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Economic Benefit Considerations in Selecting Water Quality Projects

Insights from the Rural Clean Water Program

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Abstract

The Rural Clean Water Program was initiated in 1980 to demonstrate the effectiveness of improved agricultural land management practices in enhancing water quality. Projects that preserve or improve water quality in a heavily used lake or estuary appear to have the greatest potential for generating net benefits. This appears particularly true for projects with recreational or commercial fishing impairments. About a third of the projects have good prospects for generating net benefits under current circumstances. Another third have the potential for generating benefits if they become part of a larger program that successfully preserves or expands downstream water uses.

Keywords: Rural Clean Water Program, nonpoint source pollution, economic benefits, benefit evaluation, water quality

Acknowledgments

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Summary

Runoff from agricultural land carries sediment, nutrients, bacteria, and pesticides into lakes, rivers, and streams. Elevated levels of these pollutants can harm recreation, water supplies, commercial fishing, and wildlife. The Rural Clean Water Program (RCWP) was initiated in 1980 by the U.S. Department of Agriculture and the U.S. Environmental Protection Agency to demonstrate the effectiveness of agricultural best management practices (BMP's) in improving water quality and reducing the offsite effects of nonpoint source water pollution. This report presents insights from RCWP regarding what kinds of water quality projects are most likely to generate economic benefits equal to or exceeding economic costs. In the analysis, potential and likely economic benefits are estimated for each of the 21 RCWP projects. Benefit levels are compared with type of water resource, types of use impairment, types of pollutants, and kinds of practices implemented to improve water quality.

The RCWP projects most likely to generate the highest offsite benefits are those aimed at preserving or improving water quality in a heavily used lake or estuary within or immediately adjacent to the project area. This appears particularly true for those RCWP projects addressing recreational and commercial fishing impairments in contrast to those addressing impaired water supplies. The extent of the benefits generated will depend on the level of the use impairment and the improvement in water quality. The RCWP projects with nutrient or bacteria problems frequently have a larger number of impaired water uses and potentially higher benefits than do projects with sediment problems. The cost of treating bacteria, nutrients, and sediment with structural practices such as animal waste storage systems and terraces is high compared with the cost of treating sediment and nutrient runoff through low-cost management practices such as conservation tillage. When benefits are potentially very high, more expensive structural practices and improvements appear justifiable, particularly if needed to bring water quality to threshold levels where user benefits are generated.

About a third of the RCWP projects have strong prospects for offsite economic benefits exceeding costs. Another third have the potential for positive net benefits if additional benefits can be generated by becoming part of larger regional programs that successfully sustain or expand uses of downstream major water resources. A few projects would have had better prospects for net benefits if costs had been reduced by greater reliance on management practices rather than structures such as terraces.

If high economic benefits to the public are desired in future programs, more careful consideration of project selection than that which occurred in RCWP will need to be given to the nature of the impaired water resources, the number of users affected, and the extent to which water quality improvements can be achieved at reasonable costs.

Economic Benefit Considerations in Selecting Water Quality Projects

Insights from the Rural Clean Water Program

Steven Piper
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C. Edwin Young

Introduction

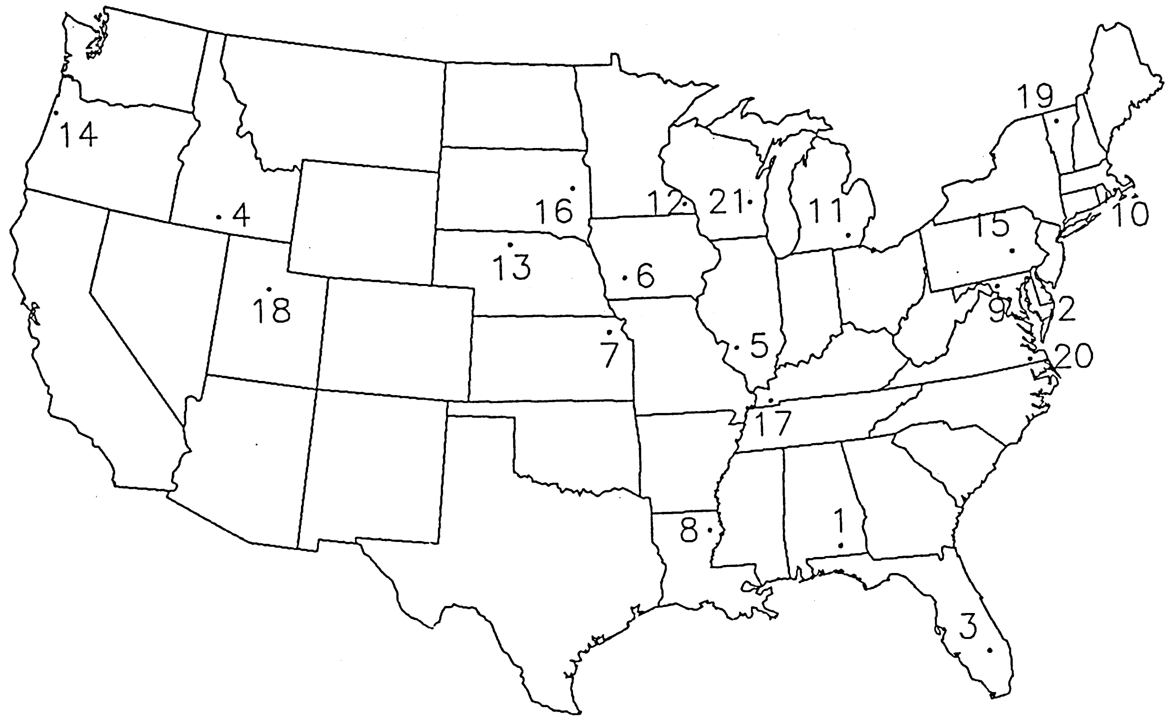
Agriculture is a major contributor to nonpoint source water pollution in the United States. Runoff from agricultural land carries sediment, nutrients, pesticides, and bacteria to downstream water resources. These residuals can contaminate groundwater supplies, impair water-related recreation, and adversely affect water supplies and treatment, commercial fishing, water storage, the aquatic habitat, and the esthetic quality of water. The application of best management practices (BMP's) on agricultural land can reduce nonpoint source pollution and related water use impairments.

The experimental Rural Clean Water Program (RCWP) was established in 1980 and has been applied to 21 projects selected for their diversity of pollution problems from agricultural sources. This analysis illustrates the relationship between project characteristics and the economic efficiency of nonpoint source control projects, as demonstrated by RCWP, and provides guidance for future project selection and program implementation. This report presents estimates of offsite economic benefits of the 21 projects and assesses project characteristics that contribute to high, medium, and low (or uncertain) gross and net benefits. Projects with uncertain benefits include those for which a smaller or larger scale, different BMP emphasis, or greater BMP implementation may have made a difference in economic efficiency.

The Rural Clean Water Program

The experimental program was initiated in 1980 to demonstrate the water quality effects of implementing agricultural BMP's. Twenty-one projects across the Nation, representing a wide range of pollution problems and impaired water uses, were included in the program (fig. 1). Each RCWP project was required to have a plan of work indicating project goals and methods of achieving those goals, as well as a water quality monitoring program to determine the effectiveness of the land treatment programs. Five of the projects were designated as comprehensive monitoring and evaluation (CM&E) projects, which received additional funding to monitor and evaluate the project impacts. Project implementation generally lasts 10 years with 5 years allowed to sign contracts. These time frames have been adjusted to account for unexpected problems or successes, such as the early termination of the Kansas project due to the lack of a demonstrated water quality impairment and the early attainment of contracting goals in Delaware.

Figure 1--Location of the 21 RCWP projects



1 - Lake Tholocco, AL

2 - Appoquinimink, DE

3 - Taylor Creek/Nubbin Slough, FL

4 - Rock Creek, ID

5 - Highland Silver Lake, IL

6 - Prairie Rose Lake, IA

7 - Upper Wakarusa, KS

8 - Bayou Bonne Idee, LA

9 - Double Pipe Creek, MD

10 - Westport River, MA

11 - Saline Valley, MI

12 - Garvin Brook, MN

13 - Long Pine Creek, NE

14 - Tillamook Bay, OR

15 - Conestoga Headwaters, PA

16 - Oakwood Lakes-Lake Poinsett, SD

17 - Reelfoot Lake, TN/KY

18 - Snake Creek, UT

19 - St. Albans Bay, VT

20 - Nansemond-Chuckatuck, VA

21 - Lower Manitowoc, WI

Farmer participation in RCWP was voluntary. In order to provide an incentive for implementing BMP's under RCWP, Federal cost shares and technical assistance were made available to participating farmers. Up to 75 percent of the costs of BMP implementation were cost-shared by the Federal Government, with a maximum cost share of $50,000 per farm. This compares with $3,500 per year per farm under previous programs. For some projects, such as Taylor Creek in Florida and Garvin Brook in Minnesota, additional money from State and county sources was made available to further reduce farmers' cost.

Study Objectives and Procedures

The objectives of this study were to obtain insights from the RCWP regarding the type of water quality projects most likely to generate economic benefits exceeding economic costs, and to present these insights as guidance for selection of future projects. To that end, we:

1. Identified major water resource uses at each project and the impairments to water uses.

2. Estimated potential benefits from RCWP preventing further water quality deterioration, and from RCWP improving water quality compared to pre-project conditions.

3. Determined likely benefits by adjusting the potential benefits estimated in 2 above to reflect probable changes in water quality from RCWP.

4. Classified the projects according to potential, likely, and net economic benefits after costs into one of three benefit groups: high benefit projects, moderate benefit projects, and low (or uncertain) benefit projects. The uncertain projects include those for which a larger or smaller scale, different BMP emphasis, or greater BMP implementation may have made a difference in economic efficiency.

5. Compared projects within and among the three economic groups for similarities and differences to gain guidance for future programs. Aspects analyzed included: type of water resource, types of use impairment, types of pollutants causing problems, and kinds of BMP's implemented to improve water quality.

These steps were completed by reviewing all the project plans of work and annual progress reports for available information. Project personnel and others familiar with each of the projects were contacted to provide more detailed information on project costs, the extent of water pollution impairments, changes in water quality and water resource use, and the value of the changes in use. Estimates of recreational use, domestic water supply treatment costs, and commercial fishing values were obtained from outside sources when information was not available from RCWP project personnel. Reports and summaries of the RCWP projects from the North Carolina State University's National Water Quality Evaluation Project (NCSU-NWQEP) were used to assist in evaluating the actual and potential changes in water quality at each project (38, 39, 40).1/

1/ Underscored numbers in parentheses refer to items listed in References.

Impaired Water Resources And Uses

The 21 RCWP projects included a variety of impaired water resources (table 1). Eleven of the 21 projects (AL, DE, FL, IL, IA, LA, OR, TN, UT, VA, SD) contained or were adjacent to impaired lakes or estuaries. Eight projects (ID, KS, MD, MA, MI, UT, WI, PA) involved polluted streams contributing to downstream problems in rivers, lakes, or estuaries. Two (MN, NE) involved polluted small streams of concern mostly within the project area. In addition, four of the above projects (SD, MN, NE, PA) had degraded groundwater supplies.

Water quality problems in the 21 project areas included excessive sediment (13 projects), bacteria (8 projects), nutrients (13 projects), and pesticides (1 project, see table 1). Agricultural sources of pollution included cropland, animal waste, and pesticide and fertilizer use. There was more than one problem pollutant and source of pollution at most of the projects. At 5 projects, sewage treatment plants or other point sources also contributed to the pollution problem.

Impaired water uses resulting from the pollution included recreation (19 projects), domestic water supply (10 projects), water storage capacity or harbor depth (4 projects), and commercial fishing (3 projects). Other effects, not quantified in this report, included degraded aquatic habitat, reduced esthetic quality, adverse wildlife habitat effects, and effects from outside of the project areas.

Benefit Evaluation

An RCWP project with its implemented BMP's can fully or partially preserve water quality that would otherwise deteriorate (preservation impacts). Also, the project may improve water quality over the pre-project condition (improvement impacts). The project can, of course, have no discernible effect on water quality.

Economic benefits do not result from preserved or improved water quality alone, but from the impact of water quality changes on the supply and demand for water use and the resulting use changes that actually occur. A simple economic framework illustrates the linkages between RCWP implementation, water quality changes, and offsite water use benefits. Figure 2 shows a hypothetical supply and demand schedule for water use at a particular water resource site. As the price of using water increases, use decreases and quantity supplied increases, assuming all other factors influencing supply and demand remain constant. The equilibrium quantity of water use is Q_o at price P_o.

Water quality is one factor that can have a significant impact on the supply and demand for water use. As water quality improves, the water resource becomes available for an increased number of activities, increasing the supply of water resources. Improved water quality will also attract water users who found water quality unsuitable before water quality improved, resulting in increasing demand for the water resource, all other things remaining the same.

The effect of an improvement in water quality on the supply and demand for water-based activities is shown in figure 3. Improved water quality shifts

Table 1--Water resources of the 21 RCWP projects

Project	Type of water resource	Major sources of pollution	Major water quality problems	Major impaired uses
Lake Tholocco, AL	600-acre lake	Cropland and animal waste	Sediment, bacteria	Recreation, water storage
Appoquinimink, DE	Small lakes, streams	Animal waste, cropland, sewage treatment plants	Nutrients, bacteria	Recreation
Taylor Creek-Nubbin Slough, FL	Streams flowing into Lake Okeechobee	Animal waste	Nutrients	Recreation, water treatment, commercial fishing
Rock Creek, ID	Tributary to Snake River	Cropland	Turbidity, bacteria	Recreation, irrigation systems
Highland Silver Lake, IL	Water supply reservoir	Cropland	Turbidity, sediment	Recreation, water treatment
Prairie Rose Lake, IA	215-acre lake	Cropland	Sediment, nutrients	Recreation
Upper Wakarusa, KS	River and water storage	Cropland	Sediment	Recreation
Bayou Bonne Idee, LA	Several streams and small lakes	Cropland	Pesticide residue, turbidity	Recreation
Double Pipe Creek, MD	Several streams	Animal waste from dairy farms, cropland	Bacteria, turbidity, nutrients	Recreation, water treatment
Westport River, MA	Lower Westport River	Animal waste, town of Westport	Bacteria	Recreation, commercial fishing
Saline Valley, MI	Two streams flowing into Lake Erie	Animal waste, cropland	Sediment, nutrients	Recreation
Garvin Brook, MN	Two small streams, groundwater supplies	Animal waste, cropland	Surface water sediment, groundwater nitrates	Recreation, groundwater

Continued--

Table 1--Water resources of the 21 RCWP projects--continued

Project	Type of water resource	Major sources of pollution	Major water quality problems	Major impaired uses
Long Pine Creek, NE	Several small streams, groundwater	Cropland, feedlots, sewage treatment plants	Surface water sediment and groundwater nitrates	Recreation, water for drinking
Tillamook Bay, OR	Estuary	Animal waste	Bacteria	Recreation, commercial fishing
Conestoga Headwaters, PA	Several streams, groundwater	Animal waste and cropland	Surface water bacteria and nitrates, ground water nitrates	Drinking water
Oakwood Lakes-Lake Poinsett, SD	Three small recreational lakes, groundwater	Cropland	Surface water nutrients and sediment, ground water nitrates.	Recreation, water for drinking
Reelfoot Lake, TN/KY	13,000-acre recreational lake	Cropland	Sediment, nutrients	Recreation, water storage
Snake Creek, UT	A portion of Snake Creek and several small ditches	Animal waste, sewage treatment plants	Phosphorus	Water treatment (Deer Creek Reservoir)
St. Albans Bay, VT	Bay located along Lake Champlain	Animal waste, sewage treatment plants	Phosphorus	Recreation, water treatment
Nansemond-Chuckatuck, VA	Several water supply reservoirs, estuary	Animal waste and cropland	Bacteria nutrients	Recreation, water supply, commercial fishing
Lower Manitowoc, WI	Several streams that empty into Lake Michigan	Animal waste, cropland	Bacteria, phosphorus	Recreation, water treatment and harbor depth

the supply schedule from Supply to S′ and the demand schedule from Demand to D′. The new equilibrium quantity increases from Q_o to Q_1. The equilibrium price of water use may increase or decrease, depending on the relative shifts in supply and demand. The increase in public economic benefits from improved water quality is represented by the difference in area between triangles ABC and EFG. A similar figure can be used to depict the impacts of fully or partially preserving water quality that would otherwise deteriorate.

Figure 2--Supply and demand for water-based activities at a hypothetical site

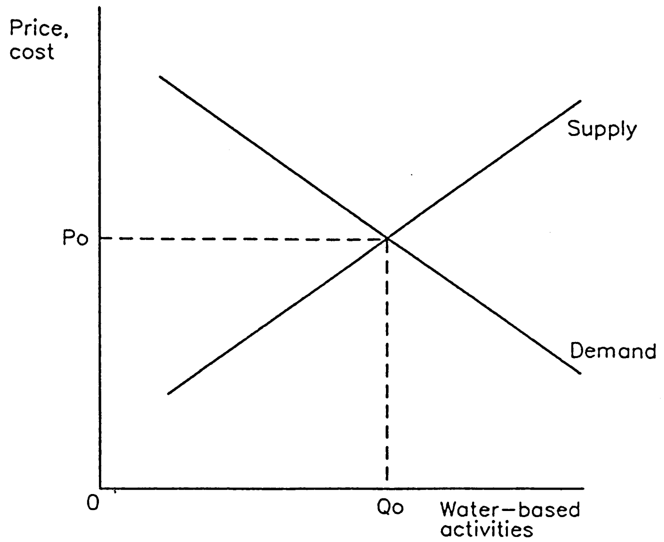
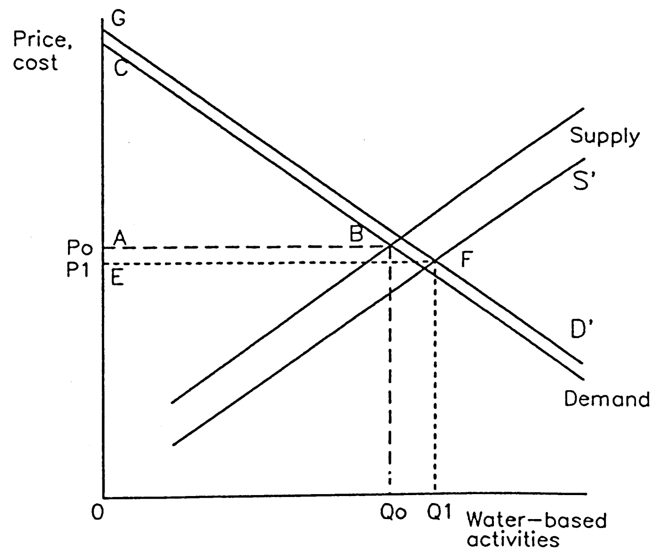


Figure 3--The effect of an improvement in water quality on the supply and demand for water-based activities



Water Quality Preservation Benefits

Estimation of the benefits from preserving pre-RCWP water quality requires knowledge of the quantity of water use, the value of water use, and water quality trends that may have continued if RCWP had not been implemented. Benefits from preserving pre-RCWP water quality can range from zero at projects where water quality would not have declined without RCWP to the full value of water use at projects where water use would have dropped to zero without RCWP. However, zero water use without RCWP does not appear likely for any of the projects.

The benefits from preserving pre-RCWP water quality are estimated for only recreation and commercial fishing. Benefits from preserving water quality are not estimated for water supplies because treatment can be used to maintain supplies even though water quality may decline. Reliable information for water supplies was not available to determine what sedimentation rates would have been in the lakes without RCWP. Very little information is available indicating the level of water quality at each project if RCWP had not been implemented. Therefore, likely preservation benefits are based on project report descriptions of water quality before RCWP.

The recreational use values for all of the projects except those in Idaho, Illinois, South Dakota, and Vermont were estimated by multiplying the number of annual user days times average user day values estimated by Loomis and Sorg (30) for different regions of the United States. The number of user days at each project was obtained through telephone interviews and mail correspondence with Soil Conservation Service (SCS) personnel, State natural resource agencies, State water quality departments, State fishery agencies, and from annual RCWP project reports. Survey results available from project reports were used to estimate recreational use values at the Idaho (53), Illinois (26), South Dakota (44), and Vermont (54) projects.

Commercial fishing benefits for the Florida, Massachusetts, Oregon, and Virginia projects were estimated to be equal to the average annual net revenues from those types of commercial fishing adversely affected by the problem pollutants in the project area over the past 5 to 10 years.

The benefit estimates from preserving pre-RCWP water quality are presented in table 2. The highest potential preservation benefits exist for the seven projects in South Dakota, Florida, Tennessee/Kentucky, Iowa, Nebraska, Oregon, and Virginia. In all of these, further deterioration of water quality in adjacent lakes or estuaries could significantly impair recreation or commercial fishing. However, in 4 of those projects (Florida, Tennessee/Kentucky, Nebraska, and Iowa) and 15 other RCWP projects, no indication could be found that water quality would further deteriorate without RCWP, or that RCWP would prevent that deterioration. Thus, for 18 RCWP projects, likely benefits of RCWP from preservation of water quality and water uses appear negligible. This leaves only three projects (South Dakota, Oregon, and Virginia) with likely preservation benefits. In all three cases, likely benefits are less than the potential maximum, since water use is not likely to drop to zero without RCWP at any of the projects.

Table 2--Estimated water quality preservation benefits of the 21 RCWP projects

Project	Type of benefit	Value of benefits: Maximum potential 1/	Value of benefits: Likely	Discussion (sources of information used to estimate benefits)
		---$1,000/year 2/---		
Alabama	Recreation	130	0	No indication of further use impairment without RCWP (30, 35)
Delaware	Recreation	160	0	No indication of further use impairment without RCWP (11, 30)
Florida	Recreation,	3,690	0	Protection of commercial fishing from high nutrient and bacterial levels (14, 15, 51)
	commercial fishing	1,000	0	
Idaho	Recreation	65	0	No indication of further use impairment without RCWP (53)
Illinois	Recreation	2	0	No indication of further use impairment without RCWP (26)
Iowa	Recreation	960	0	No indication of further use impairment without RCWP (1, 21, 30, 33, 45)
Kansas	Recreation	10	0	No indication of further use impairment without RCWP (13, 30)
Louisiana	Recreation	80	0	No indication of further use impairment without RCWP (3, 28, 30, 34)
Maryland	Recreation	3/	0	No indication of further use impairment without RCWP (12, 49)
Massachusetts	Recreation,	0	0	No indication of further use impairment without RCWP (10, 20, 25, 47)
	commercial fishing	100	0	
Michigan	Recreation	3/	0	No indication of further use impairment without RCWP (48)
Minnesota	Recreation	130	0	No indication of further use impairment without RCWP (18, 30)
Nebraska	Recreation	260	0	No indication of further use impairment without RCWP (29, 30, 32)

See footnotes at end of table.

Continued--

Table 2--Estimated water quality preservation benefits of the 21 RCWP projects--Continued

Project	Type of benefit	Value of benefits: Maximum potential 1/	Value of benefits: Likely	Discussion (sources of information used to estimate benefits)
		---$1,000/year 2/---		
Oregon	Recreation,	85	0	Preservation of recreational clamming and commercial shellfishing (2, 19, 24, 27, 30, 57)
	commercial fishing	675	0-50	
Pennsylvania	Recreation	3/	0	Too little critical area treatment to generate benefits (52)
South Dakota	Recreation	9,500	0-710	RCWP could help prevent water quality degradation (41, 44)
Tennessee/ Kentucky	Recreation	1,700	0	No indication of further use impairment without RCWP (42)
Utah	Recreation	3/	0	No indication of further use impairment without RCWP (37, 50)
Vermont	Recreation	140	0	Benefit estimates from recreational survey (54)
Virginia	Recreation,	3/260	0	Preservation of current shellfishing areas with RCWP (9, 30)
	commercial fishing	3/	0-30	
Wisconsin	Recreation	3/	0	No indication of further use impairment without RCWP (31, 43)

1/ Equals the total value of water use before RCWP, assuming use would drop to zero without RCWP.
2/ Expressed in 1986 dollars.
3/ Downstream benefits outside of the project area are possible if the project becomes part of a larger regional program that preserves water quality in major downstream resources from further deterioration.

Water Quality Improvement Benefits

We estimated benefits from improved water quality by assuming water quality will be improved so that water quality goals are achieved and impaired water uses are removed at each project. This assumption implies that agriculture contributes a large enough share of nonpoint source pollution that meeting RCWP project goals will significantly improve water quality and increase water use. Agriculture within the RCWP project areas is the major source of water pollution in all but three of the projects. Annual project reports indicate treatment of agricultural sources of pollution is necessary at each of the 21 projects to reduce water use impairments. Therefore, all benefits generated from improved water quality are attributed to RCWP and any expenditures made to reduce other sources of pollution, such as updated wastewater treatment facilities, are included in the cost estimates. Estimating benefits from improved water quality requires more information than estimation of benefits from preserving pre-RCWP water quality. Information is needed to determine the response of recreationists, water treatment plants, water storage facilities, and groundwater users to improved water quality.

Six of the 21 projects provided information useful in estimating potential improvement benefits for recreation. For the Illinois project, a survey of anglers using Highland Silver Lake indicated an improvement in water quality could increase fishing use by 55 percent despite limitations on boat size (26). A survey of recreationists at Oakwood Lakes/Lake Poinsett in South Dakota indicated that use could increase by 59 percent if algae were no longer a problem (44). In the Bayou Bonne Idee project, fishing use is estimated to have increased by 50 percent since 1981, corresponding to an improvement in the appearance of the water (34). In the Prairie Rose Lake project in Iowa, nonfishing use has increased by approximately 12 percent since 1981 (45), some of which could be due to improved water quality. A recreational survey at St. Albans Bay, indicated that recreational use could increase by 150 percent if water quality improved (54). Recreational fishing was estimated to have the potential to increase by 1,500 percent in Rock Creek if water quality increased from poor to medium and by about 5 percent if it increased from medium to good (53).

Increased recreational use estimates are used to derive a range of potential recreational benefits from improved water quality for the other 16 projects. This procedure results in fairly realistic ranges of offsite benefits. The relationship between water quality improvement and increased water use is unknown, and the relationships are likely to vary for different project areas. The total value of recreation at each project is multiplied by 0.12 and 1.5 to estimate a range of potential improvement benefits for recreation. This range of benefits represents the lowest potential increase in recreational use resulting from RCWP (Iowa) and the second highest increase (Vermont). The 1,500-percent increase in Idaho was not used as an upper estimate for other projects because improving water quality from poor to medium as defined in the Idaho survey may not be very representative for any of the other projects. Although the range used to estimate improvement benefits for recreation may not be accurate for all the projects, it does show the potential impact that improved water quality can have on recreational use and is based on surveys of RCWP projects or actual changes that have occurred since RCWP began.

The potential improvement benefits from reducing water treatment costs are estimated to be equal to the costs of treating pollutants that are to be reduced by RCWP. For example, in the Snake Creek, UT, project, approximately $4,000 is spent each year to reduce taste and odor problems caused by algae growth (5, 23, 37, 50). The project goal is to reduce nutrients that contribute to algae growth. The potential water supply benefits from reducing nutrients in Snake Creek are estimated to be $4,000 per year.

Water treatment benefits are also estimated for the Taylor Creek, FL, project and the Nansemond-Chuckatuck, VA, project. The annual reports for the Kansas and Maryland projects indicate water treatment benefits are expected at these projects from RCWP. However, there is no indication that these two projects will significantly affect water treatment levels. These improvement benefits are likely to be overestimated because some base level of water treatment will probably be continued even though agricultural nonpoint source pollution is reduced. However, the water treatment estimates do serve as a maximum value for water treatment benefits and can be compared with benefits from improving other use impairments.

We also estimated water supply benefits for the Lower Manitowoc, WI, project, where heavy rainfall occasionally causes increased bacteria levels in water drawn for domestic water supplies. As a result, rain-collector wells must be maintained as a secondary water supply. The maximum water supply benefits for this RCWP project are estimated to equal the cost of maintaining these wells, about $20,000 per year (59).

Groundwater sampling at the Minnesota, Nebraska, Pennsylvania, and South Dakota projects indicated some areas within each project with nitrate levels above Federal standards (10mg/ml). Potential improvement benefits from reducing groundwater nitrate levels are estimated to equal the cost of providing alternative water supplies to those in the project area that may be affected by high nitrate levels. We used the average retail price of bottled water (4) as the cost of alternative water supplies in this analysis. Since nitrate pollution in the range occurring in these RCWP projects is likely to affect only infants and pregnant women, we assumed bottled water to be a suitable replacement for contaminated groundwater supplies. The percentage of sampled wells with nitrate levels exceeding Federal standards is multiplied by the project area's population to estimate the population affected by high nitrate levels. We assumed the percentage of wells above Federal standards is a good indicator of the population at risk from contaminated groundwater supplies.

The cost of providing bottled water to infants and pregnant women in households with contaminated wells is only a partial measure of the potential benefits from reducing nitrate pollution. There are inconveniences associated with bottled water use, such as transport and storage of bottles, which are not included in the cost of providing bottled water. In addition, benefits from reducing nitrates could be much higher than estimated if health problems associated with high nitrate levels are avoided. Conversely, benefits could be lower than estimated if no adverse health impacts occur from consuming groundwater with high nitrate levels.

The benefits from reducing the rate of lost water storage due to sedimentation are estimated by multiplying the reduction in sedimentation rates that have occurred or that are projected to occur as a result of RCWP, by the average cost of dredging sediment. The reduction in sedimentation rates were obtained from project reports (45, 31), the U.S. Army Corps of Engineers (55, 56), and regional estimates of lake sedimentation (8). Dredging costs were obtained from SCS personnel, the U.S. Army Corps of Engineers (55, 56), and a Conservation Foundation report (6).

Improvement benefits were not estimated for commercial fishing due to the lack of data available linking estimated likely improvement in production from improved water quality. Fishing data provided by the Florida Game and Fresh Water Fish Commission (15) indicated the catch rate in Lake Okeechobee, FL, over the last 10 years has been more a function of lake depth rather than water quality. In addition, the Massachusetts Division of Marine Fisheries (20, 25) indicated shellfish production is not immediately affected by closures of shellfish beds to commercial production because fishing intensity can be increased over the short term in the beds that remain open.

The extent to which potential water quality improvement benefits materialize depends upon the extent to which RCWP improves water quality in each project. The best assessment of this has been done by North Carolina State University's National Water Quality Evaluation Project (NCSU-NWQEP), and is summarized in table 3. The water quality improvement to date category shown in table 3 is an assessment of measurable water quality improvement at the impaired water resource that had occurred as of April 1986. The realistic water quality goals category is an assessment of the potential for each project to attain water quality goals if 75 percent of the critical area is treated. The realistic water quality goals category can be compared with the percentage of acres in RCWP under signed contracts to participate in the program (percentage of critical area under contract), to determine if the water quality goals appear likely to be reached. The likely water quality improvement category is an assessment of possible improvement considering both the nature of the hydrologic system and the effectiveness of the land treatment activity. This category indicates water quality improvement at the project level that is likely to occur as a result of the RCWP effort. Contracting rates, the current level of BMP implementation, and the types of practices contracted and installed are used to determine the possibility of water quality improvements taking place. We considered the contribution of agricultural activities to the pollution problem and the pollution reductions necessary to decrease the water use impairments.

Table 4 shows that the potential offsite improvement benefits are high, over $500,000 per year, for the Florida, Iowa, Oregon, South Dakota, Vermont, and Virginia projects, with upper annual estimates ranging from $530,000 to $6.6 million. In each of these six projects, the level of water use is high and there are documented water quality problems and impaired uses. However, in only three of these six projects, Vermont, Florida, and Oregon, will high offsite benefits from RCWP likely be realized. In these three projects, water quality improvement appears to be possible and water use could be restored. Likely benefits are much smaller than potential benefits for the Florida project because past recreational fishing does not appear to have been greatly affected by water quality changes. Any past changes in fishing use have been the result of changes in lake depth due to varying precipitation levels.

Likely benefits are relatively small in the Virginia project because past recreational fishing impairments appear to have been minor. In the Iowa project, the actual increase in recreational use since RCWP began has been relatively small despite a possible improvement in water quality (1, 45). In the South Dakota project, water quality does not appear likely to improve sufficiently to expand water use.

Potential offsite improvement benefits are moderate, over $100,000 per year but less than $400,000, for seven projects, Alabama, Delaware, Louisiana, Minnesota, Nebraska, Pennsylvania, and Tennessee/Kentucky, with upper annual estimates ranging from $105,000 to $350,000. However, moderate benefits are likely to be achieved only in the Alabama and Delaware projects, which have high levels of critical area under contract.

Likely benefits are low in the Louisiana project because of inappropriate BMP's. Likely benefits in Tennessee/Kentucky are low because of the relatively low rate of implementation and several interdependent projects in the area. Likely benefits in the Pennsylvania project are near zero due to a low level of participation. Likely offsite benefits in the Minnesota project

Table 3--Factors considered in determining the likelihood of offsite benefits from the RCWP projects

Project	Pollutant from agricultural land before RCWP	Critical area under contract	Water quality improvement to date 1/	Realistic water quality goals 1/	Water quality improvement likely 1/
	---Percent---				
Alabama	75	80	yes	yes	yes
Delaware	2/50+	87	yes	yes	yes
Florida	27	78	yes	yes	yes
Idaho	3/95+	69	yes	yes	yes
Illinois	94	69	no	no	no
Iowa	100	82	no	yes	yes
Kansas	3/95+	28	no	-	-
Louisiana	3/95+	60	no	no	yes
Maryland	2/50+	96	no	no	yes
Massachusetts	50	22	no	yes	no
Michigan	2/50+	45	no	no	yes
Minnesota	90	58	no	no	yes
Nebraska	2/50+	62	no	yes	yes
Oregon	60-80	77	yes	yes	yes
Pennsylvania	3/95+	10	no	no	no
South Dakota	3/95+	66	no	yes	no
Tennessee/ Kentucky	3/95+	53	no	no	4/
Utah	15	93	yes	yes	yes
Vermont	25	76	no	yes	yes
Virginia	3/88	69	no	yes	yes
Wisconsin	60	64	no	yes	yes

1/ From NCSU-NWQEP RCWP Cross-Project Evaluation, April 1986.
2/ Municipal waste treatment contributes a significant but unknown percentage of pollutants.
3/ Other minor sources of pollution are possible.
4/ Uncertain because of non-RCWP projects existing within the same region, all affecting water quality.

Table 4--Estimated RCWP water quality improvement benefits

Project	Type of benefit	Value of benefits: Maximum potential	Value of benefits: Likely	Discussion (sources of information used to estimate benefits)
		---$1,000/year---		
Alabama	Recreation	195	65-195	No lake closures since 1980 (8, 30, 35, 39)
	Water storage	5	0-5	
Delaware	Recreation	250	15-180	High bacteria and nutrients have impaired swimming and boating. Improvement is likely (11, 30, 39)
Florida	Recreation	5,530	330-1,840	High level of use results in high potential benefits (14, 15, 17, 22, 39, 51, 58)
	Water treatment	80	0-80	
Idaho	Recreation	65	10-65	Some sediment reduction, affecting recreation and irrigation (52, 39)
	Water conveyance	15	0-15	
Illinois	Water treatment	30	0	Limited improvement (26, 39)
	Recreation	2	0	
Iowa	Water storage	45	0	Reduced sedimentation of lake, unchanged algae growth (1, 21, 30, 33, 39, 45)
	Recreation	1,445	30-130	
Kansas	Recreation	20	0	No documented water quality improvement (13, 16, 30, 39)
	Water treatment	0	0	
Louisiana	Recreation	120	0-40	Possible improvement in water quality (3, 28, 30, 34, 39)
Maryland	Recreation	1/	0	Possible downstream benefits (7, 39, 49)
	Water treatment	0	0	
Massachusetts	Recreation	2/	0	Improvement in water quality unlikely (10, 20, 25, 39, 47)
Michigan	Recreation	1/	0	Possible downstream benefits(39, 48)

See footnotes at end of table

Continued--

Table 4--Estimated RCWP water quality improvement benefits--Continued

Project	Type of benefit	Value of benefits: Maximum potential	Value of benefits: Likely	Discussion (sources of information used to estimate benefits)
		---$1,000/year---		
Minnesota	Recreation	195	0-130	Small recreational impairment, possibility of high groundwater improvement benefits (4, 18, 30, 36, 39)
	Water supplies	135	0	
Nebraska	Recreation	50	5-50	Possible improvement (4, 29, 30, 32, 39)
	Water supplies	55	0-50	
Oregon	Recreation	1,010	40-530	Commercial fishing benefits likely from preserving use (2, 19, 24, 27, 30, 39, 57)
Pennsylvania	Recreation	1/	0	Downstream benefits possible (4, 39, 52)
	Water supplies	350	0	
South Dakota	Recreation	5,900	0	Improvement unlikely, but benefits probable from maintaining use (39, 41, 44)
	Water supplies	0	0	
Tennessee/ Kentucky	Recreation	265	0-30	Difficult to separate RCWP impacts from other projects (39, 42)
	Water storage	2	0-2	
Utah	Water treatment	4	0-4	Small impact on larger water resources (5, 23, 37, 39, 50)
	Recreation	1/	0	
Vermont	Recreation	570	0-570	Water quality improvement likely (39, 54)
	Water treatment	5	0-5	
	Property value	3/	3/	
Virginia	Recreation	400	0	Extent of use impairments and improvement unsure (9, 30, 39)
	Water supplies	130	0-130	
Wisconsin	Water treatment	20	0-20	Downstream benefits possible (31, 39, 43, 55, 56, 59)
	Dredging	23	0-23	
	Recreation	1/	01/	

1/ Additional benefits outside the project area are possible if the project becomes part of a larger regional water quality improvement program.
2/ Small recreational shellfishing benefits possible, but not evaluated.
3/ Increased property values from improved water quality results in one-time benefits of $300,000 to $1.5 million, rather than annual benefits.

are low due to the small number of contracted acres, the minor impact of the project on recreation, and the length of time that may be needed to show groundwater quality improvements. Potential and likely improvement benefits appear low in the Idaho, Illinois, Kansas, Maryland, Massachusetts, Michigan, Utah, and Wisconsin projects. In the Kansas, Maryland, Michigan, and Utah projects, the benefits are negligible because the impairment is either very small or there are very few users affected. A relatively small number of water users are affected in the Idaho project area. Benefits in the Illinois and Wisconsin projects are low because the water pollution impairment appears to be fairly small. In the Massachusetts project, the number of acres under contract is small, leading to likely benefits near zero.

The RCWP projects liable to have very low benefits have either no documented impairment, a small number of users, or poor BMP implementation and probably no future water quality improvement. The projects that are liable to have high or moderate benefits all have very specific pollution problems and impaired water uses. In Florida, nutrients from animal waste are adversely affecting recreation and water treatment. In Oregon, bacteria from animal waste is causing a decline in commercial and recreational shellfishing. In Vermont, excessive nutrients are increasing algae growth, which interferes with recreation and reduces property values. The annual project reports for several of the low and moderate benefit projects identify many impaired uses and pollution problems, but no specific pollution impacts that affect a large number of users.

Factors Associated With Offsite Benefits

The sum of the likely water quality preservation and improvement benefits for each project indicates the overall level of likely gross benefits. Four projects, Florida, Oregon, Vermont, and South Dakota, appear the most liable to have high benefits exceeding $300,000 annually (table 5). Another five projects, Alabama, Iowa, Delaware, Virginia, and Minnesota, may have moderate benefits of $100,000 to $300,000 each. The other 12 projects will likely have low benefits, although some may achieve greater benefits if they become part of regional programs that achieve water quality improvements downstream.

Recreation Benefits Predominate

Preserved or enhanced recreation will be the likely benefit of greatest value in all four of the high-benefit projects and three of five of the moderate benefit projects (table 5). A lack of recreation benefits is the principal reason that 12 RCWP projects were classified as having low or uncertain total economic benefits.

Water supply benefits and water treatment benefits tend to be low in most projects because groundwater quality may not respond rapidly to land treatment (38, 46) and because surface water treatment costs change very little even when nutrient or bacteria levels are reduced, since the level of water treatment is frequently at minimum standards (17, 22, 23, 37, 50). The time lag between land treatment and groundwater quality improvement affects benefits because the benefits are discounted to the present value. Future benefits are valued less than present benefits when they are discounted.

Type of Water Resource is Critical

The key factor distinguishing all four RCWP projects likely to have high offsite benefits, and three of five projects likely to have moderate benefits, is preserved or enhanced recreational use of a nearby lake, bay, or estuary (table 5). Only three projects involving impaired recreation on a nearby lake have low likely benefits, and these are because of implementation problems (Louisiana and Tennessee/Kentucky) or special limitations on recreational water use (Illinois).

Reasons for high likely benefits when a lake or estuary is next to the project area include a large variety of recreational uses, a large number of users, and high likelihood of effective BMP implementation in improving water quality compared with rivers and streams. Also on many of the lakes or

Table 5--RCWP projects grouped by type of impaired water resource and level of likely offsite benefits1/

Impaired water resource	Likely offsite benefits of RCWP: High (over $300,000/yr.)	Moderate ($100,000-$300,000/yr.)	Low (under $100,000/ yr.) or uncertain
Lake or estuary within project area	FL (Rec, CF) OR (Rec, CF) VT (Rec)	AL (Rec, WS) DE (Rec) IA (Rec) VA (WS, CF, Rec)2/	IL (WT, Rec) LA (Rec) TN/KY (Rec, WS)
Lakes and groundwater within project area	SD (Rec, WS)	--	--
Groundwater, local stream, and downstream resources	--	MN (WS)2/	NE (Rec, WS)2/ PA (WS, Rec)2/
Local stream and downstream resources	--	--	ID (Rec) KS (Rec, WT) MD (Rec, WT)2/ MA (CF, Rec) MI (Rec)2/ UT (WT, Rec)2/ WI (WT, Rec)2/

-- = Not applicable.

1/ Codes in parentheses refer to the principal type of water use, in order of contribution to likely benefits as follows: Rec = recreation, CF = commercial fishing, WS = water supply, and WT = water treatment.

2/ Additional downstream benefits are possible if the project becomes part of a larger regional program that improves water quality in major water resources.

estuaries, commercial fishing or water supplies are liable to be preserved or improved by the project (table 5).

Two projects, one with high (South Dakota) and one with moderate likely offsite benefits (Minnesota), involved impaired groundwater resources. Improved groundwater quality could contribute to benefit levels in the South Dakota project, and would be the major source of benefits in the Minnesota project.

All but one of the 10 projects involving impaired local streams and downstream resources had low or uncertain likely benefits. The reason for this is that streams generally have fewer recreational users than lakes or estuaries. Although many of these streams contributed to bacteria, nutrients, or sediment downstream in lakes or estuaries, the RCWP project by itself is insufficient to generate measurable water quality improvements in and increased water use of these downstream resources. If such projects become part of larger regional programs that successfully improve water quality in downstream resources, additional benefits could be attributed to the projects.

Type of Pollutant May Play A Role

The RCWP projects with higher likely offsite benefits are predominantly those with probable reductions in nutrients or bacteria entering the lakes or estuaries within or adjacent to the project area (table 6). Reductions in such pollutants, where they are limiting factors, can more quickly stimulate recreational use on close-by and heavily used resources than will reductions in sediment. However, the three projects treating primarily sedimentation problems and which had low likely offsite benefits, also had implementation problems (Louisiana and Tennessee/Kentucky) or special limitations on recreational water use (Illinois). Thus, the role of the type of pollutant being treated on the level of benefits is at best cloudy.

Net Benefits of the RCWP Projects

A project has positive net economic benefits if the gross offsite benefits exceed the costs of generating those benefits. Costs are as important as benefits in determining economic justification. Based on the comparison of projected 50-year discounted Government costs compared with discounted offsite economic benefits, the 21 RCWP projects are classified (high, moderate, low or uncertain) as to the likelihood of achieving net economic benefits (table 7). The 50-year time period seems long enough to give benefits time to accumulate, since benefit generation usually peaks after costs have occurred. The costs are for the BMP's contracted through 1990 as of the end of 1985, which includes most of the likely BMP's. Onsite costs and benefits paid or received by farmers are not included, which leaves the question simply whether the water quality benefits will exceed the expenditure of public funds made to achieve those benefits.

Most of the RCWP projects (South Dakota is the exception) invested heavily in expensive structural BMP's (table 8). However, only 7 of the 21 projects appear likely to generate offsite economic benefits sufficiently high to match or offset government project costs (table 7). Roughly another third, classified as uncertain, could possibly achieve positive net benefits if the projects become part of larger regional efforts that successfully improve major water resources and generate additional downstream benefits. In addition, possibly two projects, those in Alabama and Idaho, could have reduced costs sufficiently to achieve positive net benefits by implementing lower cost BMP's. The remaining projects appear unlikely to achieve offsite benefits exceeding BMP costs, mainly because of limited water quality impact or value of that impact.

The above limited-benefit evaluation attempts to assess the major economic benefits of the various RCWP projects. No attempt was made to value the difficult-to-measure ecological and non-user benefits. The latter includes option value (what individuals are willing to pay in order to maintain the option of using the resource in the future) and existence value (what individuals are willing to pay in order to ensure the existence of a resource regardless of their personal use). There may also have been social, equity, political, or other benefits gained from the projects. For RCWP, the educational and experience value for future programs has been outstanding.

Conclusions And Implications

RCWP has been successful as an experimental program. The different water resources, pollution problems, water use impairments, land treatment practices, and implementation experiences at each project provide guidance for targeting and implementing future programs for nonpoint source water pollution control. The RCWP illustrates that vastly different gross and net

Table 6--RCWP projects treating nearby lakes or estuaries, by type of pollutant and level of likely offsite benefits

Type of pollutant	Likely offsite benefits of RCWP: High (over $300,000/yr.)	Moderate ($100,000-300,000/yr.)	Low (under $100,000/yr.) or uncertain
		Project	
Sediment	--	IA	IL, LA
Sediment and nutrients	--	--	TN/KY
Sediment and bacteria	--	AL	--
Nutrients	FL, SD, VT	--	--
Nutrients and bacteria	--	DE, VA	--
Bacteria	OR	--	--

-- = Not applicable.

Table 7--Projected economic benefits, costs, and economic efficiency of the 21 RCWP projects

Project	Projected annual offsite benefits 1/	Projected discounted 50-year offsite benefits 2/	Projected government costs 3/	Likelihood of net economic benefits
	$1,000/yr	--------- $1,000	----------	
Alabama	65-200	700-2,100	2,400 4/	Low 4/
Delaware	15-180	150-1,900	1,140	High
Florida	330-1,920	3,400-20,300	1,840	High
Idaho	10-80	100-850	2,960 4/	Low 4/
Illinois	0	0	1,950	Low
Iowa	30-130	350-1,400	680	High
Kansas	0	0	1,330	Low
Louisiana	0-40	0-400	5,030	Low
Maryland	0	0 5/	6,050	Uncertain 5/
Massachusetts	0	0	810	Low
Michigan	0	0 5/	2,760	Uncertain 5/
Minnesota	0-130	0-1,400 5/	1,310	Moderate 5/
Nebraska	5-100	50-1,100 5/	1,770	Uncertain 5/
Oregon	40-580	400-6,100	5,000	High
Pennsylvania	0	0 5/	1,550	Uncertain 5/
South Dakota	0-710	0-7,450	1,700	High
Tennessee/ Kentucky	0-32	0-370	3,780	Low
Utah	0-4	0-40	290	Uncertain
Vermont	0-575	0-6,000	2,170 6/	High
Virginia	0-160	0-300 5/	1,830	Uncertain 5/
Wisconsin	0-43	0-480	2,190	Uncertain

1/ Sum of likely maintenance and improvement benefits.

2/ Discounted at 7.875 percentage rate. Assumes benefits increase in equal increments until full benefits begin in 1990.

3/ Includes government costs related to implementation of BMP's. Excludes private costs and benefits.

4/ Greater reliance on lower cost management practices from the start of the project could have reduced costs and improved economic efficiency.

5/ Additional downstream benefits could be generated if the project becomes part of a larger regional program that significantly improves water quality in major downstream resources.

6/ Includes the value of wastewater treatment costs for phosphorus removal, $1.7 million in 1986 dollars.

Table 8--Percentage of total expenditures for major best management practices by RWCP project 1/

Project	Permanent vegetative cover	Animal waste management systems	Terrace systems	Grazing land protection systems	Waterway systems	Conservation tillage systems	Stream protection systems	Sediment retention structures	Improved irrigation and water management
				Percent of total					
Alabama	10	10	25	10	--	10	--	10	--
Delaware	--	--	--	--	--	--	--	--	--
Florida	--	17	--	--	--	--	72	--	--
Idaho	--	--	--	--	--	--	--	15	80
Illinois	--	--	--	--	54	--	32	--	--
Iowa	--	--	66	--	10	--	--	10	--
Kansas	--	70	--	--	--	--	--	--	--
Louisiana	--	--	--	--	--	39	--	31	--
Maryland	--	45	--	--	35	--	--	--	--
Massachusetts	--	95	--	--	--	--	--	--	--
Michigan	--	--	--	--	--	--	--	--	--
Minnesota	27	36	--	--	--	10	--	--	--
Nebraska	--	--	--	20	--	--	13	48	--
Oregon	--	100	--	--	--	--	--	--	--
Pennsylvania	--	22	--	--	34	--	--	--	--
South Dakota	--	--	--	85	--	--	--	--	--
Tennessee/Kentucky	--	--	--	--	--	--	--	--	--
Utah	--	100	--	--	--	--	--	--	--
Vermont	--	86	--	--	--	--	--	11	--
Virginia	--	23	--	--	56	--	--	15	--
Wisconsin	--	88	--	--	--	--	--	--	--

-- = Not applicable.

1/ The estimated distributions of BMP expenditures are based on expected or actual expenditures, depending on the information available. The percentages are used only to show the relative expenditures for BMP's within the project. Only major BMP's are included; therefore, the percentages do not add up to 100 for most projects.

Source: RCWP Annual Reports, 1981-85.

economic benefits can result from agricultural nonpoint control efforts. Only one-third to two-thirds of the RCWP projects may have economic benefits exceeding costs. Future nonexperimental programs will probably face public pressures for greater economic performance and efficiency, requiring more comprehensive project assessment and planning.

The results of RCWP indicate that the following considerations (in logical sequence) should enter into assessing potential projects for future water quality improvement programs:

1. Is there a physical water quality problem (high turbidity, excessive nutrients, chemicals in toxic levels, bacteria, and biological oxygen demand)?

2. Are there existing or likely future water use impairments (reduced recreation, degraded water supply, increased water treatment, reduced water storage, and impaired commercial fishing) which have significant economic value?

3. Will agricultural BMP's be sufficiently adopted and implemented to affect water quality enough to preserve or enhance water uses?

4. Will the preservation or improvement of water quality generate enough economic benefits to users and society to equal or exceed the costs of achieving them?

5. Are there ecological, nonuser benefits, social, equity, political, or other reasons to implement the project even though prospective economic benefits may be low, or low in relation to another project?

When the RCWP projects were originally selected, considerations 1 and 3 above were emphasized. Little or no consideration was given to economic impairments, item 2 above, or economic efficiency, number 4 above, due to the lack of readily available information and practical guidelines.

Experience gained from RCWP, other water quality projects, and benefit evaluation research make it now feasible to perform pre-project economic assessments. With tight government budgets limiting funding for future programs, such assessments will help identify projects and plan BMP's that provide higher economic benefits per dollar expended.

The following types of projects appear to be most likely to generate economic benefits:

1. Projects that successfully improve water quality in nearby lakes, reservoirs, estuaries, or groundwater with high existing or potential uses for recreation or water supply.

2. Projects other than the above that are an integrated and essential part of larger regional programs successfully preserving or improving highly used major water resources downstream.

If significant value is generated by preserving or improving water quality, fairly sizable costs can be incurred. However, if the economic benefit generation will be low, then very careful selection and targeting of BMP's will be needed to achieve economic justification. For many areas in future programs, this will mean greater reliance on lower cost management practices, such as conservation tillage and nutrient management, and careful placement of filter strips.

We have based the results of this analysis on what is currently known about each project. Many of the projects have limited water quality monitoring data, incomplete BMP implementation, and undocumented improvement in water quality, adding further uncertainty to the benefits generated by RCWP. As a result, the conclusions reached from this analysis should be reviewed as more water quality data become available and the projects reach completion.

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