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Project Summary

On-Farm Improvements to Reduce Sediment and Nutrients in Irrigation Return Flow

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Research on an 800-hectare irrigated tract consisting of a hydrologic subbasin with well-defined surface drainage covered five complete irrigation seasons (1977-81). This predominantly furrow-irrigated area was located within central Washington's Columbia Basin Project. The cooperative research project studied the effects of on-farm improvements to reduce the discharge of sediment and nutrients (nitrogen and phosphorus) from the tract via irrigation return flow. Both technical and financial (cost-sharing of construction) help were given to the participating farmers. Between the 1978 and 1979 irrigation seasons, facilities on various farms were constructed with the grant providing 70 percent (up to a pre-determined maximum amount) and the farmer providing 30 percent (plus any excess above the pre-determined maximum) of the costs. A goal of about $125 per hectare benefited was set as a maximum cost share to be provided by research grant funds. The constructed facilities included pipes to convey center pivot overflow and furrow tailwater to improved drains, sediment basins, sediment mini-basins, concrete lining of head ditches, gated pipe systems, and conversion of furrow-irrigated land to sprinkler (both center pivot and solid set). Approximately $70,000 of grant funds were spent on cost-sharing of construction.

Results showed that construction of proper sediment control facilities on furrow-irrigated farms greatly reduced the discharge of sediment from the overall tract. The 3-year average sediment discharge from the area after construction of on-farm improvements was about twenty percent of the 2-year average discharge before construction. The irrigation return flows decreased about three percent following construction.

While reductions in phosphorus loss were significant, results showed that measures which controlled sediment loss were not equally effective in controlling phosphorus loss. The 3-year average phosphorus discharge after construction was 51 percent of the 2-year average before construction. The difference in effectiveness of control measures for sediment and phosphorus was attributed to the association of phosphorus with clay-sized sediment particles which are not easily settled once they become suspended in irrigation tailwater. End-of-field sediment/phosphorus ratios were often about 1,500 whereas these ratios for water in the main drain leaving the entire study area were only about half this value.

The project activities had little effect upon the discharge of nitrogen from this irrigated tract during the period of study. A considerable part of the area was served by subsurface drainage systems, which discharged into the main surface drain through the area. The water from the surface and subsurface sources was comingled in the main drain as it left the irrigated tract. Discharge of nitrogen was about 20 to 30 kg per hectare per year during the study period.

Techniques were devised to reasonably separate the effects of ashfall

deposited into the study area by the May 18, 1980 eruption of Mount St. Helens from the effects of research project activities related to sediment and phosphorus discharges. The effects of the ashfall were mainly confined to a two-week period immediately following the eruption.

Results presented in this report address the problems of sediment and nutrient discharges on three basic levels: individual furrows, individual fields, and the total 800-hectare study area. Models are presented which deal with sediment loss, nitrogen loss and economic motivation for BMP adoption.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Irrigation return flow (i.e., water which returns to streams and rivers after being diverted and applied to the land as irrigation) can carry many substances classified as pollutants. In the Pacific Northwest, some of the major pollutants in irrigation return flow have been identified as sediment, nitrates, nematodes, phosphorus (attached to sediment), bacteria, and increased temperature. In regulations promulgated pursuant to PL 92-500 much of the irrigation return flow was classified as point sources. For a point source discharge, a "National Pollutant Discharge Elimination System" (NPDES) permit was required by PL 92-500. The State of Washington Department of Ecology (DOE) was authorized by the U.S. Environmental Protection Agency (EPA) to issue NPDES permits for discharges into the waters within the jurisdiction of the State. By late 1974, the DOE was well underway with the development of a permit program. During the development of this program, it became apparent that the greatest reduction of total sediment in irrigation return flow would be realized by change of practices on the individual farms. Once the return water reaches a common drain, opportunities for sediment removal are considerably restricted.

Because of court action, the DOE (in State of Washington) did not issue any of the irrigation return flow permits which were being prepared. Instead, a cooperative program to improve farming practices in order to reduce the sediment delivered to the Yakima River via irrigation return flow was begun. This program identified the Sulphur Creek drainage near Sunnyside, Washington, as a problem area which should receive high priority. In 1975, the Sulphur Creek Demonstration Project was started. By the end of the 1976 irrigation season, it was evident that this site had many characteristics making it unsuitable for obtaining the desired information to fully evaluate the benefits of on-farm changes in reducing sediment discharge to the Yakima River via irrigation return flow. A smaller, more compact, drainage with well-defined hydrologic boundaries having fewer sources of inflow and points of discharge was needed. Farmer participation had not been as great in the Sulphur Creek project as had been anticipated and those farmers who were participating were widely scattered throughout the drainage. Incentives for participation apparently had not been large enough.

Selection of a site for the work reported herein began in late 1976. It was decided that the greatest benefit to the State could be achieved by locating the study area within the Columbia Basin rather than the Yakima Valley. A site within the Columbia Basin would allow the project to be separated from the Sulphur Creek activities. By such separation the public would not likely be confused by the different approaches of the two studies. Criteria for selection of this site were the following:

A. Primarily surface irrigated
B. Existing sediment problems in irrigation return flow
C. Single discharge point for return flow
D. Approximately 800 hectare
E. Well defined drainage system for surface flows
F. Several farmers
G. Range of crops
H. Range of slops
I. Soils typical of much of the Columbia Basin
J. Indications of farmers' willingness to participate in the study.

In the fall of 1976, the principal investigator met with personnel of the three Columbia Basin irrigation districts, (Quincy Columbia Basin Irrigation District [QCBID], East Columbia Basin Irrigation District [ECBID], and South Columbia Basin Irrigation District [SCBID]; with the help of the directors and district personnel two alternate sites were selected. Careful review of the sites indicated that one site was clearly superior to the other in light of the foregoing criteria. In early 1977, the study site was selected in Block 86 on the Royal Slope west of Othello, Washington. The site lies within the QCBID and Grant County. The Geological Survey (USGS), the Bureau of Reclamation (USBR), and the three Columbia Basin irrigation districts agreed to monitor the irrigation supply and drainage of the study area during the 1977 irrigation season to obtain background data prior to the start of the research project. This monitoring continued throughout the duration of the project under joint funding by DOE, USGS and USBR.

In the project, both technical and financial help was given to the individual farmers for on-farm improvements to reduce sediment and nutrients leaving their farms in irrigation return flow. The first year of the project (the 1978 irrigation season) was spent analyzing the operation of all the farms in the study area, gathering data needed before changes were made. Design proceeded as soon as possible to allow for construction of necessary structures prior to the start of the 1979 irrigation season.

Since farmers were to be provided financial help in construction of facilities, participation was expected to be high. The goal was to have all farmers in the study area participating in the project. The response of the farmers to the project at an information meeting held March 8, 1977 indicated that this goal was attainable. The on-farm facilities were constructed under a cost-sharing arrangement. The research grant provided 70 percent of the cost of capital improvements up to a maximum amount. The farmer provided the other 30 percent and all costs exceeding the amount agreed upon prior to the start of construction. A goal of about $125 per hectare benefited was set as a maximum cost share to be provided by the research grant funds.

In 1977, the U.S. Congress passed PL 95-217 which expressly placed irrigation return flow under Section 208 and removed it from Section 402, NPDES permits, of PL 92-500. The planning activities under Section 208 in Washington resulted in a program of voluntary farmer participation to reduce sediment carried by irrigation return flows.

Objectives

The overall goal of this project was to assist in developing and implementing a program for reducing the negative impacts of irrigation return flows on water quality. It was recognized that reduction of pollution from these sources is most effectively achieved by improvement of farming practices on individual farms. It was anticipated that the farming practices to be studied under this project would include the best management practices (BMPs) then being developed by the local water quality committee involved in the 208 planning process for irrigated agriculture. Implementation of the 208 plans for irrigated agriculture was a significant component of this research project.

\ second general goal of this project was ɪelect a study area in which a high degree ɔarticipation by the farmer and significant ınges of farming practices could be ıieved.

ʒecause of the importance of this work the local area and to the state, another al was the timely dissemination of infor-ation via county extension agents, periodic ıeetings with the three Columbia Basin irgation districts and conservation districts, nd annual field days at the study site.

ʒesults and Conclusions

A cost-sharing program was established or the Block 86 study area to provide a neans of constructing facilities on the paricipating farmer's land. Full ownership of ıese facilities rests with the land owner. The ːost share contributed by the research grant vas viewed as an incentive for the farmer's ıarticipation and an aid to provide facilities ıecessary for the research work. All facilities vere designed by the faculty members of Vashington State University who were ıssociated with the research project. The onarm facilities included buried pipelines, ːoncrete-lined head ditches, gated pipe ·ystems, sprinkler systems (both center-ɔivot and solid-set), and sediment basins. A otal of $69,825 of research grant funds were ịpent on cost-sharing for construction of onarm facilities. Since certain areas received ɔenefit from more than one of the facilities, ı cost per hectare directly benefited is dificult to obtain. Data were collected from hroughout the study area each year in order o evaluate the magnitude of pollution from rrigation return flows. These included samɔling of: (1) losses from the study area at the nain drains, (2) losses from individual fields, ınd (3) losses from individual furrows.

The results of this research project show hat effective reduction of sediment disːharge from individual fields and from the otal study area was accomplished by conꜱtruction of on-farm facilities. The 3-year ıverage sediment discharge from the area ıfter construction of on-farm improvements vas about 20 percent of the 2-year average ɟischarge before construction. The irrigation eturn flows decreased only about three perːent following construction.

Funds provided for construction of onarm facilities averaged less than 90 dollars ɔer hectare benefited. It is extremely difficult o assess the value of total project activities nd visibility of professional people in acomplishing the observed reduction of sediıent discharge. Expenditures of similar apital construction assistance in different reas in absence of these other activities may ır may not produce the same effects.

Sediment basins were the most successful of measures used in this study for reducing sediment discharge from irrigated fields. Sediment basins constructed by farmers without technical assistance usually do not have sufficient capacity to trap sediment for a complete irrigation season. In 1981, the sediment basins removed from 53 to 85 percent of all incoming sediments with an average of 66 percent. When a single undersized basin was used to attempt to retain sediment in tailwater from several farm units, the basin filled completely after only two irrigations.

Certain problem situations, such as steep tailwater collection ditches and lack of a conveyance channel adequate for sprinkler pond overflows, were successfully corrected in the study area. Check dams were used in the steep ditches and the overflow from center pivots was piped to an improved open drain.

Reduction of sediment discharge should not be equilibrated with reduction of erosion. Properly designed and maintained sediment basins will reduce sediment discharge while on-field erosion may continue unchecked. On one particular field in the study area, the soil surface elevation at the head of the field had dropped nearly one meter since irrigation began in the 1950's.

Reduction of sediment discharge does not necessarily accomplish reduction of phosphorus discharge. Once the soil particles have been suspended in the water, normal settling will be more effective in removing sediment than phosphorus because of the association of phosphorus with clay-sized sediment particles which are not easily settled once they become suspended in irrigation tailwater. The 3-year average phosphorus discharge from the total study area after construction of on-farm improvements was 51 percent of the 2-year average before construction. End-of-field sediment/phosphorus ratios were often about 1,500 whereas these ratios for water in the main drain leaving the entire study area were only about half this value.

Nitrogen discharge from an irrigated area is not subject to effective control by practices used for this research project. Modeling results indicated that considerable time may be required to observe any change in nitrogen discharge as a result of a practice change. Measured nitrogen discharge from the total study area was not affected by project activities during the period of study. A considerable part of the area was served by subsurface drainage systems which discharged into the main surface drain through the area. The water from surface and subsurface sources was comingled in the main drain as it left the irrigated tract. Discharge of nitrogen was about 20 to 30 kg per hectare per year during the study period.

The ashfall deposited onto the study area by the May 18, 1980 eruption of Mount St. Helens did not invalidate the research findings. Techniques were developed and demonstrated to be successful for separating the effects of the ashfall in contrast to the effects of the research project activities upon the discharge of sediment and phosphorus from the area. The effects of the ashfall were mainly confined to a 2-week period immediately following the eruption.

The crop grown on a particular field has a significant effect on the sediment loss. Row crops such as sugar beets, beans, and corn produce much more sediment than close-growing crops such as wheat.

Scheduling of irrigation has an effect on the seasonal sediment loss from a field. Studies showed that reducing the number of irrigations on beans could reduce the total sediment loss for the season without lowering the yield.

Use of methods to control the stream size in individual furrows can reduce sediment in tailwater. There is a definite need for automated or semi-automated furrow irrigation systems. Cutback irrigation practices are effective in reducing sediment, but are not very popular with farmers because of large labor requirements with irrigation systems presently on the farms.

The Imhoff cone, using a 15-minute settling time, was tested as a device for measuring suspended sediment in irrigation tailwater. For sandy loam and loamy sand soil textures, the Imhoff cone reading correlated well with suspended sediment concentration measured with standard methods. These two textures account for approximately 31 percent of the land in Washington which is furrow irrigated. Another 62 percent of furrow-irrigated land is silt loam and loam. Use of the Imhoff cone may be acceptable for these textures. Perhaps the best use of the Imhoff cone for irrigated agriculture would be as a tool for comparing the relative effectiveness of various practices in reducing sediment loss from a given field. Such use should be beneficial as an evaluation aid to a farmer, and to personnel of conservation or irrigation districts. The Imhoff cone should not be used as a regulatory standard.

Working models were developed to describe the nitrogen movement and loss from furrow-irrigated land and to describe the discharge of sediment from individual irrigation furrows. The models are researchers' tools and are not yet ready for more widespread use.

Economic modeling demonstrated the importance of tax considerations in motivating

BMP adoption. Immediate attention should be given to existing institutions and programs that provide some incentive to adopt pollution abatement technologies. A program of variable incentives depending upon farm size and debt/equity position would be the most efficient expenditure of funds to produce the adoption of BMPs.

Recommendations

Incentive programs must recognize the need to reduce the on-field erosion as well as sediment discharge for furrow-irrigated land. Sediment basins should be used in conjunction with improved water management. A full program of the farmer's assistance is necessary to obtain use of proper water management primarily including appropriate furrow stream size, irrigation set time, and length of run. Development of systems for automation or semi-automation of furrow-irrigation will greatly assist efforts to obtain adoption of the changes in on-farm water management needed for effective control of on-field erosion and of sediment and phosphorus discharge. Development of these systems should receive federal and state support.

Incentive programs must also address the after-tax determination of cost effectiveness of control measures. The findings of this research support a program of variable incentives depending upon farm size and debt/equity position of the land owner.

Work should continue on model development of sediment discharge from individual furrows. This model should be used to study effects of better water management on field-wide and area-wide sediment losses. The model should be further developed to handle erosion and deposition of sediment along the furrow.

Farmers should be required to pipe center pivot sprinkler overflows to an acceptable improved drain, especially for new installation of center pivots. Steep tailwater ditches should be piped or have check dams installed. Technical assistance should be pr[illegible]vided to farmers for proper sizing and desi[illegible] of sediment basins.

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The complete report, entitled "On-Farm Improvements to Reduce Sediment and Nutrients in Irrigation Return Flow," (Order No. PB 84-155 217; Cost: $19.00, subject to change) will be available only from:
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