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STATUS REPORT ON THE CM&E PROJECTS

1985

NATIONAL WATER QUALITY EVALUATION PROJECT
North Carolina Agricultural Extension Service
Biological and Agricultural Engineering Department
North Carolina State University
Raleigh, North Carolina

In Cooperation With:

U.S. DEPARTMENT OF AGRICULTURE

U.S. ENVIRONMENTAL PROTECTION AGENCY

RURAL CLEAN WATER PROGRAM

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BY

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PREFACE

This document reports on the status of the five Rural Clean Water Program (RCWP) projects which are conducting comprehensive monitoring and evaluation (CM&E). The emphasis is on describing the present state of knowledge of the effects of agricultural Best Management Practices (BMPs) and agricultural nonpoint source (Ag NPS) control programs on water resources. The status of the CM&E projects is evaluated in the context of how they contribute to answering the important questions relating to the control of Ag NPS. Using the preliminary results from the CM&Es we have attempted to synthesize a "bottom line" answer to twenty questions which represent the knowledge needed to control Ag NPS through a land treatment program.

The report consists of a cross-project summary section which addresses major NPS control questions in the context of the CM&E projects, economic analysis of the CM&E projects, and detailed analyses of each CM&E project. We have used both our own analyses of the water quality data and those presented in project reports. We did an extensive amount of additional analysis on the Idaho project as well as moderate additional analysis on the Illinois, Pennsylvania, and Vermont projects. In all cases we have attempted to distinguish data analysis done by CM&E project personnel from our own analyses. Materials including the 1984 annual reports and personal communications with project personnel were used. In all cases we have discussed the analyses extensively with CM&E personnel.

The Economic Research Service (ERS) has made significant contributions to this document in analysis of on-site and off-site benefits/costs of the projects. The ERS component provides a more complete picture of the CM&E program than would be obtained if water quality effects were considered alone. We have integrated the ERS analysis of farm level costs into each project chapter. The second chapter of this report was contributed in total by ERS. Other contributions for ERS are incorporated in the first chapter with explicit citation.

The status and contributions of the CM&E projects will be reviewed again in 1987 and this report revised to reflect the new information. Thus, the observations and conclusions presented here are interim.

SUMMARY AND CONCLUSIONS

The experimental Rural Clean Water Program (RCWP) was initiated in 1980 by P.L. 96-108. Twenty-one RCWP projects were designated nationwide, with five projects, located in Pennsylvania, Idaho, Illinois, South Dakota, and Vermont, designated to conduct comprehensive monitoring and evaluation (CM&E) of their water quality and economic impacts.

The experimental aspect of RCWP is intended to:

1. determine whether the existing institutional structure is adequate for obtaining the needed treatment of agricultural nonpoint sources;
2. determine the water quality effects of Best Management Practices (BMPs) at the watershed and water resource level;
3. determine whether water resources impaired by agricultural nonpoint sources can be improved by a concerted voluntary land treatment program; and
4. determine the economic impacts of treating nonpoint sources.

Tentative findings from four years of the program and prominent strengths and weaknesses of the CM&E projects are summarized below. These findings and observations will be reviewed and revised in 1987 as more information becomes available from the CM&E studies.

Major Findings from CM&E

1. Field studies in the PA project indicate that groundwater levels respond rapidly in the permeable soils of their critical area, and therefore, rapid response of groundwater quality to manure and fertilizer nutrient management is likely.
2. Water quality monitoring in the ID project has shown that significant improvements in sediment concentration of irrigation canals have been achieved through BMP implementation. Control of water quality in irrigated arid land appears to be much more rapid than in humid regions.
3. The VT project has shown that by eliminating winter manure spreading in northern climates, significant reductions of phosphorus and nitrogen loss to surface runoff are possible. However, the experiment also showed that eliminating winter manure spreading increased the amount of runoff and suspended solids from the field site.
4. Analysis of monitoring results from the ID project suggest that a 35-45 percent change in a water quality parameter is required for that change to be significant at the 95 percent

confidence level for an irrigated system. The amount of change needed can potentially be reduced by improved experimental design. The amount of change required in precipitation driven systems will depend upon the extent to which meteorological variables can be accounted for. NWQEP is presently attempting to determine the amount of change needed for statistical significance in precipitation-driven systems with and without correction for meteorological variability.

5. Projected economic benefits compared with costs in three of the five projects, ID, IL, and PA, would not justify the projects except as experimental efforts. With major redirection in BMP implementation, the ID project could become economically justified.

6. Fertilizer management (BMP 15) has been found to be the least cost and potentially most effective approach to address nutrient-related water resource impairments.

7. In those projects where recommended BMPs are consistent with the farmers preference, BMP adoption is high. Examples are water management (BMP 13) and sediment control (BMP 12) in ID, conservation tillage (BMP 9) in SD, and animal waste management (BMP 2) in VT. Those BMPs not preferred by farmers have relatively low rates of adoption. An example is fertilizer management (BMP 15) in ID, SD, VT, and PA.

8. NWQEP has found that water quality monitoring information can be used in ID and IL to refine their selection of critical areas.

9. Economic onsite benefits projected over 50 years for the CM&E projects are as follows:

   ID: Long term soil productivity enhancement ($814,000).
   IL: Negligible - Productivity benefits because of deep soils.
   PA: Fertilizer savings and productivity enhancement (projections in process).
   SD: Increase net farm income (possibly over $500,000) from enhanced yields and reduced costs of conservation tillage.
   VT: Fertilizer savings of up to $2 million.

10 Economic offsite benefits projected over 50 years for the CM&E projects are as follows:

   ID: Recreation ($617,000 mostly fishing), reduced ditch cleaning ($185,000).
   IL: Water treatment savings ($225,000), recreational fishing ($24,000).
   PA: Negligible because of low farmer participation.
   SD: Recreation and property value benefits could be relatively high (projections in process).

VT: Recreation ($3.9 million), property values ($1 million).

Major Strengths of the RCWP-CM&E Program

1. The CM&Es are directed specifically to track BMP implementation and to monitor the water quality impact before, during and after implementation.

2. The scope of the CM&E projects ties together field-scale, watershed-scale, and water resource BMP/water quality information.

3. New information will be developed on the actual "in-stream" effectiveness of agricultural Best Management Practices at the watershed level.

4. The CM&E Program will document the natural water quality variability from monitoring over a 10-year period. This result will be more precise than any previous large-scale agricultural water quality study.

5. The information on inherent water quality variability from CM&E projects can be used in the future to define how much of a change in water quality is significant, i.e., to show that an observed change in water quality is not just a random occurrence unrelated to the land treatment program.

6. The CM&E Program is providing extensive information on the economics of NPS control at the farm and public levels.

7. Strong provision was made from the very early stages of the program for independent cross-project analysis and synthesis of results.

8. The two CM&E groundwater projects, SD and PA, represent a major effort to tie land treatment to groundwater quality at the field level.

9. The CM&E projects are providing important new information on appropriate criteria and procedures for selecting critical areas for control of water quality.

10. Two CM&E projects have become the first NPS control projects to collect sufficient data to be able to select farm-level critical areas on the basis of actual in-stream water quality information.

11. Economic benefits will likely exceed costs for the Vermont and South Dakota projects, and, with major BMP redirection, could possibly do so for the Idaho project. However, the five projects were selected for their diverse problems and to determine water quality impacts of improved practices rather than expectations of net economic benefits.

12. Although serious water quality problems existed in all five projects, potential offsite economic benefits from improved water quality appear substantially higher in the Vermont and South Dakota projects than in the other three because recreation and property values will be preserved or enhanced, and more people will be affected. Consideration of potential economic benefits during project selection will contribute to maximizing benefits of future clean water programs.

Major Weaknesses of the RCWP CM&E Program

1. Only two of the five CM&E projects have yet achieved the level of farmer participation envisioned for the program. A reasonable level of participation is essential to the success of the program.

2. The water resource use impairments in several of the CM&E projects are not defined as precisely as in some of the other RCWP projects. This limits the potential for the projects to achieve "success" in terms of cost-effective treatment and reversal of their water quality impairments.

3. Neither of the two groundwater projects have succeeded in defining and addressing the protection of their groundwater resource at the project-wide level.

4. Only one of the projects appears to be doing enough comprehensive monitoring of land use activity to tie water quality changes to specific land treatment activities at the watershed level. Preliminary results from this one project show that this requires much more detailed tracking of land use activities than anticipated.

5. Not all of the CM&E projects have water resources that are amenable to reversal of impairment by treatment of only agricultural NPS within the project area.

6. No provision has yet been made to provide for inter-project analysis of the CM&E effort at the conclusion of the data collection phase. Most of the RCWP projects, including the CM&E projects are not likely to produce definitive results for ten years or more, and so it would be appropriate to plan for overall analysis of results after the water quality changes have had time to develop.

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INTRODUCTION

The experimental Rural Clean Water Program (RCWP) was established by P.L. 96-108 to provide longterm financial and technical assistance to owners and operators of agricultural lands to assist in control of nonpoint source pollution (NPS). Of the 21 RCWP projects, five projects were designated to include comprehensive USDA/EPA joint project water quality monitoring:

Idaho:	Rock Creek Project
Illinois:	Highland Silver Lake Project
Pennsylvania:	Conestoga Headwater Project
South Dakota:	Oakwood Lakes - Poinsett Project
Vermont:	St. Alban's Bay Project

The five projects, which we refer to as CM&E projects have the additional mission to monitor "...basic hydrologic and meteorologic factors, ...identify and quantify changes in water quality attributable to the installation of BMPs [best management practices]," and "wherever possible, identify and quantify changes in land use, land use patterns and farming practices that will affect the quantity, quality, or timing of nonpoint source pollutants reaching an aquatic system."(Federal Register 7 CFR Part 700.41). The CM&E projects are further expected to "detail information as to the number and location of sampling stations and the frequency of sample collection [to document these aspects successfully]," and to "identify the positive and negative impacts on landowners in the project area, and estimate the community or off-site benefits expected of the project if completed as planned." The Idaho, Illinois, and Vermont projects were initiated in late 1980; the Pennsylvania and South Dakota projected were started one year later.

The ultimate goal of the RCWP agricultural NPS control effort is to alleviate actual or potential water resource use impairments caused by agriculture. The role of CM&E, in particular, is to provide the additional information to establish cause-effect relationships. This report evaluates the CM&E projects and presents an analysis of how the CM&E projects and the CM&E Program have contributed to the state of current knowledge in the field of agricultural NPS control.

The NWQEP 1984 Annual Water Quality Report proposed nine questions which would need to be answered in order to provide the essential information to address the problem of Ag NPS effectively In this report we have broken these nine questions into 20 more specific questions. The questions are grouped into the following subject areas:

- water resource treatment feasibility
- BMP effectiveness and cost
- critical area selection
- institutional/organizational considerations
- water quality monitoring.

One result of this approach is an overview of just how much of the total NPS control puzzle has been pieced together at present, and what portion of this has come from the CM&E Program.

Complete summaries and analyses of each CM&E project are presented as separate chapters of the present report. Our emphasis is on summarizing the findings of the projects and laying out the analysis and interpretation of the water quality data. A supplement to this report has been prepared separately to present the details of the analytic and statistical methods used for our analyses and synthesis.

MAJOR QUESTIONS RELATED TO AGRICULTURAL NPS CONTROL

Table 1. summarizes the present and projected contributions of the CM&E program to 20 major questions which comprise the main body of knowledge needed to addres national NPS-related water quality problems. The questions are treated in detail below.

Water Resource Treatment Feasibility

1. What types of water resources can be most effectively restored through land treatment efforts?

Among the impaired water resources being addressed in Ag NPS control projects are streams, lakes, estuaries, groundwater aquifers, and irrigation canals. All of these except esturaries are present in the CM&E projects.

From the Idaho CM&E project as well as several other irrigation projects, it has become clear that irrigation canals show the most rapid water quality improvements in response to BMP implementation. This is because of the decreased effect of meteorological variables, greater control options over the management of the water resource, and the fact that agriculture is usually the only significant pollutant source. Because of their short hydraulic residence time, streams appear to be the next most treatable water resource, although the treatability drops in direct proportion to the size of the watershed. This is attributable to an increasing variety of sources and the increasing time lag in flushing pollutants from the system. Lakes and groundwater are proving to be the most difficult water resources to restore; lakes because of nutrient recycling and because sediment filling can only be slowed, not reversed. The difficulties with addressing groundwater impairments have been related either to the problem of defining the contributing land surface area, or to the potential conflicts between some surface and groundwater protection BMPs. The results of the PA field studies, however, indicate that their intermediate depth groundwater (30-100 ft.) can be very responsive to surface activity, and thus is amenable to BMP treatment.

Table 1.
Major Questions Addressed by RCWP CM&E

Questions	Present A	Present B	by 1990 A	by 1990 B	Comments
<u>Water Resource Treatment Feasibility</u>					
1. What types of water Resources can be most effectively reversed through land treatment?			*		*Statistically based answer will be derived using all projects.
1a. What types of Ag NPS use impairments can be most effectively restored through remedial efforts?			*		*Statistically based answer will be derived using all projects.
1b. What timeframe is required to observe water quality results from land treatment programs?		*	*		*Only projects which achieve adequate implementation will contribute.
1c. Do groundwater resources respond rapidly enough to reflect changes in land management within a ten year timeframe?	PA		PA SD		
1d. How much problem definition is needed to identify and develop a successful and cost-effective NPS control program?	*	*	*		*Statistically based answer will be derived. See ERS discussion of economic problem assessment.
[illegible]e. Are those water resources impaired by irrigation return flow more readily treatable by BMPs than those impaired by storm flow?		IL ID VT	IL ID VT		Statistical answer from all projects with high implementation.
<u>BMP Effectiveness and Cost</u>					
2. How effective are the various BMPs in reducing pollutant inputs to water resources?	PA VT		PA VT	IL	ID project does not report information to separate the effects of BMPs 12 and 13.
2a. How do external (uncontrolled) factors such as meteorological conditions affect the ability of BMPs to protect or restore impaired water resources?		VT PA IL	VT PA	IL	ID does not address meteorologic variability.
2b. What BMPs are most cost-effective in addressing groundwater impairments?	PA		PA SD		
[illegible] what extent do groundwater BMPs conflict with surface water BMPs?	PA		PA SD		

code: A = Substantial contribution to answer
B = Partial contribution to answer
Numbering of questions corresponds with text.

Table 1. continued

Questions	Present A	Present B	by 1990 A	by 1990 B	Comments
2d. What degree of sediment reduction can be achieved by BMP implementation at a watershed level?		VT ID IL	VT ID IL		PA has too little land treatment to contribute to this question. SD does not monitor at watershed level.
2e. What degree of nutrient reduction can be achieved by BMPs at a watershed level?		VT PA ID IL	ID VT PA	SD IL	
2f. What degree of bacterial reduction can be achieved through various levels of BMP implementation.				VT SD	Other RCWP projects are substantially addressing this question.
Critical Area Selection					
3. Where in a watershed should BMPs be placed to restore or protect a given water resource?		VT IL ID	VT IL ID		Not addressed by PA or SD.
3a. How much of a watershed must be treated with BMPs to restore or protect a given water resource?		ID	ID VT	IL	Not addressed by PA or SD.
3b. What criteria are appropriate for selecting critical areas for protection of groundwater from NPS?		PA	PA		
Institutional/Organizational Considerations					
4. What are the most cost-effective means of obtaining farmer participation?		*		*	*Statistical answer will be derived from all projects. See ERS discussion of c/s rates.
4a. Can a project effectively address groundwater and surface water impairments simultaneously?		PA SD	PA SD		
Water Quality Monitoring					
5a. What are the groundwater levels of pesticides that can be expected in areas with intensive agriculture?	PA	SD	PA SD		
5b. How much change in NPS pollution must occur to be detectable by a comprehensive monitoring program?		VT IL ID PA	VT IL ID	PA	This may be the most definitive and important result from the CM&Es.

code: A = Substantial contribution to answer
B = Partial contribution to answer

Numbering of questions corresponds with text.

1a. What types of Ag NPS - caused use impairments can be most effectively restored through remedial efforts?

The most common impaired or potentially impaired uses being addressed by agricultural NPS projects are domestic supply, reservoir storage, recreation, commercial fisheries and aesthetic enjoyment. The primary impaired uses which exist in the CM&E projects are domestic supply (IL, PA, SD,), recreation (ID, IL, SD, VT), aesthetic enjoyment (ID, IL, SD, VT), fishery (ID), and reservoir storage (IL). The answer to what types of use impairments are most treatable will come from a statistical analysis using all projects with identified uses impaired by agricultural NPS. At the present time it appears that swimming impairments may be the easiest to restore since often all that is needed is to reduce maximum fecal coliform concentrations below 200 mpc/100ml. In many systems this can be accomplished by treating just a few of the most critical animal production operations. Impairments of domestic water supply may be .he next most readily amenable to restoration through BMPs. This is at least partly because the impairment is often caused by just a single physical or chemical parameter, and the extent of impairment can be quantitatively defined in terms of drinking water standards. Hence, once maximum nitrate levels, for instance, fall below 10mg/l, the use impairment has, by definition, been alleviated. At the other extreme are fishery and aesthetic impairments which are highly subjective in nature. We are finding that a claim of success in treating these problems can lead to a public perception of improvement. Thus, to some extent the program may reverse perceived impairments without causing a measurable change in water quality.

1b. What time frame is required to observe water quality results from land treatment programs?

Almost by definition all RCWP projects, which achieve at least a moderate level of BMP implementation and which conduct sufficient water quality monitoring, will contribute to answering this question by the end of the program. Of the CM&E projects, present indications are that only PA will lack sufficient BMP implementation to contribute any watershed level information related to the question.

Based on the present status of the CM&Es the following statements related to the time frame of water quality results can be made:

1. Four years is sufficient to begin observing sediment reductions in irrigation canals when about half of the land area is treated with BMPs.

2. Bringing half of the manure under best management will not produce statistically significant stream phosphorus reductions in a three year time frame. (We estimate that five years will probably be required.)

3. Two and one-half years is insufficient for documenting stream/lake sediment or turbidity changes due to BMP implementation on 20 percent of a watershed critical area.

1c. Do groundwater resources respond rapidly enough to reflect changes in land management within a ten year time frame?

The PA field studies prove that moderate depth (30-100 ft) groundwater in the Conestoga Watershed is significantly recharged by major precipitation events and that almost complete recharge occurs over a one-year period. In this situation we conclude that the groundwater resource can respond quickly (probably 1-2 years) to changes in land management. The SD project's plot and field studies will provide substantial information toward this question also, but that information is not presently available.

1d. How much problem definition is needed to identify and develop a successful and cost-effective NPS control project?

Our answer to this question is based primarily on determining the correlation between how thoroughly individual projects have conducted various aspects of problem definition and their projected degree of success and efficiency in addressing their water resource impairment.

This analysis (see 1985 RCWP Cross-Project Report, NCSU) indicated that only three problem definition steps are necessary to maximize the probability of a successful (improving water resource) and relatively cost-effective project:

1. Determine the extent to which a use or projected use of the water resource is impaired, and make a rough estimate of the economic and aesthetic cost of this use impairment.

2. Estimate the relative magnitude of sources that can be treated through the program and those that are beyond the program's jurisdiction, such as point sources or background. (These estimates should be updated as more information is obtained.)

3 Determine what pollutant(s) is actively causing the impairment, and estimate how much reduction in that pollutant(s) is needed to achieve the desired effect. (Subsequently BMP implementation goals should be set to achieve this amount of reduction.)

The Economic Research Service has provided the following input on the importance of assessing the economics of the water resource impairment as it relates to the CM&E projects.

"Pre-project assessment of economic impairment and potential benefits would aid in project selection and planning since potential benefits vary considerably among areas and can't be judged from simply looking at levels of pollution. For example, the Idaho, Illinois, and Vermont projects all had highly polluted water, but ERS (Economic Research Service) estimated economic benefits to the public from controlling the pollution ranged from under $250,000 for the Illinois project and $1.6 million for the Idaho project up to nearly $5 million for the Vermont project. Considering these benefits relative to project costs, the Vermont project also has a much higher Benefit/Cost ratio than the other two. If RCWP funds had not been sufficient to fund all three projects, and if the goal of RCWP had been to maximize public benefits for the money spent, this comparative information on economic impairment and likely benefits versus costs would have been invaluable to decision makers.

The importance of tying agricultural nonpoint source pollution to water quality and determining an economic impairment can be illustrated in the case of the Illinois RCWP project. When the project was initiated, the loss of storage capacity from deposition of sediment in the Highland Silver Lake was identified as the principal impairment. Reductions in erosion in the watershed would reduce sediment delivery to Highland Silver Lake, the primary source of drinking water for the City of Highland. Substantial offsite benefits were envisioned through elimination of the need for dredging the lake or finding an alternative source of water. However, subsequent analysis of the Lake's siltation revealed that much of the sediment was not settling out on the lake bottom but rather was remaining in suspension and passing through the lake. Also the reservoir capacity was large relative to future demand. Thus, there was no significant problem in terms of lost water storage capacity in the lake and the primary benefit identified for the project had negligible economic value.

A similar situation occurred in the Rock Creek Project in Idaho. Reduced siltation of power-generation reservoirs behind dams on the Snake River was identified as a potential significant benefit from the Rock Creek project. However, subsequent evaluation revealed that reductions in erosion in the Rock Creek watershed were unlikely to significantly affect the water storage facilities 100 miles downstream. Although measurable reductions in sediment delivery to the stream and subsequently to the Snake River occur, the Snake River itself will tend to pick up replacement sediment from streambanks and the river bottom.

A key factor affecting the economic impairment, and extent of potential benefits, appears to be how many people are being affected, particularly with regards to recreational opportunities. In the Vermont project the likely recreation benefits were sizable; in the other two projects they were low. Also some projects, such as in Idaho, will generate onsite soil productivity benefits, and others will not."

1e. Are those water resources impaired by irrigation return flow more readily treatable by BMPs, than those impaired by storm flow?

Indications at the present time are that water resources impaired by irrigation return flows more readily treatable than those affected by stormflow. In the case of the CM&Es, VT and ID have similar levels of BMPs implemented. Significant pollutant reductions in canals receiving return flows have been observed in the Idaho project, while no statistically significant water quality improvements can yet be documented for VT. This may be a function of meteorologic factors causing greater variability in the water quality data, rather than a direct indication that water resources in humid areas are less treatable. Also, it should be noted that water quality improvements can not yet be documented in the actual impaired water resource (Rock Creek) in the Idaho project.

BMP Effectiveness and Cost

2. How effective are the various BMPs in reducing pollutant inputs to water resources?

The water quality effectiveness of BMP or BMP system appears to be site specific in many cases. Important factors include proximity to watercourse, surface slope, soil type, and timing of precipitation. Pieces of the overall picture are coming from plot and field studies, RCWP projects, and other NPS control projects. The specific contributions made thus for by the RCWP CM&E projects can be briefly summarized as follows:

1. Managing all aspects of manure handling properly will reduce surface water inputs of manure phosphorus by 80-90 percent from northern U.S. dairy operations (VT).

2. Eliminating the practice of winter manure spreading actually increases sediment inputs and runoff volume but decreases total phosphorus (slightly) and orthophosphate (greatly) (VT). In the case of nitrogen, results from the PA and VT projects conflict to some extent. The PA studies show that the benefits of eliminating winter manure spreading and applying manure nitrogen when the crop can use it most efficiently are negated by the fact that manure storage increases (30%) the amount of manure nitrogen available for transport. The VT studies, in contrast, show mass export increases of 148 percent and 618 percent for total Kjeldahl nitrogen and ammonia respectively as a result of winter

manure spreading. The difference in results appears to be due to the fact that winter and early spring events produce the greatest pollutant yields in VT when manure is spread during winter.

3. Terraces - Terraces were installed at the PA field sites during the past year. Thus, some definitive information on the effects of terracing on pollutant surface and subsurface transport is anticipated in the near future. On the basis of the pre-implementation water quality data, the project monitoring personnel have made some projections on the effects of terraces which can be viewed with a moderate level of confidence. It is projected that terraces will increase nitrate concentrations of water transported to both surface and groundwater because of increased contact time between manure and precipitation. Increases in surface runoff nitrogen loads will be moderated by the reduced runoff volume from the terraced field. Suspended sediment and total phosphorus losses in surface runoff should be significantly reduced.

Our analyses of the Idaho water quality data show conclusively that a reduction of drainage canal sediment concentrations has occurred as a result of BMP implementation. However, both BMP-12 (sediment retention basins) and BMP-13 (irrigation management) have been integrated in such a way that it is not possible to separate the effects of the two practices. Either practice may be affecting the majority of the improvement; all we can presently conclude is that the combined effect is a significant reduction in sediment.

The Illinois and South Dakota projects have not yet produced any new BMP-water quality ef ectiveness information. It is anticipated that the IL field studies will eventually provide information on the effectiveness of sediment and nutrient control practices on natric (fine-textured) soils. The SD project will eventually produce strong recommendations concerning the effectiveness of conservation tillage, fertilizer management, and pesticide management.

ERS has provided the following economic perspective on the effectiveness of these BMPs as they are employed in the CM&E projects:

"In the case of the Idaho RCWP project, initial emphasis was given to fairly costly structural BMPs which trapped sediment at the end of the field or improved irrigation. This emphasis resulted in very high costs for BMP implementation and maintenance. Estimated total cost of implementing the RCWP project as originally designed exceeded $10 million over a 50-year period, including both government and private costs.

Alternative BMPs were examined to determine the most cost effective way of reducing sediment delivery to Rock Creek. One such BMP was conservation tillage (including no-till), which if it could be implemented throughout the watershed, would not only reduce sediment delivery below that projected for the original set of BMPs, but it would also reduce costs. However, feasibility of conservation tillage had not been demonstrated for furrow irrigated crops prior to 1980. The preliminary budgets indicate that farmers using conservation tillage in place of conventional tillage would receive a net benefit through a reduction in total operational costs. In addition, conservation tillage would help retain soil in place on the field, rather than trapping it at the bottom, and thus produce a larger soil productivity benefit, also to the farmers' advantage.

In the case of the Conestoga Headwaters RCWP project in Pennsylvania, the critical area was redefined after the project's original conception in order to emphasize the carbonate area as opposed to the triasic soils. The delivery of pollutants from the carbonate soils was found to be much greater. Also in the Pennsylvania project, the mix of BMPs is being reconsidered because of the unique high concentration of animals per acre, the highest in the United States. In such a situation, animal waste storage, generally a good BMP for reducing the discharge of animal waste constituents to water bodies, may be detrimental to water quality. Animal waste storage conserves nutrients by preventing volatilization. Also, it may make it easier for the farmer to increase the number of animals. Thus, this BMP on some farms in the project area could result in larger amounts of higher nutrient manure being applied at a given time than would otherwise occur, and more than can be utilized by crops. These excess nutrients must go somewhere. The CREAMS model used as part of the economic evaluation indicates that the excess nitrate-nitrogen tends to move downward into the groundwater and subsequently to the Conestoga River in baseflow.

A preferable BMP might be one that involves short-term manure storage and an application mode which increases nitrogen volatilization. Other alternatives may be to remove the manure from the farm to other areas which can utilize the nutrients, or to reduce the incentives for farmers in the project area to have such high concentrations of animals on their farm."

2a. How do external (uncontrolled) factors such as meteorologic conditions affect the ability of BMPs to protect or restore impaired water resources?

This is a complex question which must consider whether and to what extent large runoff events may overwhelm BMPs and which BMPs are most effective over a wide range of meteorologic conditions. Clearly, there will be a probabilistic component to the answer. At this point the CM&E provides only very limited information related to this question. Meteorologic conditions have only a minor effect on the ID irrigation canals because flow is mechanically controlled and the project is some distance from the source of water. Therefore, the effectiveness of the BMPs within the Rock Creek (ID) irrigation system has little relationship to meteorologic conditions except in the rare instance of a major runoff event. For projects emphasizing animal waste management (VT, PA) the timing of major runoff events relative to spring manure spreading could greatly affect the year to year water quality effectiveness of BMP 2. The SD project will eventually provide information on the effectiveness of BMP-9 (conservation tillage), BMP-15 (fertilizer management) and BMP-16 (pesticide management) under a wide variety of meteorologic conditions.

2b. What BMPs are most cost-effective in addressing groundwater impairments?

Substantial information relating to this question has already been generated from the PA project. These results have come from monitoring of the field sites and from CREAMS modeling done by ERS.

Preliminary results from the field site monitoring clearly indicate that a nutrient management (both fertilizer and animal waste) program, which consists of soil testing and subsequent matching of nutrient application to crop utilization rates, may be the most effective BMP for reducing nitrogen inputs to groundwater. The preliminary economic analysis suggests that, where export of manure is required to achieve this situation, the cost may be relatively high. Exporting poultry manure is more cost-effective than exporting cow manure. The field site work also suggests that building manure storage structures which allow a more timely manure spreading will have little effect on total groundwater nitrogen inputs. This is because the increased crop usage efficiency, achievable through manure storage capabilities, is negated by the increased amount of nitrogen available from stored versus daily spread manure.

In Pennsylvania, the CREAMS model predicted that conservation tillage has no real effect but terraces have a negative effect on nitrogen contamination in groundwater.

The two PA field site experiments are set up to develop much more information related to this question over the next two to three years. The SD field sites will also provide a substantial body of information related to the cost-effectiveness of conservation tillage systems for controlling groundwater nutrient and pesticide inputs.

2c. To what extent do groundwater BMPs conflict with surface water BMPs?

Of all common agriculture related pollutants only soluble nitrogen forms and soluble pesticides will generally present a potential conflict between reducing surface water and groundwater inputs. In the case of soluble nitrogen forms the experience from PA and from other field studies indicates that all surface runoff-reducing practices increase groundwater inputs to some extent. The degree of conflict depends on: 1) the relative percentage of precipitation which becomes surface runoff, subsurface runoff, and groundwater recharge, and 2) the degree to which the runoff-reducing practice increases the time of contact between water and the nitrogen source (i.e. fertilizer or manure). Practices which are designed to match nutrient application amounts and timing to crop needs do not appear to present conflicts between ground and surface water objectives.

It is anticipated that the SD field studies will provide additional information related to thi: question provided they initiate surface runoff monitoring as proposed.

2d. What degree of sediment reduction can be achieved by BMP implementation at the watershed level?

The answer to this question will develop out of results from all RCWP projects and other projects for various climates, topography, soil types and crops. The greatest contribution from the CM&Es will come from the Illinois and Idaho projects.

Idaho has shown reductions in irrigation canal sediment levels in the subbasins with high levels of sediment control BMPs installed. Our analyses show that these reductions are in the range of approximately 40- 60 percent. Additional land treatment data are needed to tie, unequivocally, the observed reduction to BMP application.

The overall level of BMP implementation is still too low in the Illinois project to observe a change of in-stream or in-lake sediment levels. Projected levels of BMP implementation along with the extent of sediment monitoring indicate that useful information related to this question will be produced.

2e. What degree of nutrient reduction can be achieved by BMPs at a watershed level?

Considerable information on nutrient loading and concentrations reduction from land treatment has been developed by the VT and PA projects. The VT project has projected, based on the BMP implementation level, water quality data, and modeling results, that total P loadings from its most extensively implemented subbasin will be decreased by 30 percent over the project timeframe. A 57 percent decrease in dissolved P is projected. It appears that these loading reductions would be even greater except that very high phosphorus levels have built up in the soils as a result of historical over-application of manure and commercial fertilizer phosphorus. The total manure P reduction from bringing manure under best management is estimated to be 80-90 percent.

Interpretation of the PA field studies and modeling efforts have led us to conclude that practices including terracing, animal waste management, conservation tillage and manure storage will have relatively minor effects on transport of nitrogen to groundwater or to stream baseflow. Terraces and conservation tillage will produce some reduction of total phosphorus and total nitrogen transport to surface waters. Matching nitrogen applications to crop needs based on soil and manure nitrogen tests, however, is projected to have a significant impact on nitrogen losses. After an initial one year flushing period we believe that nitrogen loading reductions to both ground and surface waters will be proportional to the reduction in excess N applied to soil.

The SD project will eventually provide extensive information on the effect of conservation tillage on subsurface losses of nutrients at a field level. In addition some reduction of total P is evident in the treated subbasins in the Idaho project. The P reductions are less than the sediment reductions corroborating previous studies which show that sediment - control BMPs reduce total suspended solids to a greater extent than total P.

2f. What degree of bacterial reduction can be achieved through various levels of BMP implementation?

Several RCWP projects are already providing a substantial answer to this question. None of the CM&E projects have bacterial control as a major water quality objective, however, some information will be forthcoming from the VT project as they monitor fecal coliform concentration changes in St. Albans Bay in response to improved animal waste management and sewage treatment plant performance.

<u>Critical Area Selection and Implementation</u>

3. Where in a watershed should BMPs be placed to restore or protect a given water resource?

Partial answers to this question are currently available from analysis of results in the ID, VT, and IL projects. Specifically, each of these projects initially analyzed the scope of its water resource impairment, then identified critical areas according to their estimated impact on the receiving water. The IL project, in particular, set very specific criteria for its critical area and later refined these to include only a small portion of the watershed.

Recent results from the projects suggest a means of improving critical area identification by analysis of the monitoring results. Water quality data presented by the ID project show clearly the location of at least one untreated critical source and one subshed that will not respond with any substantial improvement to further land treatment. Similarly, data from the IL project suggest that one section of the project contributes disproportionately to the total load of sediment to the reservoir. These examples show that critical area selection can be refined as water quality data become available.

The IL, ID, and VT projects are expected to provide extensive information that can be used in developing procedures for identifying critical areas and installing effective BMPs. The PA and SD projects are not likely to contribute substantially to answering this question. PA will contribute little because it does not follow its critical area guidelines due to low farm participation. The SD project also will contribute little because it does not monitor the overall water quality effectiveness of the project.

3a. What fraction of a watershed must be treated with BMPs to restore or protect a given water resource?

The monitoring program associated with the ID project has shown a water quality improvement at the subwatershed level that appears to be associated with treatment of 36 percent of its critical area. Further documentation of the actual extent of implementation, however, is needed in order to confirm this result. The IL project has treated 10 percent to 20 percent of its critical area and has not yet observed any water quality response. In this case treatment of the entire critical area may not have sufficient effect to improve water quality significantly.

Results from ID and VT should provide a substantial basis for answering this question by the completion of the project.

3b. What criteria are appropriate for selecting critical areas for protection of groundwater from nonpoint sources?

This question has been considered extensively in the two groundwater CM&E projects, PA and SD. Both projects have developed guidelines for the selection procedure: PA considers the extent of excessive nutrient application at the surface (number of animal units on the farm), the soil permeability, and the location of the impaired groundwater (whether carbonate or noncarbonate area); SD considers proximity to regional groundwater, thickness of soil above aquifer, and drainage characteristics. At present PA has information from field monitoring which shows that 67 percent of the groundwater wells in the carbonate area exceed 10 mg/l nitrate-N, while only 27 percent of the wells in the noncarbonate area exceed this standard. These studies also show that groundwater nitrate levels respond to the application of excessive amounts of manure. The PA results provide direct confirmation that their critical areas were selected properly. By the end of the project, data from both SD and PA should provide a substantial basis for answering this question.

Institutional/Organizational Considerations

4. What are the most cost-effective means of obtaining farmer participation?

The CM&E projects will contribute some information toward answering this question, because a wide variety of Information and Education approaches including newsletters, radio bulletins, public meetings, personal contacts between project personnel and farmers, local newspaper articles, and on-farm demonstrations are used. In addition, the levels of incentives vary from project to project, and in some cases, such as SD, the incentive may be in the form of services such as scouting programs. Socioeconomic analysis, including farmer workshops such as that conducted in the SD project offer the potential for a great deal of information. A complete analysis of the different institutional/organizational considerations in CM&E and other RCWP projects should provide worthwhile lessons that can be used for guidance of future implementation programs.

ERS has provided the following input relating to how cost-sharing resources could be used more efficiently in future programs based on the experience of the CM&Es.

> "An implication of the economic evaluation of the CM&E projects is that lower cost-share rates may be feasible in some cases. For example, budgets for conservation tillage in the Idaho, Illinois, and South Dakota projects all indicate a net cost savings on the average over conventional tillage. This suggests that relatively more effort in these projects might go into information and education, and that financial assistance levels may be reducible in the second or third year after the farmer tries the improved practices.
>
> Another example is found in the Vermont project. Here the primary BMP being implemented is animal waste storage which conserves nutrients and reduces the need for purchased fertilizer. The economic evaluation indicates that the savings in fertilizer purchases over a 20-year planning horizon allow a farmer to recapture most of the costs of installing the animal waste storage structure. Thus, if farmers understand this, they may be willing to adopt manure storage structures at a lower government cost-share rate than the present 75 percent available in the project. A substantial savings to the government may be feasible with minimal reduction in the overall level of implementation of the animal waste storage BMP.

A factor which needs greater consideration in establishing cost-share rates for structural BMPs, such as terraces or animal waste storage structures, is the potential income tax deduction for this type of investment. In some cases, much of the farmer's costs for structural BMPs can be deducted from income taxes, which may make feasible lower cost share rates."

4a. Can a project effectively address groundwater and surface water impairments simultaneously?

The two groundwater CM&E projects should contribute substantially to answering this question. The experience in SD, to date, indicates that severe problems can arise in multiple-objective projects unless considerable effort is devoted to determining how to combine objectives properly. The lack of clarity and definition of the surface water and groundwater objectives has slowed the development of the SD project. Information from the PA project shows that there are some BMPs, such as fertilizer management, that can reduce both surface and groundwater impairments. Heavy reliance on runoff-reducing practices can have negative effects on groundwater quality, thereby, solving surface water problems by impairing groundwater.

Water Quality Monitoring

5a. What are the groundwater levels of pesticide that can be expected in areas with intensive agriculture?

Both the SD project and the PA project routinely monitor pesticide concentrations in their groundwater samples. South Dakota assays for a wide range of herbicides and insecticides that are used in their project area, but too few data are available at present to answer this question. Herbicide concentrations in the PA monitoring wells show significant increases following field application periods in the spring. The concentrations observed in PA were consistently less than 1 ppb, which does not constitute a water use impairment.

5b. How much change in nonpoint source pollution must occur to be detectable by a comprehensive monitoring program?

The monitoring data from the ID, PA, VT, and IL projects are sufficiently detailed to develop good estimates of the background variability in water quality in each of these projects. This information can be used to assess future projects in similar areas to evaluate *a priori* whether a monitoring effort is feasible or not. The data to estimate the natural variability of water quality, and the minimum detectable water quality change may be two of the most valuable outcomes from the CM&E program.

RELATIVE CONTRIBUTION OF RCWP CM&Es TO AG NPS KNOWLEDGE

The preceding section provides an overview of how much the CM&E projects have and will contribute to the knowledge needed to effectively address Ag NPS pollution problems in coming years. It also summarizes present CM&E knowledge contributions as they relate this "big picture". It should be noted, however, that there are numerous other sources from which this essential information is being generated. These include, but are not limited to: other RCWP projects, on-going ACP projects, the completed but not fully analyzed MIP projects, the EPA 108 program, the PL 566 program, recently initiated state-level NPS control programs, and a large number of plot and field level research experiments.

We have identified over 70 watershed level Ag NPS projects nationwide and have located published results of several hundred plot and field studies related to Ag NPS. A full analysis of the contributions of these various efforts to answering the 20 major Ag NPS questions above is planned for future reports. However, at this point we can summarize the CM&E contribution relative to other Ag NPS information sources.

Figures 1 through 5 illustrate the projected relative contribution of the RCWP CM&Es, RCWP general projects, other watershed level projects and plot/field studies to information base needed to protect and restore water resources impaired by agricultural NPS effectively. We have divided this Ag NPS knowledge into the broad categories of :

1. water resource treatment feasibility,
2. BMP effectiveness and cost,
3. critical area selection,
4. institutional/organization considerations, and
5. water quality monitoring.

The percentage assigned to each information source is based on our knowledge of how many on-going projects address each question. The percentage for CM&E is based on whether the CM&E projects will contribute highly quality information or more information relative to other projects on a given question.

Figure 1 displays the relative contribution of information on water resource treatment feasibility covered in Questions 1, 1A, 1B, 1C, 1D, and 1E. As noted previously the answers to some of these questions are developed from statistical analysis of all projects which have a documented water quality problem caused by agricultural NPS and which have a high level of BMP implementation. On this basis we conclude that the CM&E projects will contribute to this subject area in proportion to the number of projects which meet these criteria. By 1990 we project that an adequate knowledge of the treatability of water resources affected by Ag NPS will have been developed with the RCWP programs being the primary contributor.

Figure 2 shows the relative contributions to the overall area of BMP effectiveness and cost as encompassed by Questions 2, 2A, 2B, 2C, 2D, 2E, and 2F. At present the majority of our knowledge on BMP effectiveness comes from plot and field studies. However, as shown in Figure 2, we believe that the information to be gained from these studies is approaching its upper limit. This is because our major remaining need in this area is to determine actual "in-stream" effects of BMPs at a watershed or water resource level. This information can only come from NPS control projects with a high level of land treatment, and a water quality monitoring system capable of quantifying water resource response.

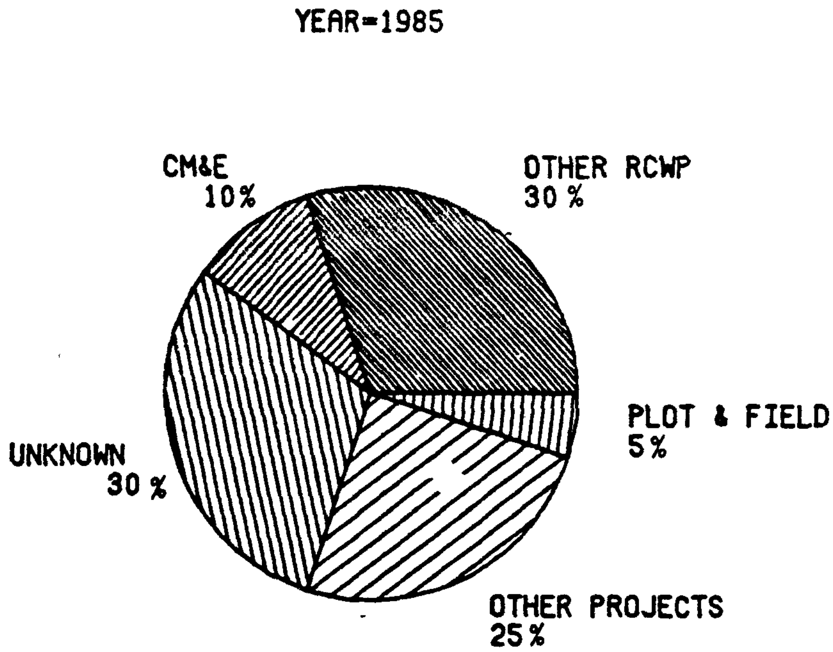
A largely uncharted area of NPS control is the process of identifying critical areas within watersheds for maximizing the water quality effects of BMPs. As shown in Figure 3 our present information comes almost entirely from RCWP which represents the first legitimate attempt direct BMP implementation on this basis. Plot and small field experiments provide very little insight on the subject. We project that RCWP will have made substantial inroads on correct critical area selection by the end of the program.

All watershed level by NPS control projects face the problem of obtaining farmer participation within the context of voluntary programs. Although numerous approaches have been and are being tried, no vigorous studies of relative effectiveness have been conducted. Thus, as shown in Figure 4, we have only limited knowledge of how best and most cost effectively to achieve BMP adoption by landowners. More knowledge will be gained over the next few years from practical experience and from analysis of the social, educational and economic factors which have produced success in RCWP and other programs.

As with all public financial investments, there exists a legitimate concern that the returns be measured and weighed against costs. Thus, the feasibility and sensitivity of monitoring programs to document water quality response to land treatment has become an increasingly important issue in the field of NPS control. Such documentation has proven to be extremely difficult due to the natural variability of aquatic systems affected by NPS and also because the nature of NPS water resource impairments is often subtle, chronic, and transient. As illustrated in Figure 5 determining which water resource responses can be best detected, how much response is needed, and the time frame required to document water quality benefits, may be the greatest achievement of the RCWP CM&E program. Figure 5 shows that, while other RCWP projects will also provide insight, the CM&E has and will continue to be our major source of information in this important area.

The overall perspective that emerges from Figure 1-5 is that 25-40 percent of our current information on various aspects of agricultural NPS control is presently coming from RCWP. By 1990

RCWP is projected to contribute for 40-70 percent of the available information on these various aspects.



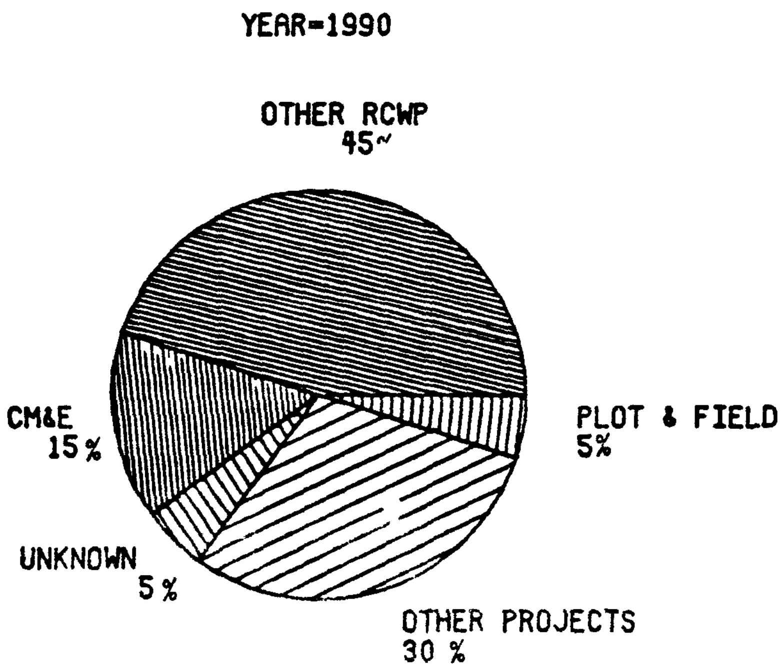
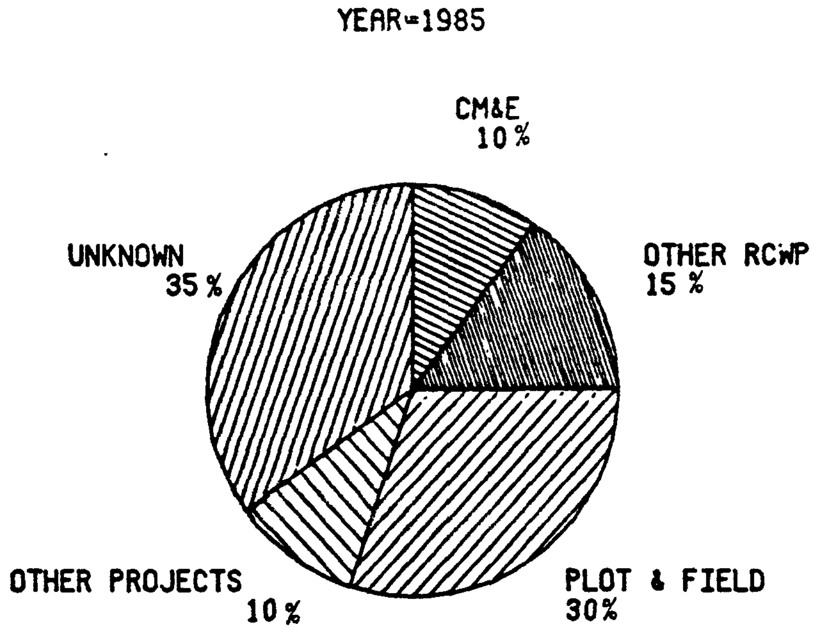


Figure 1. Relative information contributions concerning treatability of water resources impaired by NPS.



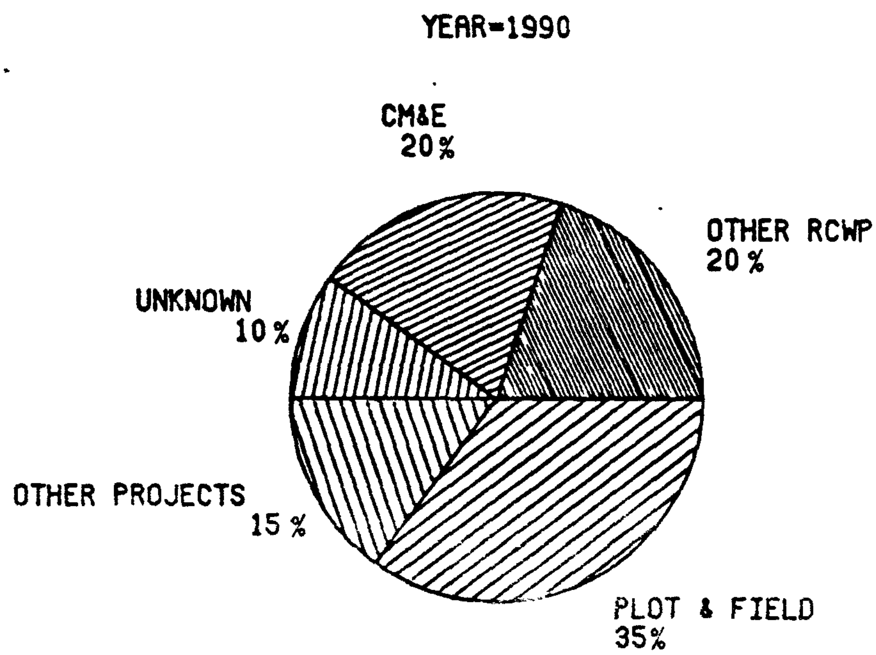


Figure 2. Relative information contributions concerning BMP effectiveness and cost.

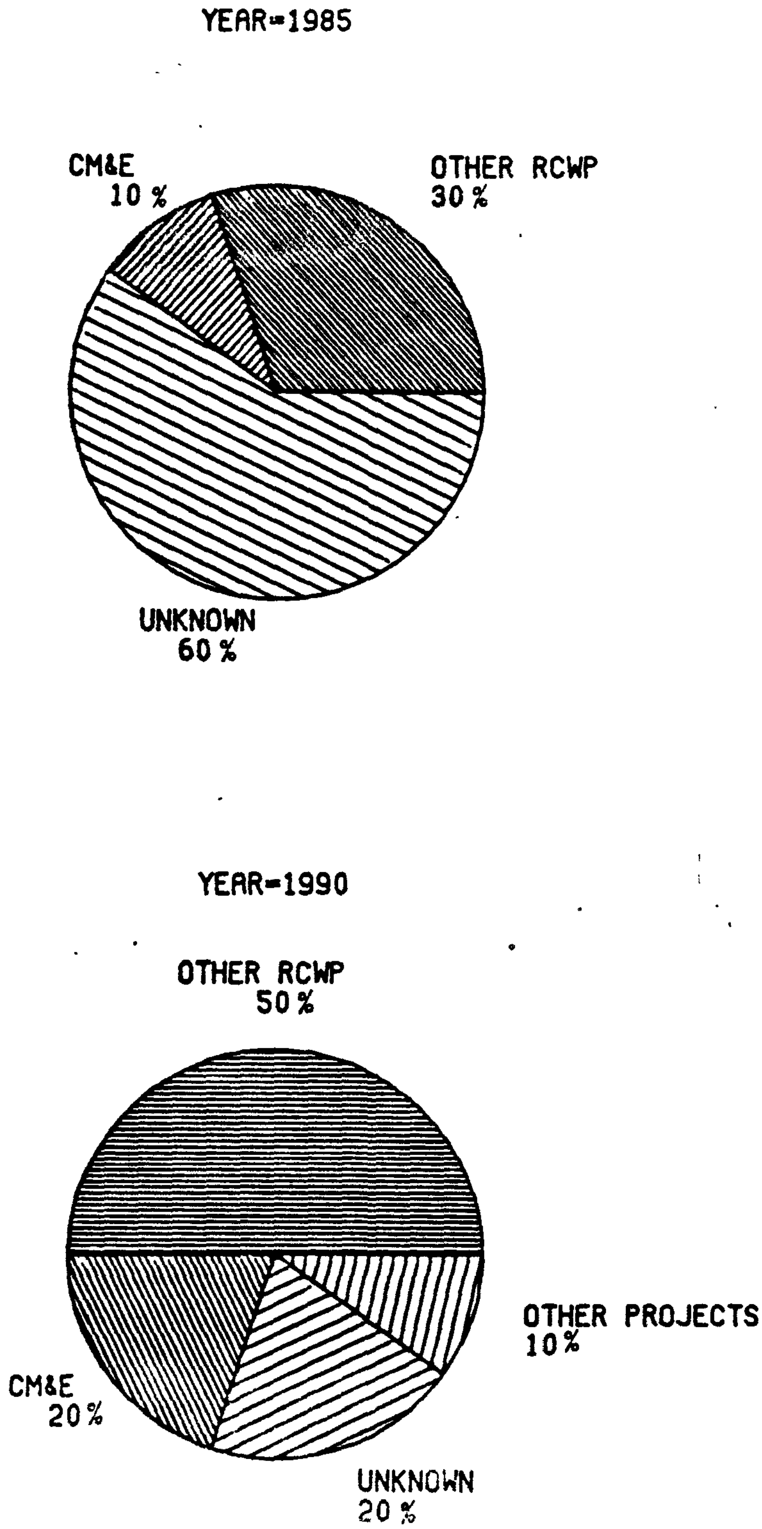
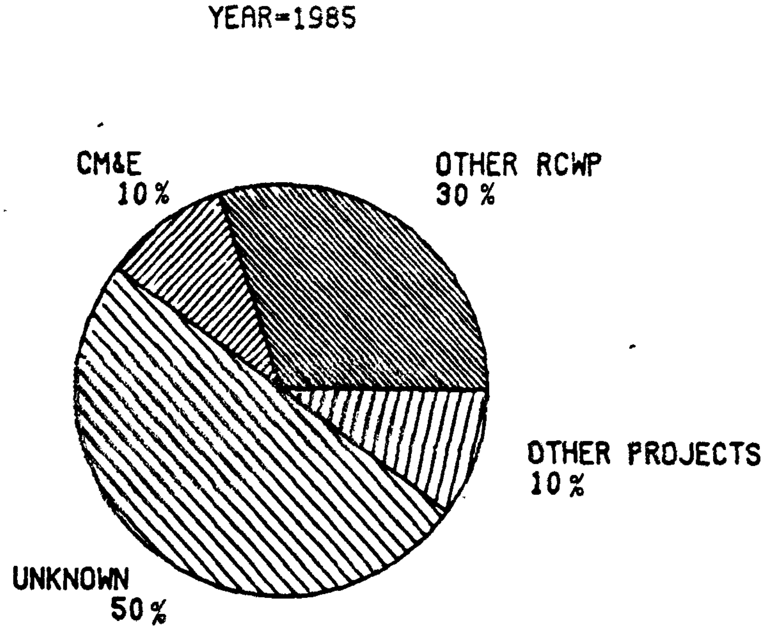


Figure 3. Relative information contributions concerning NPS critical area identification.



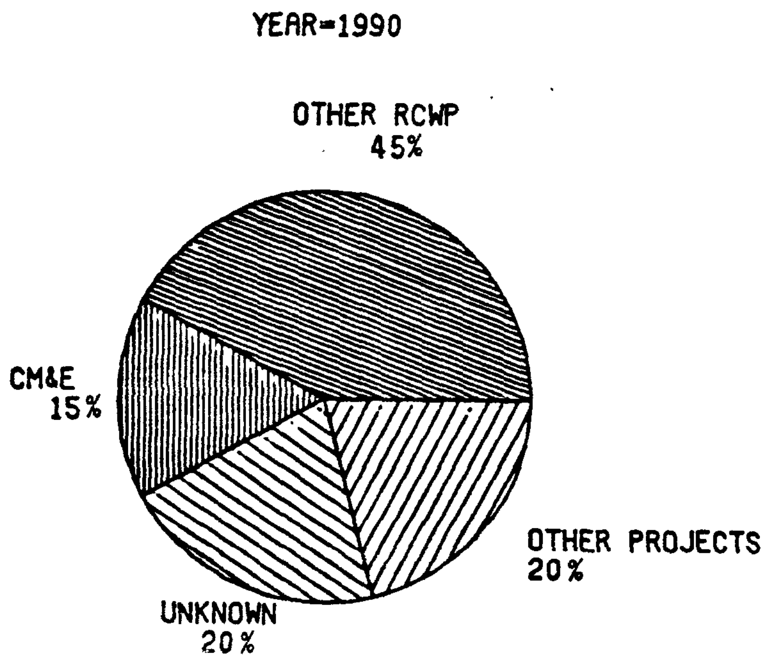


Figure 4. Relative information contributions concerning effective organizational methods for Ag NPS control projects.

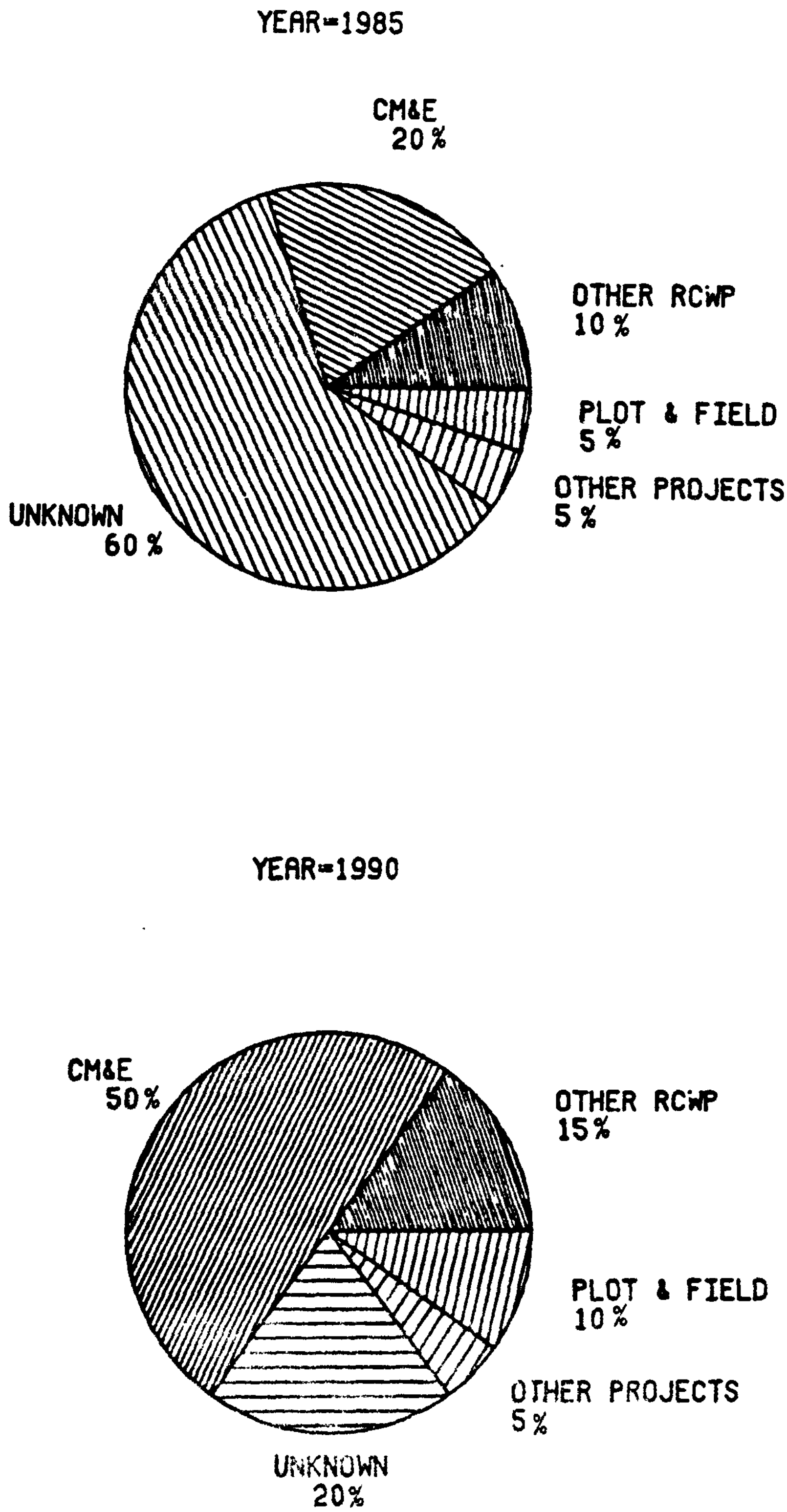


Figure 5. Relative information contributions concerning water quality monitoring of Ag NPS contrc, projects.

ECONOMIC IMPACTS OF THE CM&E PROJECTS

The evaluation of the economic impacts of the CM&E projects is being conducted by the Economic Research Service of the USDA. Initial analyses are summarized here and in subsequent chapters of this report. The details of these analyses are presented in the projects' 1984 annual progress reports. These analyses will be expanded and refined in 1987.

Total Project Costs

The aggregate effects of RCWP on project areas are discussed in this section. Practices implemented or planned to be implemented are evaluated in 1984 and in those instances where possible effects are projected to 1991 and 2031.

The cost estimates associated with the individual RCWP CM&E project are presented in Table 2. Costs are divided into direct government costs, cost share costs and private costs. Direct government costs include information and education costs and technical assistance costs. The cost estimates associated with private costs cannot be compared directly across projects. The cost estimates include the changes in the operations of the farms that are made in response to RCWP for the Highland Silver Lake, Rock Creek and St. Albans Bay projects. For the two other projects only the direct costs of BMP implementation are included, presumably farmers in these projects could make changes in their operations which would result in lower costs of implementation.

Nevertheless there is considerable variation in the cost estimates associated with the five projects (Table 2). The estimated impacts range from a high of $6.8 million for the Rock Creek Project with a 50-year planning horizon, to a low of negative $409,000 for the St. Albans Bay project when it is projected to a 50-year planning horizon. In the case of the St. Albans Bay project adoption of manure storage structures saves nutrients which can be used to replace purchased fertilizer. This savings significantly reduces the total costs to the farmer. In the long run (over 20 years) the cost savings from reduced purchases of fertilizer may exceed the costs of installing the manure storage structure. Farmers in the Conestoga Headwaters project area may also benefit from reductions in purchases of fertilizer associated with installation of manure storage structures. The benefits to farmers in the Conestoga Headwaters would be considerably lower than those for the St. Albans Bay project, because of excess amounts of nutrients available from animal manures in the Conestoga Headwaters project area.

Table 2. Aggregate onsite impacts ($1,000) for the five CM&E RCWP Projects.

Project	Year Projected	Direct Government Costs	Cost Share	Total Government Costs	Private Cost	Total Cost
Conestoga Headwaters, PA	1984	242	517	759	204	963
	1991	422	627	1,049	274	1,323
Highland Silver Lake, IL	1984	349	646	995	215[a]	1210
	1991	524	1,039	1,563	346[a]	1909
Oakwood Lakes - Poinsett, SD	1984	215	2,418	463	87[a]	550
	1991	N/A	1,431	1,431+	N/A	1,431+
Rock Creek, ID	1984	N/A	412	412+	1,030	1,442+
	2031	983	2,439	3,422	3,336	6,758
St. Albans Bay, VT	1984	198	1,174	1,372	(325)	1,047
	1991	231	1,400	1,631	(893)	738
	2031	231	1,400	1,[illegible]	(2,000)	(409)

[a]Includes only the direct costs of BMP implementation.
( ) indicates a negative value.

The estimated costs for the Rock Creek project are extremely high. The BMPs initially installed were primarily end of the field practices. While treating the ends of the fields and trapping sediment once it leaves the field are effective in limiting sediment delivery to the stream, they are costly options. These types of BMPs take land out of production, reducing income to the farmer. The Rock Creek project is being redirected to emphasize sediment control on the field through the use of conservation tillage and no till. The advantages to these BMPs may include: land is not taken out of production, these practices are less costly than conventional tillage, and the soil remains on the field thus providing a long run productivity benefit.

Offsite Benefits

The purpose of the experimental Rural Clean Water Program is to determine whether or not agricultural best management practices can be used to improve water quality for society. As part of the economic evaluation of RCWP estimates of the value of water quality improvement were developed for three of the projects (Highland Silver lake, Rock Creek, and St. Albans Bay).

When estimating offsite benefits for a program such as RCWP, several factors must be considered. First, a linkage between water quality and BMP implementation must be established. Is water quality likely to change and can the change be attributed to RCWP? Second, what uses of water are being impacted by agricultural nonpoint source pollution and how will this use change with water quality improvement? Finally, water quality benefits do not occur at the same time that BMPs are installed. A significant amount of time may elapse between BMP installation and water quality improvement. Once water quality improves the offsite benefits will continue over a long time period.

The initial examinations of offsite benefits for the RCWP projects were not limited to examination of measurable economic benefits, rather identification of all potential benefits was addressed. After review of potential benefits that could be attributed to the various projects, an attempt was made to measure benefits in order to conduct benefit/cost evaluations for each project.

Water Quality Improvements

In order to estimate the offsite benefits of RCWP projects, it is necessary to project the level of water quality improvement that can be attributed to RCWP. As a result of the Idaho RCWP project, sediment delivery to Rock Creek will be reduced. Monitoring data indicated some improvement in the quality of water in Rock Creek in 1984. The amount of reduction in sediment delivery will depend upon the type and number of BMPs installed. In Illinois the water quality impact will be a small reduction in the turbidity of Highland Silver Lake. Monitoring and modeling results indicate that deposition of sediment in the lake will be reduced slightly. Since the natric soils tend to remain in solution, the rate of sediment deposition in the lake is significantly lower than originally hypothesized. Water quality in St. Albans Bay in Vermont is projected to improve to a level that would again permit water contact recreation with installation of the RCWP BMPs and the upgrading of the wastewater treatment plant. Water quality in the bay has improved, however, the improvement can not yet be tied to control of agricultural nonpoint source pollution with available data. The water quality improvement may be delayed for up to two years until phosphorus in the bay's sediments are used up.

Benefit Estimates

Estimates of offsite benefits for three of the CM&E RCWP projects are presented in Table 3. The estimates range from a low of $249,000 for the Highland Silver Lake project to $4.9 million for the St. Albans Bay project. The major differences in the estimates relate to two factors which are present in St. Albans Bay but are not present in the other two projects. The first and most important factor is whether or not RCWP has a measurable effect on water quality. In the case of St. Albans Bay, preliminary estimates indicate that water quality is likely to improve in the bay as a result of the clean up effort. The second major feature present in St. Albans Bay that is vital to generating estimates of offsite impacts is that the water quality impairment has an impact on people. If the quality of water in St. Albans Bay is improved, recreational activity in the bay could increase substantially.

Offsite benefits were not estimated for the Conestoga Headwaters and Oakwood Lakes - Poinsett projects except in a qualitative sense. Offsite benefits for the Conestoga Headwaters project were felt to be very small due to the low level of BMP implementation in the project. If, however, agricultural nonpoint source discharges were controlled in the Conestoga Headwaters and surrounding areas, substantial benefits would result. The Conestoga River is part of the Chesapeake Bay drainage basin. The Conestoga Headwaters project area has been identified as a primary contributor of agricultural nonpoint source pollutants to Chesapeake Bay.

Potentially, water quality improvement in Oakwood lakes - Poinsett could result in substantial offsite benefits. If RCWP causes a change in water quality in the lakes, so that recreational activity changes by 4 percent, recreational benefits would exceed the costs of the project.

Recreation Benefits

Each of the three projects has a measurable benefit that can be attributed to the project. In the case of the St. Albans Bay, Vermont and Rock Creek, Idaho projects, recreation is the major benefit related to the project ($3.9 million and $617,000 respectively).

Table 3.

Offsite Benefits for Three RCWP Projects.

Benefit	Rock Creek, Idaho	Highland Silver Lake, Illinois	St. Albans Bay, Vermont
	$1,000		
Recreation	$617	$ 24	$3,886
Water Storage Facilities	$ 0	$ 0	N.A.
Property Values	N.A.	N.A.	$1,008
Water Conveyance Facilities	$185	N.A.	N.A.
Water Treatment	N.A.	$225	N.A.
Other	N.A.	N.A.	$ 27
Total	$596	$249	$4,921

N.A. = Not applicable or negligible

Different procedures were used to estimate the recreational benefits for the three RCWP projects. A comprehensive study of fishing in the northwest was used as the basis for the benefit estimates for the Rock Creek, Idaho project. Data from the water quality monitoring of the RCWP project were used to rate fishing success. The ratings were incorporated into travel cost demand functions for the northwest to estimate an average value of $7.94 for a trip to Rock Creek. With water quality improvement an additional 7,075 user days per year are projected for Rock Creek. Recreational benefits have not yet been evaluated for the Snake River.

Fishermen who currently use Highland Silver Lake were asked how much they would be willing to pay for water quality improvement. These estimates of willingness to pay were expanded to represent the total population of fishermen in the Highland Silver Lake area. Total benefits of $24,000 were estimated.

Survey data were also used to estimate recreational benefits for the St. Albans Bay project. A questionnaire was administered to a selected sample of recreationists in the northeastern portion of Lake Champlain. Data were collected on age, household income occupation, family size, home address, local address (if different), type of recreation engaged in, and views regarding recreating at St. Albans Bay if water quality were improved. Only individuals familiar with St. Albans Bay were interviewed.

The data were divided into present and former users of St. Albans Bay and separate travel cost models were estimated. The data were segmented because there is no reason to assume that those who continue to use the bay and those who have stopped using it will receive the same benefits if water quality is improved. Those who have stopped using the bay have indicated that they have a different preference function than those who continue using it. For current users, benefits are estimated at $106.52 per user, while for former users benefits are $84.00 per user. Aggregate benefits for water quality improvement are estimated to be $464,800 per year. Prevention of further deterioration of water quality in the bay is estimated to be worth $118,300 per year. Total recreation benefits are estimated to be $3.9 million with a 50 year planning horizon, a 7.875 percent discount rate and water quality improvement occurring in 1989.

Water Storage Benefits

Sedimentation of water storage facilities was identified as the primary offsite impact for the Rock Creek and Highland Silver Lake projects. Sedimentation of storage pools for several hydroelectric generating plants on the Snake River was attributed to sediment losses from the Rock Creek project area. Highland Silver Lake is the primary source of water for the City of Highland. The storage capacity of the lake was estimated to be declining rapidly due to sediment delivered from the watershed.

There are no measurable benefits that can be attributed to either of these projects for reductions in loss of water storage capacity. Reductions in sediment delivery to Rock Creek and subsequently to the Snake River were felt to have a minimal impact for two reasons. 1) The first water storage facility of any size along the Snake River is approximately 120 miles down stream from the confluence with Rock Creek. 2) Because of the hydrologic features of the Snake River, reductions in sediment delivered to the river could be partially offset by stream bank and channel erosion. The potential benefits from a much larger program along the Snake River were not evaluated.

The situation in Highland Silver Lake is also unique. The soil characteristics in the Highland Silver Lake watershed are such that once soil particles enter solution, they tend to not settle out. Investigation of the rate of sediment deposition in Highland Silver Lake revealed that sediment is being deposited in the bottom of the lake at a much lower rate than was originally hypothesized.

Property Value Benefits

Property value impacts were estimated for the St. Albans Bay project using a hedonic model. With a hedonic model, the value of a property is assumed to be a function of the characteristics related to the property, one of which is access to high quality water for recreation. Data on property characteristics and sale values were collected from town records for the study. Property values are estimated to increase by $4,300 per property if water quality in St. Albans Bay improves. Water quality improvement in

St. Albans Bay is expected to increase property values by over one-million dollars. The property value estimate for St. Albans Bay includes recreational benefits in addition to the aesthetic impacts that can be attributed to the water quality improvement. To avoid double counting of benefits owners of property adjacent to the bay were excluded from the travel cost estimate of recreation benefits described previously.

Water Conveyance

The effects of sediment reduction on water conveyance facilities were estimated for the Rock Creek Idaho and Highland Silver Lake Illinois projects. Irrigation return flow from the Rock Creek project area is discharged into a system of drains and lateral canals. The Twin Falls Canal Company which maintains this irrigation network incurs costs for sediment removal throughout its canal system. Implementation of the Rock Creek project as originally proposed would result in a reduction in sediment deposition in the irrigation canals of approximately 18,000 tons a year for a cost savings of $185,000. For the Highland Silver Lake Illinois project, benefits are estimated to be zero, since the sediment from the natric soils tends to remain in solution and is not being deposited in the lake at a very high rate.

Water Treatment

The final category of offsite effects evaluated is the impact on water treatment costs. Highland Silver Lake serves as the source for portable drinking water for the City of Highland. A reduction in sediment delivered into Highland Silver Lake would result in a reduction of water treatment costs that would be worth $225,000, which could be attributed to the project. Although the magnitudes of the benefits were not estimated, reductions in nitrate levels would generate water supply benefits for the Conestoga Headwater and Oakwood Lakes-Poinsett projects.

Onsite Benefits

In two of the three projects, RCWP is generating some onsite economic benefits from preserving soil productivity or from reductions in farmers' costs of operations which more than offset their installation costs of RCWP practices.

In Idaho, planned implementation of conservation tillage and other practices which help keep soil in place on the fields will reduce long term soil productivity loss, and generate benefits estimated at $814,000. In this case, these productivity benefits are as great as the offsite benefits.

In the Illinois project, conservation tillage is the principal BMP, but because the soils are deep and fertile, long term productivity benefits are negligible.

In the Vermont project, the installation of improved animal waste storage facilities reduces manure handling and fertilizer costs over time by more than the farmers' initial share of putting in the system. This negative cost of over $2 million can be considered an onsite private benefit. Note that it is about 40 percent as large as the public benefits.

Benefits Versus Costs

Benefit/cost ratios are a traditional measure of economic efficiency for project evaluation. A benefit/cost ratio compares the present value of the stream of benefits to the present value of the stream of costs for a project. Benefit/cost ratios can be computed for three of the five CM&E RCWP projects. The relative magnitude of the benefit/cost ratio can also be discussed for the two other projects.

How do the estimated economic benefits in the three RCWP/ CM&E projects compare with the costs of implementing the projects to generate the benefits? The answer to this question depends on which benefits are compared with which costs. First, compare total economic benefits, including both public and private, with total costs, including again both government or public and private. The Vermont project with a benefit/cost ratio of 1.8 to one, is the only one of the three in which total economic benefits exceed total costs (Table 4). In the other two projects, total economic benefits are only one-fourth or less as large as total costs.

If we are interested in just comparing public benefits with public costs, and include productivity benefits as a public benefit, the result changes slightly. The Vermont project is still the only project with benefits exceeding costs, but its benefit/cost ratio drops to 1.3 while the ratio for the Idaho and Illinois projects improve slightly, but still remain low. If cost share rates could be reduced without affecting farmer participation in the Vermont project as the economic analysis indicates, the benefit/cost ratio including only government costs would increase.

If we say that these projects were undertaken to improve water quality and produce offsite benefits, and we are interested in how much we are getting for the government buck, we would compare offsite benefits against government costs. When we do this, the benefit/cost ratio for the Idaho project drops to 0.2 while the others remain the same. In terms of strictly offsite economic benefits, the Vermont project remains by far the most economically efficient of the three.

The benefit/cost ratios are considerably less than one for the Rock Creek and Highland Silver Lake projects. Because there are limited potential benefits associated with the Highland Silver Lake project, it is unlikely that this project could ever have a benefit/cost ratio greater than one. In the case of the Rock Creek project, however, a benefit/cost ratio greater than one could have been obtained with a redirection of the project.

if the project were redirected to emphasize conservation tillage and erosion control, the costs of the project would fall while benefits would increase. The primary benefit from redirection of the project would be onsite productivity enhancement. Since total sediment losses would be lower, recreational benefits would also increase.

Benefit/cost ratios were not computed for the Conestoga Headwaters and Oakwood Lakes - Poinsett projects. However, the relative magnitudes of the ratios can be projected for each project. For the Conestoga Headwaters project, the benefit/cost ratio would be very small since there appears to be limited benefits associated with the project as it is being implemented.

Table 4. Estimated benefits compared with costs for three RCWP projects with a 50 year planning horizon. *(PRELIMINARY)*

ITEM	IDAHO PROJECT	ILLINOIS PROJECT	VERMONT PROJECT
	Million Dollars		
Benefits			
Offsite	.8	.2	4.9
Onsite (Productivity)	.8	---	---
Subtotal Public	1.6	.2	4.9
Private Benefits	---	---	2.0
Total Benefits	1.6	.2	6.9
Costs			
Government Costs[a]	3.4	1.6	3.9[b]
Private Costs	3.3	.3	---
Total Costs	6.7	1.9	3.9
	Ratio		
Benefit/Cost Ratios			
Total Benefits/ Total Costs	.2	.1	1.8
Public Benefits/ Government Costs	.5	.2	1.3
Offsite Benefits/ Government Costs	.2	.2	1.3

[a] Includes cost share payments, technical assistance, and information and education costs.
[b] Includes costs of phosphorus wastewater treatment for the City of St. Albans, VT

The benefit/cost ratio is likely to exceed one for the Oakwood Lakes - Poinsett project. As was previously indicated, a 4 percent change in recreational activity would be sufficient to obtain a benefit/cost ratio of one for this project.

Limitations

Several limitations to the economic evaluations need to be pointed out. These evaluations are preliminary and at best give only ball park numbers. The estimates of load reductions are based on modeling. Corresponding achievements in load reduction have not yet been measured in the projects to verify the predictions.

The RCWP projects were not selected on the basis of anticipated benefit/cost ratios, but rather to experiment or try out the program in different problem and geographical situations. Although the Idaho, Illinois, and some other RCWP projects may have low benefit/cost ratios, the information they provide will be valuable for guiding future programs.

In addition the RCWP projects are not representative statistically of possible agricultural NPS projects in general. Thus the benefit/cost results should not be used to generalize about the economic efficiency of a future program.

Rock Creek, Idaho

RCWP - 3

INTRODUCTION

Background

The Rock Creek project, located in south central Idaho, is 45,000 acres with 28,000 acres designated as critical. There are about 350 farm units in the area with emphasis on dry beans, dry peas, sugar beets, corn, small grains, alfalfa, and livestock. The reported pollutants are sediment, phosphorus, nitrogen, and bacteria. Recreation, fishing, and aesthetics are impaired in Rock Creek. In addition Rock Creek empties a dispropo..ionate load of sediment to the Snake River.

Due to low annual rainfall, irrigation is required for crop production. Water is supplied to crops primarily by furrow irrigation. Irrigation ditches, which originate from main canals, carry water to individual farms and eventually empty into Rock Creek, which discharges into the Snake River (Figure 6). Rock Creek has been reported to have poor water quality. A 1975 report by the Idaho Department of Health and Welfare documented the water quality status of Rock Creek and recommended clean-up of both point and nonpoint sources. Major sources of nonpoint pollution in the area are sediment and associated pollutants from irrigation return flows. Animal waste is another contributor to the NPS problem.

Perspectives of the Project

The water quality goals of the Rock Creek project were redefined in 1983 to improve the water quality of the effluent from project subbasins rather than Rock Creek itself. The water quality goals are to reduce: (1) sediment by 70 percent, (2) phosphorus by 60 percent, (3) nitrogen by 40 percent, (4) pesticides by 65 percent, and fecal coliform by 65 percent. However, there is not yet any indication whether these reductions would be sufficient to reverse the impairment of Rock Creek.

Several questions can be addressed by analysis of this project:

(1) Have any significant water quality changes occurred over the past four years of the project?

(2) If there have been water quality changes, are they attributable to changes in land management (i.e. BMPs)?

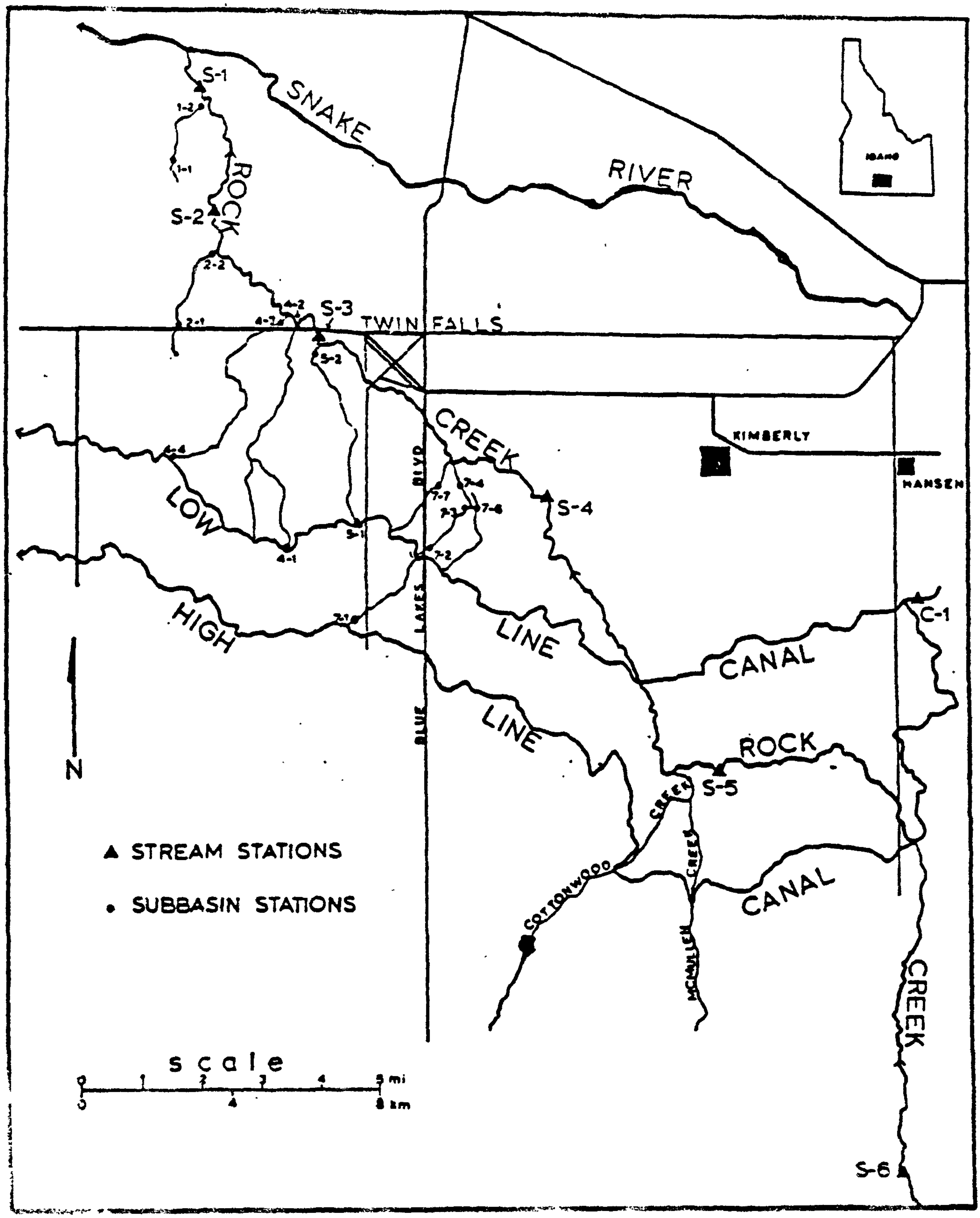


Figure 6. Map of the Rock Creek Rural Clean Water Program Study Area, Twin Falls County, Idaho. (page 9 of the 1984 Idaho Annual Report, DOE)

(3) How effective are sediment retention basins (BMP 12) and irrigation management systems (13) at reducing sediment loading/concentrations from irrigated cropland?

The first question refers to changes in the identified pollutants at either the subbasin level or in Rock Creek. The project water quality analyses as well as our own analyses will be discussed in this report. The last two questions, which relate water quality changes to BMP implementation, are also monumental tasks of the project. At the present time, the data are not sufficient to address this issue satisfactorily.

Land Treatment Strategy

The project area has been divided into 10 subbasins, which have been prioritized by need of land treatment. However, most irrigated cropland is designated as critical and is not prioritized within the subbasins. Animal waste is not addressed explicitly in this critical area scheme.

The BMPs approved for land treatment include 1, 2, 9, 10, 11, 12, 13, 15, and 16 (permanent vegetation, animal waste management, conservation tillage, stream protection, permanent vegetation on critical areas, sediment retention, irrigation management, and fertilizer and pesticide management, respectively). These practices are appropriate for the problems identified.

Water Quality Monitoring Strategy

Monitoring stations have been established on Rock Creek since 1980 and in 6 of the 10 subbasins since 1981. The subbasin stations are located on irrigation ditches; most of these ditches originate from the canals (Figure 6). Some of the subbasin stations have been positioned in pairs at the upstream and downstream points of the ditches within the subbasins, with the downstream stations representing outlets from the subbasins to Rock Creek.

Grab samples are taken biweekly during the irrigation season at the Rock Creek stations; the subbasins are sampled biweekly at the beginning and end of the irrigation season and weekly during the middle of the season (mid-May to early August). The samples are usually analyzed for total phosphorus, dissolved ortho phosphate, suspended solids, fecal coliform, Kjeldahl nitrogen, and inorganic nitrogen. Flow measurements are also taken at each sample collection visit.

BMP IMPLEMENTATION ACHIEVEMENTS

Although the subbasins have been prioritized, the implementation of BMPs does not correspond well with the priority of the subbasins, with the exception that subbasin 7 has the highest reported implementation and first priority. Contracts for BMPs have been established for 62 percent of the critical area. Approximately 36 percent of this area is receiving erosion control benefits from BMPs, according to the 1984 Annual Report.

The practices that have been installed as of September 1984 are mostly permanent vegetation on critical areas, sediment retention, and irrigation and water management (BMPs 11, 12, and 13). There is little implementation of practices which are more effective at keeping soil and nutrients on the land. Only one animal waste system (BMP-2) and 21 acres of conservation tillage (BMP-9) have been implemented. No implementation of BMPs 15 and 16, fertilizer and pesticide management, have been reported. Conservation tillage and animal waste management should have more emphasis in order to address the water quality problems.

It is difficult to determine the actual amount of installed practices for a given subbasin. The 1984 Idaho DOE Annual report included the total acres benefited by all erosion control practices in each subbasin; however, these numbers were determined by adding the benefits of all BMPs in the subbasin, some of which have overlapping benefits. The Idaho Annual Report (Executive Summary) details the amount of land treated by components of BMPs for each subbasin, but upon close inspection the number of BMPs implemented was found to be inconsistent. This problem has been pointed out to the project and will be corrected in the 1985 report.

ANALYSIS OF FARM LEVEL COSTS

Impacts of RCWP on typical fields in the Rock Creek project are shown in Table 5. The farm has 79 acres of cropland in 7 fields ranging in size from 6 to 37 acres and with slopes of 0.5 to 3.5 percent. Five of the fields had dirt ditch irrigation before RCWP, the other two had concrete ditch or gated pipe. None had any sediment control practices. Erosion rates ranged from 2 to 20 tons per acre per year.

Under RCWP, improved irrigation was implemented on 6 of the 7 fields. Dirt ditch irrigation systems were changed to concrete or gated pipe, frequently in conjunction with irrigation water management. Sediment basins were installed on 6 of the 7 fields. The improved irrigation practices reduced erosion rates by 60 percent on most fields. Installation costs of the BMPs totaled just over $13,000.

Assuming the farmer maintains the improved practices over 50 years, he has a stream of increased costs partially offset by cost-share payments received and a stream of improved returns

Table 5. Impacts of RCWP On a Typical Farm in the Rock Creek, Idaho RCWP Project Area.

Item	Field 1	2	3	4	5	6	7	Total farm
Acres	37	7	6	6	8	8	7	79
Slope (percent)	3.5	3.5	1.5	0.5	1.0	1.5	0.5	
Irrigation practices: 1/								
Before	3	3	3	3	3	6	4	
After	106	6	104	3	104	106	104	
Sediment practices: 2/								
Before	0	0	0	0	0	0	0	
After	0	6	6	6	6	6	6	
Erosion rate (tons/acre/year)								
Before	20	20	7	2	2	7	2	
After	12	18	4	2	1	4	1	
Installation costs ($000)								
Irrigation practices	5.3	0	1.3	0	5.0	1.2	0	12.8
Sediment practices	0	0	0.4	0	0	0	0	0.4
50-year changes in costs (discounted $000)								
Irrigation system costs	9.5	0	2.3	0	8.9	2.2	0	22.9
Sediment practice costs	0	1.0	0.9	0.9	1.2	1.2	0	5.2
Less cost-share payments	-2.7	0	-0.9	0	-2.5	-0.6	0	-6.7
Total change in costs	6.8	1.0	2.3	0.9	7.6	2.8	0	21.4
50-year changes in returns (discounted $000)								
Reduction in yield loss	3.8	0.2	0.3	0	0.2	0.4	0.2	5.1
50-year net change in returns before income taxes (discounted $000)	(3.0)	(0.8)	(2.0)	(0.9)	(7.4)	(2.4)	0.2	(16.3)

1/ Irrigation system codes:
[illegible] = dirt ditch
[illegible] = concrete ditch
[illegible] = concrete ditch with irrigation water management
6 = gated pipe
106 = gated pipe with irrigation water management

2/ Sediment practice codes:
0 = no practices
6 = sediment basins

from reductions in yield loss. For all fields except one, the discounted increased costs exceed the discounted increased returns, resulting in a net loss before income taxes of some $16,000 in current dollars, or just over $200 per acre on the average.

Similar projections were made for all 101 participants in the RCWP project through September 1983. The results are summarized in Figure 7. Only about 40 percent of the farmers will gain economically or break even from their participation in RCWP. The other 60 percent will lose from a few dollars up to over $200 an acre. Why are they participating then? Several reasons may exist:

1. Tax savings may make participation economically beneficial.

2. The budgets of costs and returns for the practices may be in error or may inadequately consider the reduced management needed under the improved irrigation practices. (Budgets will be further reviewed.)

3. The farmer places a high noneconomic value on preserving his farm for future generations or on having an improved irrigation system.

4. The farmer does not realize the economic impact of practices on his farm's future net returns.

An implication for the project is that those farmers not gaining or breaking even from their participation will tend to drop the practices after the RCWP contract expires.

Federal income tax regulations impact farmers' decisions to adopt BMPs. Cost-share payments are not considered taxable income and thus do not add to a participating farmer's tax liability. Total costs of annual practices can be counted as deductions. Also 10 percent of the investment in BMPs involving structures with a life span of several years can be deducted as an investment tax credit from the amount of taxes owed. The balance of the capital investment can be depreciated, permitting an additional deduction from taxable income. In the best circumstances, particularly for larger farms facing higher tax rates, the tax savings from BMP implementation may approach or even exceed the noncost-shared part of BMP costs. Thus, it is conceivable that some farms (in addition to those where cost reduction and yield savings exceed the total of other costs) may actually make money from RCWP participation. To be more specific than this would require looking at individual tax circumstances, which is beyond the scope of the analysis.

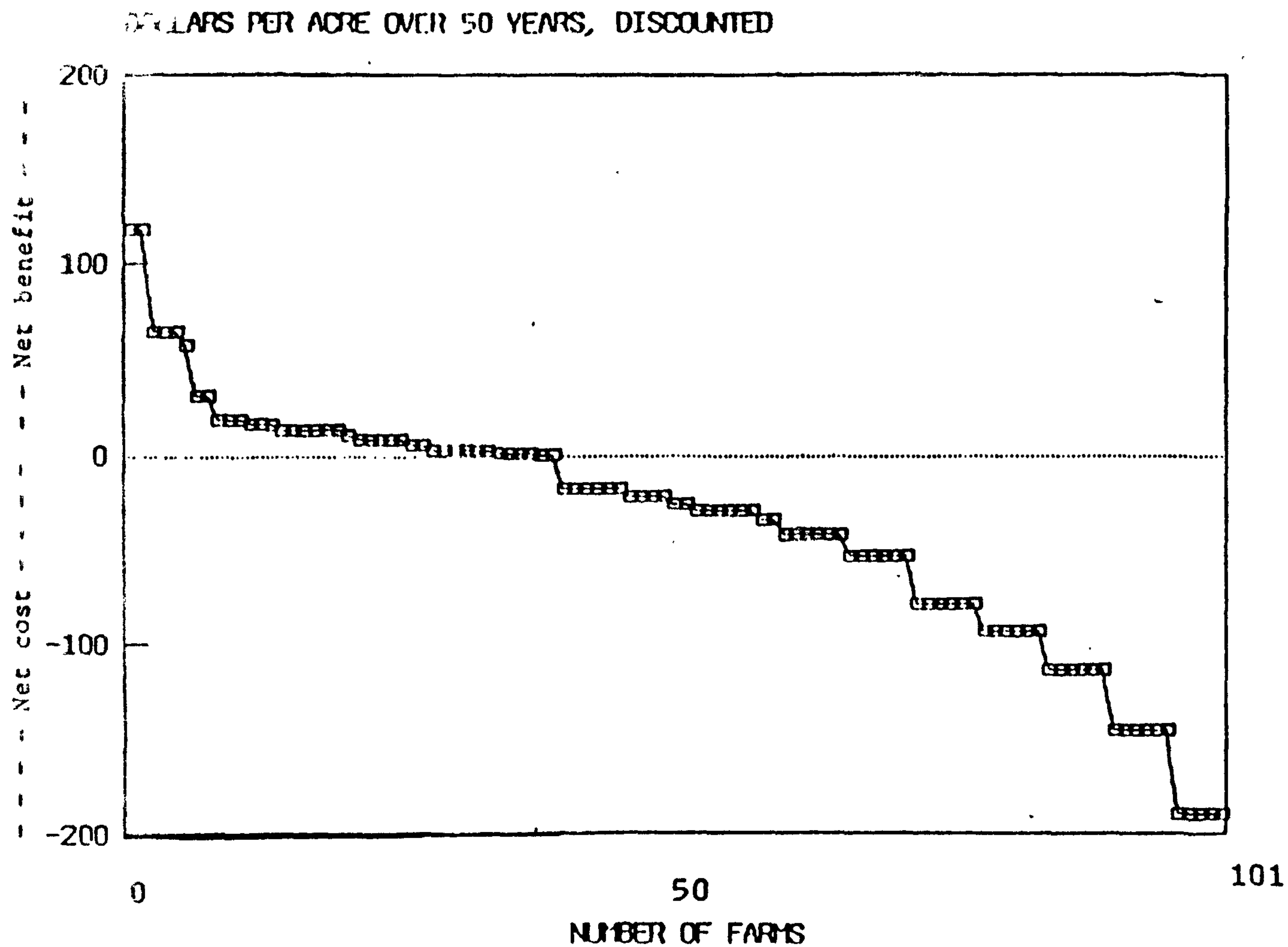


Figure 7. Farmer benefits per acre for the Rock Creek RCWP project.

Summary of Project Results

Included in the project 1984 Idaho DOE Annual Report were results of some statistical analyses of the water quality monitoring data, but data for 1984 were not analyzed. All the data were transformed to approach a normal distribution by taking their logarithms before other analytical techniques were applied. Table 6 summarizes the analyses for the Rock Creek and subbasin monitoring data from the 1984 Annual Report.

Table 6. Summary of Idaho DOE Data Analysis for Rock Creek RCWP.

Analysis	Sampling Stations Analyzed	Explanation
Adjusted downstream concentration (D*)	Subbasins	Upstream variability accounted for by using regression of upstream vs. downstream concentration pairs to adjust the downstream values. Percent change from 1981-83 between the yearly averages reported.
Normalized Mass export loading	Subbasins and Rock Creek	Normalized Load $= \frac{MEL}{Q_i} Q_T$ Where: MEL = annual Mass Export Loading Q_i = mean flow for year i Q_T = mean flow for all years Reported change from 1981-83 for the subbasins' downstream stations and from 1980-83 for Rock Creek stations.
Annual logarithmic mean concentration (ALMC)	Rock Creek	Reported change from 1980-83, not adjusted for upstream or yearly variability.

The Idaho DOE examined 6 pairs of upstream and downstream subbasin stations, with the upstream stations representing incoming sources to the subbasins and the downstream stations representing the outlets of the subbasins. Adjusted downstream concentrations, D* , were computed for each subbasin by regression between paired upstream and downstream concentrations for 1981 to 1984 data. This procedure adjusted for the variability of incoming concentrations over time. Assumptions associated with using this procedure are (1) the samples are properly paired with the up- and downstream samples representing the same parcel of water and (2) that the slope relationship between up- and downstream concentrations is the same for each year.

Results from the Idaho DOE analysis of D* are shown in Table 7. Significant decreases of sediment D* values from 1981 to 1983 were reported for 5 out of 6 stations; 3 stations for Kjeldahl nitrogen; 2 stations for total phosphorus, and only 1 station for both dissolved orthophosphate and fecal coliform bacteria. Inorganic nitrogen showed significant increases in both downstream stations of subbasin 4 and no significant decreases in any of the other subbasin stations.

Table 7. Calculated percent difference from 1981 to 1983 by two methods: normalized mass export loading (MEL) and adjusted downstream concentrations (D*) for downstream subbasin stations. (Compiled from pages 40 and 48 of the 1984 Idaho Annual Report, DOE.)

Subbasin Station	Suspended Sediment D*	Suspended Sediment Normalized MEL[1]	Total Phosphorus D*	Total Phosphorus Normalized MEL	Orthophosphate D*	Orthophosphate Normalized MEL	Fecal Coliform D*	Kjel-N D*	Inorganic N D*
	percent								
7-4	-51**[2]	-73	-29	-28	+22	+62	+12	-62**	-45
5-2	-42**	-75	-18	-28	+13	-11	+32	-36	+17
4-2	-58**	-46	-15	+14	+36**	+38	-15	-21	+292**
4-3	-65**	-75	-53**	-59	-42**	-20	-70**	-55**	+131
2-2	-60	-59	-48**	-38	+6	+22	-38	-49**	+39
1-2	-7	+8	+3	+18	-23	-54	-20	-18	-19

1 No statistical analysis of significance level was executed on normalized MEL
2 Trends are indicated as follows:

- + = Increase
- \- = Decrease
- * = Significant at p <0.05
- ** = Significant at p <0.01

The 1984 Annual Report also presented flow weighted normalized loads and a percent change in the normalized loadings which were calculated for both the Rock Creek and downstream subbasin stations. These results for the subbasins are shown in Table 7. The normalized load was obtained by dividing the annual load (called MEL, Mass Export Loading) by the mean flow of that year and multiplied by the overall mean flow for all years. Loadings were calculated for suspended sediment, total phosphorus, and dissolved orthophosphate. The percent change in normalized loadings representing the change over time compared to the first year's load was computed as:

$$\text{percent change in normalized load} = \frac{\text{Normalized Load}_A - \text{Normalized Load}_{1983}}{\text{Normalized Load}_A} * 100$$

Where:
A = 1980 for Rock Creek Stations;
or
A = 1981 for subbasins stations.

The changes in normalized loadings were not tested for statistical significance. On the subbasin level, the percent changes of normalized loadings were similar to D*, with decreases for the same 5 out of 6 stations for suspend sediment. The results were not as consistent, however, for total phosphorus and dissolved orthophosphate.

The difference between the annual logarithmic mean concentrations (ALMC) between 1980 and 1983, at stations on Rock Creek, are shown in Table 8. Suspended sediment, total phosphorus, and dissolved orthophosphate concentrations, not adjusted for variability of upstream inputs nor changes over time, showed both positive changes (representing increases in concentrations over time) and negative changes (representing decreases in concentrations over time). ALMC of suspended sediment, total phosphorus, and dissolved orthophosphate were found to decrease significantly for station S-1, which is located at the base of the project area on Rock Creek. Significant changes were not reported in ALMC over time for total phosphorus and dissolved orthophosphate for the other Rock Creek stations. Significant ALMC decreases between the two years for suspended sediment were also reported for stations S-3 and S-6. S-6 is the upstream station not affected by RCWP. Therefore, the change in S-1 can not be attributed definitively to RCWP. The changes in normalized loads for Rock Creek stations were not consistent with the ALMC changes for any of the tested parameters. In summary, there appears to have been a consistent decline in suspended sediment concentrations and a less consistent decline in sediment loadings from Rock Creek and the subbasin stations. The analysis did not show consistently significant decreases in parameters besides sediment at other stations.

Table 8. Calculated percent differences from 1980 to 1983 by two methods: normalized mass export loadings (MEL) and annual logarithmic mean concentration (ALMC) for the Rock Creek stations. (Compiled from page 41 and 49 of the 1984 Idaho Annual Report, DOE.)

Rock Creek Station	Suspended Sediment		Total Phosphorus		Orthophosphate		Fecal Coliform	Kjel-N	Inorganic N
	Normalized MEL	ALMC	Normalized MEL	ALMC	Normalized MEL	ALMC	ALMC	ALMC	ALMC
	percent								
S-1	-50[2]	-40**	+24	-10*	-26	-25**	+6	-48**	+10*
S-3	-63	-67**	-23	-15	-10	-9	-63**	-53**	+18
S-4	+55	-13	+143	+11	-17	+3	-72**	-56**	+41*
S-6	0	-43**	+130	-12	+166	+20	-9	-77**	-82**

1 No statistical analysis of significance level was executed on normalized MEL
2 Trends are indicated as follows:

- \+ : Increase
- \- : Decrease
- * : Significant at $p < 0.05$
- ** : Significant at $p < 0.01$

Further Analyses and Interpretations

We performed further analyses on project data for the subbasin monitoring stations. We included the 1984 monitoring data which were omitted in previous analyses. We also used different analyses to determine if trends could be established from this expanded database. Table 9 describes three groups of analyses that we performed. The first two groups used paired data of upstream and downstream concentrations, with the assumption that the same parcel of water is represented in the upstream sample as in the downstream sample of the pair. The third group of tests employed unpaired data to avoid this assumption. Thorough details of these analyses are given in the supplement to this report. Described below are the results and implications from the additional analyses.

Table 9. Summary of Further Analyses of Rock Creek RCWP Subbasin Data, 1981-84.

Analysis	Explanation
1. Analysis of Variance (ANOVA) of downstream data over 4 years with upstream sediment concentration as a regression covariate.	Log transformed data tested, similar to the reported D* analysis, but includes 1984 data. Detects significant differences in downstream concentrations between years after adjusting for upstream concentrations.
i. Homogeneity test of slopes to determine if the downstream stream : upstream concentration relationship was the same over the four years.	
ii. Homogeneity test of midpoints to assess if the adjusted downstream concentration values decreased over time.	
2. Regression of Paired Data: Sediment Concentrations vs. time	Transformed data tested over over the whole period of record, where time is a continuous variable. Truncated, non-negative differences and normalized data account for upstream variability by subtracting upstream from corresponding downstream concentrations.
3. Regression Unpaired Data: Concentrations vs. Time (all parameters, including sediment)	Annual means and variances of log transformed downstream and upstream concentrations plotted against time to evaluate whether an improving water quality trend is likely.
i. t-test, if differences between downstream and upstream were greater than zero	
ii. Slopes (direction and magnitude), homogeneity test	
4. BMP Implementation Effectiveness	Relate BMP implementation to water quality changes by subbasin.
Mininum Detectable Change in Water Quality Parameters	Using the estimated variations of the sampling system, calculate the minimum water quality change required to detect a significant improvement.

The subbasin suspended sediment data were selected for our first two analyses since water quality changes would be more evident on the subbasin level than in Rock Creek and because sediment appears to be one of the more important pollutants being addressed by the RCWP project implementation. The project area has been divided into 10 subbasins; however, these subbasins may not be hydrologically unique, with water from one subbasin possibly passing into another from farm irrigation systems (Martin, personal communication). This complex hydrology of the area adds to the difficulty of documenting water quality changes and the relationship between these changes and land management. Due to the uncertainty of separation between hydrologic units, we did not use loadings; our analyses deal instead with the concentration data only.

Seven pairs of stations located upstream and downstream within subbasins were chosen; six of these are the same pairs described in the 1984 Idaho RCWP report along with an additional pair (7-1 and 7-3) within subbasin 7 to avoid the input of another ditch at site 7-6, which enters below 7-3 but above 7-4 (Figure 6).

These upstream and downstream suspended sediment concentration data were tested for normality with the Shapiro-Wilk test (when $n \leq 50$) or the Kolomogorov-D statistic (when $n > 50$). Most of the data were found not to be normal. The data were then transformed by adding 1 to each observation and taking the log. All of the transformed data were found to be normal, except the upstream concentrations and positive differences (downstream minus upstream concentrations) of subbasin 2 and the upstream concentrations of station 4-1. For these exceptions, however, the skewness and kurtosis were both greatly reduced by the log transformations (i.e. kurtosis reduced from 52.9 to 4.8 for station 2-1), and thus were much closer to a normal distribution.

<u>Analysis of Variance of Downstream Sediment Concentrations Between Years 1981 to 1984 Using Upstream Concentration as a Regression Covariate.</u> Linear regression of sediment concentrations of upstream vs. downstream stations were found to be significant ($P \leq .05$) except in subbasin 2 (Table 10.) This relationship suggests that the downstream concentration can be adjusted for changes in upstream concentration.

A set of analyses of variance (ANOVA) were performed on the data to test differences in downstream concentrations between years using upstream concentrations as a covariate for each subbasin. Two characteristics of these tests were examined: the midpoints and slopes of the annual regression lines. The relationship between the slopes indicates possible changes with time. The midpoint represents the average of the downstream concentrations for a given year adjusted for upstream values. This analysis is similar to the parameter D* that was presented in the 1984 annual report. Our analysis, however, includes the

Table 10. Analyses of Variance of downstream logarithmic suspended sediment concentrations, multiple comparisons among years 1981 to 1984 using upstream concentration as a regression covariate. (Idaho RCWP)

Subbasin	Significance of Regression Between Downstream and Upstream	Among Years ----- Test of Equality ----- of Midpoints[1]	Slopes
1-1, 1-2	+	NS	NS
2-1, 2-2	NS	*	NS
4-1, 4-2	+	*	*
4-4, 4-3	+	*	*
5-1, 5-2	+	*	*
7-1, 7-3	+	*	NS
7-1, 7-4	+	*	NS

1 = Test for equality of midpoints for each year were performed using the appropriate model (i.e. common or unique slopes for each year).
NS = no significant differences
* = one or more significant differences exist between slopes or midpoints, with each regression line representing one irrigation season (P<.05).
\+ = significant regression relationship between downstream and upstream concentrations exist (P<.05).

1984 data and the additional statistical tests for equality. The homogeneity of the slopes and midpoints for each of the four years in each subbasin were tested. Results are shown in Table 10. Subbasin 5 and both pairs of stations in subbasin 4 were found to have significantly different slopes, indicating that at least one of the four years had a slope that was different from the others. The other subbasins showed no evidence that the slopes were significantly different between years. Significantly different midpoints were also found for all of the regressions, except subbasin 1. The difference of the midpoints signifies at least one year had a different adjusted downstream concentration than the other years for that particular subbasin. It is interesting to note that the downstream sediment concentrations in subbasin 7 did not show a significant decrease over time if they were not adjusted for upstream concentration. The downstream vs. the upstream sediment concentration relationship for each year for subbasin pair (7-1,7-4) is shown in Figure 8.

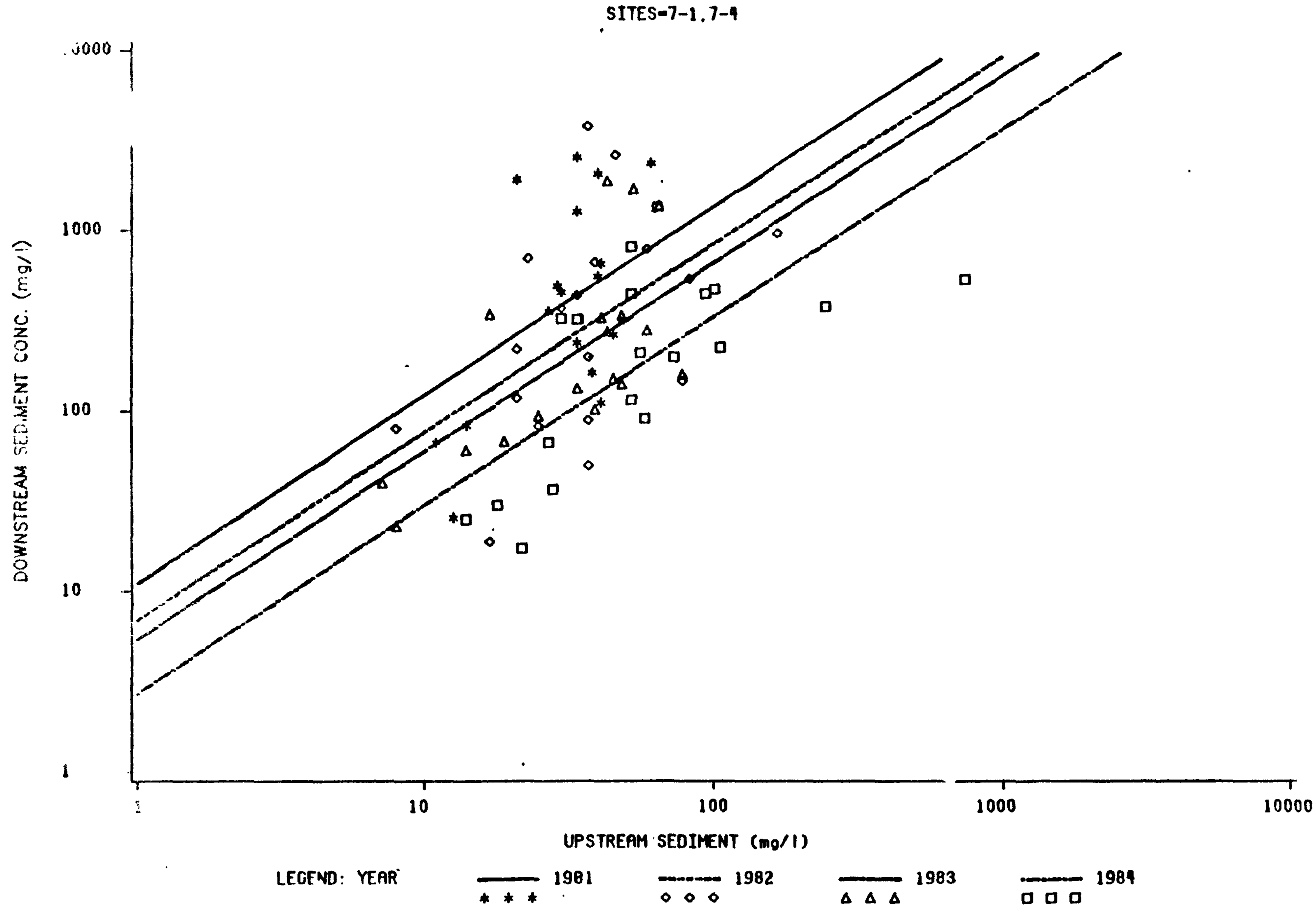


Figure 8. Downstream Vs. Upstream Suspended Sediment Concentrations for Subbasin pair 7-1,7-4 for each year of period 1981 - 1984. A significant decrease in the midpoints over years is seen. (Idaho RCWP)

The supplement to this report has the statistically significant relationships shown for all the subbasin pairs in similar fashion to Figure 8.

The conclusions from these tests are:

1. Downstream sediment concentration is significantly related to upstream concentration for the subbasins tested, except that of subbasin 2. (test of significance of regression)

2. Subbasin 1 has the only pair of stations for which the downstream sediment concentrations adjusted for upstream values were not significantly different between any of the years. At least one year had a different adjusted downstream concentration for each of the other pairs of stations. (test of equality of midpoints)

3. Differences among slopes between years were found for the regression of sediment concentrations from subbasin 5 and station pair (4-1, 4-2). (test of homogeneity of slopes)

Regression of Paired Data: Downstream Minus Upstream Concentrations vs. Time. In this analysis we adjusted the downstream sediment concentration by subtracting the upstream concentration from the downstream concentration for each pair of samples within each subbasin. This resulted in a difference concentration, which represents the portion contributed by the area between the two sampling stations. (Difference = Downstream Concentration - Upstream Concentration.) The log of the difference concentration was taken to reduce the skewness and kurtosis. (It should be noted that this is not the same as using the difference of the logs of down- and upstream concentrations which represents the ratio of the two values). Logarithms of the differences could not be taken when upstream concentration exceeded downstream concentration due to its negative value.

The variations of the upstream, downstream, and difference concentrations over time for subbasin 2 are shown in Figure 9a and b. Similar graphs for the other subbasins are presented in the supplement to this report. The upstream suspended sediment concentration appears to have an annual pattern with two large peaks: one at the beginning of the irrigation season and the other in August. The canals and thus the upstream stations can be influenced by irrigation return flow from other drainages. Also, the initial flush of the canals at the beginning of the season may contain sediment laden waters. The peaks could be related to land use practices, because many fields are irrigated just prior to planting to enhance germination. The

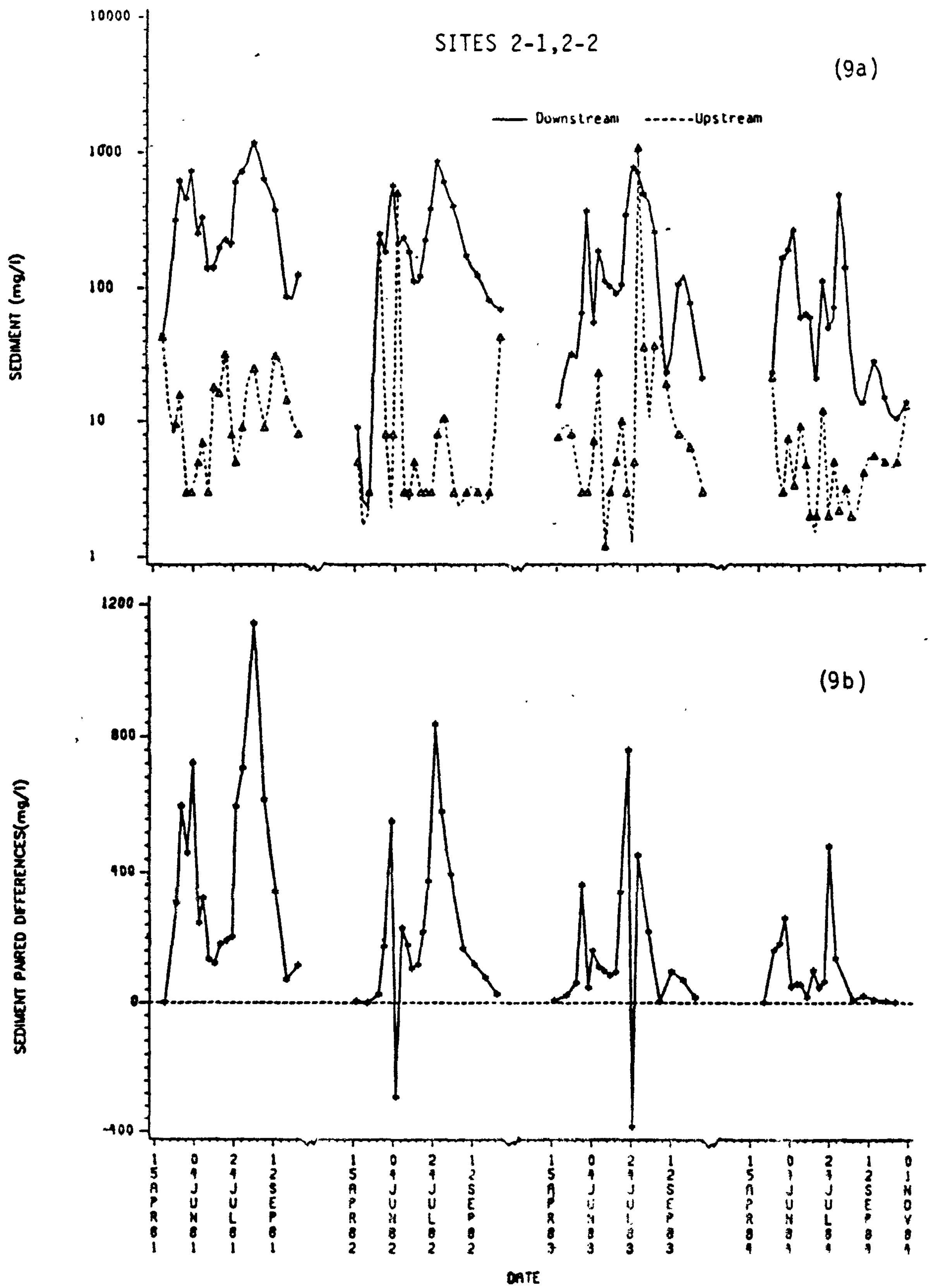


Figure 9 (a) Upstream and Downstream Suspended Solids Concentrations and (b) Difference Between Downstream and Upstream Sediment Concentrations for Subbasin 2, 1981 to 1984. (Idaho RCWP) peak in August may coincide with the harvesting of many of the fields (Neubeizer, personal communication). Close inspection of land use activity during these peak concentration periods could reveal useful information relative to management for water quality.

There are periods when the upstream concentration is greater than the downstream concentration, resulting in a negative difference concentration. The actual budget is not available, because of unknown sources and losses of water. Several factors could be contributing to this phenomenon. For instance, the ditch could be at or near carrying capacity at the upstream station so that a decrease in velocity would cause deposition. Alternatively, water with less sediment could be entering the system between the upstream and downstream stations. The effect of BMPs would not be observed under such circumstances. It is doubtful, however, that this phenomenon is due to BMPs themselves because subbasin 1 has more occurances of upstream concentration exceeding downstream concentration but has a low level of BMP implementation. With this in mind, we examined the case where downstream concentrations were greater than upstream concentrations; this set of data we called the "truncated" data because the negative differences were excluded.

Regression analysis was used to test the relationship of the difference concentrations against time in years. Time in years was used as a continuous variable for the four years rather than a discrete variable for it is a stronger test statistically.

The truncated difference concentrations were found to be significantly correlated with time for each subbasin pair, except subbasin 1. The slopes of all of these significant regressions were negative, indicating a decrease over time. None of the data tested for subbasin 1 were significantly correlated with time, even though the annual means of the downstream data decreased each year. The upstream site in subbasin 1 has very high sediment concentrations, significantly higher than the other upstream sites ($P < .001$) as shown in Figure 10. The source of high incoming sediment concentration in subbasin 1 is presently unexplained. On-site investigation would be useful to identify and, if possible, treat any apparent sources near the inlet to subbasin 1.

The mean of the upstream sediment concentrations were plotted for each of the four years for stations 1-1, 2-1, upstream stations which feed from the low line canal (4-4, 4-1, and 5-1), and 7-1 (Figure 10). Station 1-1 had significantly higher means than the other sites for all 4 years. Stations 1-1 and 2-1 are both spring fed, but have extremely different sediment concentrations. Station 2-1 had the lowest upstream mean concentrations over the period of all upstream stations. The upstream stations which come from the low line canal had significantly higher mean concentrations than station 7-1, except in 1984 where the means were not significantly different.

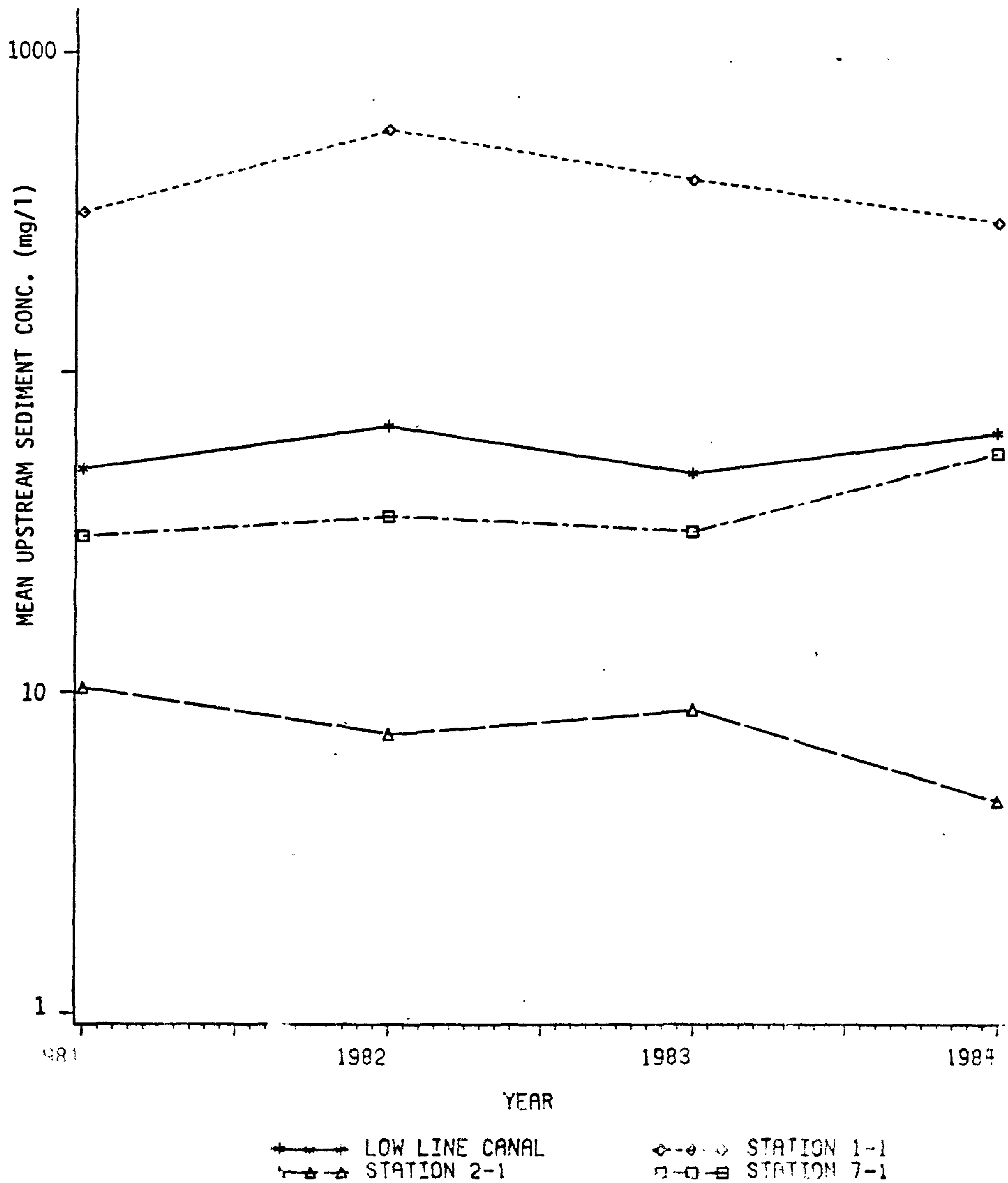


Figure 10. Annual Mean Logarithmic Sediment Concentrations for Upstream Stations Over Time, 1981 to 1984. (Idaho RCWP)

In summary, there is evidence of a significant decrease in suspended sediment concentrations contributed by the subbasins, except for subbasin 1. This test of differences vs. time is more powerful than the previously discussed test of downstream vs upstream concentrations. Nonetheless, evidence from these tests are consistent in that: (1) subbasin 1 does not indicate a significant change in sediment concentration over the period, (2) there appears to be a significant change for at least one year in sediment concentration for all other pairs of stations and (3) significant decreases in sediment concentrations over time for subbasin 5 and the pair (4-1, 4-2) in subbasin 4.

<u>Regression of Unpaired Data: Concentrations vs Time</u>. Both types of the above tests (downstream concentrations vs. upstream concentration for each year and differences vs. time) employed paired data, which have certain inherent assumptions. The most important assumption is that the same parcel of water is represented in the upstream sample as in the downstream sample of the pair. To avoid using this assumption, we examined unpaired data for the same subbasins.

The linear slope of the log of downstream concentrations over time was compared to the linear slope of the log upstream concentrations for each subbasin. The magnitude and direction of the slopes were determined; slopes were tested to establish if they were significantly different from zero. Then, a homogeneity of slopes test was performed to determine if a significant difference existed between the slopes of the downstream and upstream concentrations at each subbasin pair.

Possible results from these comparisons can be classified into three scenarios:

(1) No significant change occurs in adjusted downstream concentration over time, represented by equal slopes or parallel lines.

(2) Significant decrease occurs in the adjusted downstream concentration over time, represented by unequal slopes and converging lines.

(3) Significant increase occurs in the adjusted downstream concentration over time, represented by unequal slopes and diverging lines.

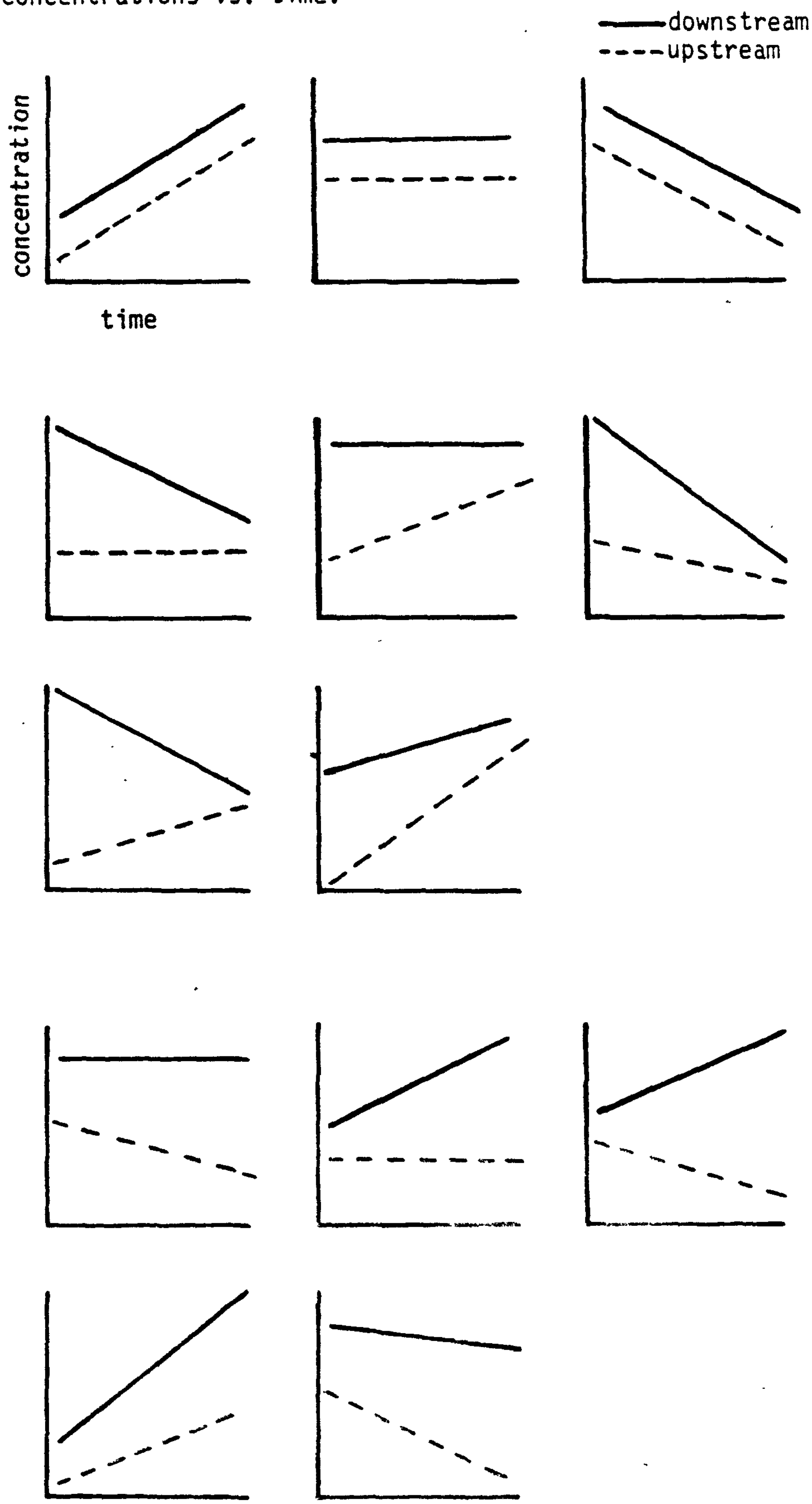
The adjusted downstream concentrations can be pictured as the distance between the upstream and downstream lines (Figure 11). As shown in Figure 11, the distance between the lines remains constant over time for scenario 1; the distance between the lines decreases over time for scenario 2; and for scenario 3, the distance between the lines increases over time.

Figure 11. Diagrams representing the possible scenarios for the comparison of upstream and downstream linear slopes of concentrations vs. time.

Scenario 1:

Scenario 2:

Scenario 3:



The yearly means with 2 standard deviation limits are shown for log sediment concentrations by subbasin in Figure 12. The intervals are approximately equal to the 95 percent confidence intervals on the geometric mean values. These pictures represent the application of the Figure 11 scenarios to the data. Similar plots for the other parameters (Fecal coliform, total-P, TKN, Inorganic-N and stream flow) are found in the supplement to this report.

The magnitude of potential improvements in downstream sediment concentration can be seen by examining the plots in Figure 12. Subbasin 1 has upstream concentrations almost as high as downstream concentrations, which indicates that most of the sediment is not contributed by the subbasin. Improvement of downstream concentrations of subbasin 1 is not likely unless the incoming source is treated. Downstream station 5-2 and 4-2 have statistically significant decreases in sediment concentration with time, but now appear to have downstream concentrations approaching the incoming source concentrations. Any further decrease in these 2 subbasins' contribution of suspended sediment will depend on improving the quality of the incoming water source. However, subbasins which are drained by sites 2-2, 4-3, 7-3, and 7-4 appear to have the greatest potential for improvement. The upstream sediment concentrations for both upstream sites in subbasin 4 are approximately the same, but outlet site 4-3 has higher sediment than the outlet site 4-2. The BMP implementation defined for the two drainages in subbasin 4 should be directed to emphasize the sediment control in the basin drained by site 4-3.

Table 11 summarizes the results of statistical tests to place each of the six water quality parameters examined in each of the seven subbasin station pairs into the appropriate scenario. The test revealed that suspended sediment concentrations decreased significantly over time for all stations except subbasin 1. In fact, no significant changes over the period for any of the parameters were found for subbasin 1. This may be explained by the observation that the water quality parameters for subbasin 1 upstream are high. Only pair (4-4, 4-3) was found to have a significant decrease in fecal coliform concentrations over time; this corresponds with the reported removal of some cows from the stream in 1983. Fecal coliform concentrations were much higher at stations (2-2 and 4-2) than expected. This suggests that major sources of fecal coliform may exist in these subbasins, and that these should be identified and treated.

This example shows clearly that water quality data from the monitoring program can provide indispensible information for identifying critical areas and critical sources.

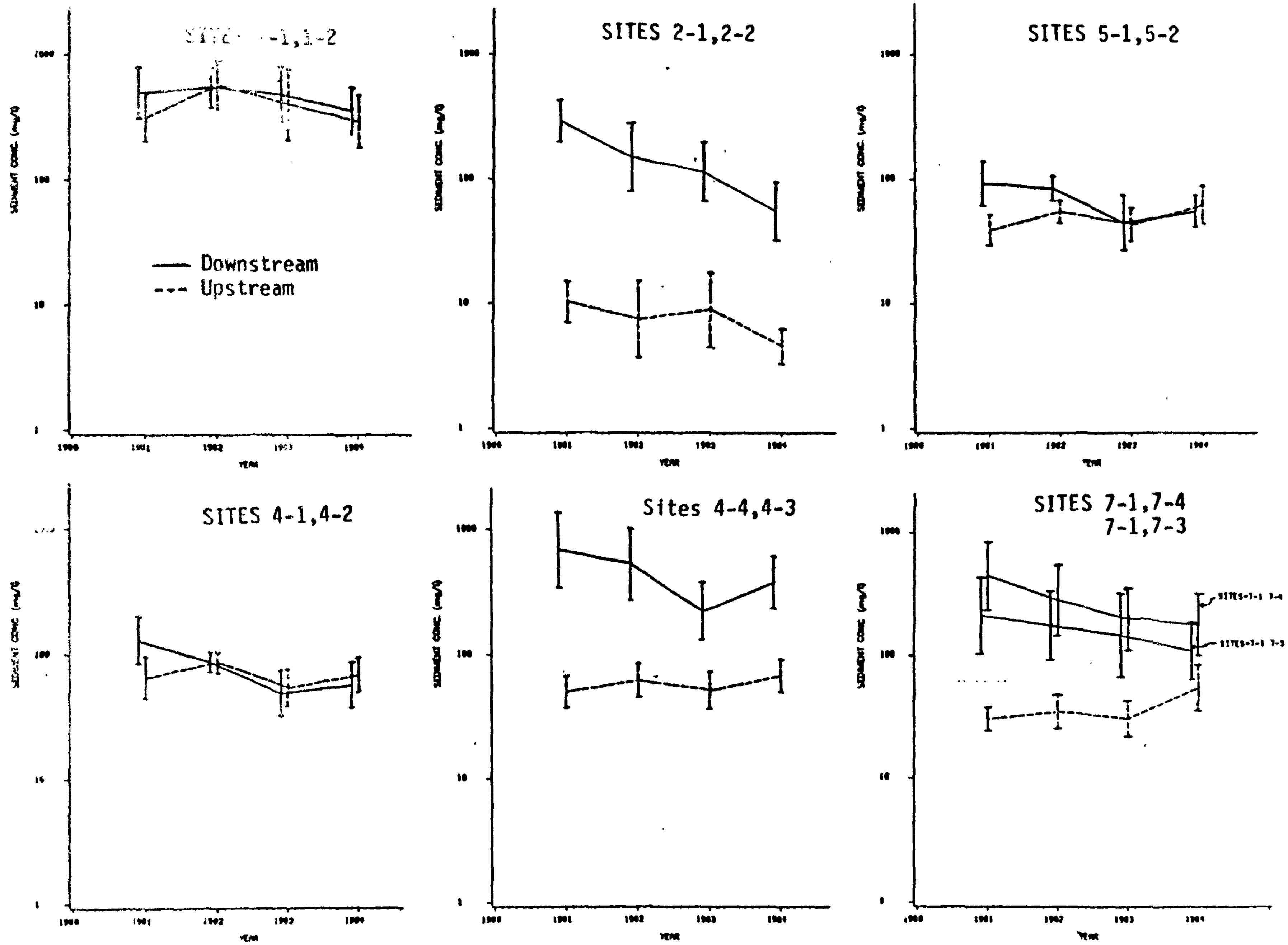


Figure 12. Yearly geometric means of upstream and downstream suspended sediment concentrations by subbasin. Error bars indicate two standard deviations about the mean. (Idaho RCWP)

Table 11. Changes in adjusted downstream concentrations over time (1981-1984), represented by scenarios described in Figure 11. (Idaho RCWP)

Subbasin	Suspended Sediment	Fecal Coliform	Total-P	Ortho-P	TKN	Inorganic N
1-1,1-2	1	1	1	1	1	1
2-1,2-2	2	1	2	1	1	1
4-1.4-2	2	1	1	3	1	1
4-4,4-3	2	2	1	1	1	1
5-1.5-2	2	1	1	3	1	1
7-1,7-3	2	1	2	1	1	1
7-1,7-4	2	1	2	1	1	1

Scenarios:
1= no change over time
2= adjusted downstream concentration decreased over time.
3= adjusted downstream concentration increased over time.

Significant decreases in total phosphorus for the period were identified for subbasin 2 and both pairs in subbasin 7. However, significant increases in dissolved orthophosphate concentration over time were found in subbasin 5 and the pair (4-1, 4-2). Both of the station pairs where orthophosphate concentrations increased had no significant change in total phosphorus concentrations over the same period. The upstream stations originating from the low line canal (4-1, 4-4, and 5-1) had the same general pattern of orthophosphate concentration decreasing between 1981 and 1983 and relatively no change between 1983 and 1984. The downstream orthophosphate concentration remained approximately the same for stations 4-2 and 5-2, but decreased dramatically between 1982 and 1983 for station 4-3. This decrease could also be related to the removal of cows from above station 4-3; however, this decrease was not enough to indicate a significant change between the downstream and upstream concentrations

No significant changes were noticed in either total Kjeldahl or inorganic nitrogen. There was much less nitrogen data reported than other parameters. No data for TKN were available and very few inorganic nitrogen data were reported for the second year, 1982, and the variability of these data is extremely high, masking any changes that could have occurred.

In summary of this analysis, (1) sediment concentrations were found to decrease significantly for all subbasins except subbasin 1, (2) significant decreases in total phosphate were identified in 3 of 7 pairs of stations, (3) only one station pair (4-4, 4-3) had a significant decrease in fecal coliform concentrations, and (4) two pairs (4-1,4-2) and (5-1,5-2) were found to have increases in orthophosphate concentrations over the period.

BMP Implementation Effectiveness. In order to examine the relationship of water quality to land treatment, we plotted the reported percent critical area with implementation of BMPs against sediment load for each downstream subbasin station (Figure 13). The suspended sediment load at the base of the subbasins, was normalized by adjusting for flow of that year and for the average flow for the whole period at that site. The relationships between percent of critical area treated and water quality were not the same from one subbasin to another, but for sediment load vs. BMP the trends were in the expected directions for all stations but 7-3. The sediment load appeared to decrease from 1981 to 1982 at site 7-3 and to increase from 1982 to 1983, even though, at the same time, the area with implementation increased. Likewise, dramatic decreases in sediment loads were not always related to large increases in implemented area, i.e. stations 2-2 and 4-3. Perhaps these areas received their optimal effect from BMPs at low implementation levels, although imprecise reporting of BMP implementation could also reduce the effectiveness of this analysis.

Minimum Detectable Change in Water Quality Parameters. Variation of the sediment concentration data were examined to estimate the magnitude of changes in water quality needed to detect significant differences over time. Variations in water quality measurement are due to several factors including:

(1) A change in land treatment resulting in decreased loadings to receiving waters.

(2) Sampling error

(3) Analytical error

(4) Changes in meteorologic and hydrologic conditions.

(5) Changes in inputs to the system; for example, changes in upstream concentration can affect the downstream water quality.

Adjustment should be made for items 2-5 if possible. When the unadjusted variability associated with these items is large, the required change in water quality parameters for statistical significance is also large. Several steps are involved in calculating the amount of uncontrollable variability in a system and then the amount of changes in water quality necessary to detect significant trends that may be due to changes in land treatment.

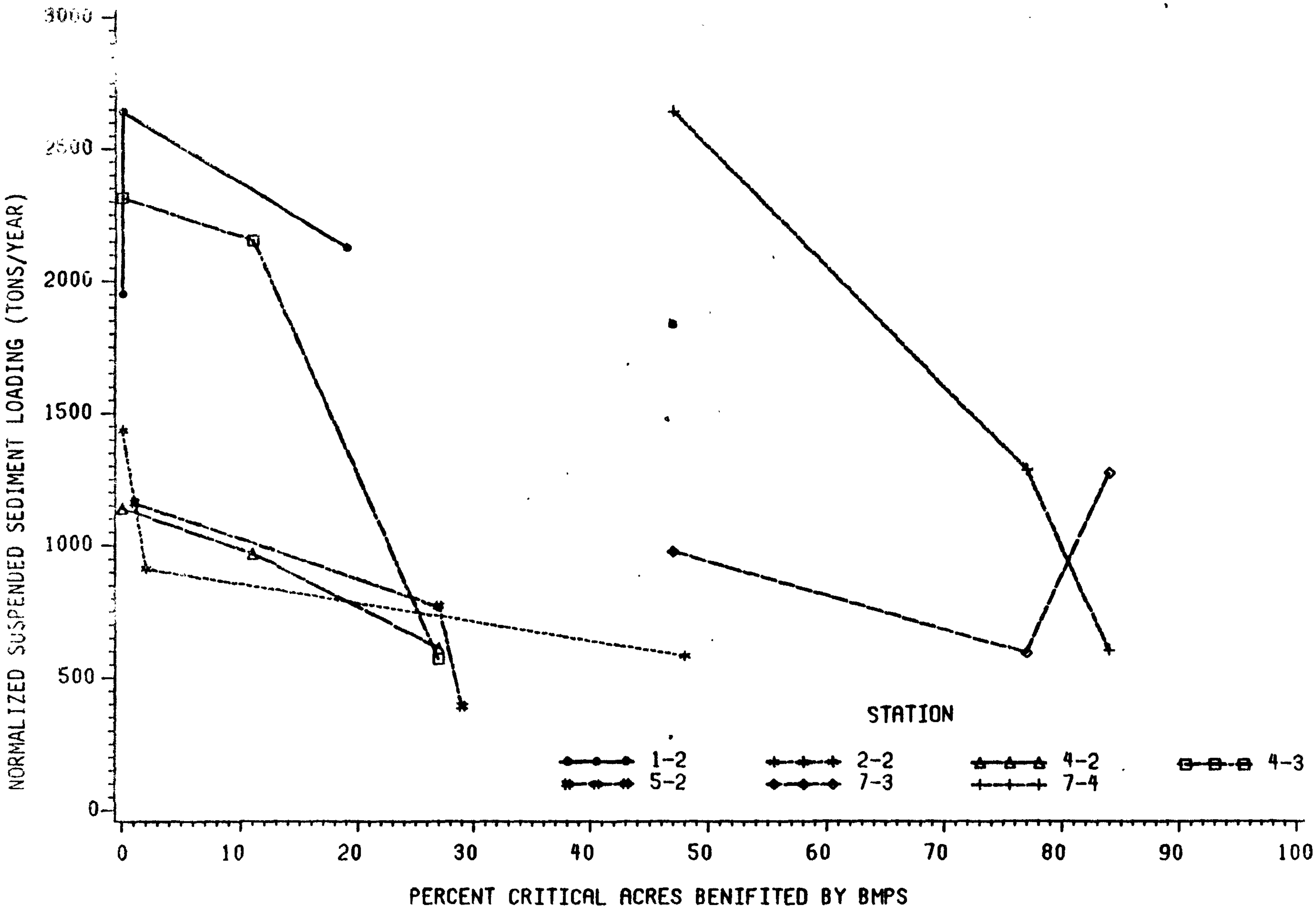


Figure 13. Normalized Sediment Loading Vs. BMP Implementation for Rock Creek RCWP.
(The data was obtained from pages 42 and 53 of the Idaho Annual Report, DOE)

These steps are:

(1) Estimate the expected variability of the sampling system for the unit of time that is to be compared, e.g. the time period corresponding with the irrigation season. This should include a year to year variability component which addresses changes in meteorological effects. This variability can be expressed as a variance which corresponds to the mean square error (MSE) from the regression model:

(a) log downstream conc. = $B_0 + B_1$(year)

or

(b) log downstream conc. = $B_0 + B_1$(year) + B_2(log upstream conc.)

wher B_0 = intercept
B_1 = regression coefficient for year
B_2 = regression coefficient for concentration

and (b) is used if the downstream concentrations are adjusted for upstream concentrations.

(2) For comparison of one year to another, a multiple comparison statistic for a minimum mean difference between 2 years can be calculated. (i.e. a least significance difference).

(3) A more powerful test, however, is to perform a regression analysis. For example, the minimum confidence limit in water quality can be calculated for 4- and 10- year experiments. The confidence limit in this case is a function of the standard deviation of the slope estimate.

Figure 14 summarizes the average percent decrease per year relative to the initial yearly geometric mean downstream sediment concentration required to detect a significant difference over a 2-, 4 - and 10- year monitoring scheme. (20 samples per year are assumed.) The means and ranges indicated in Figure 14 correspond with values from each subbasin. These data indicate that 35 to 55 percent reduction over any given time period is required to detect a real change. The project's stated goal, to reduce sediment concentrations by 70 percent, should therefore be detectable if accomplished. Note that the percent change required to compare any 2 years is very large, but the change per year required over a 4 to 10-year period using regression analysis is much less. Also, the change required per year over a 10 year period is one-third of that required during a 4 year period. This indicates that a longer time is required to detect a weaker change. Correction of downstream concentration with upstream concentrations improves sensitivity as much as 10 percent. A more detailed description of this analysis can be found in the supplement to this report.

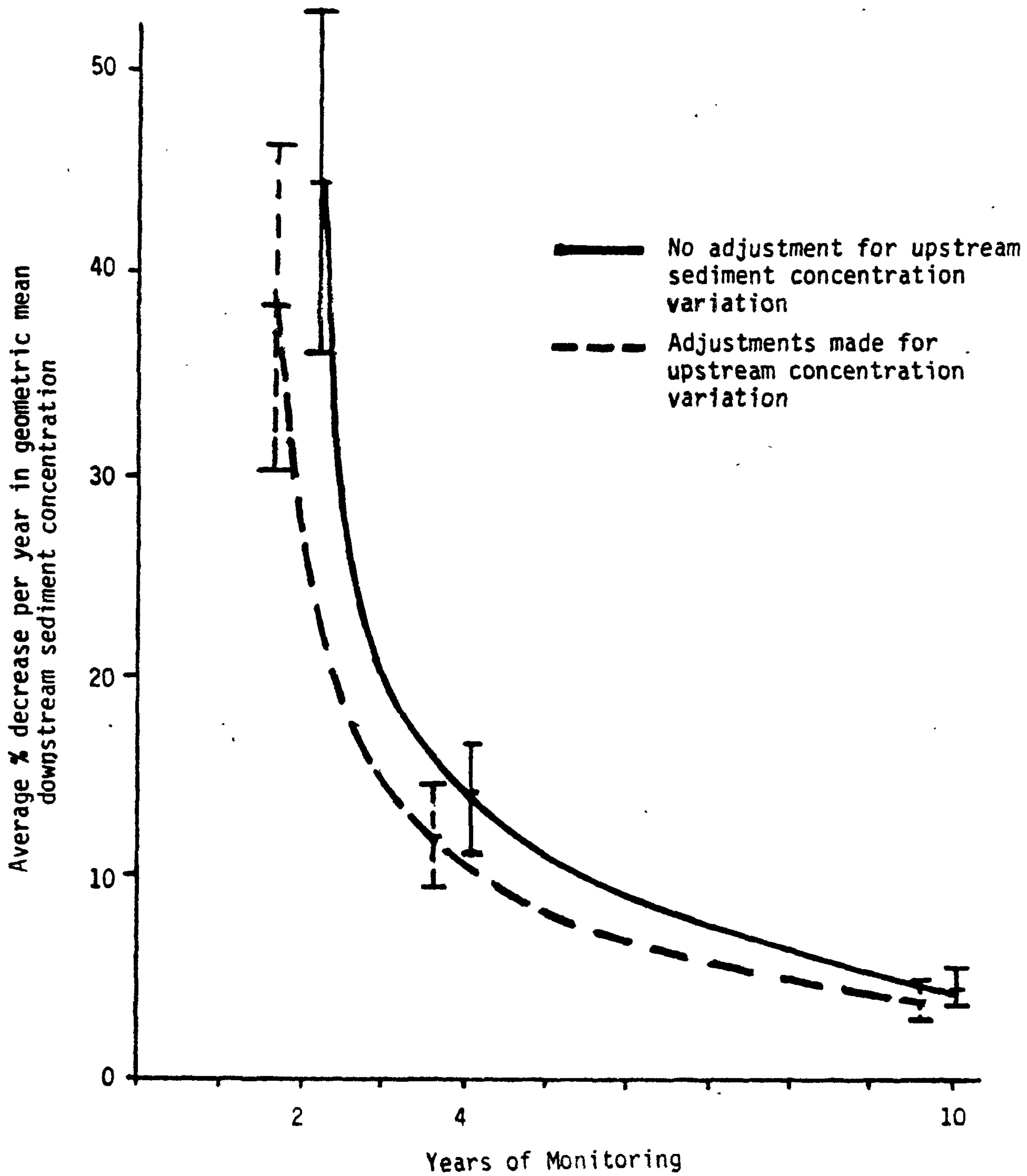


Figure 14. The average percent decrease per year relative to the initial yearly geometric mean downstream sediment concentration required to detect a significant decrease over a 2 year, 4 year, and 10 year monitoring scheme. The range over all subbasins is shown. 20 samples per year are assumed. (Idaho RCWP)

Similar percent reductions to those shown in Figure 14 for fecal coliform are required to show a significant decrease. The reductions required for total-P, ortho-P, TKN, and inorganic-N are approximately 10 percent less due to lower variability.

PROJECTIONS

Selection of critical subbasins which could benefit from BMPs can be partly performed by examining the water quality data. Table 12 lists the concentration differences between the mean upstream and mean downstream values observed in 1981 and 1984 and their projections to 1990 for the 6 water quality parameters. The mean downstream concentration used for these 3 years are those predicted by the linear regression of the log downstream values against the 4 discrete years of 1981 to 1984. The mean upstream concentrations correspond to the geometric mean for the 1981 to 1984 upstream concentrations. The numbers correspond to actual concentration differences so the reader can infer whether the difference is practically important. The 1990 values were obtained by extending the linear trend existing for 1981 through 1984 under the assumption that the present trends will continue. In many cases, this implies the downstream water quality will be equal to the upstream water quality in 1990. (the 0.0 values in Table 12). There is no certainty that this same trend will continue, however. For each subbasin, Table 12 indicates which parameters show a potential for water quality improvement from BMPs. In general, subbasins that are drained by sites 2-2, 4-3, 7-3, and 7-4 deserve continued attention by increased BMP implementation that could decrease the sediment, fecal coliform, and phosphorus contribution to the water. The data also suggest there is nothing to be gained by increased treatment on the areas drained by stations 4-2 and 5-2, and there is little to be gained in subbasin 1.

IMPLICATIONS

The Rock Creek project has implemented BMPs approximately on one-third (36%) of its critical area. After four years of water quality monitoring, significant sediment concentration reductions have been found in 6 of the subbasins. Additional documentation of the relationship between land treatment and water quality will be helpful to establish a cause-and-effect of BMPs and water quality improvements.

Irrigated areas, like the Rock Creek project, appear to respond faster to land treatment than do other non-irrigated, humid areas. This is probably due to a relatively low variability in the nature of the irrigated system. Further comparison with other projects will help to confirm this hypothesis.

The percent decrease in water quality parameters required to detect a real trend is about 30 to 50 percent. The projects water quality reduction goals of 70 percent, 60 percent, 40 percent, and 65 percent reduction for sediment, phosphorus, nitrogen, and fecal coliforms, respectively, would be detectable if obtained.

Table 12. Concentration Differences Between the Mean Upstream and the Mean Downstream Values Observed in 1981 and 1984 and projected for 1990 for 6 Water Quality Parameters if the 1981 to 1984 Trend Continues Through 1990[1].

Site	Suspended Sediment			Fecal Coliform			Total Phosphorus			Ortho Phosphate			Total Kjeldahl-N			Inorganic - N		
	1981	1984	1990	1981	1984	1990	1981	1984	1990	1981	1984	1990	1981	1984	1990	1981	1984	1990
	ppm			count			ppm			ppm			ppm			ppm		
1-1,1-2	166	0	0	185	135	51 +	.083	.067	.04	.025	0	0	0	.15	1.73	0	0	0
2-1,2-2	271	50	0 +	544	308	72 +	.256	.120	0 +	.019	.034	.08 +	.60	.21	0	0	0	0
4-1,4-2	47	0	0	1260	701	205 +	.064	.011	0	.030	.030	.03 +	.32	.06	0	.68	2.3	25.4 +
4-4,4-3	558	210	0 +	1733	811	158 +	.66	.277	0 +	.051	.014	0 +	.89	.54	.08	.75	.65	.49 +
5-1,5-2	48	0	0	293	493	1362 +	.083	.021	0	.025	.020	.01 +	.17	0	0	.16	.09	.02 +
7-1,7-3	179	77	0 +	231	136	38 +	.385	.167	0 +	.056	.037	.01 +	.33	.17	0	.02	.01	0
7-1,7-4	317	112	0 +	416	461	567 +	.555	.196	0 +	.056	.043	.02 +	.13	0	0	.02	.02	0

1. The mean upstream concentration used for 1981 1984 and 1990 corresponds to the geometric mean for the 1981 to 1984 upstream concentration. The mean downstream concentrations used for 1981, 1984 and 1990 correspond to that predicted by the linear regression of log downstream concentrations vs. time.

\+ There is a potential for improvement, i.e. the downstream concentrations are much higher than the upstream values.

Highland Silver Lake, Illinois

RCWP 4

INTRODUCTION

Background

The Highland Silver Lake project is located in southwestern Illinois. Recreational, water supply, and fish and wildlife uses of the lake are impaired by high turbidity levels. It is reported that approximately 14 percent of annual water treatment costs are due to the high turbidity of the water. With the present levels of phosphorus and nitrogen in the lake, these same uses could be impaired by eutrophic conditions if the turbidity problem were reduced, allowing more light to penetrate the waters and promoting additional plant growth.

The project area is 30,640 acres, most of which (82%) is in row crops (i.e. corn, soybeans, and wheat). Some of this agricultural land is highly erosive, composed of fine particles, and is believed to be an important contributor of suspended sediments to the lake. Streambank and channel erosion are nonagricultural NPS of sediment and are being studied to estimate their loadings to the lake. Livestock operations within the watershed are sources of nutrients which are also addressed by the project.

Perspectives of the Project

The water quality goals of the Highland Silver Lake RCWP are to: (1) reduce turbidity and increase visibility to greater than 2 feet and (2) reduce total suspended solids concentrations to an average that is less than 25 mg/l. Goals for nutrient concentrations will be determined if a reduction in suspended sediments yields a eutrophication problem.

Broad questions that can be addressed by this project are:

1. How much reduction in suspended sediment loading in the lake can be expected with treatment of 75 percent of the critical area?

2. If suspended sediment loadings are reduced, will there be a corresponding reduction in turbidity of the lake?

3. Which of the BMPs are more effective at reducing suspended sediment loadings: (a) from the fields, (b) to the streams, and (c) to the lake?

4. If land treatment practices adequately reduce suspended sediment loadings and turbidity levels of the lake, will these same practices reduce nutrient loadings, or

will additional animal waste and fertilizer management practices be required to avoid eutrophication of the lake?

5. Have any significant water quality changes occurred at the tributary and/or lake levels of the project?

The answers to these questions and others can give insights to enhance the use of BMPs in order to obtain maximum benefits for given costs.

Land Treatment Strategy

Land treatment practices were selected to reduce the detachment and transport of soil particles, to maximize settling of suspended particles, and to redrce nutrient losses. Thus, BMPs that increase the ground cover, decrease the velocity of surface runoff, and improved the management of livestock waste were approved for the project. (This includes BMPs 1,2,4,5,7,8,9,10,11,12,14,and 15.)

Of the 30,640 acre watershed, approximately 6,525 acres have been designated as critical. Criteria for the selection of critical areas are:

1. crop and pasture lands composed of natric soil with slopes $\geq$2% with fine particle size, and high erodibility, and

2. crop and pasture lands composed of non-natric soils with slopes $\geq$5% with high erodibility and proximity to water course.

Feedlots were identified as critical depending upon the distance to water course and number of animal units. These criteria appear to be appropriate to address selection needs.

Water Quality Monitoring Strategy

Highland Silver Lake is an impoundment which has several streams contributing to it and one spillway as a point of discharge (Figure 15). The monitoring strategy has different components to accommodate the hydrology of the watershed. First, the lake is sampled monthly at nine sites; 5 stations are located in the main lake and 4 stations are located in bay areas. Secondly, the outflow of the lake is sampled biweekly at the spillway. Three tributary sites witn continuous gaging equipment are sampled biweekly; these sites are also sampled twice a year for biological monitoring. In addition, 8 field sites, ranging from 29 to 332 acres in area, are sampled during runoff events. A livestock waste management practice is also being monitored. The water samples are analyzed for certain parameters as specified in Table 13.

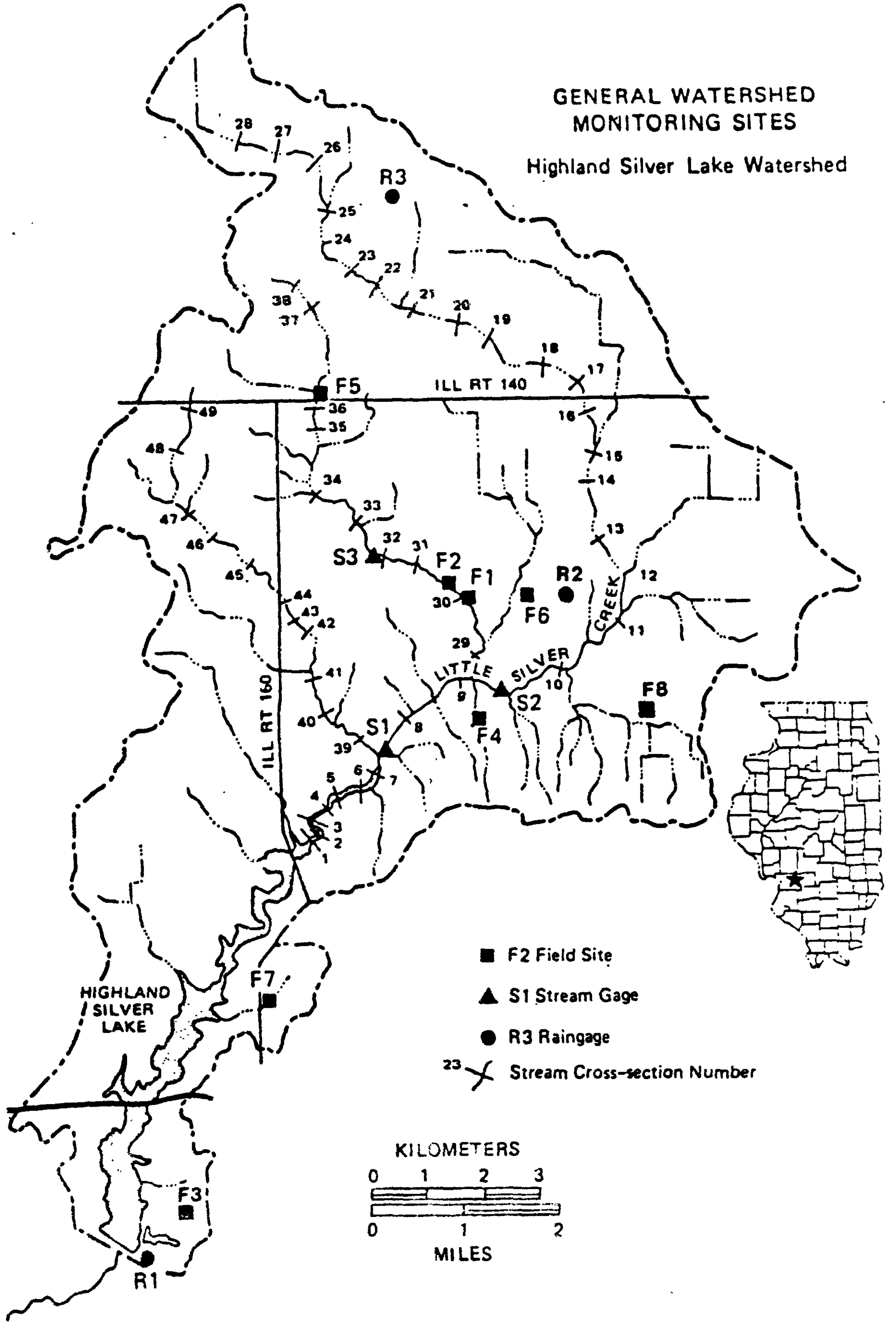


Figure 15. Monitoring Sites of the Highland Silver Lake Watershed (p.36 from the Summary Report Fiscal Year 1984).

Table 13. Data Collection Schedule and Parameter Coverage[2]

	MWF	BIWEEKLY	MONTHLY	EVENT
Field Sites	--	--	--	TSS, TVS, NTU TKN, PTL
Tributary Sites	TSS, TVS, NTU	TSS, TVS, NTU, PTL DSP, TKN, NH_3, N32	ICAP metals	TSS, TVS, NTU, TKN, PTL
Lake Outflow	--	TSS, TVS, NTU PTL, TKN, DSP, NH_3, N32	ICAP metals	--
Lake Stations[1]		Secchi readings	DO/Temp profile Secchi, pH, Alkalinity Conductivity, TSS, TVS, NVS, PTL, N32, NH_3, TKN, CAC, NTU, ICAP, Organics	--
Vegetative Filter System Site	-	--	--	FC, FS, NH_3, TKN, TSS, TVS, COD, PTL, DSP

[1] Sampling is not scheduled for January and February.

[2] p.39 from the Highland silver Lake Summary Report Fiscal Year 1984.

BMP IMPLEMENTATION ACHIEVEMENTS

The rate of implementation is lower than anticipated in the original project plan. As of September 1984, 2412 acres (37%) of the critical area were under contract. The amount of BMPs actually implemented in the critical area was not clearly indicated in the 1984 Annual Report, but appears to be considerably lower than the implementation goals in the plan of work. The practices that are emphasized are waterways, stream protection, terraces, diversions, conservation tillage, vegetative cover, and waste management. Six animal waste operations out of a total of 14 are under contract, 3 of which have been installed.

It was reported that the BMPs applied thus far have caused an estimated sediment reduction of 12,073 tons/year. There is no guarantee, however, that a reduction in suspended sediment loadings will yield a reduction in lake turbidity because:

1. the finer size particles will still be transported to the lake,

2. the natric (sodium) nature of the soil keeps particles in suspension, and

3. turn-over in the lake may cause resuspension of particles that have settled.

These factors need to be evaluated with respect to hydraulic retention time, settling rate and frequency of resuspension to determine if the present strategy of land treatment can reduce the supply of fine particles sufficiently to reduce lake turbidity levels.

Information and Education

The Illinois RCWP included several methods of I&E to inform people in the area and to encourage farmers to use conservation practices. Among these methods were: (1) radio shows, (2) newspaper articles to 13 regional papers, (3) a semi-annual TV show, (4) a bimonthly newsletter devoted to more specialized topics was sent to farmers and agri-businesses, (5) slide presentations, and (6) no-till demonstration. The cost-effectiveness of these methods was not reported.

ANALYSIS OF FARM LEVEL COSTS

Five farms were identified for analytical purposes using [illegible] linear programming models. These do not correspond to actual operating units although their boundaries do include farm fields in production--some of which are being monitored for water quality data. Soils included on these farms are representative of major crop production areas in the project watershed. For purposes of this summary, only the results for one farm (Table 14)

Table 14. Onsite Impacts of Agricultural Activities on a 416-Acre Typical Farm in the Highland Silver Lake Watershed.

Item	Before RCWP	Project life: Ten year analysis: 1991 — Without RCWP	Project life: Ten year analysis: 1991 — With RCWP	Future after RCWP: Fifty year analysis: 2031 — Without RCWP	Future after RCWP: Fifty year analysis: 2031 — With RCWP
Crop rotation and tillage [1] (percent)					
CSWS-ct	100	42	46	46	46
CSWS-nt		18	17	17	17
CS-rt			27		
CCSWAAAA-nt			10		
CSWM-nt		37		37	37
AAAAA					
Soil loss (average annual tons/acre)	4.3	NA	NA	1.7	1.64
Average annual costs/acre	NA	NA	NA	43.59	44.40
Average annual net returns/acre	79.68	91.87	105.15	91.83	94.49

[1] For the management systems above C is corn, S is soybeans, W is wheat, M is meadow, A is alfalfa, ct is conventional (fall chisel spring disk) tillage, nt is no tillage, and rt is reduced tillage.

Source: University of Illinois and ERS files.

and general findings are discussed.

Profit maximizing solutions without cost sharing included primarily row crops or permanent hayland grown under no-till resulting in estimated erosion levels far below those of the baseline or preproject conditions (Table 14). For most typical farms, these solutions did not exceed Illinois' allowable erosion limits. These profit maximizing activities involve a greater use of no-till and reduced-till systems with increased acreages devoted to pasture and hayland. According to analyses of crop budgets, these activities were more profitable in both the short and long run.

Availability of cost share funds would have little impact on land use and treatment. Cost sharing would induce previously profit maximizing operators to make only minor adjustments in cropping activities during the ten years of project life. These adjustments would mainly be shifts to no-till from reduced-till and from permanent pasture to rotations including row crops and multiple hay crops. These changes found in the first 10 year period would revert back in subsequent periods when cost share payments were no longer available.

The University of Illinois SOILEC model simulated erosion impacts of a 50 year planning horizon (Eleveld and Starr, 1983). Average erosion rates were virtually identical with and without cost sharing (a difference of .11 tons/acre). The reason is that less profitable activities, which are also slightly more erosive, become more profitable with the addition of cost share payments.

The typical farm analytical models incorporated productivity impacts of soil erosion on yields. The SOILEC model estimated crop yields by soil for crops and BMPs allowed in the farm analyses. The lower sloping soils of primary concern in this project are the most productive soils in the watershed. The erosion rates for these soils for a CSW/S rotation were estimated to be very low for all management alternatives considered. Related productivity impacts were also low enough to be negligible.

In several instances, the availability of RCWP cost share payments created a different allocation of land use and treatment compared to that created without such funds (Eleveld and Starr). This indicates a dilution of the impact of transfer payments. That is, when a land use and/or BMP is selected as part of an efficient resource allocation when cost sharing is available but is not selected when funds are not available, the farm model selected a crop management alternative having a lower per acre net return without cost share payments. Therefore, some of the transfer payment is being used to compensate for a somewhat less profitable crop management system. The implication is that desirable conservation impacts might be obtained with lower total transfer (cost share) payments. This might be possible if operators could be convinced to change to profit maximizing management activities suggested by analyses when cost sharing was not available rather than those suggested when such funds were available.

Cost share payments affect net income only during the first 10 year period in the typical farm analyses. The average annual returns for the 416 acre farm illustrated in Table 14 in the 10 year analysis suggests a sizeable impact of $13.28 per acre per year for production under cost sharing.

Terracing and contouring although included in the farm model alternatives were not selected as part of any solution. This was in part due to the expense of these practices and in part due to the relatively low levels of erosion inherent in both of the alternative future conditions under the profit maximizing assumption.

None of the results of these analyses suggests differential economic impacts due to farm size. Identifiable differences seem more related to the quality of the resource endowment of the typical farms analyzed.

WATER QUALITY DATA ANALYSIS

Summary of Project Results

Extensive analyses of the Illinois RCWP data performed by project staff have been reported in the 1984 annual report and previous reports. The project should be commended for its efforts in data analysis and also for its clarity in reporting the results of these analyses.

For most analyses performed by the project, the data were stratified by two different factors, time and flow. The yearly data were divided into 3 periods based on agricultural activities and condition of the land surface:

period 1 (P1) April to June: fertilizer, seed bed preparation, and crop establishment

period 2 (P2) July to November: reproduction and maturation of crop

period 3 (P3) December to May: residue.

The flow was classified by baseflow and event flow for data analysis purposes.

The data analysis in the 1984 annual report included 2.25 years of small watershed study data and 3 years of lake water quality data. The standard deviations of the concentrations for stream baseflow and event flow are quite high, sometimes exceeding the means. This high variation makes it difficult to document significant water quality changes over a short period of time. However, a few significant changes were reported. Total suspended solids (TSS) and total phosphorus concentration at the spillway were found to be significantly less than that at gage site 1, located immediately above the lake. This suggests that the lake acts as a trap for TSS and phosphorus. TSS concentrations during events in periods P3 and P1 were generally higher than those during P2 , this may be related to precipitation and land use activities. No significant differences were found among stream stations for concentrations of TSS or turbidity. Event concentrations were found to be significantly higher than base-flow concentrations for both these parameters.

Several observations from the field site data indicated that, TSS yields from 7 of the 8 fields were composed mostly of inorganic soil particles, and phosphorus concentrations were highly correlated with TSS concentrations during P1, less correlated during P2, and least correlated during P3. Nutrient concentrations from feedlot runoff were also reported to be significantly higher than from croplands.

The monthly loads measured at the stream and spillway stations also had a high amount of variation. Loadings during P3 were generally highest; probably due to snowmelt and spring runoff. Unit area loadings of TSS from stream gage site 3, the smaller watershed, were about twice as high as at sites 2, except during P3-1981. This disproportionately high unit area load from stream site 3 suggests that this subbasin may contain an important untreated source.

Two levels of modeling are planned for this project: field scale and watershed. Different land use practices were modeled on the field scale using CREAMS. To summarize the results, (1) the most effective practice was no-till with 80 percent residue, (2) spring moldboard and fall chisel plowing were found to produce approximately the same change in water quality, (3) grass waterways reduced concentrated flow erosion, and (4) sediment loadings were reduced by dry dams. CREAMS is also being used to model two field sites which are also monitored. The results of comparisons between simulated and observed data for the 2 sites is planned for the 1985 Annual Report. Results from watershed modeling, performed with the AGNPS model, has not yet been reported.

Several regression analyses were performed and reported in attempts to establish the relationship between different variables. Land use (i.e. type of crop) was not found to be significantly related to sediment and nutrient yields on the watershed-scale. However, this comparison did not consider other important characteristics such as management practices, soil type, slope of field, farm location, etc.

Regression of nutrient and sediment yields vs. rainfall energy and rainfall/runoff ratios indicated that rainfall energy and the amount of runoff were related to nutrient yields at the three stream sites, but rainfall energy and runoff were related to suspended solids at only site 3.

To document the relationship between water quality of the stream (site 1) and lake, regression analysis was used. No significant correlation was found. However, only baseflow data that were not stratified into periods (due to small sample size) were examined. Perhaps after additional data are collected, a relationship between stream and lake water quality will be more apparent.

Duncan's multiple range test was used to compare the means of the lake water quality data. The variation in the lake data was high, but not as high as the stream data. Generally, however, Secchi transparency improved in the summer (P2) probably due to stratification of the lake. Approximately 70 percent of TSS is non-volatile. TSS is correlated to turbidity, with a better correlation found in main lake samples than in bay samples, however, neither the significance level nor the regression coefficients were reported. Nutrient levels in the lake were high, especially during P1. Chlorophyll a concentrations were low, probably due to limited light penetration.

The following spatial trends in the lake data were observed, although they were not significant at 95 percent confidence. In a direction going toward the dam, Secchi transparency and dissolved oxygen increased and total suspended solids, non-volatile solids, and alkalinity decreased.

Simple regression of lake water quality parameters against time indicated significant increases in inorganic nitrogen, dissolved phosphorus, and Secchi over the three year period. However, upon brief inspection of the reported Secchi data, it appears that Secchi transparencies in the lake were decreasing over time. Further analysis of these data, with stratification of data by time period, may clarify this apparent discrepancy.

Further Analysis and Interpretations

Additional data were presented after the 1984 Annual Report in a report from the Illinois State Water Survey (Report No. 357, February 1985). We examined these data to determine if the differences in water quality at gage sites 2 and 3 were indeed significant. Although the report covers the period from February 1982 to April 1985, it included only 8 storms where loads were estimated at both gage sites 2 and 3. Total storm runoff and runoff ratios were estimated for 32 events. Additional storm data probably exist but were not reported.

We examined the data by regression analysis. Storm loads of TSS and event mean concentrations of TSS and turbidity were transformed to their logarithms. Paired observations from the two subbasins were then regressed by linear least squares, and the simultaneous hypotheses that the intercept is equal to zero and slope is equal to one were tested.

Results from the regression analysis are shown in Table 15. A clear indication of differences in water quality between the two subbasins was observed. At 90 percent confidence, we found that TSS concentration and TSS unit area loading rates were higher in subbasin 3, the smaller basin, than in subbasin 2. Turbidity was not significantly different at the 90 percent confidence level.

Because both loading and concentration were found to be significantly different, we considered whether storm runoff volume and rainfall/runoff ratio might also be different. Results are shown in Table 15. A higher level of confidence was possible in this analysis because there were more stormflow observations that could be paired between gages than there were water quality observations that could be paired. The runoff ratio was not transformed to its log. The analysis indicated that runoff volume from the two sites were not significantly different, but the rainfall/runoff ratio in subbasin 3 was significantly higher than that of subbasin 2 (p=.95).

These results suggest that the runoff response and the concentration of sediment in stormflow from subbasin 3 is greater than that of the larger subbasin. Subbasin 3 is generally not included in the designated critical area of the project. These observations suggest that the water quality data should be considered in a reevaluation of critical areas. Specifically, subbasin 3 should be examined for unique characteristics that make it contribute more than is expected.

Table 15. Regression analysis to test for differences between water quality at Gage Site 2 and Gage Site 3*. (Illinois RCWP)

Parameter	N	Conclusion	Confidence
TSS EMC**	8	S3 > S2	90%
TSS Load	8	S3 > S2	90%
Turbidity	8	S3 = S2	
Runoff	32	S3 = S2	
Runoff/Rainfall	32	S3 > S2	95%

* Data from State Water Survey Report 357.
**EMC is Event Mean Concentrations.

Other analyses from the available data may be useful in guiding the project and producing early projections of the results. Separating the bay water quality data from the mean lake water quality data would allow analyses of each data set. The bays may respond to land treatment at a different rate than the main lake. Since all of the land around the bays is designated as critical, data from the bay stations may indicate other sources of loading. Also, a relationship between concentration in storm samples and discharge rate can be developed and applied to storms with incomplete records to utilize more of the information in the monitoring data.

Many of the water quality projections and analyses of the project are based on a delivery ratio developed from analysis of soils, slopes, and distance to stream network (Davenport, 1984). Delivery ratios from this analysis varied from 22 percent to 100 percent for one field site. In general, they concluded that the site specific delivery ratio was even higher than 47 percent, the previously estimated overall delivery ratio.

To consider the validity of a delivery ratio of 47 percent or more, we compared an estimate of annual TSS load from gaging sites 1, 2, and 3 with an estimate of gross erosion. Results are shown in Table 16. This is a rough estimate, because the actual gross erosion for the period of study may be different from the average annual gross erosion estimated by the USLE. The observed sediment delivery ratio was about one-half of that used by the project. It seems likely that the delivery ratio for larger particles may be low, while the ratio for fine particles may approach 100 percent. An accurate delivery ratio is extremely important in getting a correct projection of water quality results from this project.

Table 16. The Relationship of Average Annual Gross Erosion to Observed Total Suspended Solids Yield, (Illinois RCWP)

Land Use/Cover	Percent of Area	Average Erosion Rate (t/acre/yr)
Cropland	82.3*	3.8**
Pasture/Hayland	5.4	0.9
Woodland	4.1	0.2
Urban	0.7	0.7
Feedlots	0.3	17.4
Other	7.2	1.6
Overall	100.0	3.30

Site	Months***	Average TSS load t/acre/yr	Deliv. Ratio percent
GS 1	22	0.779	23
GS 2	20	0.452	14
GS 3	19	0.707	21

* data from Davenport, 1984
** data from 1982 Annual Report
***only months with complete records used

PROJECTIONS

The absence of significant water quality improvement could be due to any single factor or combination of factors such as the following:

1. The period of record is still too short.

2. There is not enough BMP implementation to cause a detectable change in water quality.

3. BMPs are not adequate to reduce these water quality problems.

4. Critical areas may not be correctly defined.

5. Other phenomena are masking the effects of BMPs.

The water quality data collected thus far have relatively high variation and represent a relatively short period of time. Thus far, only 37 percent of the critical area is under contract, and roughly 10 to 20 percent of the critical area has implementation of BMPs. A change in water quality might be detected when there are higher levels of BMP implementation. The fine particles that are responsible for the high turbidity in the lake and the natric (sodium) nature of the soil may not be appropriately addressed by the BMPs that have been used. These BMPs may have the potential of reducing erosion, but may not substantially reduce the fine particles concentration in runoff water. In the unique case of natric soils, practices designed specifically to reduce the volume of runoff may be more effective than those which have primary effectiveness for erosion control.

Other phenomena, such as lake turnover, may also mask the effects of the BMPs. Lake turnover causes resuspension of fine particles from the bottom sediments, but this process also helps purge the lake of sediment build up. At this time, it is difficult to determine exactly which factor or combination of factors is predominant, but it is clear that considering the low level of BMP-implementation and the short period of monitoring record, we would not expect to observe a water quality effect in the lake.

The 1984 Annual Report projected a 67 percent reduction of suspended solids load at gage site 1 under the following extremely optimistic conditions: (1) all cropland is managed with conservation tillage, (2) pastures ard woodlands are well managed, (3) waterways and structures are implemented where needs indicate, (4) rainfall runoff is reduced by 50 percent, and (5) rainfall energy is reduced by 45 percent. No projections of changes in lake water quality were attempted. The complexity of the system makes all of these projections rather tenuous.

IMPLICATIONS

The Highland Silver Lake project had much advance planning. Critical areas were defined and a sound monitoring approach was developed. Yet there is no certainty at this time whether or not the water quality impairment can be reversed. The main question remaining to be answered is: "Can BMPs effectively reduce the erosion of fine particles of sediment from natric soils sufficiently to reverse the impairment of Highland Silver Lake?"

The field study data should contribute substantially to the answer to this question. These data should be analyzed to determine which BMPs are best for treating natric soils. With this information, the more effective BMPs could be promoted for implementation. The water quality data should be used to reevaluate where critical areas and important sources of pollutants are located. Th relationship between stream and lake water quality needs to be well established. Characteristics of the lake (i.e. hydraulic retention time and the rates of sediment settling and resuspension) would help to estimate the potential effects that the recommended land treatment would have on Highland Silver Lake.

St. Albans Bay, Vermont

RCWP 12

INTRODUCTION

Background

The St. Albans Bay Project is located in northwest Vermont on Lake Champlain. Agricultural activity in the 33,344 acre project area consists primarily of dairy operations with an average of 330 acres and about 100 dairy cows.

The water resources use impairments are related to eutrophic conditions in the Bay. Excessive macrophytic plant growth impairs boating; algal conditions impair swimming, fishing, aesthetic enjoyment, and shore-line property values. Phosphorus, contributed from the sewage treatment plant (76%) and from non-point sources (24%), is believed to be the limiting nutrient. Bacteria from these same two sources impair use of waters for swimming.

Perspectives of the Project

The following questions related to agricultural management and water quality are relevant to the project situation.

1. What degree of phosphorus, nitrogen and sediment loading reductions can be accomplished through treatment of 80 percent of the critical areas and sources in an intensive dairy farming area?

2. What are the most effective manure management practices for reducing phosphorus loading in northern U.S. climates?

3. What is the relationship between total phosphorus loading reductions and orthophosphate reductions from improved animal waste management?

4. To what extent and how quickly will a lentic water body respond to significant pollution loading reductions from both point and non-point sources?

5. What will be the effect on stream nutrient loading of eliminating the application of manure to frozen ground in northern U.S. climates?

6. How well does the CREAMS model predict actual pollutant losses from various agricultural management systems in northern U.S. climates?

7. What is the minimum water quality change which can be detected by a well-designed, comprehensive monitoring program?

8. What role does sediment-bound phosphorus play in improving the trophic status of a phosphorus-limited lentic water body?

Land Treatment Strategy

All RCWP BMPs except BMP 13 and BMP 16 have been approved for the project. The emphasis has been on BMP 1 (permanent vegetative cover), BMP 2 (animal waste management), BMP 8 (cropland protective system), and BMP 15 (fertilizer management). The greatest need has been for BMP 2 which has been part of every RCWP water quality plan written in the project.

The project has developed a relatively rigorous method for selecting critical areas. The criteria include present manure management practices, water resource accessibility, on-site evaluation, and water quality monitoring needs. A total of 15,257 acres or 45.8 percent of the total project area has been designated as critical.

Information/Education efforts in the project have been extensive. Information about the project has reached every resident within the watershed, and the effectiveness of these activities is evidenced by the fact that nearly every landowner in the critical area has signed up for the program.

Water Quality Monitoring Strategy

A thorough and complex water quality monitoring (WQM) program is an integral part of the project. The design can be briefly summarized as follows:

1. monitoring of St. Albans Bay. (This includes special studies such as bay circulation patterns and phosphorus remobilization from bay sediments.)

2. automated sampling of streams to determine pollutant loading trends.

3. random grab sampling of streams to determine concentration trends.

4. monitoring at the edges of two small paired watershed sites.

5. monitoring of the St. Albans Bay sewage treatment plant effluent.

BMP IMPLEMENTATION ACHIEVEMENTS

The project has been quite successful in attaining its BMP implementation goals. Credit for this achievement belongs to all of the agricultural agency personnel involved who have created a high level of farmer awareness of both the water quality and economic benefits of participation in the project.

BMP implementation is occurring under both RCWP and ACP contracts. Of 85 dairies and 15,257 acres identified as needing treatment, 69 dairies (56 - RCWP, 13 - ACP) and 12,762 acres (10,330 - RCWP, 2392 - ACP) were under contract as of September 1984. The project estimates that 13,442 acres and 74 dairies will eventually receive treatment. This represents 87 percent of the critical dairies and 88 percent of the critical acreage.

Project personnel believe that the awareness brought about by the RCWP project has contributed an impetus to other dairy operations for initiating barnyard improvements under ACP and for achieving a general reduction in fertilizer usage as farmers understand better the nutrient values of manure. Of the 56 farms under RCWP contract as of September 1984, treatment had been completed on 29. Almost exactly half of the animal manure produced in the project was under best management as of this date. This percentage is much higher if only the critical area is considered. Nearly all cost-share funds (96%) have gone for managing animal waste. This includes cost-sharing directly for BMP 2 (86%) and also for BMP 12 (10%) which has actually involved barnyard runoff improvements.

Overall the project personnel estimate that 74 percent of all BMPs contracted have been completed. This indicates clearly the farmer enthusiasm for the project.

The project requested and received supplemental funding for FY 1985 to cost-share additional requests and to modify existing contracts. In addition to these pending applications, howeve , there remain several dairy operations in the critical area which have not applied for RCWP. It is somewhat unclear whether these farms could be persuaded to participate if cost-sharing were available.

ANALYSIS OF FARM LEVEL COSTS

Impacts at the individual farm level are illustrated in Table 17, which shows the relevant financial and physical impacts associated with BMP adoption. Two representative farms, a medium and large size, are depicted in the table. In each instance the daily spreading situation is presented which reflects the pre-project condition. The project effects can be determined by comparing the various manure storage alternatives with the daily spread situation. This is consistent with the "with and without" analysis required to determine project efficiency.

Table 17. Annual Impacts of BMP Adoption for Two Typical Dairy Farms in the Jewett Brook Subwatershed of the St. Albans Bay RCWP Project.

Impacts	Medium Farm: w/o RCWP	Medium Farm: w/ RCWP		Large Farm: w/o RCWP	Large Farm: w/ RCWP
	Daily Spread	Semi-Solid A-Frame	Liquid (Earthen Pit)	Daily	Liquid (Earthen Pit)
Financial Effects					
Gross Revenue	109,470	107,619	108,948	191,500	191,500
Pre-tax Net Income 1/	27,427	29,785	28,752	42,675	45,800
Cost Share (Gov't)	0	27,862	11,312	0	16,005
Cost Share (Farmer)	0	8,966	17,783	0	22,633
Environmental Effect					
Gross Erosion (Tons)	102.6	68.0	68.2	171.0	114.3
Delivered Sediment (Tons)	40.0	26.7	26.7	66.6	44.8
N Loss					
Adsorbed (lbs)	554	407	407	941	699
Dissolved (lbs)	171	93	126	302	226
Total	725	500	633	1243	925
P Loss					
Adsorbed (lbs)	30.8	22.6	22.6	51.6	38.0
Dissolved (lbs)	141.0	23.0	72.0	239.0	123.0
Bioavailable	171.8	45.6	94.6	290.6	161.0
Farm Operations					
Cows Milked	58	58	58	100	100
Replacement: Bought	32	20	29	70	70
Replacement: Raised	9	21	12	0	0
Crops					
Corn (Acres	48.0	53.1	53.1	87.4	87.4
Alfalfa (Acres)	60.4	60.4	60.4	114.0	114.0
Manure Spread (Tons)					
Spring	450	915	904	761	1522
Summer	450			761	
Fall	450	915	904	761	1522
Winter	450			761	
Fertilizer Purchased (Tons)	20.5	9.04	9.7	39.8	22.0
Labor Hired (Hrs)					
Spring	290	228	224	414	304
Summer				108	
Fall	276	194	190	383	240
Winter	214	138	129	303	167
Total	780	560	543	1208	711

1/ Pre-tax net income to land, management, and owner labor. Values are adjusted after 20 years when the facility is totally amortized and repair and replacement costs are assumed to be 50 percent of original costs.

Pre-tax net farm income is used as a measure of project efficiency since taxes tend to mask what is occurring with respect to the allocation of resources. For example, rapid depreciation schedules do not provide a realistic measure of equipment life. Also, consider two pre-tax situations that are identical, but because of different exemptions the net incomes can be markedly different. Consequently, pre-tax net farm income is used when examining economic efficiency.

Examination of Table 17 reveals that in each case the installation of a manure storage facility with a 75 percent RCWP cost sharing of eligible costs results in an increase in pre-tax net farm income when compared with the pre-BMP state of daily spreading. In the case of the medium size farm, the semi-solid and liquid storage facilities provide increases in pre-tax net farm income of $2,358 and $1,325, respectively. The adoption of a liquid manure pit yields an increase in pre-tax income of $3,125 in the large farm setting. After 20 years these values increase somewhat as the structures are assumed to be fully amortized at that time. However, it is further assumed that repair and replacement will be 50 percent of the original cost. Thus, the annual pre-tax net farm income figures for the medium size farm after 20 years will be $2,887 and $2,355 respectively, and $4,435 for the large farm liquid pit. Although there exists an increase in current income it must be recognized that the simulation performed by the LP model accounted only for the farms financial commitment, i.e., 25 percent of eligible RCWP costs plus some noneligible costs, not the government's cost share.

After tax income was not used to evaluate project efficiency because it does not properly account for resource use, but also because the number of possible tax scenarios was too many to incorporate into the analysis. However, the reality of every day decision making dictates their consideration. Although it is difficult to make a specific statement about the tax implications it can be generalized that the Federal and Vermont state tax laws are such that they will reduce the negative impacts of BMP adoption. The farmer has several tax incentives applicable to the 25 percent farm cost share and other RCWP associated expenditures. An investment tax credit can be claimed on the manure storage facility if it is more than an earthen structure. This of course would apply to additional spreaders, tractors, and pump investments. Further, manure pits that do not qualify as soil and water conservation expense and can therefore be deducted from taxable income.

Vermont's income, property, and sales taxes also have provisions that can affect conservation and environmental programs. Vermont's income tax schedule is based on a straight percentage (26 percent) of the federal tax. As such, all tax considerations applicable to BMPs for federal tax purposes also apply to Vermont. In addition, manure storage facilities are also exempted from property taxes.

Summary of Project Results

St. Albans Bay The Bay monitoring program consists of:

1. periodic (approx. 20/year) grab sampling at four sites.

2. some biological monitoring at these four sites.

3. sediment phosphorus release studies.

4. a study of bay circulation which involves using wind, water, current and concentration data to determine the effect of bay circulation on water quality.

The bay concentration data show no obvious trends over the 1982-1984 period. Mean concentrations of total suspended solids, total P, and TKN were slightly higher in '83-'84 than '82-'83. This may be associated with higher than normal precipitation during '83-'84, although it must be remembered that most of the nutrients in the bay itself come from the sewage treatment plant. Ortho-P concentrations were about the same both years.

No biological monitoring results from the bay were included in the 1984 report materials. However, extensive biomonitoring information from the five tributary sites was reported.

The sediment phosphorus release studies appear to have been completed. The following results are evident from this study:

1. Phosphorus is released from bay sediments under both aerobic and anaerobic conditions; however, release is more rapid under anaerobic conditions.

2. Phosphorus release rates increase with both temperature and flow rate at the sediment-water interface.

3. Over extended periods of time phosphorus can be released from deeper sediments as well as the upper several centimeters.

4. The sediment column contains sufficient phosphorus to be a long-term source for continued supply.

These results have several possible implications relating to potential water quality improvement in the bay. Most importantly they suggest that improvement of the bay's trophic status may lag behind anticipated reductions in phosphorus input. It is not clear from information contained in project Annual Reports, just how large a sediment phosphorus reservoir exists.

Another implication is that, as volatile suspended solids, nutrients, and oxygen-demanding dissolved organic loads are substantially reduced, the incidence of bay sediment conditions becoming anoxic may be reduced. In this case flushing of sediment phosphorus may take longer, but the bay may exhibit improved trophic conditions in the meantime.

Bay Circulation Studies No results of the bay circulation studies were included in the 1984 annual progress reports. Earlier reports indicated that detailed computer models of bay circulation patterns have been developed and are ready for use.

Tributaries The tributary (level 2) studies include:

1. automated stream sampling to determine loading and concentration trends in the four main tributaries.

2. biological monitoring of fish species, benthos, other invertebrates, and periphyton.

3. meteorological monitoring to relate tributary water quality changes to meteorological variables.

4. detailed land use monitoring (manure spreading logs, dates of field operations, etc.) to relate tributary water quality observations to land use activity.

Only two full years of tributary monitoring had been completed, analyzed and reported as of September 1984. The WQM personnel are, thus, reluctant to project any water quality trends based on this short period of record. Also, BMP implementation was in progress throughout this period, although completed implementation was significantly higher during the second year.

The analysis conducted by the project shows several noteworthy spatial trends. The subwatershed (Jewett Brook) with the greatest intensity of agricultural activity shows the highest concentrations and loads of agricultural NPS pollutants. Phosphorus loads are about 20 times the average for U.S. agricultural watersheds. It is this subwatershed which receives the greatest BMP coverage, and thus, has the most potential to show water quality improvement during the RCWP timeframe.

Although the WQM personnel are hesitant to claim a water quality improvement in Jewett Brook, we believe that there are already some good indications of a significant reduction in nutrient concentrations. Referring to Figure 16, large (approx. 50%) reductions in mean orthophosphate and total Kjeldahl nitrogen concentrations are evident between Year 1 and Year 2 of monitoring. As noted above, there were substantially more manure management systems completed in Year 2. The observed reduction in orthophosphate concentration occurred even though precipitation was 30 percent greater in Year 2 which would tend to increase NPS nutrient concentrations. This gives further support to the suggestion that the manure management BMPs are having a positive effect. It is anticipated that these trends will become clearer given a longer monitoring period and the high level of

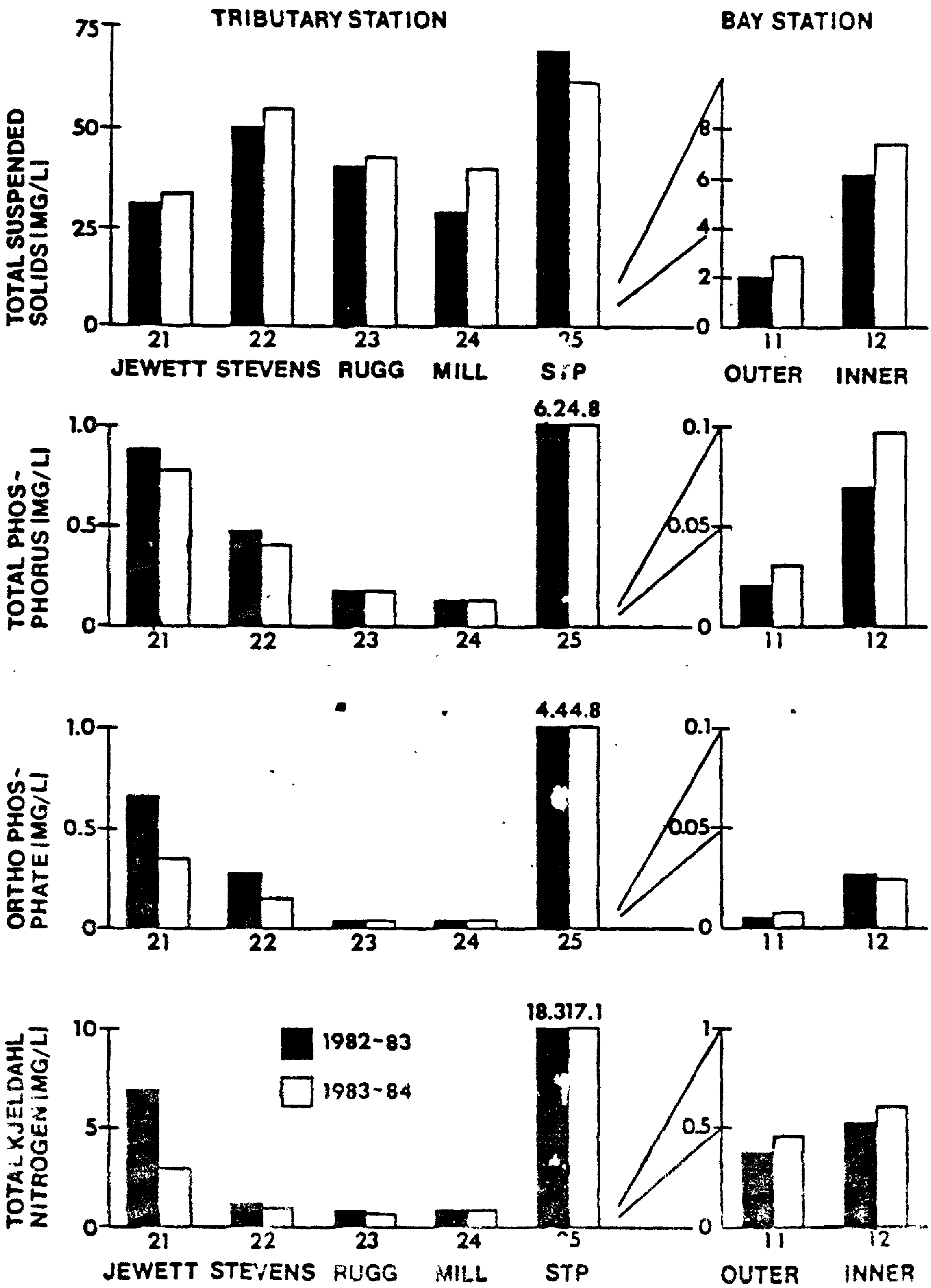


Figure 16. Mean Concentrations of Solids, Phosphorus and Nitrogen at the Tributary and St. Albans Bay Trend Stations for Two Years. (From VT 1984 Summary Report, page V-2.)

BMP implementation (80-90%) projected. Based on the percentage of manure brought under best management, the project has developed models which estimate that total P runoff losses have been reduced about 21 percent and dissolved P runoff losses by about 57 percent in the Jewett Brook drainage (Figure 17). Reductions by 1990 are projected to be 30 percent and 86 percent respectively. The 1984 report suggests that the large majority of P inputs after bringing manure under BMP is from soil erosion. It would appear, therefore, that a large excess of P has built up in some project soils. These results emphasize again the need for good fertilizer nutrient management to achieve maximum reduction in P loadings. The project has noted that further refinements of these models are underway and should improve the accuracy of the projections.

Figure 16 also provides a graphic portrayal of the magnitude of the nutr ent inputs from the sewage treatment plant.(STP) Plants constructed or up-graded in the past ten years are expected to produce final effluent with total P concentrations of less than 1 mg/l. This illustrates once again the importance of the STP upgrading to obtaining improvement in the Bay itself.

The biological monitoring information presented in the 1984 Report reflects essentially pre-BMP or baseline conditions. The tributaries were found to have basically the fauna expected of small Vermont warm-water streams moderately impacted by NPS. Jewett Brook exhibited a unique fish species composition and distribution which may change significantly as NPS loads are reduced.

"Paired Watershed" Field Sites The objective of a "paired watershed" experiment was to show the effects of land management on water quality by effectively controlling for meteorological and other tim. - related variation. The paired watershed design conducted by the project is shown in Figure 18.

Essentially the design involved doing the opposite of the RCWP BMP implementation: (1) two corn fields initially were cropped under best manure spreading practices during the calibration period; (2) management on one field reverted to the pre-RCWP practice of field spreading manure through the winter. Thus, the expected result from comparison between fields was an increase in pollutant losses from the winter spread field that should be approximately equal to the reductions accomplished by installing animal waste BMPs on poorly managed fields.

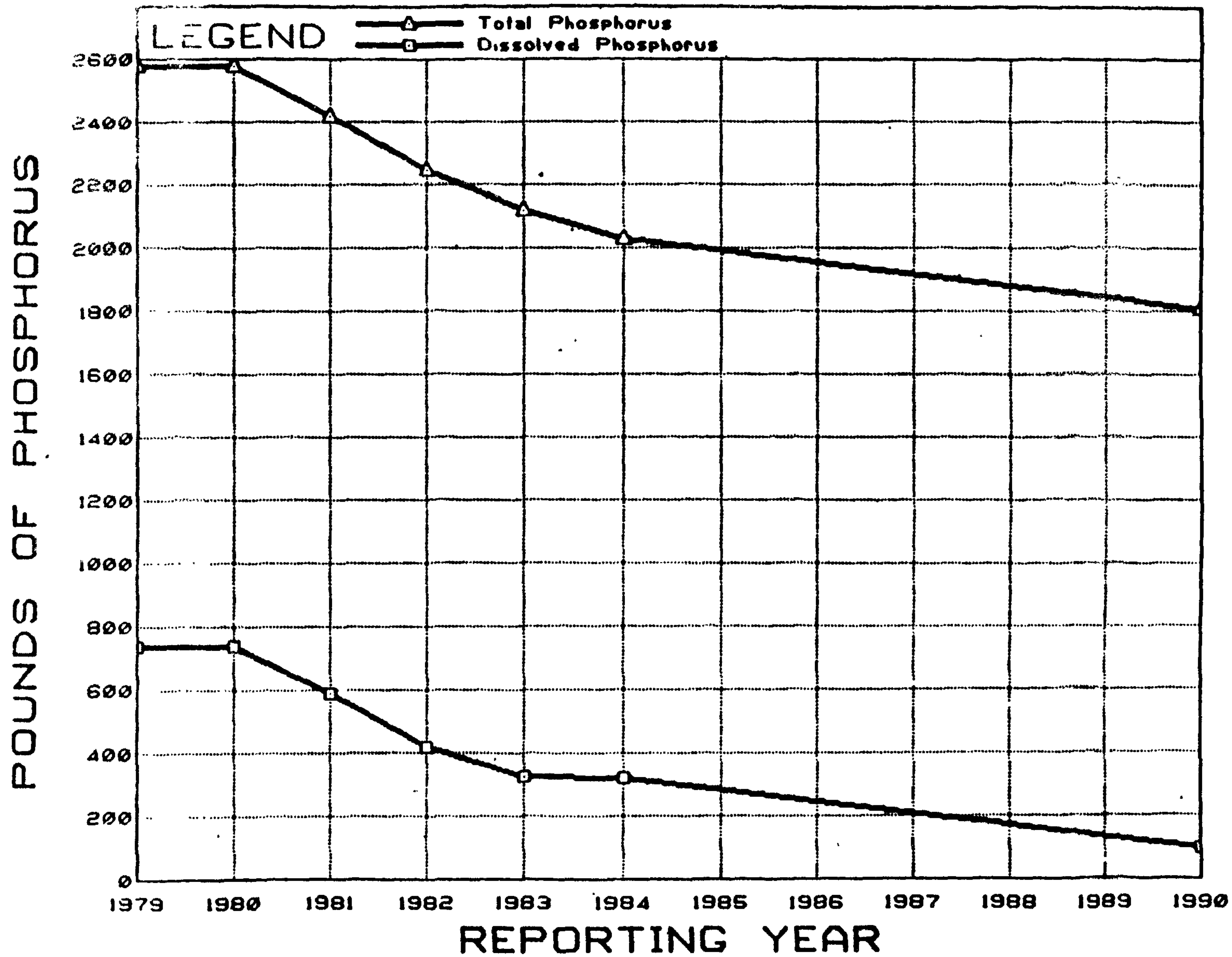


Figure 17. Estimated Average Annual Phosphorus Runoff Reductions For Jewett Brook (Station 21) of the St. Albans Bay RCWP. (From VT 1984 Summary Report, page III-23.)

Paired Watershed Treatment Schedule

Watershed:	PHASE: Calibration	PHASE: Treatment
Control	Best Manure Management	Best Manure Management
Treatment	Best Manure Management	Winter Spreading

Figure 18. Paired watershed treatment schedule (from Vermont Summary Report V-3, 1984)

Further Analysis and Interpretations

The project monitoring personnel have conducted extensive analysis of the paired watershed experiment. A somewhat surprising result was that winter manure spreading actually decreased runoff concentrations and mass export of total suspended solids (TSS) by 68 percent and 50 percent, respectively (Figures 19 and 20). The reduction in TSS was attributed to a "mulching effect" of the winter-applied manure. Volatile suspended solids (VSS) concentrations were also reduced by winter spreading. Our analysis of the TSS and VSS data confirmed these results. The divergence of the regression lines in Figure 20 suggests that the mulching effect is most pronounced at high TSS concentrations.

In contrast to TSS and VSS, concentration increases of total phosphorus, ortho-phosphate, total Kjeldahl N and ammonia N have been observed as a result of winter spreading (See Figures 19, 21, and 22). In general, the elimination of winter spreading reduced concentrations more than mass export because the winter manure application reduced runoff volume from the treatment site by 78 percent. This is presumably due to improved infiltration conditions.

The project found that total mass export increased from the winter spread field of ortho-P, 1500 percent, total P, 11 percent, TKN, 148 percent, and ammonia N, 618 percent, even though the amount of runoff decreased (Figure 23). This gives a direct indication of the probable effectiveness of eliminating the practice of winter spreading. It should be noted that BMP 2 in this project also reduced manure-derived stream inputs by eliminating losses from stacked manure and by improving barnyard and milkhouse manure conditions. Thus, the expected improvements from treatment of a farm with BMP 2 might be different from what was indicated by the paired watershed experiment.

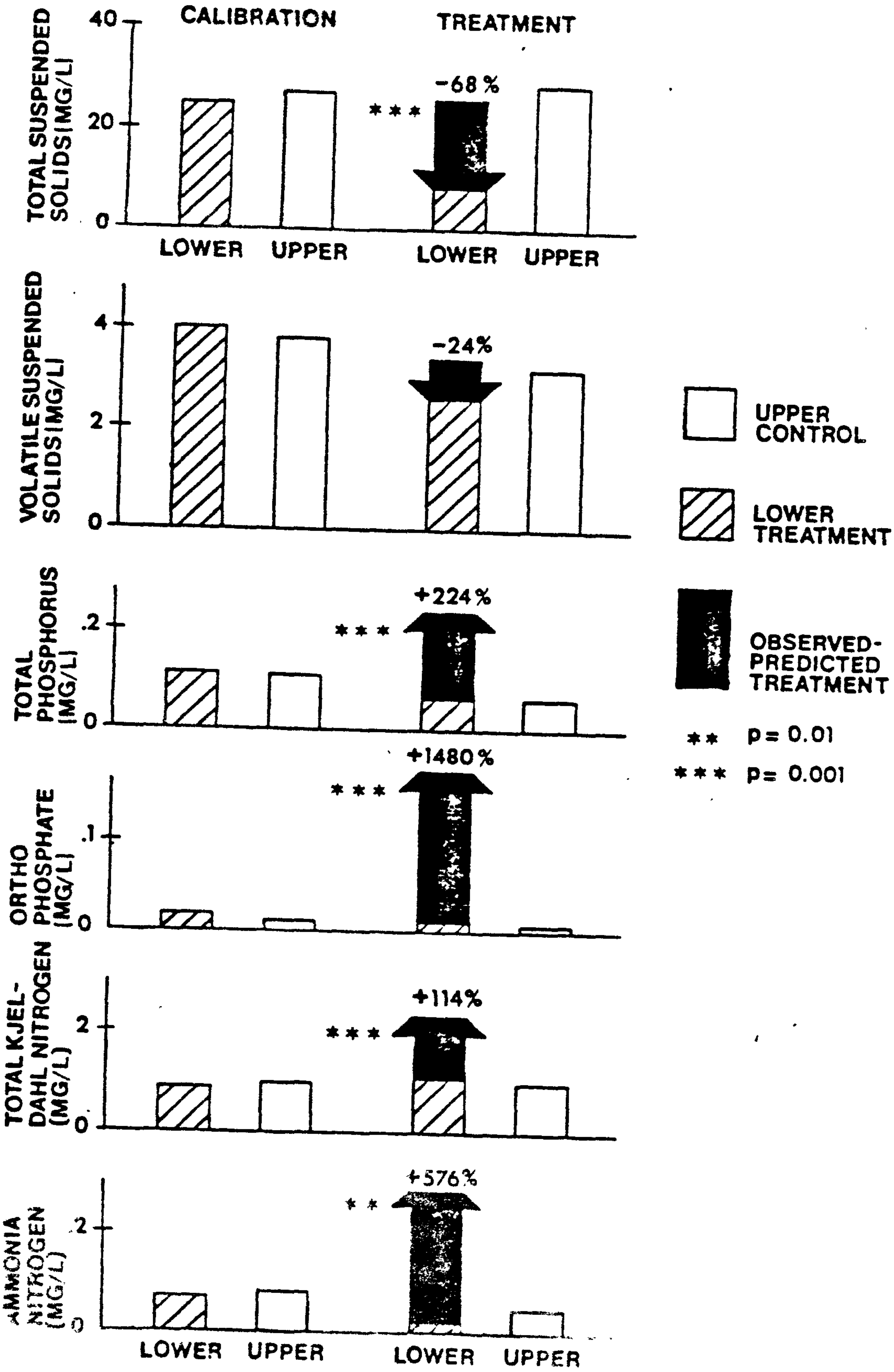


Figure 19. Mean concentrations in runoff from the LaRose farm paired watersheds. (From VT 1984 Summary Report, pg. V-5)

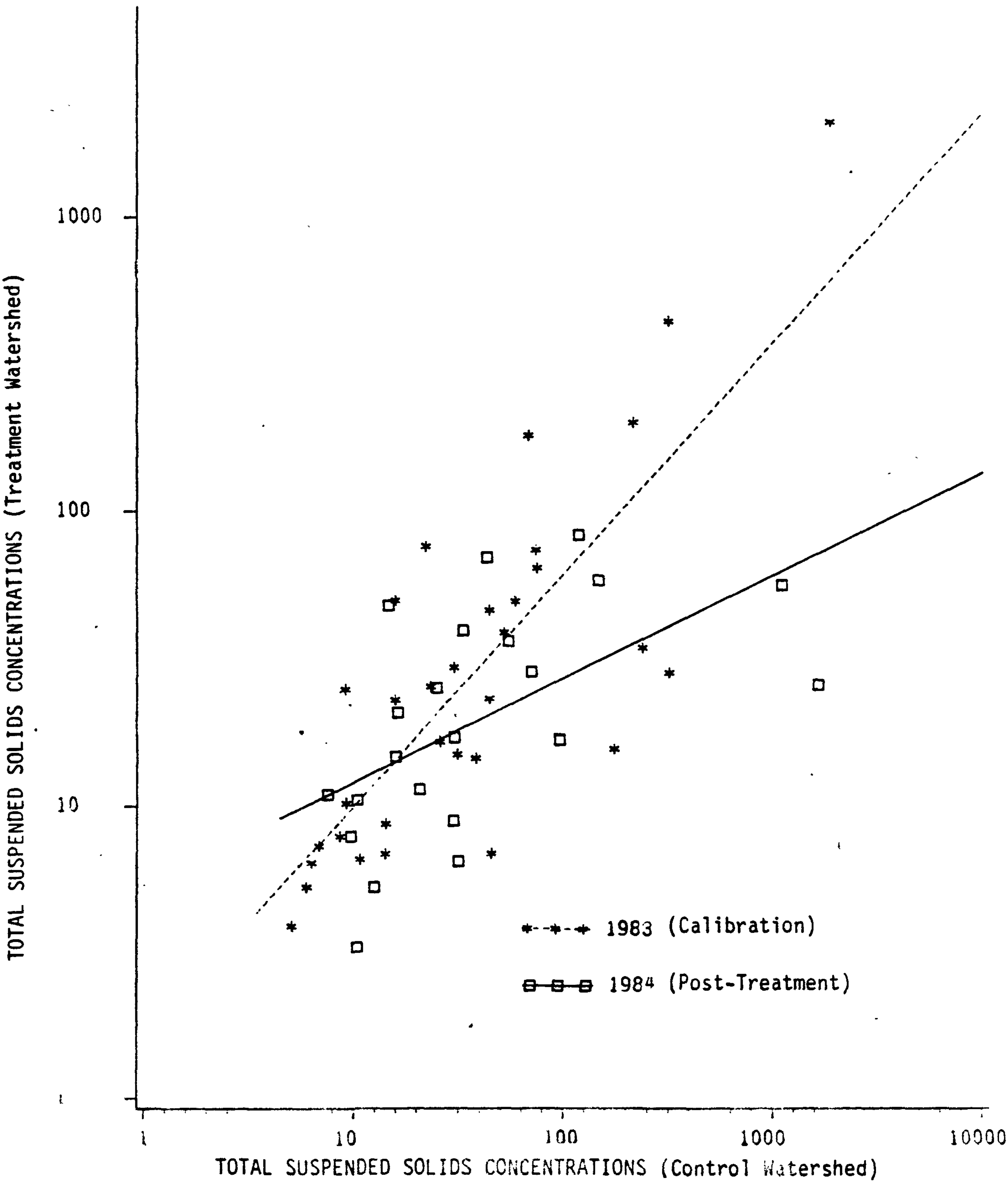


Figure 20. Regression analysis of paired observations of total suspended solids concentrations, treatment vs. control watersheds, 1983-1984. (VT RCWP)

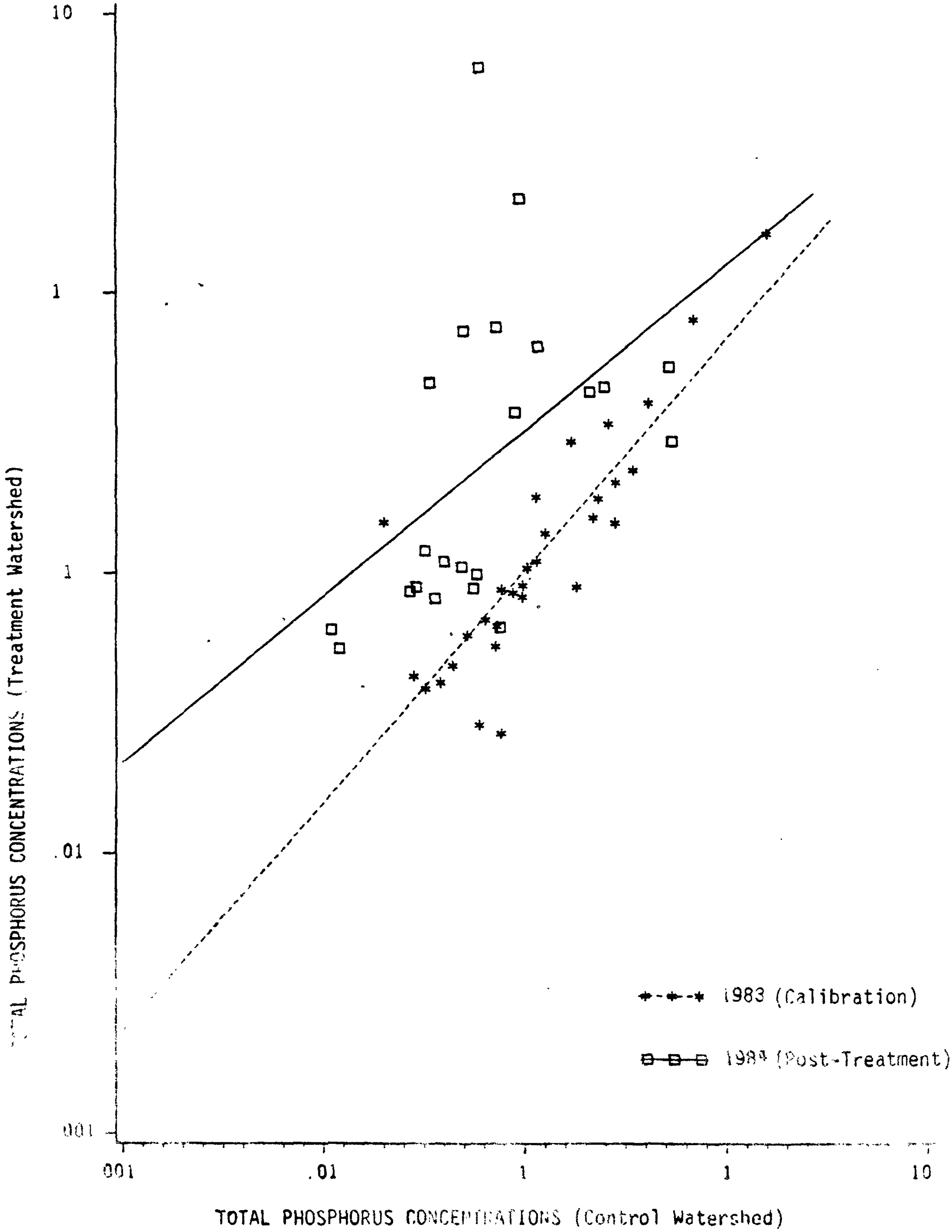


Figure 21 Regression analysis of paired observations of total phosphorus concentrations, treatment vs. control watersheds, 1983-1984 (VT RCWP)

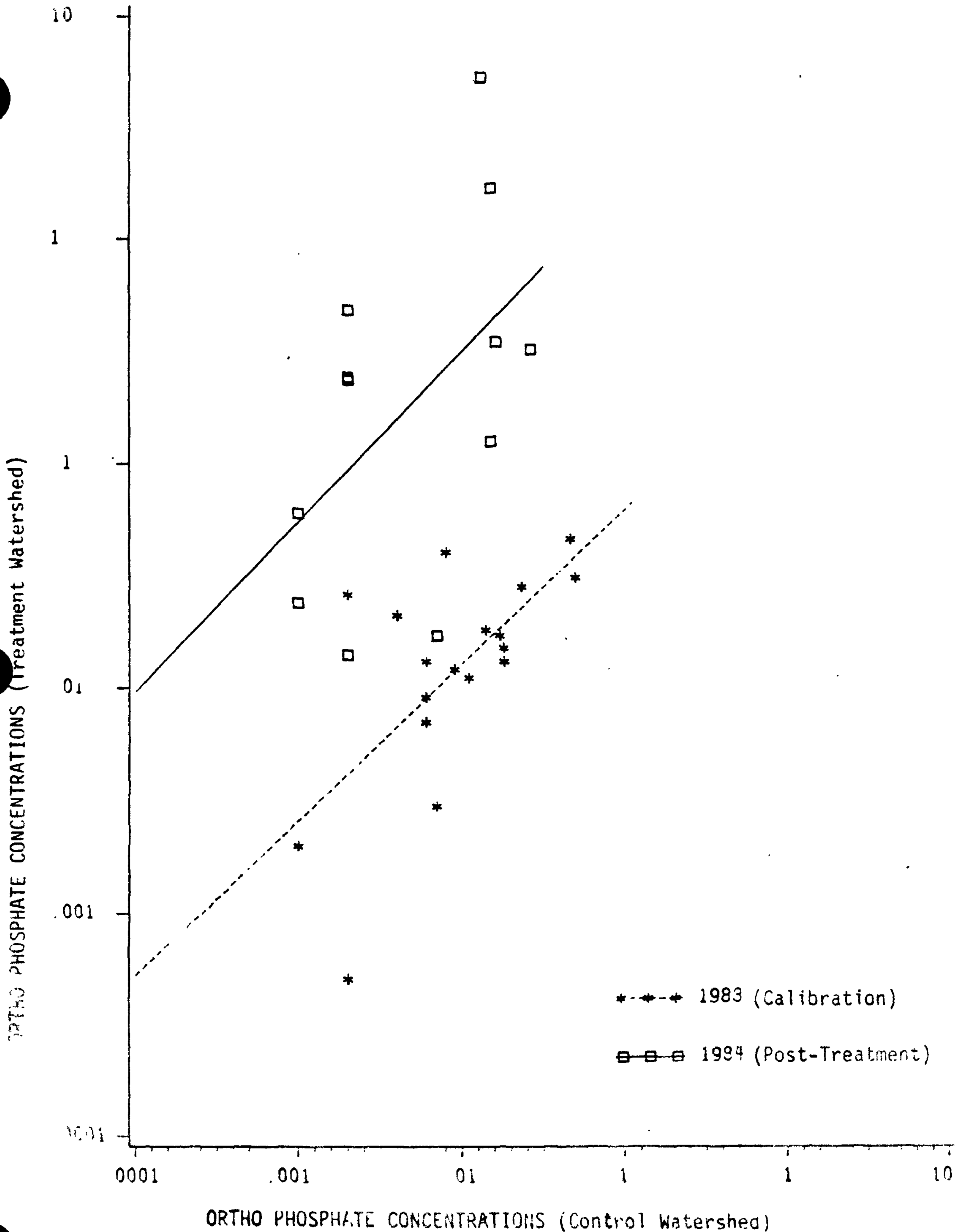


Figure 22. Regression analysis of paired observations of ortho phosphate concentrations, treatment vs. control watershed, 1983-1984.(VT RCWP)

IMPLICATIONS

This project is making several important contributions to our knowledge of agricultural NPS control. These are briefly summarized below:

1. A properly conducted paired watershed experimental design can document water quality effects of specific BMPs within a two year timeframe.

2. A very detailed land use information base is necessary to attribute water quality changes to specific land management activities.

3. Eliminating the practice of winter manure spreading in northern U.S. climates would have the effect of increasing suspended sediment losses but would reduce surface losses of total phosphorus, orthophosphorus, and total nitrogen.

4. The major portion of surface pollutant transport in northern dairy areas is associated with winter thaw, spring snow-melt or spring precipitation events.

5. Some modification of the CREAMS model is needed to describe field losses of agricultural pollutants in northern U.S climates.

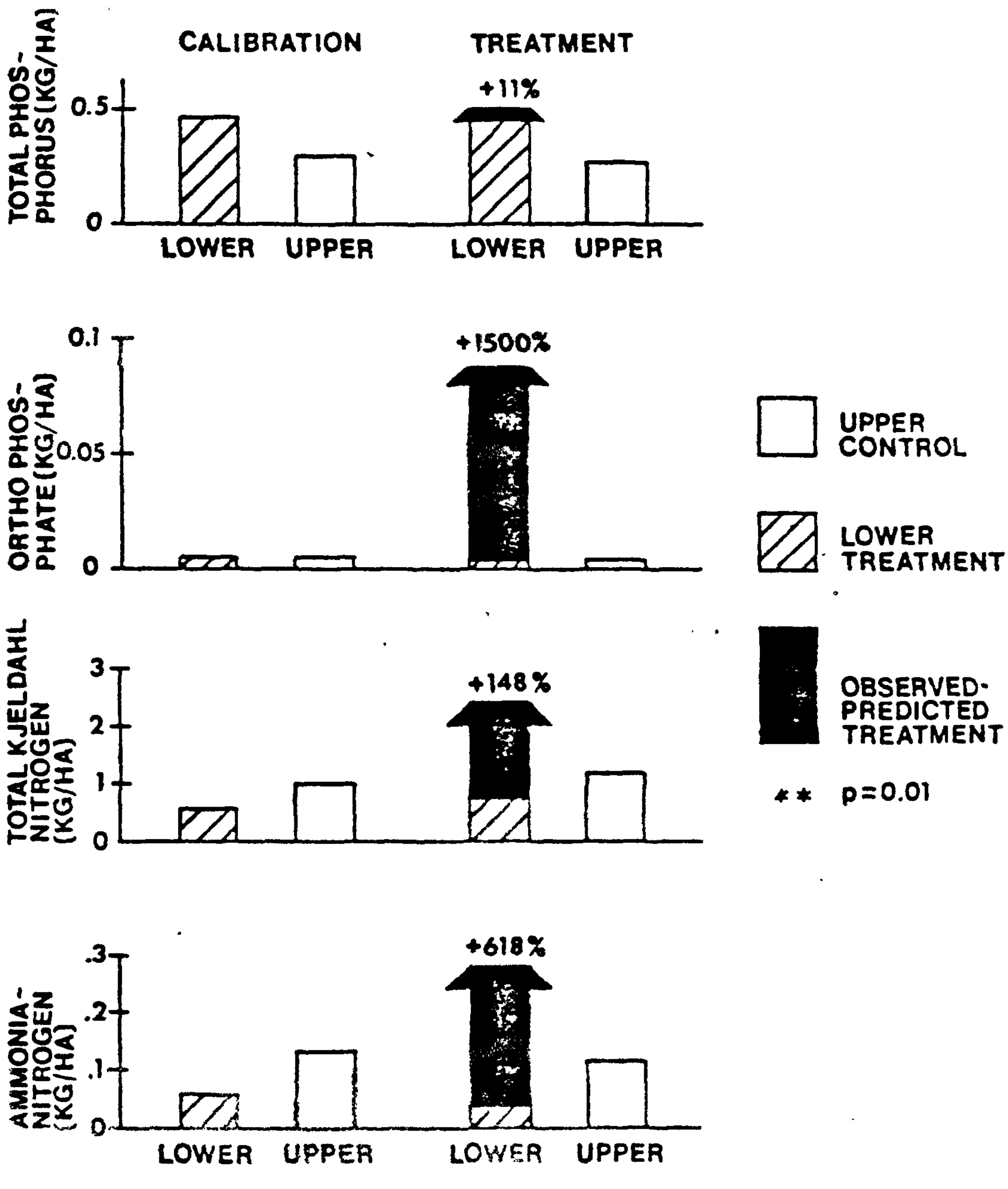


Figure 23. Mass export of phosphorus and nitrogen from the LaRose Paired watersheds. (From VT 1984 Summary Report, pg. V-7)

Conestoga Headwaters, Pennsylvania

RCWP 19

INTRODUCTION

Background

The Conestoga Headwaters project is located in Lancaster County, which is acknowledged to be the most intensive non-irrigated agricultural county in the U.S. The intensity of agricultural production in the project area is even greater than for the county as a whole. This production takes the form of row cropping as well as intensive animal production (approx. two animal units (a.u.) per acre). As a result severe groundwater (bacteria, nitrates) and surface water impairments (sediment, phosphorus, nitrogen, bacteria) have been documented. From among the multitude of agriculture-related impairments(fishery, water supply, contact recreation, aesthetics and downstream eutrophication) the project has chosen to focus increasingly on the drinking water impairment caused by excessive nitrates in groundwater. In the opinion of NWQEP, this is the most serious water resource impairment because it impairs the drinking water supply for 175,000 people both within and outside the project area. Several cases of methemoglobinemia have been reported by the project for infants in the project area. There has also been increasing concern about surface transport of nitrogen forms and herbicides in the context of the Chesapeake Bay studies.

Perspectives of the Project

The following questions related to agricultural management and water quality are relevant to the project situation.

1. Can animal manure be managed sufficiently to protect water quality in an area where the nutrient content of this manure exceeds crop needs?

2. Is there an inherent trade-off between practices designed to reduce surface transport of nitrogen and those designed to minimize nitrogen transport to groundwater?

3. Do groundwater resources in karst areas respond rapidly enough to reflect changes in land management within a ten year timeframe?

4. Can groundwater nitrate levels be reduced below 10mg/l in an area with an animal density of 2 a.u./acre with a public investment of approximately $60/acre of agricultural land?

5. How will groundwater nitrate levels change in response to the construction of manure storage facilities which permit

better timing of manure application?

6. Do herbicides impair groundwater in a karst area with intensive row cropping?

7. What BMPs are the most cost-effective for reducing groundwater impairments caused by agricultural activity?

Land Treatment Strategy

All RCWP BMPs except BMP 13 have been approved for the project. The emphasis has been on BMP 2 (animal waste management), BMP 4 (terraces), BMP 7 (grassed waterways), BMP 9 (conservation tillage) and BMP 15 (fertilizer management).

Targeting of cost-sharing to critical areas has been undermined greatly by lack of farmer participation. The project has established three priority areas based on water quality monitoring needs and groundwater nitrate levels.

Priority 1 - The Little Conestoga watershed (3700 acres)

Priority 2 - Other lands within the carbonate area (areas with highly permeable soils).

Priority 3 - Non-carbonate area.

Information/Education efforts during FY84 included a newsletter sent to 25 percent of farms, visits to 12 percent of farms by SCS and ASCS, availability of two no-till corn planters, fifty RCWP posters, 1500 pamphlets, public meetings, and meetings with Amish church leaders.

Water Quality Monitoring (WQM) Strategy

There are three levels of WQM being performed. The first level is a regional network which monitors ground and surface waters in the entire project area. The network includes 2 stream gauges which monitor major storms, four baseflow sites sampled monthly, and 43 groundwater sites sampled quarterly.

The second level involves more detailed monitoring of the Little Conestoga watershed. (2 stream gauges - major storms; 7 base flow sites - 17 times/year; 5-10 groundwater sites - quarterly). The watershed has two paired watersheds within it, one designated for a high level of BMP implementation (nutrient management) and the other to serve as a control.

The third level is the two 25 acre field sites which have intensive monitoring of surface and groundwater pollutant transport. These sites are scheduled to have nutrient management and/or erosion control BMPs installed after a suitable background monitoring period. One site is presently in the BMP implementation phase while the other is still in the pre-BMP phase.

BMP IMPLEMENTATION ACHIEVEMENTS

The actual implementation of BMPs through the RCWP program has been far below anticipated levels. Out of 1250 farms in the project area only 96 have filed an RCWP-1 application through 9/30/84. During this same period 51 contracts have been signed which cover less than 4 percent of the project area. Only ten contracts were signed during FY84. The original project goal was to obtain contracts on 300 farms; however, this has been revised to 90 farms in the face of low farmer participation.

The reasons for the lack of participation are numerous and complex. The Economic Research Service (ERS) reported a 40 page, indepth analysis of the situation in the 1984 Progress Report. In the opinion of NWQEP, the basic problems are that:

1. Animal production is so intensive that manure nutrients exceed crop utilization potential, and thus the economic incentive to properly manage animal waste is lost.

2. The BMPs which potentially benefit the farmers by protecting their soil resource base are not the same BMPs which are needed to address the groundwater nitrate problem.

3. The cost-share rates for several key BMPs have been set too low to expect significant participation.

4. Farmers have had inadequate access to soil nitrogen content information to make cost-efficient judgments on fertilizer usage.

5. Over 50 percent of the farmers are Amish with a strong cultural history of self-sufficiency.

The underlying assumption throughout the RCWP program has been that farmers will have inherent economic interest in utilizing animal waste to its fullest potential in meeting crop nutrient requirements. Hence cost-sharing BMP 2 was intended to assist with the relatively large initial capital outlay for constructing a storage and application system. However, when manure nutrients exceed crop needs, there is no longer an economic incentive to efficiently store and apply manure. From this perspective it is not surprising that there has been little farmer interest in constructing manure management systems at a 50 percent cost-share rate. Even in RCWP projects where crop nutrient requirements exceed manure nutrients, and manure storage has greater value, a 75 percent cost-share rate has often not insured the desired level of farmer participation.

For farmers with an excess of manure nitrogen, manure storage systems should be designed to allow maximum ammonia volatilization and denitrification. The ERS report states that an uncovered, 6-month storage system is optimal for this purpose.

These systems are now being emphasized in the project. It should be noted that maximum nitrogen volatilization takes place under conditions of daily spreading. Manure storage systems partially compensate for this disadvantage by enabling the farmer to refrain from spreading on frozen ground and immediately preceding storm conditions which increase nitrogen transport to ground or surface water resources. The net result is that somewhat more nitrogen is percolated to groundwater under the storage-application system than under the daily spreading system when manure is applied at the nutrient-excessive rate of 40 tons/acre. When manure is applied at 20 tons/acre (i.e. an amount better matched to crop needs) storage systems are predicted to reduce losses to groundwater because of the improved application timing options.

The previous discussion emphasizes the importance of nutrient management to address the groundwater nitrate impairments in the project area. The typical situation at the beginning of the project was that excess manure nutrients were being applied to cropland and then chemical fertilizer was used in addition. The economic analysis of BMPs performed by the ERS shows clearly that BMP 15 (fertilizer management) is the most cost-effective BMP for reducing losses of nitrate to groundwater. Considerable progress has been made toward reducing unnecessary chemical fertilizer usage primarily through: educational efforts, obtaining a 50 percent cost-share for BMP 15, requiring BMP 15 in all contracts with an animal density of 1.5 animal units per acre or greater, and increasing the accessibility to nitrogen soil and manure tests.

Even with these efforts, however, only $16,185 (7.5%) of RCWP cost-share funds have been contracted for BMP 15. The proj ct personnel estimate that BMP 15 has reduced edge of field nitrogen loss by 38,880 pounds which is 56 percent of the total N reduction. At the other extreme 49 percent of cost-share funds have gone for terraces which have been responsible for only 6 percent of nitrogen loss reductions. If the primary goal of the project is to cost-effectively address the groundwater nitrate impairment, it is clear that an increasing emphasis on nutrient management and a decreasing emphasis on expensive erosion control practices is needed.

It should be noted that the project estimates that more BMPs have been implemented exclusive of the RCWP program than under RCWP contract since the project began. This phenomenon has been attributed to the restrictions built into the RCWP contracts which essentially require that any land under contract must have practices which reduce erosion down to "T". The ERS analysis shows clearly that the most cost-efficient surface transport reductions of nitrogen, phosphorus and sediment are accomplished by practices which are not sufficient to reduce erosion to "T", but rather reduce erosion by 30-60 percent at very low per-acre cost. The adoption of these practices, including contour strip-cropping, cover crops, reduced tillage, diversions, and grassed waterways, through ACP and without cost-sharing indicates the increased acceptability of these practices to farmers relative to the RCWP contracts being developed.

The total nutrient losses to project surface and groundwater resources can only be reduced to a somewhat limited extent (approx. 30-35%) through optimal management of nutrients in the watershed and traditional soil and water conservation practices. It is recognized that further reductions can be achieved only by either:

1. reducing the number of livestock

2. exporting nutrients from the project area.

The project is continuing to explore possibilities for exporting nutrients. These include hauling manure to be used on cropland outside the project area and drying/composting and bagging manure for retail sale. The 1984 Annual Report stated that at least one such facility has begun operation in the project area.

Another aspect of the manure management situation which has been overlooked involves poultry manure. While poultry accounts for only about 13 percent of total manure production its nitrogen content is such that it accounts for approximately 40 percent of manurial nitrogen in the project. Thus 40 percent of the manurial nitrogen could be removed by exporting poultry manure with minimal transport costs, compared to costs of hog or cattle manure export. The poultry manure also has the highest market value as fertilizer. Thus, although the ERS analysis showed that cow manure hauling would be very expensive per pound of nitrogen removed, the analysis should be about three times more favorable for poultry manure.

ANALYSIS OF FARM LEVEL COSTS

Two approaches were used to model the farm level impacts of participation in the Conestoga Headwaters RCWP project. A representative farm linear programming model was used to assess the impacts of alternative manure storage and handling systems. The impacts of field level BMPs were evaluated using budgets. Environmental effects were modeled using the CREAMS model in both approaches.

Manure storage allows the farmer to conserve nutrients and restrict runoff losses of plant nutrients and bacteria when cropland is in crops or over the winter period. However, preliminary modeling results indicate that storage can be detrimental to surface and groundwater quality, when nutrients from manures exceed crop needs. When high concentrations of animals are present, storage facilities should be designed to enhance volatilization losses of nitrogen when nutrients from animal manure are in excess of crop needs.

Uncovered 6-month solid storage and 12-month earthen basin storage were the most cost-effective systems for preventing field losses of nitrogen, both because of lower capital outlays for these two systems and the lesser amount of plant nutrients available compared to other types of storage, particularly the 6-month uncovered solid storage (Table 18). A "typical" Lancaster County farmer can reduce nitrogen losses by 10 percent with no loss in income by applying manure evenly on all farm fields in an environmentally sound manner for a given crop and by reducing the rotation intensity of some land--a clear indication of the utility of the fertilizer management BMP.

Cost information is combined with field losses of soil and plant nutrients in Table 19 to illustrate the cost effectiveness of field BMPs for reducing losses. Costs shown are total costs, with the life span of nonstructural practices being 5 years and structural practices requiring maintenance for 10 years as part of RCWP contract requirements by farmers. The costs shown are estimated average costs and do not include cost sharing to farmers or other considerations (such as tax incentives).

Among the nonstructural practices, conservation tillage--reduced tillage and no-till--are effective in reducing pollutant losses at a cost assumed to be zero for purposes of RCWP cost sharing. Other benefits such as reduced soil compaction and increased moisture-holding capacity make this BMP a critical element in any economically sound nutrient and soil management program. The deep, well-drained soils typical in the project area should provide equal crop yields compared with conventional tillage in normal years (Bepper, et al., 1981). Crop yields may actually be better for conservation-tilled land relative to conventionally tilled land in those years when rainfall is significantly below average. The only clear disadvantages are: 1) the capital outlays required to convert tillage equipment; 2) the possibility of increased reliance on herbicides to control weed problems normally controlled by deep tillage; 3) conservation tillage, especially no-till, has been found to require greater fertilization to attain equal yields (although this may not be a major concern for many farmers who have considered or are using conservation tillage. The use of herbicides that are incorporated into the soil during tillage or planting, combined with the reduced runoff associated with conservation tillage. The use of herbicides that are incorporated into the soil during tillage or planting, combined with the reduced runoff associated with conservation tillage, may help to alleviate the latter problem.

Permanent vegetative cover will obviously control a number of pollutant problems, but should only be considered in critical areas due to its high cost to both farmers and government (50 percent cost sharing is provided). Other nonstructural practices include residue management, stripcropping, and contouring. It has been assumed in the RCWP project area that farmers' costs are the same with contouring and stripcropping (largely due to protection of agricultural productivity) as they are for conventional practices once the strips and contours have been

Table 18. Net Returns, Livestock Numbers, Alfalfa Acreage, Environmental Losses for Various Storage/application Systems, Varying Nitrogen Loss Constraints for a 60-acre Farm in the Conescoga Headwaters RCWP Project Area.

System	Percent reduction	Net returns	Reduction from optimum	Cows	Alfalfa (acres)	Soil loss (tons/acre)	Phosphorus loss (lbs/acre)
Daily spread	0	18,600	---	45	12	7.15	17.45
Daily spread	10	18,325	275	45	13.8[a]	6.72	14.42
Daily spread	30	14,598	4,002	38.9	28.8	4.64	9.89
Daily spread	50	9,349	9,251	32.8	42	2.67	5.21
Uncovered solid	0	17,923	---	45	12	7.15	16.84
Uncovered solid	10	17,923	---	45	12	7.15	16.84
Uncovered solid	30	16,370	1,553	42.2	17.8	6.17	12.16
Uncovered solid	50	11,526	7,074	33.4	28.5	4.47	6.98
6-month liquid	0	19,354	---	45	12	7.15	17.24
6-month liquid	10	18,629	725	45	17.5	6.18	13.38
6-month liquid	30	14,015	5,339	35.9	24.0	5.07	9.04
6-month liquid	50	7,408	11,946	28.0	36.4	3.28	6.05
12-month liquid	0	17,874	---	45	12	7.15	17.03
12-month liquid	10	17,874	---	45	12	7.15	16.95
12-month liquid	30	14,554	3,319	38.3	12	6.80	13.10
12-month liquid	50	9,904	7,969	29.2	30.4	4.21	7.55
12-month liquid [b]	0	17,488	---	45	12	7.15	16.29
12-month liquid [b]	10	17,366	122	45	12	7.15	16.19
12-month liquid [b]	30	16,470	1,018	42.7	12	6.92	14.05
12-month liquid [b]	50	10,898	6,590	32	15.8	6.04	9.13

[a]Three year stands of alfalfa vs. four year.

[b] Injected

Table 19. The Costs and Effectiveness of Conservation Practices for Continuous Corn Silage with Daily Spread on a 5 Percent Slope, 20 Tons Manure Per Acre for the Conestoga Headwaters RCWP Project.

Conservation Practice	Estimated Cost Per Unit	Percent soil Saved Per Acre	Percent Nitrogen in Surface Runoff Saved	Percent Total Nitrogen Saved	Percent Total Phosphorus Saved
Conventional Practices	N/C	---	---	---	---
Permanent Vegetative Cover	$120/Ac	95	87	45	91
Contour Strip-cropping	N/C	39	30[b]	18[b]	33[b]
Winter Cover and Residue Management	$20/Ac (annually)	14	11[b]	8[b]	13[b]
Chisel Plowing/ Reduced Tillage	N/C	44	34	20	37
No-till	N/C	68	50	38	54
Terrace System	$1.60/Ft. ($375/Ac)	72	56	32	62
Diversion System with 20-ft. Wide Grass Filter Strip	$1.00/Ft.	43[a]	42[b]	24[b]	46[b]
Stream Protection System	$ .25/Ft.	NA	NA	NA	NA
Sod Waterway System	$1.75/Ft.	64	49[b]	29[b]	52[b]
Reduced Tillage with terraces, contouring, stripcropping, residue management, and sod waterway	$425/Ac	89	78	43	82

[a] Source: USDA/ASCS, 1983 (1980 prices).
[b] Estimated based on soil loss and CREAMS estimates associated with other BMPs.

established. Inasmuch as farmers, who have signed contracts with no cost sharing, have adopted these two practices, they are both cost effective since their assumed annual cost is zero; i.e. benefits to farmers are perceived as matching the costs.

Structural practices are not applied on a "per acre" basis and are slightly more difficult to evaluate. However, they are more expensive than nonstructural practices, with the exception of permanent vegetative cover. The stream protection system, or livestock fence, is designed to keep livestock out of the stream and thus from adding nutrients directly to waterway. Savings of nitrogen, phosphorus, and fecal coliform bacteria from fences would depend on the number of animals and could be substantial.

Other practices include terraces, diversions, and sod waterways. Examining the costs of the three systems, it is evident that terraces are much more expensive. Estimated costs per acre for terraces are based on examination of contracts in the project . However, terraces do retain nutrients and soil more uniformly throughout the field, and are effective in those cases where a great deal of control is needed in addition to those obtained through nonstructural practices.

Practices which reduce runoff on the field also conserve valuable nutrients for crop production. For example, looking at Table 19, the full set of BMPs modeled for continuous corn silage can be installed at a one time cost of $425 per acre (which has a life of 10 years with proper maintenance). At 20 tons of manure per acre per year, 36 pounds of nitrogen per acre could be saved each year at a value of $10.00 ($0.28/lb. N), plus the savings of phosphorus, potash, and organic matter. Without the cost of expensive structural practices, particularly terraces, the benefits of nutrient and organic matter retention on the field may outweigh the costs of the practices. Reduced tillage, for example, saves 23 pounds total nitrogen and 11 pounds phosphorus per acre per year when manure is applied at 30 tons per acre.

WATER QUALITY DATA ANALYSIS

Summary of Project Results

The water quality results from the project to date have come primarily from the Zimmerman farm, 22 acre experimental site with some additional results from the Little Conestoga 3700 acre watershed. All of the water quality results should be considered as pre-BMP implementation. However, the documentation of spatial and temporal trends as well as the coincidence of land activities with observed water quality responses lend considerable insight into the potential effects of BMPs in the watershed.

Listed below are some of the major observations that the project monitoring personnel have reported. These observations are then discussed in more detail in relation to interpretation and implications for RCWP program goals. We also present some of our own analysis and interpretation of the water quality data.

1. Of the 43 wells in the regional network 67 percent in the carbonate areas exceeded 10mg/l. nitrate, while 27 percent in non-carbonate area exceeded the standard. This trend persisted throughout the year with somewhat higher mean concentrations during the summer.

2. Most of the nitrogen transported in surface waters is in the nitrate form during baseflow periods but organic nitrogen predominates during storm flow.

3. The water levels in field site monitoring wells (carbonate area) respond quickly (i.e. days) to major precipitation events.

4. Suspended sediment runoff concentrations were lowest during frozen ground and maximum crop cover conditions.

5. The highest surface runoff nitrogen concentrations were observed during snowmelt where the water-manure contact time was longer.

6. Groundwater nitrate levels at the field site respond rapidly to the combination of manure application and precipitation.

Our own analyses of the project's raw data corroborate these findings. As will be discussed subsequently each of these results has important implications relating to the effects of BMPs and the potential for the project to address its water resource impairments. Our analysis of the water quality data indicates some qualification of results #3, #5 and #6. In regard to # 3 it should be noted that the field site wells not only respond quickly to precipitation events but also show large rises in water table levels relative to the amount of precipitation. For instance, a one-inch infiltration appears to raise the water table by about a foot. This indicates a porosity of the groundwater aquifer of less than 0.1. This would be a common value in many areas but is significantly lower than we would have expected for this karst topography which clearly has a preponderance of direct infiltration routes.

The projects' analysis and interpretation of results #5 and #6, while correctly indentifying trends and causal factors related to groundwater nitrate levels, give the somewhat misleading impression that groundwater nitrate levels show a large response to precipitation, snow-melt and manure application patterns. While the trends summarized in # 5 and # 6 are evident, these results should be placed into the context that the groundwater nitrate concentrations at the field site are actually fairly constant, and the responses to precipitation and manure spreading are relatively small. For the site analyzed most thoroughly the total range of nitrate concentrations was only 5-18 mg/l and 80 percent of the observations fell between 10.0 and

16.0 mg/l. It would have been easy for the project to have dismissed this data as showing no trends or causal relationships, so it is to their credit that they performed the level of analysis needed to show that concentrations increased following manure spreading combined with precipitation events. However, the implication of our analysis is that a substantial period with no additional manure application would probably be required for nitrate levels to flush to a significantly lower level.

The project has also attempted to develop a regression equation which relates nitrate concentration to manure application and precipitation. The purpose of the equation is to enable prediction of future (post-BMP) nitrate concentrations. The regression equation developed: $NO3 = 0.035$ Manure Load $- 0.073$ water level rise $+ 9.995$, while generating results of the same general trend as observed results, is probably not the best regression equation to explain the effects of these two variables on nitrate levels. First, the statistical equation indicates that water level change has a negligible effect. Second, the effect of recent manure applications appears to be underestimated. One reason for this may be the use of the previous 120 day period for calculating manure application. A shorter period would probably provide a better predictive equation. Also, a temporal staggering of water level and nitrate level would appear to explain better the relationship of these two variables.

PROJECTIONS

A number of interpretations of the present water quality data and projections to the future effects of BMPs can be made. Some of these have already been postulated by the project water quality monitoring personnel. The following includes some specific BMP projections based on the observed water qualit, results to date. For the most part these are fairly similar to the projections developed by ERS through the use of the CREAMS model.

1) Terraces

Terracing will greatly increase the time of contact between applied manure and precipitation which infiltrates the soil. This will increase the nitrate concentrations of infiltrating water. In addition a slightly larger percentage of precipitation will reach groundwater. The combined effect is an increase on groundwater nitrate concentrations. The terraces would be expected to increase dissolved nutrient concentrations in surface runoff but somewhat decrease total surface nutrient losses. Sediment loads would be reduced significantly (70-80%).

2) Animal Waste Management

The pre-BMP management strategy is to spread manure daily when field conditions permit. Generally this means that no spreading is done during June, July and

August when corn is in the field. The animal waste BMP involves 6 month open storage so that manure is applied when crops can make maximum use of the nutrient (i.e. May for field crops and September for cover crops).

The projected effect is that ground and surface water nitrate concentrations would increase over present values for the periods following application and would be lower the rest of the year. Hence, it is probably the range of values which will be most affected. The loss of nutrients to water sources would be reduced by more timely plant uptake, but this would be counteracted by the increased nutrient content of stored versus daily-spread manure.

3) Nutrient Management

We see nutrient management in this project as having four basic components:

a) Soil and manure testing to insure that no unnecessary chemical fertilizer is used.

b) Growing crops which use rather than fix nitrogen (i.e. corn).

c) Applying manure nutrients when they can best be used by the crop.

d) Exporting manure where nutrient supply greatly exceeds crop needs.

The nutrient management BMP is projected to greatly reduce both surface and groundwater nutrient concentrations. Fluctuations would still be observed as a function of application dates and precipitation events. However, the mean concentration and the frequency of nitrate values greater than 10mg/l would be reduced. We estimate that the reduction would be greater than the percentage reduction in nutrients applied because of a closer match of application and plant usage rates.

Pesticides Considerable monitoring for herbicides in surface and groundwater is being conducted in the project. Some analysis and interpretation of this data has been done by the project including tabular and graphic presentations of the concentration data.

Our inspections and analysis of the data reveal the following information relevant to pesticide surface and groundwater transport in the project area.

1. Herbicide concentrations in groundwater at the field sites rise to barely above detectable levels following application.

2. Herbicide concentrations in groundwater throughout the pro-

ject area are surprisingly low (generally less than 1 ug/l) given the amount of usage and the karst topography.

3. Herbicide concentrations in stream baseflow are also very low (less than 1 ug/l) but show small though clear increases during the summer months.

4. Moderate concentrations of alachlor (2-5 ug/l), atrazine(7-17 ug/l), cyanazine (7-16ug/l) and metolachlor (1-18ug/l) were observed during a storm event in the Little Conestoga basin following spring herbicide application.

5. High concentrations (greater than 50 ug/l) were observed in surface runoff from the field site during first runoff event following application. Elevated concentrations appear to persist for about 2-3 months following application.

6. The surface water pesticide data from the Little Conestoga Basin strongly suggest that there is another source of herbicide input beside field application (elevated concentrations year-round and consistent observation of elevated levels of herbicides no longer in common use). Further investigation revealed the presence of a pesticide disposal area in the upper part of the watershed. Further investigation of the impacts of this source are underway.

IMPLICATIONS

It is possible, although unlikely, that nutrient management and other BMPs will be implemented to an extent sufficient to significantly reduce area-wide surface and groundwater pollutant loads within the project timeframe. However, since it has been shown that shallow groundwater is recharged by the land area immediately (with a few hundred feet) up-gradient, BMP groundwater relationships for the project can be established with relative accuracy from the field sites.

Thus, at this point it appears that the projects' primary contributions to overall BMP water quality understanding will come from the field sites and possibly from the 3700 acre small watershed site. Relevant information from the overall project will probably relate primarily to economic, social and institutional factors which affect the success of the voluntary project approach. These contributions are summarized below:

1. To gain farmer participation and to select appropriate BMPs and critical areas a project needs to decide early on which water resource impairment is to be given top priority. This is particularly true when both groundwater and surface water impairments exist. All subsequent project activities need to be consistent with this decision.

2. A 50 percent cost-share rate for animal waste management structures will probably be inadequate to gain farmer participation in areas with excess manurial nutrients.

3. Land conservation contracts which are developed to meet 'T' may not be a cost-efficient method of meeting surface or groundwater quality goals.

4. There may be inherent trade-offs between BMPs designed to improve surface water and groundwater quality.

5. In an area where subsurface flow re-emerges as stream baseflow, BMPs which reduce surface runoff losses of nitrogen will generally increase stream baseflow nitrogen loads proportionately.

6. The project illustrates what may be a very common situation which is that pesticide disposal practices and sites constitute at least as great a source of pesticides as field applications.

7. The application timing advantages provided by manure storage versus daily spreading are partially or completely nullified by increased manurial nutrient availability.

8. Groundwater nitrate concentrations from the field site increased significantly in response to periodic manure applications.

9. Precipitation infiltration, which raises the water table, can have either an increasing or decreasing effect on groundwater nitrate concentrations depending on the time interval since manure application and on the quantity of manure applied. A common situation observed at the field site is that precipitation first has a diluting effect on nitrates. However, as slower percolating water, which has had longer soil nutrient contact time, reaches the water table, nitrate concentrations increase.

10. Used properly as a BMP, nutrient management reduces nitrogen inputs to both surface and groundwater.

Oakwood Lakes - Poinsett, South Dakota

RCWP 20

INTRODUCTION

Background

The Oakwood Lakes - Poinsett RCWP is a 106,000-acre project located in the glacial lakes region of east central South Dakota. The project area includes about 80 percent crop and grass land with the balance state/federal lands or lakes. Area soils are a mix of relatively impermeable till and less interspersed with highly permeable areas of sand and grav l outwash. Use impairments have been documented for groundwater affected by excessive nitrate levels and for eutrophic recreational lakes that receive excessive plant nutrients and sediment. Both impairments have been attributed to loss of soil and fertilizer nutrients from cropland and grasslands.

The impaired surface waters of the project include three large lakes and a number of smaller lakes. The lakes are generally shallow, average depth from 4 to 10 feet. The three largest lakes are Lake Poinsett, 7,868 acres draining 32,452 acres (83 percent cropland), Oakwood Lake, 2,184 acres draining 52,856 acres (50% cropland), and Lake Albert, 2400 acres, within the drainage of Lake Poinsett. Average depth of Lake Albert is only 4 feet. These lakes have very high recreational value which is impaired primarily by eutrophication.

Perspectives of the Project

Because this project has both documented groundwater and surface water impairments, there are four general questions to be answered analytically:

1. What BMPs are most cost-effective for reducing the impairment of groundwater by agricultural activity?

2. What BMPs are most cost-effective for reducing the impairment of surface water by agricultural activity?

3. To what extent do BMPs designed to protect surface water exacerbate groundwater impairments?

4. What will be the economic benefits from reduced water quality impairment and how can these be achieved most efficiently?

To date, the project has developed a monitoring program to investigate the impact of agricultural management on groundwater but has not monitored surface water. Therefore, there has been

no contribution from this project toward the answers to questions 2 or 3. A monitoring effort to evaluate the overall effectiveness of the RCWP in reducing the impairment of the water resources has not been attempted because there are no continuous streams in the project area, and the subsurface hydrology is very complex. Specifically, the interconnections of the surficial sand and gravel aquifers with the major groundwater resource of the area, the Big Soux aquifer, or with the lakes, are generally unknown.

Project monitoring efforts have concentrated on evaluating the relative effectiveness of management practices in reducing nitrate and pesticide leaching.

Specific questions addressed by monitoring include:

1. Do conservation tillage (no till or chisel plowing) reduce the downward flux of nitrate-N?

2. Does residue management affect the nitrogen content of the soil profile through denitrification, leaching, or crop uptake?

3. Does the quality of groundwater beneath agricultural lands with conservation tillage or fertilizer and pesticide management differ from that of areas with conventional farming practices?

4. What is the relationship between soil characteristics (glacial till or sand and gravel outwash) and groundwater quality under alternative agricultural management practices?

5. Is the quality of groundwater beneath agricultural land different from that of a control area where there has never been any agricultural activity?

Operationally, the monitoring component of the project is investigating whether or not agricultural BMPs can prevent nitrate and pesticide contamination of groundwater. Plans have been developed to install runoff gaging and sampling devices at each groundwater monitoring site to look at trade-offs between protection of surface and subsurface waters, but these plans have not been implemented. Although the land treatment component of the project is concerned with reducing sediment and nutrient transport to the lakes, no clear experiment has been developed to demonstrate this type of effect.

Land Treatment Strategy

Before the project was initiated, 52 percent of the crop and grassland was considered adequately treated for erosion. Therefore, the focus of the RCWP land treatment effort has been on reducing the contamination of groundwater by fertilizer nitrogen and preventing their contamination by pesticides. Because the surficial aquifer occurs irregularly throughout the project area,

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