas Of Concern. The words, *cost-effective*, are often used in a vague general sense but the concept is seldom applied rigorously.

The identification of alternatives and the operational use of cost-effectiveness is linked. Cost-effective evaluation involves the identification of the least cost mix of actions to meet a particular objective or environmental quality level. A more detailed discussion of the evaluation process was reported earlier with typical results shown in Figure 22.3. The cost-effective approach does not mean that the least-cost solution should be selected for implementation. Other factors such as economic incentives and institutional arrangements may lead to selection of another alternative. It is important to estimate the least-cost alternative associated with achieving a given level of desired results/outputs, so that society can “see” what it is getting for additional expenditures.

22.4.4 An institutional structure and financial system for continuous management

Most complex water resource problems today involve the jurisdictions of many public bodies, including local and regional governments, state regulatory agencies and a variety of federal and, often, international agencies. Many of the bodies have ongoing management responsibilities, e.g., in the US, the Corps of Engineers, the Environmental Protection Agency, the Fish and Wildlife Service, the state water resources regulatory agency and the local sewerage agency. The lack of an appropriate management structure to address most of the water resource problems discussed in this paper, i.e. those that cross over many jurisdictions, is a primary deterrent to wise decision making. A continuous management effort is needed to address these problems, just as one is needed for a private electric utility or a public municipal water utility. A new agency is not necessarily needed but a lead agency with participation by others certainly is. A financial system to allow for planning investments over an extended time period, ten years, if possible, is also needed. This means that an office, a staff and a budget are needed. Without them, most estuarial, sound, bay and upstream watershed water resources management efforts will be very difficult to maintain, much less improve.

22.5 Conclusions and Recommendations

Reform to our present system of solving water quality problems in the eastern and central, more humid, regions of Canada and the United States is needed. Primary dependence on technology-based regulations as the implementation tool is becoming less effective as money for public sector activities continues to be severely limited. Policy innovation is needed which involves a

combination of technology and water-quality-based standards. The combination should include the identification of alternative actions and measures of the consequences of those actions. Cost-effectiveness is one important measure.

The Remedial Action Plan process is at the stage where the opportunity exists to consider some innovative reforms. That opportunity rests with the stage 2 planning effort. Holistic studies including the cost-effectiveness approach are recommended for the stage 2 effort in developing Remedial Action Plans. Those Areas Of Concern with multiple use impairments would benefit especially. These studies would provide critically needed information for making wise investments in water quality improvements throughout the Great Lakes. Increased attention to the research and monitoring needs for gaining a better understanding of the Great Lakes ecosystems is also recommended. Without it, the ecosystem philosophy will not evolve to the improved operational understanding that is badly needed for better management.

Stormwater and water quality modelling will continue to be important tools in the planning and management of water quality but the framework within which they are used is more important than the model. Cost-effectiveness is needed today as a key part of that framework.

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