ESTIMATING ECONOMIC BENEFITS

of Cleaning Up Contaminated Sediments in Great Lakes Areas of Concern

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Executive Summary

Sediment remediation has come to the Great Lakes Basin. In the past 13 years, 17 of 43 Great Lakes Areas of Concern (AOCs) have had 38 sediment remediation projects at a cost of nearly $600 million (SedPAC 1999; Zarull 1999). Most of these projects were the result of regulatory actions in which a specified mass of contaminated sediment had to be removed. Current interest in the economic analysis of benefits from remediation is indicated by a recent paper from a committee of the International Joint Commission (SedPAC 2000).

This booklet provides a critical look at possible methods for studying the economic benefits of sediment remediation. A two-stage approach based on the needs of decision-makers has been outlined. As a first stage, a simple scoping study based on easily acquired data and available studies done elsewhere may be all that is necessary to make a reasonably good judgment about whether benefits are likely to exceed expected costs or vice versa. If not, then a second stage involving a deeper investigation of benefits and costs can be conducted.

Scoping study results can be helpful in judging which valuation methods are most promising for arriving at useful, practical results. In this booklet, an example of proposed cleanup of PCBs from Wisconsin's Fox River in Wisconsin serves to illustrate how this would work in practice. In this case, high estimated remediation costs indicated that a scoping study alone would probably not be sufficient to judge whether or not benefits will exceed costs. It appeared that most of the benefits will be associated with recreation and nonuse values. The additional benefits of sediment cleanup associated with Great Lakes shipping and other potential beneficiaries are not well understood.

There are formidable technical problems to be overcome in estimating recreational benefits based on a travel cost analysis. Even if a good metric could be found, the resulting benefit estimates would likely fall far short of the expected remediation costs. However, the total value of the benefits, including nonuse values, could be larger than these costs. Therefore, in the case of Fox River sediment cleanup, it appears that the wisest strategy for evaluating the cleanup will be to do a contingent valuation study so that nonuse as well as use values can be considered in estimating the benefits of sediment cleanup.

Results from a contingent valuation study of potential Fox River cleanup showed that remediation of contaminated sediments is valued by citizens in the Fox-Wolf watershed, and beyond the watershed. These citizens are willing to put a dollar value on cleanup of these waters. Estimates from the contingent valuation survey indicate a "willingness to pay" range of $100 to $300 per household, annually. The estimates include a perceived $222 per household per year benefit from achieving 100% of the "desired state" in the Fox River/Green Bay AOC. Estimates vary depending upon the models and assumptions used.

Many citizens use the Fox-Wolf Basin and lower Green Bay, and they are concerned about the quality of its waters. A full 60% of all respondents indicated that they were worried or very worried about health problems that could be associated with eating fish caught in the Fox-Wolf Basin and lower Green Bay.

The information generated in this case study of the economic benefits for the Fox River/lower Green Bay AOC provides a first step in evaluating the merits of contaminated sediment remediation. Benefit estimation for remediation projects will be hampered by a lack of information about how cleanup of specific sites will affect the larger ecosystem and the economic benefits tied to the larger ecosystem. In the case of the Fox River/lower Green Bay AOC, the consequences of sediment remediation on contaminant concentrations in fish were modeled in the prior Fox River/Green Bay Mass Balance Study (DePinto 1994, USEPA 1992 and 1993, WDNR 1991).

The problem about what to do with contaminants in the environment will often separate citizens into two camps. On the one side will be environmentalists who may be convinced that remediation should be carried out regardless of costs. From an economic perspective, they are assuming that benefits are very large or even infinite. On the other side will be economic interests who will be strongly oriented toward use values and particularly use values of market goods. This latter group may quickly come to the conclusion that benefits are small. A well-designed scoping study, followed where necessary by deeper second stage studies tailored to the situation, will help arrive at economically sound decisions by providing more objective information about the magnitude of some of the benefits of sediment remediation projects.

An approach described in this booklet uses the question: "Do we expect that the benefits of sediment cleanup will be larger than the cost for a particular alternative on a per household or individual basis?" This question gets beyond the more usual question: "What are the benefits of remediation?"

This approach makes a focus upon the costs of alternative remediation options a much more defensible one. Defensible, that is, as long as it is recognized that one needs to both choose the most cost-effective manner of achieving a given remediation goal and consider whether the goal itself is one which can be reasonably expected to yield benefits in excess of its minimized achievement costs. This approach to sediment remediation indicated that the costs of remediation, which at first glance seem quite intimidating, are more reasonable than one might initially expect. A critical variable in such an approach is a determination of how widely, and in what manner, the costs of remediation should be shared among responsible parties and those incurring cost savings from remediation.

If the per household cost of sediment remediation would equal the cost of milk in a month, a decision to remediate may seem reasonable. If the cost of sediment remediation per household would equal annual food expenditures, one might question whether households would find such a remediation decision acceptable.

There are other economic issues that can arise in considering sediment remediation projects. The issue of who would pay for sediment cleanup was not examined in this paper. Concerns about plant closings and loss of jobs arise if private parties pay the cleanup costs. This issue, though important, is beyond the scope of this booklet.

The best strategy for economic analysis may be different for other Great Lakes Areas of Concern (AOCs). If a scoping study shows that recreational, shipping, or other benefits are likely to predominate, a method or combination of methods other than contingent valuation could be applied where technically feasible.

There is a need to identify how to get the most benefits out of a sediment remediation effort. This suggests that the benefits and costs methodologies in a remediation decision framework should be used interactively in a manner allowing perceived benefits to alter options considered and vice versa.

This perceived need suggests that a benefits module should be written and incorporated into the REMSIM (REMediation SIMulation) software that was created in the project funded by the Great Lakes Protection Fund, the USEPA Great Lakes National Program Office, and Wisconsin Sea Grant. This software would allow a user to compare expected benefits and expected costs of sediment remediation in an AOC. A new benefits module in the software would incorporate the scoping approach discussed in this booklet. In addition, it would provide for usage of benefits transfer estimation based upon other studies of remediation benefits. The usefulness of such a module (and the methodology that supports it) will grow as case histories of the benefits of sediment remediation at other locations become available for module "calibration" and revision.

The economic benefits analysis described in this booklet can contribute to the current policy debate about natural resource valuation and damage assessment, and the benefits of sediment remediation in the Fox River valley and in the rest of the Great Lakes region. The general framework can enable the issues to be discussed in a more coherent fashion. All choices have both costs and benefits. There are opportunity costs associated with both the decision to remediate and the decision not to remediate contaminated sediments. The failure to make a decision to remediate is, in fact, a decision; it is a decision not to remediate. It is hoped that this booklet will assist citizens throughout the Great Lakes' region in making the "hard" choices in remediation issues reasonably and wisely.

Introduction

This booklet is drawn from a much larger *framework report* (Keillor et al. 2000) that documents the current state of development of a decision framework for sediment remediation, intended for use in Great Lakes AOCs. The framework was developed in 1995-1997 by research groups at four university campuses: The University of Windsor (Ontario, Canada); the University of Minnesota (Duluth), and the University of Wisconsin (Green Bay and Madison). This work was funded by the Great Lakes Protection Fund under Grant Number AOC594-1904, 1905, 1906; by the U.S. Environmental Protection Agency under Grant Number GL985062-01-0; and by the University of Wisconsin Sea Grant Institute under grants from the National Sea Grant Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and from the State of Wisconsin. Federal Grant Number NA46RG0481, Project Number A/AS-24.

This booklet describes the work that was done to satisfy one of the project objectives: *to develop an economic analysis approach to benefits and costs of sediment remediation.* The authors of the booklet are: Dr. John Stoll, Director, Center for Public Affairs, University of Wisconsin, Green Bay (Section II, III, and Appendix); Dr. Richard Bishop, Department of Agricultural and Applied Economics, University of Wisconsin, Madison (Section I); and Philip Keillor, Sea Grant Institute, University of Wisconsin, Madison (project manager, executive summary and introduction).

The terms *framework* or *decision framework* refer to the entire assembly of developed benefits and costs methodologies plus the empty places where additional methodologies are needed to help make logical, coherent and comprehensive evaluations of options to remediate, or not to remediate, contaminated sediment deposits. The cost side of the framework consists of one or more chains (or trains) of linked steps in remediation from site investigation to disposal. The benefits side of the framework consists of one or more stages of economic analysis followed by a comparison with cost side estimates in an attempt to answer the question: Are the apparent economic costs of remediation justified by the economic benefits of remediation? The rationale for the framework is described in Keillor (1996).

Some of the Economic Benefits of Sediment Remediation

Interest in resource valuation has increased in recent years, including the Great Lakes Basin (SedPAC 2000). This includes interest in the economic benefits of sediment remediation. It was this interest in 1995-1997 on the part of the Great Lakes Protection Fund, the USEPA Great Lakes National Program Office and Wisconsin Sea Grant that led to funding of the benefits analysis that this booklet describes. Project economists have found the prediction of economic benefits to be a major challenge, given the very short history of sediment remediation.

There has been insufficient time for case histories and a "track record" of remediation benefits to develop and become available for analysis. In remediation projects, little attention has been paid to economy of effort, and to cost-effectiveness. As a result, there has been unanticipated cost growth (Keillor, 1993). Remediation has usually been mandated by governments and the magnitude of economic benefits of remediation have not been addressed.

Section II in this booklet outlines a two-stage approach to the benefits question, based on the needs of decision-makers. In the first stage, a simple scoping study based on easily acquired data and available studies done elsewhere may be all that is necessary to make a reasonably good judgment about whether benefits exceed expected costs or vice versa. If a simple study is not adequate, a deeper investigation of benefits and costs is needed. Contingent valuation appears to be one of the most promising ways to investigate the possible benefits of cleaning up contaminated sediments. Contingent valuation is a method of estimating total values (including nonuse values) that has gained substantial (but not universal) acceptance among economists (DOI 1994; Hanemann, 1994; Portney, 1994; NOAA, 2000; SedPAC 2000).

Section II also contains a scoping study example is given for calculating remediation costs over time on a per household basis. The example considers very large remediation costs ($700 million to $1 billion) for sediment cleanup in the Fox River/lower Green Bay Area of Concern (AOC), spent over five to ten years, and providing benefits for many decades. If costs are calculated on an annual basis, per household in the AOC region, then average annual costs per household may be within the range of benefits that result from the cleanup, as perceived by residents. This seems to be particularly true if costs are spread over multiple decades, similar to the expected time span of benefits.

Section III describes the economic analysis and methods used for a contingent valuation survey that was done in the Green Bay Area of Concern. The sampling strategy was based partly on the expectation that remediation benefits the population as a whole.

However, the residents of the counties closest to the area to be remediated will place a higher value on increased environmental quality in the area as a result of remediation because they have greater access and cause to use the affected resources, than those living further from the area. This group of residents, when surveyed, will demonstrate what is referred to as *use values*. Those residing farthest from the area to be remediated, and least likely to recreate within the remediation area, will probably have more of their valuation of remediation motivated by *existence values*.

Section IV describes the results of the contingent valuation survey that was done in the Green Bay Area of Concern in the spring of 1997, using a three-tiered, random, stratified sample of 1,500 households. The appendices contain the tables of results from the survey and the survey document.

There are other economic issues that can arise in considering sediment remediation projects.

Some of these issues are discussed in SedPAC (2000). The issue of who would pay for sediment cleanup was not examined in the economic analyses described in this booklet. Concerns about plant closings and loss of jobs arise if private parties pay the cleanup costs. This issue is important, and beyond the scope of this study.

The best strategy for economic analysis may be different at other AOCs (SedPAC 2000). Where a scoping study shows that recreational, shipping, or other benefits are likely to predominate, a method or combination of methods other than contingent valuation could be applied where technically feasible.

On the cost side of the decision framework within which our benefits analyses resides, a software program called REMSIM (REMediation SIMulation) was created to make the cost and performance estimates for the various steps in remediation. It seems possible to add a benefits module to the REMSIM software which may allow a user to compare expected benefits and expected costs of sediment remediation in an AOC. The usefulness of such a module and the methodology that supports it will grow rapidly with time as case histories of the benefits of sediment remediation at other locations in the Great Lakes Basin become available.

I

Economic Benefits of Sediment Remediation

A. Economic Analysis of Sediment Remediation

Most sediment remediation projects will involve efforts to remove, cap, or otherwise neutralize sediments containing toxic substances or other materials deleterious to environmental resources and/or humans. Economic analysis can be used to evaluate the costs and benefits of proposals to remediate contaminated sediments. The goal of such cost-benefit analyses is to evaluate the economic justification for sediment remediation. Are there sufficient benefits to society as a whole to justify the expenditure of public and/or private funds on sediment remediation projects?

Consider pending proposals to deal with PCBs in the sediments of Wisconsin's Fox River and lower Green Bay (a subject covered more fully in Section II). PCBs from recycling of carbonless carbon paper and other industrial sources entered the river over many years. Some PCBs were carried downstream to Green Bay immediately. The rest were deposited in river sediments and continue to be washed downstream and into the bay. PCBs have entered Green Bay from other sources, yet experts currently believe that the Fox River is the main source of PCBs now in Green Bay. Green Bay exports PCBs to Lake Michigan. Although production of new PCBs was banned many years ago, some old PCBs remain in the environment and cause various problems in the river and the bay, including contamination of fish consumed by humans and adverse effects on wildlife.

To illustrate how valuation methods might be applied to the Green Bay area, consider dredging Fox River PCB deposits and disposing of them in ways that would do little or no harm to the environment or people. Sediment deposits in Green Bay itself are too dispersed to make dredging feasible there, so current dredging proposals are limited to the Fox River. Though economic analyses of Fox River cleanup are very incomplete, enough is known to use this area as an illustration of how a full economic analysis would work. The economic benefits of other remediation options could be considered in a similar way.

For purposes of this evaluation, *full* cleanup of the Fox River PCBs is intended, meaning that all significant deposits would be removed, not every last pound of PCBs in the Fox River. It is important to recognize that real-world remediation projects can involve any level of cleanup that decision-makers and the public choose. Benefits and costs for a partial cleanup would be different (i.e., lower), but otherwise the analysis would take much the same form.

Our economic study could be planned and conducted in two stages, beginning with what we will term a "scoping study" and concluding with a second-stage study.

B. Scoping Studies

Scoping studies assess what can easily be learned about the potential benefits and costs of proposed projects. A scoping study alone might show that the benefits of a specific project are in all likelihood greater (or smaller) than the costs, or the study might simply help define what sort of more detailed second-stage study is needed before judgments about the relative magnitudes of benefits and costs can be made.

Scoping of Costs

Preliminary cost estimates are a necessary ingredient of a scoping exercise. These estimates require knowledge of the size of the sediment deposits; the alternative technologies available for removal, treatment and disposal; and the estimated costs of the remediation. The majority of this report is devoted to the process of evaluating costs, including the development of the REMSIM (Remediation Simulation) computer software to aid in this process. Costs are not only important in their own right but also serve as an important consideration in scoping out potential benefits, as shown in the "Benchmarking Benefits" section.

The costs of contaminated sediment removal from the Fox River have yet to be fully estimated, but current estimates for removal of all significant deposits range from $250 million to $750 million, taking 5 to 10 years. An alternative would be to roughly estimate the cost at $100 million per year for 10 years, or $1 billion (prior to discounting to a present value equivalent).

Benefits in Concept

Contaminated sediments may contain sufficient concentrations of toxic substances to harm plants, animals, and people through direct contact, but more often harmful effects show up via the mechanisms of bioaccumulation. Fish, birds, and mammals high on the food chain may accumulate levels of these substances sufficient to harm themselves or the people and predators that consume them. Economic losses occur as the use and nonuse values people place on affected resources are reduced. Use values are economic values that people place on their actual use of the resource, such as catching and eating fish and wildlife. Fish and wildlife may pick up PCBs from the sediments of the Fox River and lower Green Bay, transmitting them to humans. Nonuse values are the economic value that people place on a natural resource that they don't directly use. To the extent that natural resources are affected by PCBs, sediment cleanup will affect both use and nonuse values. Both types of values are discussed in following sections on economic methods.

Several categories of benefits from sediment remediation in the Fox River are obvious. Nearly all fish species used by recreational anglers in the river and lower Green Bay are subject to fish consumption advisories (FCAs). FCAs advise anglers and others who might eat their catch how to limit their fish consumption to minimize health risks. Primary emphasis is on protecting the health of fetuses and children, but cancer in adults is also a possible risk. If sediment remediation would help reduce or eliminate FCAs, several benefits might arise. Some potential Green Bay and Fox River anglers may have decided not to fish there because of the FCAs. If so, sediment cleanup and changes in FCAs would increase the number of angler days on the river and bay, thus increasing angling benefits. Additionally, the quality of fishing may have been adversely affected for those who have continued to fish there. They may practice catch-and-release fishing more often than they would prefer, fish for different species, or fish less often in response to the risks described in the FCAs. Therefore, if contaminant remediation leads to lower risks from eating the fish, those who have continued to fish the river and bay despite the health risks may receive benefits that would count as part of the benefits of remediation. Even those who are not anglers or potential fish consumers may benefit if the fish become safer to eat, since they may hold nonuse values for reducing the risks to others from fish consumption.

Though probably smaller in magnitude, similar benefits would probably accrue from reducing or eliminating existing consumption advisories for waterfowl taken by hunters in the area.

PCBs have been linked to other environmental problems as well. If sediment cleanup reduces or eliminates these problems, both use and nonuse benefits may be generated. Bald eagles have poor nesting success along the bay, and scientists believe PCBs are to blame. Similar effects are suspected for two species of terns, including one that is listed as endangered by the state of Wisconsin. Cormorant chicks have been found with deformed bills that limit their survival, although other contaminants may also be contributing to these deformities. PCBs may be partly to blame for different, subtler effects on birds and other wildlife that may be identified in the future. Scientists are currently investigating whether the lack of natural reproduction of lake trout in Green Bay is linked to PCBs. If remediation of Fox River sediments will reduce these various effects, a healthier ecosystem in Green Bay and Fox River may increase the value of these areas to users and nonusers.

Additional benefits might accrue to those involved in water transportation of goods and raw materials. Periodic dredging of shipping channels and harbors is necessary, and disposal of contaminated dredged material is often more expensive than disposal of clean dredged material. Clean dredged material can be reused for various purposes, offsetting some of the dredging and handling costs, whereas contaminated dredged material poses environmental hazards and may incur additional expenses. Cleaning up PCBs in the Fox River should lead to cleaner sediments in the Port of Green Bay and reduce the costs of dredging and disposal to maintain access to port facilities.

In sum, many of the benefits of sediment remediation are likely to be enjoyed by anglers as the FCAs are reduced or removed. However, hunters, nonconsumptive users of wildlife (e.g., bird watchers), property owners, and those who bear the costs of dredging of shipping channels and harbors might also benefit. The citizenry at large may hold nonuse values associated with reduced impacts of PCBs on fish, wildlife, and people.

Benchmarking Benefits

A good place to begin a benefits scoping exercise is to ask how large the benefits would have to be before they would equal, or exceed, costs. This is typically done on a per household or per person basis to place the dollar figures into perspective. If costs per household seem quite modest—say a few dollars or tens of dollars per household—remediation may seem economically justified. If there is widespread public support for remediation, one might judge that in all likelihood, benefits, if actually measured, would be very likely to exceed costs. In these cases, it might not be necessary to estimate benefits.

Benefit estimates from other studies of roughly comparable situations might be enough to reach an informed judgment about the economic justification for the remediation project in question. Should the scoping study show that costs per household are larger—say hundreds or thousands of dollars per household—the economic justification for remediation would be less clear. In this latter situation, more detailed second-stage studies to evaluate actual benefits should be considered, at a minimum, before casting judgment upon economic feasibility.

The Fox River-Green Bay situation can be used to illustrate how benchmarking benefits work. How great would the benefits have to be per household to equal or exceed the costs? For benchmarking purposes I will use the estimated costs of $100 million per year for 10 years mentioned earlier. Let us consider this question from several perspectives involving both the regional and state levels.

Assume that sediment remediation costs will be $100 million per year for 10 years. Assume that the discount rate is 3%. The present value of costs, PV(C), are given by the following equation:

$$PV(C)=(\$100\ million)\sum_{t=1}^{10}(1.03)^{-t}=\$853\ million.$$

Assume that B is the annual benefits of remediation, a fixed amount, accruing each year for a set number of years. For purposes of this analysis, I will assume that the "time horizon" over which benefits are to be counted is 50 years. Setting the time horizon is always somewhat arbitary, but because of discounting, using a longer time horizon would not make a lot of difference to the numbers. Using 50 years, the benchmark level for society as a whole is found by solving the following equation for B:

$$B\sum_{t=1}^{50}(1.03)^{-t} = PV(C) = \$853\text{ million}$$

Solving, B = $34.12 million per year. B is the annual benefits over 50 years that would be needed before benefits would equal costs that are to be expended during the first 10 years. In order for benefits to exceed costs, *annual benefits would need to exceed $34.12 million*. This is the "aggregate benchmark" for purposes of the scoping study.

The aggregate benchmark is a starting point for the scoping analysis, but it is not very helpful by itself. We need a way of considering how plausible it is that aggregate benefits exceed the aggregate benchmark. We will do this by considering benchmarks that are stated in terms of annual household benefits. To get per-household benchmarks for benefits, $34.12 million is divided by the population of the area over which benefits are to be counted. Judging the "extent of the market" over which benefits should be counted is an important issue when benefits are actually measured. Because we have very little information about the boundaries of the area where people have a stake in Fox River and Green Bay resources, for purposes of the scoping study it will be necessary to explore the implications of alternative assumptions.

Our first assumption will be that benefits are confined to the 10 Wisconsin counties whose boundaries include or touch on portions of the Lower Fox River and Green Bay. According to the 2000 Census, there were 323,000 households in those counties. If only people in those counties would benefit from sediment remediation, the $34.12 million per year would amount to about $106 per household per year. For scoping purposes, the question then is whether benefits per household are likely to exceed $106 per household per year. We can think of the $106 as the "10-county benchmark."

Assuming that the beneficiaries of remediation would be limited to the 10-county region seems conservative. Surely many people living elsewhere would also benefit. A second assumption would be that all Wisconsonites (2.1 million households in 2000) are potential beneficiaries. Thus, we can calculate a "Wisconsin benchmark" of $16 per household per year and ask whether benefits appear likely to exceed that figure. Notice that this assumption does not require that each and every household in Wisconsin enjoy positive benefits from remediation. Many households could have no benefits so long as the *average* benefits exceed $16 when households having positive benefits are averaged in with those that would receive no benefits.

A third possible benchmark is suggested by the fact that the Bay of Green Bay extends into the state of Michigan. Wisconsin and Michigan combined had 5.9 million households in 2000. Thus, we can calculate a "Wisconsin-Michigan benchmark" of about $6 per household per year.

The question then becomes, what do we know about how actual benefits might compare with these benchmarks? We do have some clues. One source is the work conducted by Stratus Consulting (2000) for several federal agencies, Indian tribes, and the state of Michigan. The study was conducted as a part of a "Natural Resource Damage Assessment" and was designed to serve as a basis for determining how much restoration of natural resources would be necessary to make the public whole for losses incurred because of release of PCBs into the Fox River and Green Bay. However, results from the study can also be used to calculate monetary benefits from remediation of sediments. The results (Status Consulting, 2000, Appendix A, Table 6.2) imply that benefits from an aggressive plan that would reduce the time until PCBs decline to safe levels from 100 years to 20 years would be worth about $116 per household in the 10-county region per year for 10 years. To make this figure comparable to our benchmarks, we need to convert it to an annual value over 50 years. The calculation is equivalent to what you would do if you were considering paying off a major asset in annual payments over 10 years or lower annual payments over 50 years. It turns out that, after accounting for interest as well as principal, $116 per year for 10 years is equivalent to about $40 per year for 50 years. This falls short of our 10-county benchmark of $106, implying that costs exceed benefits. However, it applies only to households near the Lower Fox River and Green Bay. Presumably other people in Wisconsin would benefit as well. So no firm conclusion follows.

Another comparison is provided by a study of the benefits of sediment remediation in the California Bight off of Los Angeles (described as an example in the "Contingent Valuation" section of this chapter). The benefits to California households of capping a deposit of DDT and PCBs amounted to $56 per household as a lump sum (NRDA 1994). This is equivalent to $2.26 per household per year on average over 50 years. This would fall substantially below our Minnesota-Wisconsin benchmark of $6. If people in Wisconsin and Michigan value or benefit from sediment remediation in the Fox River similar to the value or benefit of California Bight cleanup to Californians, then this would leave one skeptical about whether the benefits of Fox River cleanup will exceed the costs.

On the other hand, John Stoll reports a study in detail below where he estimated that Wisconsin households are willing to pay between $100 and $300 per year for sediment remediation in the Lower Fox River. These estimates, though imprecise, compare very favorably with our Wisconsin benchmark of $16. Though this comparison leads to optimism about the possibility that the benefits of cleaning up the Fox River exceed the costs, it also seems to contradict results of the Stratus (2000) study cited above. Recall that the Stratus team's findings implied annual benefits of about $40 per household in the 10-county region. One would expect per-household benefits for the 10-county area to exceed those for the state as a whole. Presumably those living closer to the resource have higher values on average, but this does not happen when the Stoll and Status results are compared. As often happens in economics, it will not be possible to say which result is closest to being correct without further study.

Unfortunately, then, the scoping exercise is inconclusive about how likely it is that benefits would exceed costs for Fox River cleanup. Additional second stage studies would be needed in order to clarify the benefits. This will not always be the result of scoping exercises, however. Had the remediation costs been different in this exercise, the answer might have been clearer. For example, if the remediation costs are expected to be $10 million per year for ten years, it would have been much more likely that benefits will exceed costs. Statewide benefits would only have to be in the ballpark of the California Bight results for this to be true. If the remediation costs are expected to be an order of magnitude larger than what the scoping analysis assumed, the prospects for benefits exceeding remediation costs would be dim indeed.

It turns out, though, that the scoping does clarify what sorts of "second stage" economic valuation studies would help determine the relative magnitudes of benefits and costs.

C. Planning Second-Stage Studies

Scoping study results describe what sorts of benefits could be present, and they may reveal a bit about how large those benefits might be. At the second stage, planners must consider the prospects for successful application of alternative benefit valuation methods and the potential relevance of results in the decision-making process. For example, a study of recreational fishing values with and without FCAs will not reflect benefits of sediment clean-up to those who might otherwise have to deal with contaminated sediments dredged from shipping channels and harbors, for example. Choices among valuation methods will normally be based on the specific characteristics of the problem at hand, technical feasibility, and the size of the research budget. Specific characteristics will vary from site to site.

For example, if the scoping study shows that shipping-related benefits are likely to be predominant, market valuation methods may be most useful. If recreational benefits appear to be paramount, the travel cost method may be most useful. Most methods yield partial estimates of benefits, so it makes sense to measure the benefits that are expected to be large enough to matter in the overall comparison of benefits and costs. Bear in mind that a method that proves useful in one setting may not be feasible in another for technical reasons, as demonstrated in a following section for Fox River sediment cleanup. In some cases, desirable benefit studies may simply be unaffordable.

Assuming that additional benefit studies are being considered for Fox River sediment cleanup, consider the following methods: benefits transfer, market valuation, hedonic, travel cost demand, and contingent valuation.

Benefits Transfer

Benefits transfer is simply the transfer of results from one benefits study to another—clearly an inexpensive method.. The usefulness of benefits transfer for sediment remediation projects will begin when more valuation studies have been completed, especially some of the 37 sediment remediation projects undertaken in 42 Great Lakes Areas of Concern (Zarull 1999).

We did employ informal benefits transfer procedures as part of the scoping exercise when we compared benchmark benefit levels for Fox River sediment cleanup with benefit estimates for cleanup in the California Bight. Without more such studies, benefits transfer lacks the support needed to gain credibility as a stand-alone benefit estimation approach.

Market Valuation Studies

The commercial fisheries of Green Bay are so small that any benefits to them from Fox River cleanup will be of little consequence compared with remediation costs. Dredging is necessary to give Great Lakes ships access to the Port of Green Bay port facilities, as mentioned in the earlier Scoping Studies section. It is conceivable that Fox River cleanup could eventually reduce contaminant levels in dredged material and reduce the costs of disposal through beneficial reuse of the cleaner material. A thorough scoping study might show that a detailed study to document these benefits is worthwhile. The scoping study would be used to examine the amount of dredging that is likely to be needed in the future under various climate change and water level scenarios and the extent of the possible cost savings if dredged material can be reused. If this scoping effort shows that substantial benefits might be present, further study is needed to estimate the probable magnitude and timing of the benefits, their estimated effects on port survival or growth, and influence on the regional economy.

Hedonic Methods

If environmental amenities like clean air and clean water enhance the quality of life, we ought to be able to see their influence on property values. As home buyers, for example, consider buying property in different neighborhoods with different air quality levels, they can be expected to bid up the prices of homes where the air is cleaner compared to the prices of homes where air quality is poor.

The "hedonic price method" uses data on property values and housing characteristics (including neighborhood environmental quality) to infer the value residents place on environmental amenities. For example, a hedonic study of the Chicago area air quality applied statistical methods to compare property values in areas with relatively poor air quality with property values in areas with relatively good air quality. It was possible to assess how much air quality affected property values when other factors were held constant (NOAA, 2000).

Unfortunately, the relationship between PCBs in sediments and property values appear to be too complex and subtle to make hedonic studies promising. Most hedonic studies have been performed where there are substantial variations in environmental quality within a relatively limited geographic area.

The effects of PCBs are much less localized and variable than those of air quality in Chicago. For example, FCAs are somewhat different for the Fox River than for Green Bay, but within relatively large areas they are the same. To pick up the effects of PCBs on property values it would be necessary to find another region of the state or nation that is more or less comparable to the Green Bay region except for the PCB problem. This is a tall order.

Also, the areas of the Green Bay region where PCB contamination is the worst (in the Fox River and in Green Bay at the mouth of the Fox) also suffer from other water quality problems such as high turbidity and algae blooms, which would not be affected by PCB cleanup. It would be hard to sort out the effect of PCBs on property values, if any, from the effects of these other forms of pollution. Many of the benefits of cleanup, particularly those associated with nonuse values, would be overlooked by a hedonic study.

Travel Cost Demand Estimation

Since PCBs affect fishing, waterfowl hunting, and other outdoor recreation activities, the travel cost method appears applicable to Fox River cleanup, at least in principle. However, pursuing a travel cost study does not seem wise for a number of reasons. In this situation, the travel cost demand method suffers from the same limitations as the hedonic method. The travel cost method uses variations in environmental quality across recreation sites as a basis for teasing out the value of high-quality sites compared with low-quality sites. In essence, people reveal the value they place on high-quality recreation sites by spending extra money to get there.

This would be difficult to measure in the case of Fox River cleanup because there is so little variation in PCB levels across sites. Even if this problem could be overcome, the travel cost method is only capable of estimating recreational benefits of cleanup.

Furthermore, recreational benefits alone are likely to fall far below sediment remediation costs. Consider recreational fishing. A rough estimate is that Green Bay and the Fox River are supporting 300,000 angler-days per year. This number is based on Wisconsin Department of Natural Resources creel census data. Suppose that by improving fishing quality on existing fishing days sediment remediation increases the value of existing fishing by $10 per angler-day. This would be $3 million in benefits.

More anglers might be attracted to fishing in the area if the FCAs were reduced or eliminated. Suppose that there would be a 30% increase in angler days and that these new angler days are worth $30 each. That would be an additional $2.7 million. Such sums are certainly significant on their own terms. However, even if the hypothetical dollar figures used here are off by a wide margin, the economic benefits from improved fishing seem likely to be a small percentage of sediment remediation costs if those costs are in the hundreds of millions of dollars. The economic benefits of improved waterfowl hunting, bird watching, and other activities are likely to be substantially smaller than angling benefits simply because there are probably fewer people involved in these activities.

Contingent Valuation

Contingent valuation (CV) uses survey methods to estimate values of environmental amenities. In personal or telephone interviews or mail surveys, respondents are asked to make choices contingent upon hypothetical circumstances. For example, would the respondent support remediation of contaminated sediments to a particular level if implementation of the program would cost the respondent's household $50 per year?

These choices can be used to reveal, directly or indirectly, respondents' willingness to pay to achieve environmental improvements or avoid environmental degradation. The more meaningful and well-defined the contingent choices placed before participants, the more their responses reveal about the choices they would make if the situation were real.

Responses are analyzed in various manners to estimate values for the circumstances described by the constructed scenario. Because of their contingent nature and lack of reliance on observed market behavior, CV approaches are applicable to a wider array of policy circumstances than other valuation techniques. CV is useful in estimating both nonuse and use benefits of sediment remediation in the Fox River.

Given the array of nonmarket environmental effects of PCBs in the Fox River and Green Bay and the potential for nonuse values associated with those effects, CV appears promising as a way to investigate the possible benefits of Fox River cleanup. With careful design, a CV study could pick up nonuse benefits associated with effects on fish and birds (including endangered species) and other environmental assets along with recreation values of the affected resources. If decision-makers want or need benefit-cost comparisons, a CV study appears to be the most promising avenue for estimating benefits of contaminated sediment remediation. It is the only method of estimating "total values," including nonuse values, which has gained substantial acceptance among economists. *If* a CV total valuation study is judged to be valid, it allows decisions to be made with consideration of the broader values that the public may hold for environmental amenities, rather than basing choices on use values alone. To many readers, CV may seem rather new and unconventional. Fortunately, a previous application to sediment remediation is available that will illustrate how it works.

D. A Case Study Use of Contingent Valuation in Sediment Remediation

The Problem

Beginning in the 1940s, a plant in Los Angeles manufactured DDT and discharged DDT-contaminated waste into the county sewer system, which discharged to outfalls in the Southern California Bight, an area in the Pacific Ocean off the Palos Verdes Peninsula. PCBs also entered the marine environment through the sewage outfall. Even though discharges to the sewers ended in the 1970s, DDT and PCBs continue to enter the food chain from sediments covering an area about five miles long and two miles wide.

Bald eagles and peregrine falcons are very rare in a large area of southern California, and efforts to reestablish the birds there have been hampered by a nearly total lack of reproduction. Two species of fish, kelp bass and white croaker, have also experienced reproduction problems in areas near where the chemicals were released. Recreational anglers have been warned about the dangers of eating both species, and commercial fishing for white croaker has been banned in the area. Kelp bass are not fished commercially. These environmental problems have been linked directly to the sediments of the Southern California Bight. Other effects are probably present but have been more difficult to document.

A study estimated the benefits of a program to "cap" the contaminated sediments with a layer of clean material that would prevent further uptake of DDT and PCBs into the food chain (Natural Resource Damage Assessment, Inc. 1994). The goal of the study was to estimate the losses the public would suffer as a result of the contaminants, not to estimate the benefits of capping the sediments. Covering perhaps 10 square miles and lying under 100 feet of water, the sediments would be difficult, expensive, and perhaps technically impossible to cap. Therefore, they are expected to continue to affect birds and fish for at least 50 years.

The study was done in the context of a lawsuit brought by the U.S. Department of Commerce and the State of California under the Superfund program. If Californians were willing to pay some amount of money to fix the problem, then this would serve as an estimate of the value lost if the problem cannot be fixed. The researchers who did the study went to great lengths to make the capping project seem plausible to respondents. Although this situation is different from the situation in Green Bay, it provides a glimpse of how the benefits of a real sediment remediation project can be evaluated using CV.

The Valuation Approach

The CV survey began with a couple of questions focusing on how respondents felt about several activities funded by the State of California, including building new prisons, providing public transportation, and improving education. This served as general background data about how each respondent felt about various governmental programs and introduced the topic of government spending. Next came an overview of the capping proposal. This part of the survey was quite long and detailed, and only a brief outline is given here. It began by telling respondents:

> "Proposals are sometimes made to the state for new programs. The state does not want to undertake new programs unless taxpayers are willing to pay for them. One way for the state to find out about this is to give people like you information about a program so that you can make up your own mind about it.
>
> In interviews of this kind, some people think the program they are asked about is not needed; others think it is. We want to get the opinions of both kinds of people."

The survey then introduced the elements of the contamination problem and the capping project, including:

- A description of the reproductive problems of the affected birds and fish and where they were located, including sketches of the organisms and maps.
- An explicit statement that there are many other species of birds and marine life in the area that are not currently affected.
- An explicit statement about the status of the affected species. (The fish were not endangered; whereas both birds were listed as endangered in California and several other states. However, populations of both birds were increasing elsewhere in California and in other states.)
- A description of how the problems for these species are due to DDT and PCBs and how these chemicals got into the environment in the first place.
- A discussion of how such compounds remain in the sediments and continue to get into the food chain many years after their release was discontinued.
- Explanations of how commercial fishing controls and consumption advisories for recreationally caught fish protect human health.
- A discussion of how new clean sediments from natural sources are slowly covering the contaminated sediments and will ultimately form a barrier between the contaminated sediments and the food chain, thus solving

the problem in about 50 years without human intervention.

- A description of a "speed-up program" that would cap the sediments and allow the birds and fish to recover in only 5 years rather than 50 years. (Several diagrams were presented here to make the speed-up program seem realistic.)

- A statement to the effect that the capping project, if carried out, would be paid for by a one-time increase in next year's California income taxes.

Next in the survey came two valuation questions. They were posed as referenda and specified the amount by which the respondent's household income tax bill would increase. Each time, the respondents were asked whether they would vote for or against the proposal. They were then asked about a higher or lower tax, depending on whether they "voted" yes or no to the previous question.

The sample was designed to be representative of English-speaking Californians, 18 years of age and older. In the first half of 1994, trained interviewers from a leading survey firm completed 2,810 personal interviews, which constituted 72.6 percent of the eligible households in the original sample.

Statistical procedures used to analyze responses to the valuation questions were designed to estimate a lower bound on the average value per household, which turned out to be $55.61. This would imply that the total benefits from the capping project are at least $575.4 million (estimated standard error = $27.5 million).

E. Implications for CV Studies

The CV method has some distinct advantages over other methods of answering benefits questions. CV can include a more comprehensive set of environmental values, including both use and nonuse values, held by the public, whereas other methods will limit values to those directly associated with resource uses like recreational fishing. Limiting benefit estimates to use values carries a risk: based on an overly narrow definition of benefits, the costs of remediation projects may be judged to exceed benefits when in fact a more complete accounting of benefits using CV may lead to the opposite conclusion.

Results from the California study underscore the need for a full accounting of benefits. Remediation of sediments in the Southern California Bight would lead to improved fishing and bird watching, but this is only the tip of the iceberg. Results from the CV study indicate that much larger values lie just underneath the surface, values associated not with immediate direct uses of affected resources but with the public's broader concerns about the environment. To a greater or lesser degree, the same conclusion may be true for contaminated sediments in the Great Lakes region. The only way to know is to estimate the full range of values using CV. In this way, CV is capable of contributing much toward sound decision making about where and when to apply remedial measures to contaminated sediments.

F. Summary

At the first stage of evaluating economic benefits, a simple scoping study based on easily acquired data and studies done elsewhere may be all that is necessary to make a reasonably good judgment about whether benefits are likely to exceed expected costs or vice versa. If not, deeper investigation of benefits and costs can be conducted in a second stage. Here, the scoping study results should be helpful in judging which valuation methods are most promising for arriving at useful practical results.

The proposed cleanup of PCBs from the Fox River serves to illustrate how this would work in practice. In this case, high estimated remediation costs indicated that a scoping study alone probably would not be sufficient to judge whether or not benefits will exceed costs. Furthermore, although potential benefits associated with Great Lakes shipping are not well understood, it appeared that most of the benefits will be associated with recreation and nonuse values.

Even if a good measure of recreational benefits could be found based on a travel cost analysis (and here there are formidable technical problems to be overcome) the resulting benefit estimates would likely fall far short of the expected remediation costs. This would leave decision makers and citizens scratching their heads about the economic justification for the cleanup proposal. Recreational benefits seem to be less than the expected remediation costs, but the total value of the benefits, including nonuse values, could be larger than these costs.

Thus, it appears that the wisest strategy for evaluating Fox River sediment cleanup will be to do a contingent valuation study so that nonuse as well as use values can be considered. In Section III we describe the results of a new contingent valuation survey dealing with various water quality issues in the Green Bay Area of Concern (AOC).

This section has focused on methods to evaluate the economic justification for sediment remediation projects in terms of benefits and costs. There are, of course, other economic issues that can arise in considering such projects. For example, the issue of who would pay for sediment cleanup was not examined in this chapter. Concerns about plant closings and loss of jobs arise if private parties pay the cleanup costs. This issue, though important, is beyond the scope of this chapter.

The best strategy for economic analysis may be very different at other Great Lakes AOCs. Where a scoping study shows that recreational, shipping, or other benefits are likely to predominate, a method or combination of methods other than contingent valuation could be applied where technically feasible.

The problem about what to do with contaminants in the environment will often separate citizens into two camps. On the one side will be environmentalists who may be convinced that remediation should be carried out regardless of costs. From an economic perspective, they are assuming that benefits are very large or even infinite.

On the other side will be economic interests who will be strongly oriented toward use values and particularly use values of market goods. This latter group may quickly come to the conclusion that benefits are small. A well-designed benefits scoping study, followed where necessary by deeper second stage studies tailored to the situation, will help arrive at economically sound decisions by providing more objective information about the magnitude of some of the benefits of sediment remediation projects.