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AGRICULTURAL RETURN FLOW MANAGEMENT IN THE STATE OF WASHINGTON

A Case Study of the Yakima Basin

Prepared by CH_2M Hill

April 1975

PREFACE

This WRIS Technical Bulletin is the summary report of a study of methods of improving the quality of irrigation return flows. The study was done under contract to the Department of Ecology by CH_2M Hill Inc. A copy of the report may be reviewed in the following libraries:

State Library in Olympia

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AGRICULTURAL RETURN FLOW MANAGEMENT

IN THE

STATE OF WASHINGTON

SUMMARY REPORT

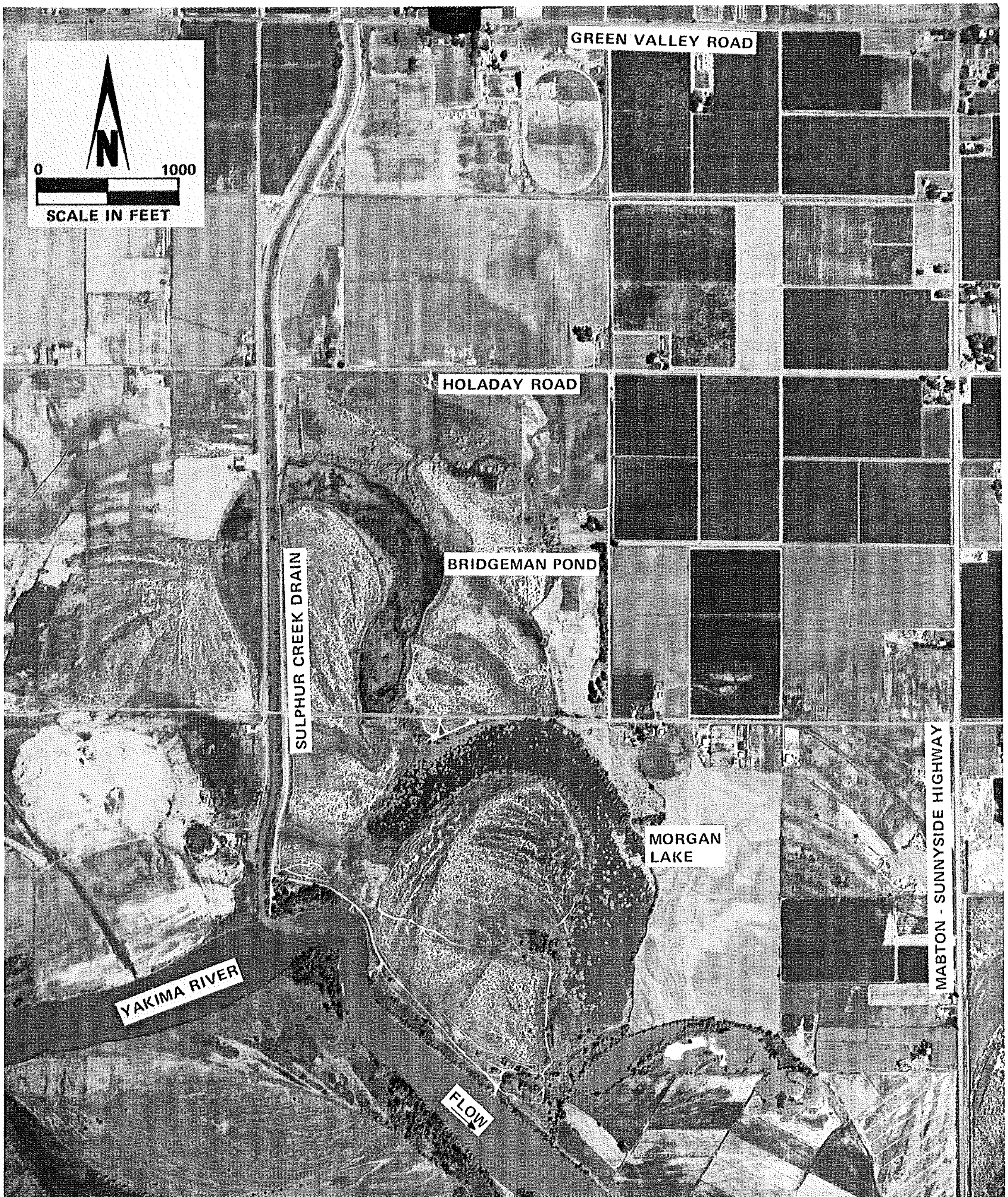
PREPARED FOR THE

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

BY

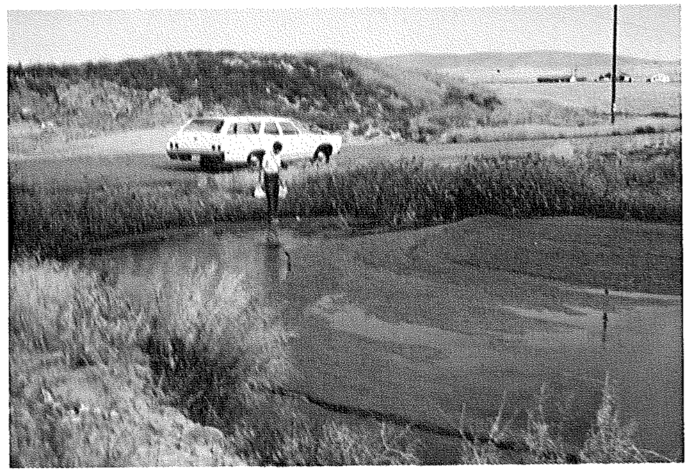
CH2M HILL

APRIL 1975



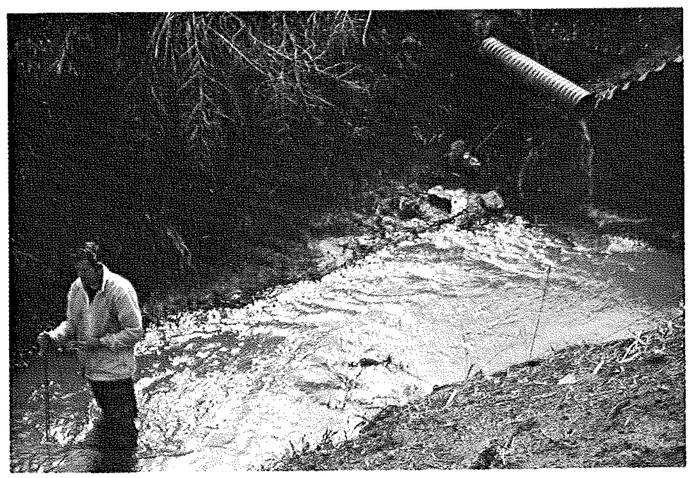
Aerial photograph of Sulphur Creek as it discharges to the Yakima River. The sediment laden Sulphur Creek water produces a visible plume as it mixes with the Yakima River water. Numerous ox bow lakes in the area could possibly be used for sediment removal and treatment of return flow. (Photo taken 24 July 1974)

1. Recirculation pond above Roza Canal at Scoon Road. Photo taken 26 June 1974, shows sediment delta forming at the head of the pond.



2. Same pond as in photo number 1, showing growth of sediment delta. Water level in pond (21 August 1974) is approximately 3 inches lower than in photo number 1.

3. Pump platform in same recirculation pond as shown in photo numbers 1 and 2. Alfalfa crop can not grow too near the pond due to high ground water.



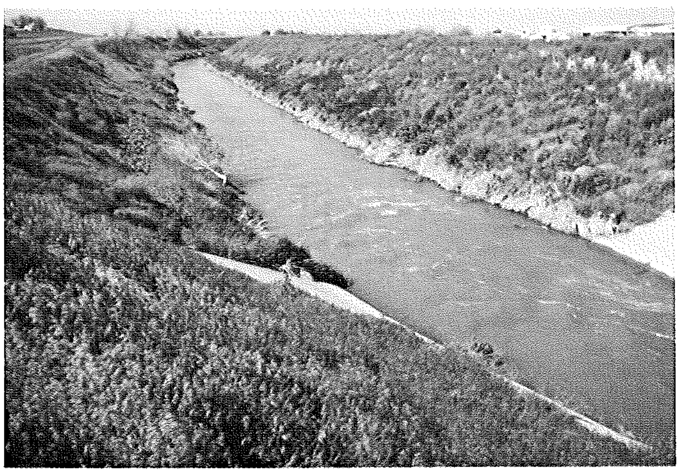
4. Stream flow measurement being made in Washout Drain near Allen Road. Note small discharge from adjacent field through metal pipe.

5. Livestock grazing near Sunnyside Canal. Animals have access to ponded water which was caused by surface runoff from over - irrigation.

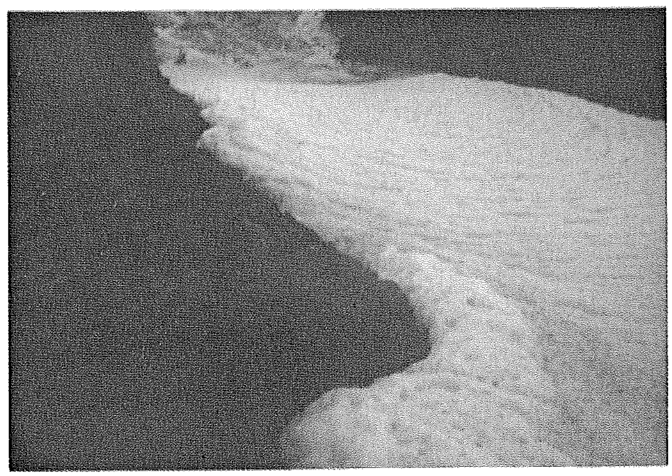
6. Livestock have access to agricultural drain, a common occurrence throughout the Yakima Basin.

7. Tailwater from alfalfa field shown in photo number 3. Sediment accumulation can be seen in the ponded water.

8. Tailwater ponded at the end of a hopyard.

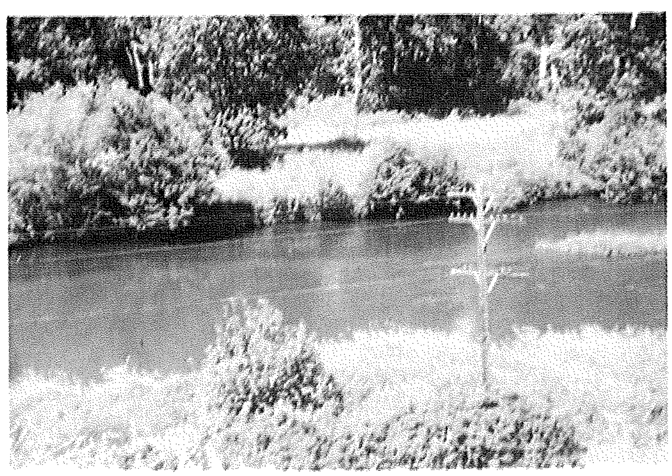


9. Sulphur Creek Drain looking downstream from Duffy Road.



10. Runoff originating in a dairy was the result of heavy rainfall. Foam was formed where runoff entered local drainage system.

11. DID 18 Drain discharging into Sulphur Creek as seen from Edison Road. As much as 60 tons of sediment per day can come from the 4 foot pipe at the flow rate pictured.



12. Wilson Creek discharging into the Yakima River. Note turbid Willson Creek Water (near side) and clear Yakima River water (far side).

SUMMARY

Significant improvements have recently been made in controlling and upgrading municipal and industrial waste treatment. With the enactment of Public Law 92-500 in October 1972, attention began to turn to controlling diffuse waste sources. Of special concern in eastern Washington are the wastes from irrigated agriculture, feed lots, dairies, and other agricultural-oriented activities.

The State of Washington's Department of Ecology (DOE) has accepted responsibility from the Environmental Protection Agency (EPA) for administering the National Pollutant Discharge Elimination System (NPDES). The NPDES permit program, created by Public Law 92-500, requires that certain dischargers obtain discharge permits. Application of the NPDES permit program to municipalities, industries, and some other activities is noncontroversial and is similar to the State permit program previously in effect. However, applying the permit program to agricultural activities is complicated due to the lack of information, effluent guidelines, and, particularly, an entity with the legal power to accept the responsibility for irrigation return flows.

In April 1974, the Department of Ecology contracted with CH2M HILL, Inc., to conduct a study with four general objectives:

1. Determine the relative contribution of point and nonpoint sources to water quality degradation in a predominantly agricultural area.

2. Determine alternative methods of reducing or eliminating the addition of wastes from these sources to surface water bodies.

3. Identify institutional constraints on applying the NPDES permit program to return flow management.

4. Recommend methods of applying the NPDES permit program to feed lot and irrigation return flows to result in improved instream water quality.

CH2M HILL conducted the study in three phases. The first phase was a detailed study of the Sulphur Creek Drainage, a subbasin within Washington's Yakima Basin. The second phase was a semidetailed study of the Sunnyside-Roza Area of the Bureau of Reclamation's Yakima Project. In the third phase, the results of the first two phases were applied to the entire Yakima Basin.

The results of this study, presented below, are in three general topics: Water Quality Considerations, Alternative Methods of Reducing Pollution, and Institutional Considerations.

WATER QUALITY CONSIDERATIONS

The effect of agricultural, municipal, and industrial activities on water quality was investigated through a detailed water quality sampling program, measuring flows in numerous drains, collecting quantity and quality data from various agencies, and field observations. During the basic water quality sampling program, samples were collected and analyzed twice-monthly from five stations on Sulphur Creek and from five stations on the major tributary drains. In addition, approximately 100 samples were collected from various basin locations. The data collected as a result of this sampling program are presented as part of the main report.

The U.S. Bureau of Reclamation, the U.S. Geological Survey, and the State DOE have conducted extensive water quality sampling programs. Results of these programs were used to estimate water quality conditions for other areas of the Yakima Basin. Water quality conditions for the major drains in the Yakima Basin are shown in table 1.

The distribution of irrigation water within the Yakima Basin is through many miles of main canals, and open canal and closed pipeline lateral systems, with mostly gravity diversions to individual farms. Onfarm applications are by flood or rill methods, sprinklers, and a few acres of drip irrigation. The main features of this system are shown on the attached folded map (figure 1).

Onfarm practices, as they affect water quality, range from excellent to poor. The most noticeable effects of farm practices are the large quantity of surface runoff with high concentrations of suspended soil particles. Though this problem was noted in many areas of the basin, it was most prevalent in steeper areas where rill irrigation was practiced. Virtually all water quality samples taken indicated that high phosphate levels occurred whenever high suspended

TABLE I

COMPARISON OF MAJOR DRAINS IN YAKIMA BASIN AVERAGE VALUES FOR 1974 IRRIGATION SEASON

MEASURED PARAMETERS		SULPHUR CREEK @ GREEN VALLEY RD.	GRANGER DRAIN @ HIGHWAY 223	SPRING CREEK @ HESS RD.	SNIPES CREEK @ OLD INLAND EMPIRE RD.	WILSON CREEK @ CANYON ROAD	WIDE HOLLOW CREEK @ WASHINGTON AVE.	MOXEE DRAIN @ BIRCHFIELD ROAD	SOUTH DR. @ HIGHWAY 22 NEAR SATUS	MARION DRAIN @ HIGHWAY 97
FLOW (cfs)		310	28	34	40	135	24	32	69	244
TEMPERATURE (°C)		13	15.2	16.5	16.8	13.0	14.6	16.8	14.9	13.3
DISSOLVED OXYGEN (MG/L)		10.0	6.8*	8.1*	8.0*	8.3	8.2	7.4	8.2	8.8
pH (UNITS)		7.6	7.7	7.8	7.8	7.8	8.0	7.7	7.8	7.6
CONDUCTIVITY (MICROMHOS/CM)		261	404	299	193	230	288	372	412	281
BACTERIA	TOTAL COLIFORM (COUNT/100 ML)	35,000	40,000*	1,700*	3,200*	6,500	1,800	-	-	-
	FECAL COLIFORM (COUNT/100 ML)	2,800	1,600*	660*	260*	770	160	-	-	-
COD (MG/L)		13	22	14	10	14	14	17	15	10
NITROGEN -N	$NO_3 + NO_2$ (MG/L)	1.80	1.64	1.23	0.25	0.38	0.65	0.81	1.68	2.30
	KJELDAHL (MG/L)	0.59	0.80	0.40	0.29	0.42	0.52	0.60	0.61	0.42
PHOSPHATE -P	ORTHO-P (MG/L)	0.15	0.18	0.06	0.03	0.09	0.09	0.16	0.10	0.08
	TOTAL P (MG/L)	0.45	0.54	0.25	0.16	0.15	0.12	0.40	0.22	0.13
SUSPENDED SOLIDS (MG/L)		229	157	87	84	20	13	134	48	20
TURBIDITY (J.T.U.)		73	42	32	27	7	3	30	17	8

* SAMPLES NOT TAKEN OVER WHOLE IRRIGATION SEASON

sediments were present. This is expected since phosphates attach themselves to soil particles. In some areas, the loss of phosphate could amount to over 40 pounds per acre a year.

A serious, but less obvious, problem is the increasing quantities of nitrogen added to the Yakima River. The increasing use of fertilizers has resulted in nearly five-fold increases in nitrate nitrogen in the lower Yakima River in the last 20 years. Unless this trend in reversed, further problems resulting from algal growth may become acute.

Surface runoff from irrigation averages about 25 to 40 percent of the water delivered to the farm for the Sulphur Creek drainage. Much greater amounts occur on the steeper-sloping lands. Problems with runoff and erosion are greatest when slopes exceed about 5 percent.

Approximately 35 to 40 percent of the return flows measured in the study area surface drains are derived from subsurface flows. The percentage is difficult to determine due to the widespread occurrence of subsurface return flows. However, in reviewing flow, nitrate, and dissolved solids data, it would appear that this percent is a good approximation. Flows in lower Sulphur Creek, for instance, dropped from about 250 cfs in August to about 100 cfs in November after irrigation ceased.

Subsurface flows, important because they are typically high in nitrates and dissolved salts, originate as water applied to a field in excess of the plant requirements. This excess is transmitted through the shallow ground water aquifer until it intercepts a drain, stream, or Sulphur Creek.

Nitrates and salts dissolve readily in water and are carried away with the subsurface flows. Estimates indicate that about 30 pounds per acre of nitrogen are discharged from Sulphur Creek each year. Since irrigators typically apply about 150 to 200 pounds of nitrogen fertilizer per acre annually, approximately 20 percent of this is unavailable to the plants.

In addition to being a loss to the farmer, the erosion of valuable topsoil causes other problems. Approximately $65,000 in spent annually clearing sediment from the various drains in the Sulphur Creek drainage. The sediments that remain suspended while water from Sulphur Creek is added to the Yakima River cause increased turbidity and poor aesthetics. The photograph attached at the back of the report shows the effect of Sulphur Creek on the Yakima River. Excessive concentrations of nitrates and phosphates lead to algal growth, particularly after these materials reach the slow-moving waters of the Yakima River. The algal growth and eventual die-off cause low dissolved oxygen levels in the Yakima River.

In summary, the main effects of agricultural activities are high suspended sediment, phosphate, and nitrate concentrations.

The effects of other activities--municipal, domestic, and industrial--are less significant on overall water quality, primarily because of the relative magnitude of flow from these sources. The quality of waters in the DID 3 drain, a major tributary of Sulphur Creek that passes through Sunnyside, is generally poorer than the other drains as measured by higher bacteria counts and oxygen demands. Other parameters compared favorably with the other drains.

The presence of high concentrations of bacteria appears to be widespread in the various drains in the Yakima Basin. Virtually every sample collected showed concentrations in excess of minimum State standards for streams. Based upon the relationship between fecal coliforms and fecal streptococci, it appears that bacteria present in most of the drains are of animal origin. The two drains passing through the city of Sunnyside, however, show indications of contamination of human origin. Total coliforms counts include soil bacteria and are not suggested to be a measure of bacterial contamination.

The operation of any irrigation system cannot be 100 percent efficient. Losses are incurred from operations, evaporation, seepage, etc. Once the water is delivered to the farm, losses occur due to surface runoff and deep percolation. Based upon the data collected and information received from the irrigation districts, operational spills and main canal and lateral losses average about 30 percent of the water diverted. Onfarm efficiencies average about 56 percent based upon the amount of water delivered at the farm headgate.

The efficiencies found result in an overall efficiency of about 40 percent from diversion to crop use. These efficiencies are comparable to those found in similar facilities in the West. Some improvements are possible through better management at little cost to irrigators or irrigation districts. Significant improvements in efficiencies will require substantial expenditures by both the irrigators and the districts.

ALTERNATIVE METHODS OF REDUCING POLLUTION

There are three general ways to improve water quality in an agricultural area. They are:

1. Improve onfarm practices to reduce pollutants added to return flows.

2. Improve distribution efficiencies to allow better use of available supplies.

3. Treat irrigation wastewaters prior to discharge to streams.

To implement these general approaches, several specific alternative methods of improving water quality in the major drains and in the Yakima River have been developed. For each alternative, identifiable capital and annual costs have been estimated, as well as water quality and economic benefits. In some cases, it is not possible to quantify all benefits because many results can only be measured as improvements in water and farm product quality, or ease of operations for the irrigation district. Many alternatives have a significant negative benefits. For example, increased energy is required for pumping stations to replace gravity methods of distributing water.

Based on relative costs and benefits, the alternative methods of reducing pollution fall into three categories, which are listed below. The following sections present alternatives within each category.

1. Those that should be implemented initially.

2. Those that should be implemented after the alternatives in the first category have been implemented and evaluated.

3. Those that do not appear to be beneficial to water quality, are uneconomical to implement, or with marginal water quality benefits but significant benefits to the farm operator.

Alternatives that could and should be implemented <u>initially</u> include:

1. Sprinkler systems should be considered by the farm operator to reduce erosion and runoff for irrigated lands on Yakima Basin slopes steeper than 5 percent.

2. Erosion-control facilities--such as sediment ponds, recirculation ponds, grassed ditches, and collector pipes--should be installed on all land not converted to sprinkler application to reduce the discharge of sediments from individual farms.

3. Where shown to be economical, facilities should be constructed to reuse irrigation return flows.

4. Improvements should be made to the present irrigation delivery systems that can minimize the wastage of water by operational spills.

The following alternatives should be investigated for feasibility <u>after</u> the above have been installed and their improvements assessed:

1. A settling and treatment pond should be constructed in the lower end of the Sulphur Creek drainage for the removal of sediments and nutrients prior to discharge to the Yakima River. Similar facilities could be evaluated for areas in the Wapato Project.

2. Implement modifications in the present delivery systems that will minimize water losses and reduce the diversion requirements for the main canals.

In most cases, large settling and treatment ponds would be an expensive way to improve water quality. However, because of a unique topographic situation at the mouth of Sulphur Creek and on the Wapato Project, this alternative may be suitable for early construction if a method of financing the construction and operation could be found.

The above suggested course of action recognize that the major problems in irrigation return flow are onfarm practices. Though the problems are widespread throughout the Yakima Basin, the major areas of concern are in the steeper portions where flood and rill irrigation is practiced. The implementation of better water application methods will have two major advantages. First, erosion can be controlled, which will reduce sediment deposition problems and the resulting removal of phosphates. Second, with better application methods, application rates should be lower, which should reduce the amount of water (and consequently nitrates) leached below the root zone.

It is unfortunate that the present water rights system does not encourage better management of our water resources. Though water shortages can occur in some years, the Yakima

Basin is basically assured of a firm water supply through its series of upstream reservoirs. Almost all of the alternative methods of reducing total water diversions will result in substantial costs to the irrigation districts and, eventually, the irrigators. Since the entire State of Washington will benefit from water quality improvements resulting from improving water management, ways for the State to share in the cost of implementing these alternatives should be considered. Referendum 27 funds, on a cost-sharing basis, are a distinct possibility. Extensive treatment systems may eventually be the only method of obtaining good quality water. However, there may be no equitable way to recover the high construction and operation costs involved in extensive treatment systems. Consequently, it is recommended that treatment systems be considered only <u>after</u> evaluating results of improved onfarm practices on water quality.

INSTITUTIONAL CONSIDERATIONS

An immediate concern to the Department of Ecology is the implementation of the NPDES permit program. Though the DOE is faced with a deadline for issuing permits, it is obvious that the problem will not be solved just because a permit is written. Therfore, several alternative courses of action are suggested for consideration.

The plan for implementing water quality improvements at the present time is based upon the issuance of a permit to irrigation districts. It is believed that this procedure is not an effective way of getting to the problem. We suggest that the Department of Ecology pursue a course of action with the following features:

1. Recognize that individual farm operations are the significant cause of pollution in irrigation return flows. The strategy should be geared to ways of improving onfarm practices. The initial emphasis should be on the small percentage of farmers responsible for the majority of the problems.

2. The irrigation districts must play a major role in seeking solutions to water quality problems by identifying problem areas, improving water deliveries, and encouraging better water management.

3. Statewide and regional advisory committees could be an effective way to assist the Department of Ecology in developing and implementing a pollution abatement program for irrigated agriculture.

4. The basic approach to improving water quality should be through an education program designed to assist individual farm operators. The Bureau of Reclamation, the Soil Conservation Service, and Washington State University have developed programs encouraging better onfarm water management.

5. Water quality monitoring should be continued and should be designed to measure long-term quality changes. Quantity measurements should be an integral part of all quality measurements.

This approach for improving water quality results in the Department of Ecology being the lead agency in pollution control from irrigated agriculture. The role of irrigation districts would be a slight expansion of their present roles as water suppliers. The technically-oriented agencies and organizations would be relied upon to provide help to the individual farmer. Advisory groups would assist the DOE in establishing a statewide plan and adapting it to all regions of the state.

FIGURE 1
IRRIGATION SYSTEMS IN THE YAKIMA RIVER BASIN