REPORT 75

IRRIGATION WATER USE EFFICIENCY DEMONSTRATION PROJECT. PHASE I: STATE-WIDE EVALUATION OF IRRIGATED AREAS

by

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State of Washington Department of Ecology
Agreement No. C0090043

December, 1989

STATE OF WASHINGTON
WATER RESEARCH CENTER
WASHINGTON STATE UNIVERSITY AND
THE UNIVERSITY OF WASHINGTON
Pullman, Washington 99164-3002

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PHASE 1: STATE-WIDE EVALUATION OF IRRIGATED AREAS

by

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Abstract

Results of the first phase of a three-phase project to develop a demonstration plan for improving water use efficiency in irrigated agriculture are reported. This phase involved a state-wide evaluation of major irrigated areas and the selection of one of these areas for the development of a demonstration conservation plan (to be completed in a later phase of the project). The potential benefits, impacts, and costs of irrigation water conservation as well as local interest in improving irrigation water use efficiency in each area were evaluated. Evaluation methods and results are described and irrigation-related-data for each major area are presented. The Walla Walla Basin was selected for the demonstration project. This work was directed by the Washington State Department of Ecology as per Substitute House Bill 1397 passed by the 1989 Washington State Legislature.

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Irrigation Water Use Efficiency Demonstration Project
Phase 1: State-Wide Evaluation of Irrigated Areas

by

Larry G. James, Thomas W. Ley, Roger P. Sonnichsen
Walter R. Butcher and Norman K. Whittlesey

Introduction

Currently there are almost 2 million acres of irrigated land in Washington. These lands are distributed throughout the state with well over half of them located in the Columbia and Yakima basins in Eastern Washington (see map in Figure 1). The primary sources of irrigation water are the Columbia River and its tributaries and the basalt aquifers that underlie most of Eastern Washington. Water is delivered to over 1.2 million acres in canals (mostly unlined) and pipelines operated by organizations of irrigators. Sprinkle irrigation is the most popular form of irrigation in Washington, being used on approximately three-fourths of the irrigated land. Trickle irrigation is used on one to two percent of the land, with furrow irrigation being used on the remaining land. Approximately 65 different crops with a market value of over $1.7 billion are irrigated in Washington.

About 9 million acre-feet of water is used in the average year for irrigation in Washington. Due to losses that occur during the delivery and application of irrigation water, this is over twice the amount of water needed to satisfy crop water requirements. It appears that considerable water could be conserved if these losses were reduced. Saved water could be used in a variety of ways without detrimentally affecting existing water rights. These include:

a. Additional irrigation (i.e., saved water could be used to enhance supplies in water short areas or possibly to irrigate additional lands).
b. Instream flow enhancement.
c. Industrial, municipal, and other consumptive uses.
d. Water quality improvement.
e. Recreation.
f. Navigation.

Water conservation in irrigated agriculture may also have several potentially adverse impacts. Reducing irrigation caused seepage and runoff may, in some areas:

a. Decrease the amount of return flow. (Return flow is irrigation water that drains or runs off from an area and flows to another area where it is used for irrigation, recreation, etc.)
b. Decrease ground water recharge and lower water tables.
c. Damage wetlands and wildlife habitat.

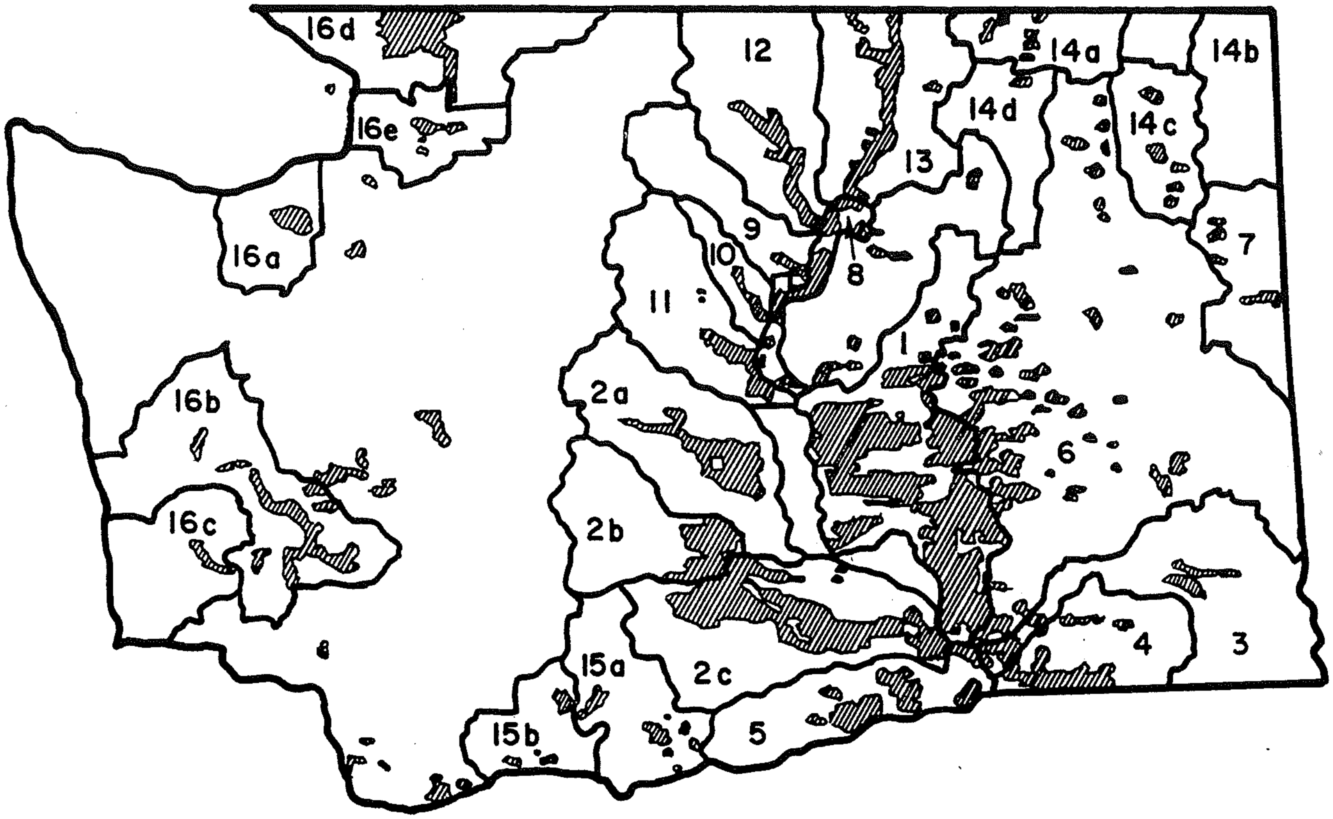

Figure 1. Major Irrigated Areas in Washington. (Shaded areas are irrigated land.)(ref. 63)

1. Columbia Basin
2. Yakima Basin
   a) Kittitas Valley
   b) Naches Valley
   c) Mid- and Lower-Valley
3. Snake River
4. Walla Walla Basin
5. Horse Heaven Hills
6. Columbia Plateau
7. Spokane Basin
8. Mid-Columbia Mainstream
9. Chelan Basin
10. Entiat Basin
11. Wenatchee Baasin
12. Methow Basin
13. Okanogan Basin
14. Upper Columbia Tributaries
   a) Kettle River
   b) Pend Oreille River
   c) Colville River
   d) Sanpoil River
15. Lower Columbia Tributaries
   a) Klickitat River
   b) White Salmon River
16. Western Washington
   a) Dungeness River
   b) Chehalis River
   c) Willapa River
   d) Nooksack River
   e) Skagit River

In addition, improving water use efficiency in irrigated agriculture may reduce farm income. Structural revisions to off- and on-farm irrigation systems and more intensive levels of irrigation system management required for improving irrigation water use efficiency may increase the cost of owning and operating irrigation systems.

Recognizing the potential benefits, impacts, and costs of improved water use efficiency in irrigated agriculture and the need to quantify, to the extent possible, these quantities, the 1989 Washington State Legislature authorized the development of a water conservation demonstration plan for a selected irrigated area of Washington (Substitute House Bill No. 1397). This project is to be completed by the Washington State Department of Ecology (DOE) in the following three phases:

1. State-wide evaluation of irrigated areas and selection of an area for a voluntary demonstration project.

2. Assessment of the benefits, impacts, and costs of water conservation measures and practices for irrigated agriculture appropriate to the selected study area.

3. Formulation of a demonstration water conservation plan for the selected area.

This report describes the procedures and results of the first phase of this project.

PROCEDURES

Selection of an area for a demonstration project included the following major steps:

1. Appointment of a Task Force by DOE.

2. Securing technical support for the Task Force.

3. Identification of major irrigated areas in Washington.

4. Identification of data needed to evaluate an area's suitability for the demonstration project.

5. Acquisition and summarization of information for each area.

6. Development of an evaluation process.

7. Selection of five areas for more detailed evaluation.

8. Identification of data needed for detailed evaluation of the five areas.

9. Acquisition and summarization of detailed information for each of the five areas.

10. Development of an evaluation process.

11. Selection of one area for the demonstration project.

RESULTS

Appointment of a Task Force

A nine member task force was appointed by DOE to conduct a state-wide evaluation of irrigated areas and to select one of these areas for a voluntary demonstration project. The Task Force had members representing the Washington State Departments of Ecology, Agriculture, and Wildlife; the Washington Water Resources Association; the Soil Conservation Service; the Bureau of Reclamation; an environmental group; a tribal government; and irrigators. Task Force members are listed in Appendix A.

Technical Support for the Task Force

The DOE contracted with the Washington Water Research Center located on the Washington State University (WSU) campus in Pullman for technical support. The Water Research Center assembled a study team headed by Dr. Larry G. James, Professor and Chair of Agricultural Engineering, to assist the Task Force. Other team members were Thomas W. Ley, Extension Irrigation Specialist located at the Irrigated Agriculture Research and Extension Center in Prosser and Drs. Walter R. Butcher and Norman K. Whittlesey, Professors of Agricultural Economics. Roger P. Sonnichsen, graduate research assistant in the WSU Agricultural Engineering Department, was another key team member. The contract officer for DOE was Jerry Parker prior to October 25, 1989 and George Krill thereafter.

Major Irrigated Areas in Washington

The Task Force identified the 31 major irrigated areas listed in Table 1 at its July 7, 1989 meeting in Yakima. These areas are identified on the map in Figure 1.

Table 1. Major Irrigated Areas in Washington.

Columbia Basin	Chelan Basin
East District	Entiat Basin
Quincy District	Wenatchee Basin
South District	Methow Basin
Black Sands	Okanogan Basin
Columbia Plateau	Kettle River
Yakima Basin	Pend Oreille River
Kittitas Valley	Colville River
Naches Valley	Sanpoil River
Mid and Lower Valley	Klickitat River
Snake River	White Salmon River
Walla Walla Basin	Dungeness River
Horse Heaven Hills	Chehalis River
Mid-Columbia Mainstream	Willapa River
Spokane Basin	Nooksack River
	Skagit River

Data Needed for Area Evaluation

The Task Force also identified data needed for evaluating an area's suitability for the demonstration project at its July 7th meeting. This information was used by the WSU study team to develop a draft set of information categories which were reviewed by the Task Force at its meeting in Yakima on September 22, 1989. Minor refinements were made to the information categories in response to Task Force comments and a final set of information categories were developed by the WSU study team. These information categories, which were approved by the Task Force at its December 5, 1989 meeting in Ellensburg, are summarized in Table 2. A more detailed description of the information categories is presented in Appendix B.

Table 2. Information Categories Used to Evaluate an Irrigated Area's Suitability for the Demonstration Project.

- Physical Characteristics
  - Amount of Irrigation
  - On-Farm Irrigation System Type
  - Diversity of Crops
  - Hydrology of Area
  - Source of Irrigation Water
- Institutional Characteristics
  - Water Delivery Organization
  - Local Awareness of Water Conservation
  - Competition for Water
  - Cost (to irrigator) of Water and Energy
- Summary of Potential for Detailed Study
  - Potential for State-Wide Application
  - Potential for Improving Water Use Efficiency
  - Potential Benefits from Improved Water Use Efficiency

Data for the 31 Irrigated Areas

Data from published reports and the knowledge and experience of members of the Task Force and WSU study team were organized according to the information categories in Appendix B. This information for each of the 31 areas is presented in Appendix C and summarized in Tables 3, 4, and 5. Information categories and ratings in these tables and Appendix C are described in Appendix B.

Evaluation Process

A scoring system was developed to rank the 31 areas according to their suitability for a demonstration project. This scoring system assigned points to each area's ratings in Table 5 according to Table 6 and Equation 1.

Table 3. Physical Characteristics of Major Irrigated Areas in Washington. (See Appendix C for explanation of information categories, ratings, and abbreviations.)

Region	Amount of Irrigation	On-Farm Sys Type	Crop Diversity	Hydrology of Region	Water Source
Columbia Basin	Large	All	Very	Complex	All
East District	Large	All	Very	Complex	SW, Can
Quincy District	Large	All	Very	Complex	SW, Can
South District	Large	All	Very	Complex	SW, Can
Black Sands	Moderate	Spr	Moderate	Moderate	GW, Pres
Columbia Plateau	Moderate	Spr	Limited	Simple	GW, Pres
Yakima Basin	Large	All	Very	Complex	All
Kittitas Valley	Large	All	Medium	Complex	SW, Can
Naches Valley	Medium	All	Limited	Complex	All
Mid and Lower Valley	Large	All	Very	Complex	All
Snake River	Medium	Spr	Medium	Simple	S&GW, Pres
Walla Walla Basin	Medium	Spr, Sur	Very	Complex	All
Horse Heaven Hills	Medium	Spr, Tri	Very	Moderate	S&GW, Pres
Spokane Basin	Medium	Spr, Tri	Medium	Complex	All
Mid-Columbia Mainstream	Medium	Spr, Tri	Limited	Simple	SW, Pres
Chelan Basin	Small	Spr, Tri	Limited	Simple	SW, Pres
Entiat Basin	Small	Spr	Limited	Simple	SW, Pres
Wenatchee Basin	Medium	Spr, Tri	Limited	Simple	All
Methow Basin	Small	Spr, Sur	Limited	Moderate	All
Okanogan Basin	Medium	Spr, Tri	Limited	Moderate	SW, Both
Kettle River	Small	Spr, Sur	Limited	Moderate	SW, Can
Pend Oreille River	Small	Spr, Sur	Limited	Moderate	All
Colville River	Small	Spr, Sur	Limited	Moderate	S&GW, Pres
Sanpoil River	Small	Spr, Sur	Limited	Mod-Comp	S&GW, Pres
Klickitat River	Small	All	Limited	Complex	S&GW, Both
White Salmon River	Small	All	Limited	Simple	SW, Can
Dungeness River	Small	Spr, Sur	Limited	Complex	SW, Can
Chehalis River	Small	Spr, Sur	Limited	Simple	S&GW, Pres
Willapa	Small	Spr, Sur	Limited	Complex	SW, Pres
Nooksack	Small	All	Medium	Complex	S&GW, Pres
Skagit River	Small	All	Very	Complex	S&GW, Pres

Table 4. Institutional Characteristics of Major Irrigated Areas in Washington. (See Appendix C for explanation of information categories, ratings, and abbreviations.)

Region	Delivery Organization	Local Awareness	Competition for Water	Cost of Water, Energy
Columbia Basin	USBR	Moderate	Low	Low, Low
East District	USBR	Moderate	Low	Low, Low
Quincy District	USBR	Moderate	Low	Low, Low
South District	USBR	Moderate	Low	Low, Low
Black Sands	Indep	Active	High	Low, Low
Columbia Plateau	Indep	Active	Some	Low, High
Yakima Basin	Mix	Active	High	Mod, Mod
Kittitas Valley	Mix	Active	High	Mod, Mod
Naches Valley	Mix	Active	High	Mod, Low
Mid and Lower Valley	Mix	Active	High	Mod, Mod
Snake River	Indep	Moderate	Low	Low, High
Walla Walla Basin	Mix	Moderate	Some	Mod, Mod
Horse Heaven Hills	Indep	Active	Low	Low, High
Spokane Basin	Mix	Little	Low-Some	Mod, Low
Mid-Columbia Mainstream	Indep	Little-Mod	Low	Low, Mod
Chelan Basin	Non-USBR	Active	High	Mod, Mod
Entiat Basin	Indep	Little	Low	Low, Mod
Wenatchee Basin	Mix	Moderate	Some	Mod, Mod
Methow Basin	Mix	Active	High	Mod, Mod
Okanogan Basin	Mix	Moderate	High	Mod, Mod
Kettle River	Indep	Little	Low	Mod, Mod
Pend Oreille River	Indep	Little	Low	Mod, Mod
Colville River	Indep	Moderate	Low	Mod, Mod
Sanpoil River	Indep	Moderate	Some	Mod, Mod
Klickitat River	Indep	Moderate	Some	Mod, Mod
White Salmon River	Mix	Moderate	Some	Mod, Mod
Dungeness River	Mix	Moderate	Some	Mod, Mod
Chehalis River	Indep	Moderate	Some	Mod, Mod
Willapa	Indep	Moderate	Some	Mod, Mod
Nooksack River	Indep	Moderate	Some	Mod, Mod
Skagit River	Mix	Moderate	Some	Mod, Mod

Table 5. Summary of Potential for Detailed Study of Major Irrigated Areas in Washington. (See Appendix C for explanation of information categories, ratings, and abbreviations.)

Region	Potential for Statewide Applic	Water Use Eff Improve	Potential Benefits	Score
Columbia Basin	Moderate	Good	Moderate	77
East District	Moderate	Good	Moderate	77
Quincy District	Moderate	Good	Moderate	77
South District	Moderate	Good	Moderate	77
Black Sands	Poor	Good	Moderate	70
Columbia Plateau	Poor	Moderate	Moderate	55
Yakima Basin	Good	Good	Good	100
Kittitas Valley	Good	Good	Mod-Good	92
Naches Valley	Good	Good	Good	100
Mid and Lower Valley	Good	Good	Good	100
Snake River	Poor	Moderate	Poor-Mod	48
Walla Walla Basin	Mod-Good	Good	Good	96
Horse Heaven Hills	Poor	Poor	Poor-Mod	33
Spokane Basin	Poor-Mod	Poor	Moderate	44
Mid-Columbia Mainstream	Poor	Moderate	Poor-Mod	48
Chelan Basin	Poor	Poor-Mod	Poor-Mod	41
Entiat Basin	Poor	Moderate	Moderate	55
Wenatchee Basin	Moderate	Mod-Good	Mod-Good	78
Methow Basin	Moderate	Mod-Good	Mod-Good	78
Okanogan Basin	Poor-Mod	Moderate	Moderate	59
Kettle River	Poor	Moderate	Moderate	55
Pend Oreille River	Poor	Moderate	Moderate	55
Colville River	Poor	Moderate	Moderate	55
Sanpoil River	Poor	Moderate	Moderate	55
Klickitat River	Poor	Moderate	Moderate	55
White Salmon River	Poor	Moderate	Moderate	55
Dungeness River	Moderate	Mod-Good	Good	85
Chehalis River	Poor	Moderate	Moderate	55
Willapa	Poor	Poor-Mod	Moderate	48
Nooksack River	Moderate	Moderate	Moderate	62
Skagit River	Moderate	Poor	Poor-Mod	40

$$\text{Score} = SA + WUE + PB \quad (1)$$

where,
- Score = Total points in last column of Table 5
- SA = Points from Table 6 for potential state-wide application
- WUE = Points from Table 6 for potential for water use efficiency improvement
- PB = Points from Table 6 for potential benefits of irrigation water conservation

Table 6. Values for SA, WUE, and PB in Equation 1 for area ratings in Table 5.

Table 5 Rating	SA	WUE	PB
Poor	5	10	10
Moderate	12	25	25
Good	20	40	40

Scores for each of the 31 areas are given in Table 5.

<u>Selection of Five Areas for Detailed Study</u>

At its meeting in Yakima on September 22, 1989, the Task Force used the scores in Table 5 to guide its selection of five areas for more detailed evaluation. The Task Force agreed to eliminate the Columbia and Lower Yakima Basins because of the large number of irrigation related technical studies of these basins. This eliminated from further consideration the Naches Valley and Mid and Lower Valley areas of the Yakima Basin and in the Columbia Basin, the Black Sands area and the East, Quincy and South Districts. The five areas selected by the Task Force for more detailed evaluation were the:

Walla Walla Basin
Kittitas Basin
Dungeness River
Methow Basin
Wenatchee Basin

<u>Data for Detailed Evaluation of Five Areas</u>

The information categories used for selecting the five areas were expanded by the WSU study team and approved by the Task Force at its September 22, 1989 meeting in Yakima. An outline of the expanded information categories utilized for detailed evaluation of the five areas is given in Appendix D.

<u>Detailed Information for the Five Areas</u>

Additional published reports and phone interviews of knowledgeable people in each area were used to supplement and verify previously collected information (in Appendix C). Information for each of the five areas was organized according to the outline in Appendix D. This information is presented in

Appendix E and summarized in Table 7. Information in Appendix E was reviewed by the people listed in Appendix F.

Evaluation Process

Scores for ranking the five areas were computed using Equation 2.

$$\text{Score} = 5 * \text{PSCR} + \text{NC} + \text{LI} + \text{ST} + \text{WL} + \text{DA} + \text{SIZE} \qquad (2)$$

where,

Score	=	Total points for area
PSCR	=	Score from Table 5 divided by 10 and rounded to the nearest whole number
NC	=	Number of potential water conflicts (0 to 9)
LI	=	Local Interest in the area (0 = negative interest, 10 = positive interest)
ST	=	Existing and potential surface and ground water storage (0 = none, 10 = considerable)
WL	=	Existence of wetlands (0 = none, 10 = considerable)
DA	=	Data availability (0 = none, 5 = considerable)
SIZE	=	Size of the area (0 = large, 5 = small)

Equation 2 and its parameters were developed by the Task Force at its December 5, 1989 meeting in Ellensburg.

Selection of Study Area

Values for the parameters in Equation 2 and total scores computed with Equation 2 for each of the five areas are given in Table 8. The rating categories and values in Table 8 were developed by the Task Force at its December 5th meeting in Ellensburg.

The Task Force identified the following areas of concern:

Kittitas	Potential conflict with on-going adjudication process.
Walla Walla	A major portion of the watershed is located in Oregon and the possibility exists that some irrigators may not be willing to implement efficiency measures.
Methow	Potential conflict with on-going DOE studies and planning efforts, limited crop diversity, and potential high cost of efficiency improvements (because of high ratio of canal length to acres irrigated).
Wenatchee	Limited crop diversity, lack of existing and potential storage sites, and potential high cost of efficiency improvements (because of high ratio of canal length to acres irrigated).
Dungeness	Not a good representative of diversified irrigated areas.

Table 7. Summary of Information for Five Irrigated Areas Selected for Detailed Study.

	Dungeness River	Kittitas Valley	Methow Basin	Walla Walla Basin	Wenatchee Basin
County	Clallam	Kittitas	Okanogan	Columbia, Walla Walla	Chelan
WRIA	18	39	48	32	45
Drainage Area(sq-mi)	197(ref. 7)	2,135(ref24p4)	1,794(ref59)	1,758(ref8)	1,310(ref59)
Surface Inflows(ac-ft)	NA	3,750,000(ref24p10)	3,100,000(ref45p6)	1,440,000(ref14p6)	4,576,000(ref61tableII-
Grounwater Inflows(ac-ft)	NA	NA	NA	172,500	NA
Mean Instream Flows(cfs)	390 annual(ref. 7)	2,980(ref24p9)annual	1,591annual	592annual	3,375annual
ET(ac-ft)	NA	1,590,000(ref24p10)	1,160,000(ref45p6)	880,000(ref14p6)	NA
Total water use(ac-ft)	NA	533,000(ref24p42)	114,500(ref45p11)	228,000(ref8p2)	94,300(ref62p4)
Irr water use(ac-ft)	55,250(ref. 7)	526,800(ref24p41)	54,600(ref64p34)	157,320(ref8p2)	66,586(ref64p34)
Ind & Mun water use(ac-ft)	NA	6,260(ref24p41)	457(ref64p21)	70,680(ref8p2)	30,220(ref62p4)
Surface Outflows(ac-ft)	NA	2,160,000(ref24p10)	1,200,000(ref45p6)	440,000(ref14p6)	2,379,000(ref61tableII-
Groundwater Outflow(ac-ft)	NA	AN(ref24p10)	740,000(ref45p6)	91,000	NA
Wetlands (acres)	120	NA	NA	50-100	NA
Industry & municipal					
Surface Water	City of Sequim	1%	1%	85%(ref8p1)	small
Ground Water	NA	99%(ref24p41)	99%	15%	NA
Precipitation(in)	16(ref. 7)	10(ref24p2)	20(ref20p19)	12(ref43p10)	20-15(ref61plateII-8)
Growing Season(days)	180	140-180	130-150	180-210	150-180
Irrigable Acres	15,100	106,800	16,400(ref37p45)	133,435(ref8p2A)	17,021
Irrigated Acres	15,100(ref64p33)	106,800(ref24p41)	15,300(ref64p34)	76,000	17,021(ref62p6)
Surface Water	99%(ref64p33)	95% 97%(ref12)	95%(ref20)	93%(ref12)	95%(ref12)
Ground Water	1%	5% 3%(ref12)	5%	7%(ref12)	5%(ref12)
Crop Acres					
Forage	80-90%	75-80%	11,500(ref20p12)	28%	1,685(ref27)
Field Crop	0	10-11%	0	29%	0
Vegetable	0	8-9%	0	24%	915(ref27)
Seeds	5-10%	0	0	18%	0
Fruits	5-10%	4-7%	2,800(ref20p12)	1%	16,472(ref27)

Table 7. (continued) Summary of Information for Five Irrigated Areas Selected for Detailed Study.

	Dungeness River	Kittitas Valley	Methow Basin	Walla Walla Basin	Wenatchee Basin
Organization	10ID&Companies	2 ID	16 IDs & Comp(ref37p47)	6IDs(ref26)	8IDs(ref26)2comp(ref55p
Electrical Utilities	Clallam Co. PUD	Kittitas PUD & PSP&L	Okanogan Co. PUD & REA	Columbia REA & PP&L	Chelan Co. PUD
Water Costs	$12-20/ac-ft	$20-25/acre	$12-20/ac-ft	$12-20/ac-ft	$40-60/acre
Energy Costs	$20/ac-ft	$15-20/ac-ft	$15-20/ac-ft	$20-40/ac-ft	$15/ac-ft
Water Regulations	planned instream protection plan(ref47)	planning ajudication	Instream Protection Plan Complete(ref47)	Major rivers Adjudicated, CWSP	Instream Protection Plan Complete(ref47)
Water Demand	Instream flows City of Sequim	instream flows recreation, irrigation	instream flows, mining recreation, ski hill	instream flows recreation, Mun&Ind	fish,recreation, hydropower(ref55)
Adequacy of Supply	adequate	Adequate	Limiting in dry season	limiting	Limiting in dry season
Water Quality	class A,AA(ref60p8)	class A(ref60p27)	class A,AA(ref60p20)	class B,A(ref60p26)	class A,AA(ref55p16)
Reservoirs	none	Three	Three small lakes	none	none
Potential Storage	none	no new	some new	possible groundwater	none
Delivery System					
Type	open ditch	open ditch (ref27)	open ditch(ref37)	open ditch (ref27)	earth canal,pipe(ref27)
Efficiency	Unknown(ref27)	75%(ref27)	40%(ref37p40)	unknown(ref27)	66%(ref27)
Application Systems					
Type	Sprinkler 99% (ref12)	Surface 79% Sprinkler 21% (ref12)	Sprinkler 95% Surface 2% (ref12)	Sprinkler 99% (ref12)	Sprinkler 98% (ref12)
Efficiency	poor	poor-moderate	poor	poor	moderate
Water Management Practices	unmeasured deliveries	measured deliveries	unmeasured deliveries	unmeasured deliveries	measured deliveries
Current Activities	Pipe portion of main canal Agnew ID(ref47) Highland ID replace wooden siphon(refRS.DOE)	Yakima Enhancement surge irr. studies PAWS & WIF	Delivery system plan Methow Valley ID (refRS.DOE)	NA	Peshastin ID(refRS.DOE) Replace wooden fume Wenatchee RD(refRS.DOE)

Table 7. (continued) Summary of Information for Five Irrigated Areas Selected for Detailed Study.

	Dungeness River	Kittitas Valley	Methow Basin	Walla Walla Basin	Wenatchee Basin
Potential Improvements	good	good	good	good	mod-good
Local Interest	moderate	active	active	moderate-active	moderate
					groundwater (ref55p14)
Data					
Quantity	limited	abundant	moderate	moderate	moderate
Quality	poor	good	good	good	good

The Kittitas Basin was eliminated from further consideration because of a potential conflict with the on-going adjudication process even though the basin was recognized to be an excellent study area and to have a high potential for efficiency improvement. The Task Force selected the Methow Basin for the demonstration project.

Following the Ellensburg meeting several members of the Task Force wished to reconsider the selection. A teleconference was held December 11, 1989 to further discuss the five areas. Four of the nine members of the Task Force participated in the teleconference. Other participants included Darlene Frye, proxy for Howard Powell, Ken Mitchell representing the Yakima Indian Nation, Larry James and Roger Sonnichsen of the WSU study team, and George Krill from DOE.

The WSU Study Team reported that it had reviewed the information and procedures used to evaluate the five areas. It observed that the score in Table 5 was a good indicator of an areas overall suitability for a voluntary demonstration project and recommended that these scores be given more weight in the evaluation of the five areas. After confirming its decision to eliminate the Kittitas Valley from consideration, the Task Force selected the Walla Walla Basin for the demonstration project primarily because it felt that the concerns listed above for the Walla Walla Basin were less serious that those listed for the Methow Basin and Dungeness River. George Krill indicated that he had contacted missing Task Force members and that they all agreed with the selection of the Walla Walla Basin.

The next phase of the project involves assessing the benefits, impacts, and costs of various water conservation measures and practices for irrigated agriculture in the Walla Walla Basin. Several structural and management changes to delivery and on-farm irrigation systems for improving water use efficiency in the basin will be evaluated. In the third and final phase of the project, a water conservation plan for the Walla Walla Basin will be developed using information from the assessment phase. A committee with members representing a cross-section of affected local water users, the public, and tribal governments will formaulate this plan.

Table 8. Values of Parameters in Equation 2 and Total Scores Computed with Equation 2 for the Five Areas Selected for Detailed Evaluation.

Area	SOR	NC[1]	LI	ST	WL	DA	SIZE	Score
Kittitas	9	8 ws, wq, if rf, f, rec wl, TI, __	6	10	10	5	0	84
Methow	8	8 ws, wq, if __, f, rec wl, TI, gw	7.5	6	10	5	3	79.5
Walla Walla	10	7 ws, wq, if __, f, ___ __, TI, gw	5	6	5	5	1	79
Wenatchee	8	5 ws, wq, if __, f, rec __, __, __	7.5	0	5	5	2	64.5
Dungeness	9	6 __, wq, if __, f, ___ wl, TI, gw	8	0	10	5	5	79

[1] Potential Water Problem/Conflict Abreviations:

ws = water supply
wq = water quality
if = instream flow
rf = return flow
f = fisheries
rec = recreation
wl = wetlands
TI = Tribal Interests
gw = ground water

APPENDIX A

TASK FORCE MEMBERS

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APPENDIX B

INFORMATION CATEGORIES AND RATINGS USED IN TABLES 3, 4, AND 5

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

   Small: < 25,000 acres
   Medium: > 25,000 acres and <100,000 acres
   Large: > 100,000 acres

2. On-Farm Irrigation System Type

   Spr: Sprinkle Irrigation
   Tri: Trickle Irrigation
   Sur: Surface Irrigation

3. Diversity of Crops Irrigated

   Very: Cereals, forage, field, vegetable, seed and fruit crops grown
   Medium: Many of the above crops grown
   Limited: Dominated by one or two crop types

4. Hydrology of the Region

   Simple, Moderate, or Complex depending on:

   Ground/surface water interactions including wetlands
   Interaction with other regions
   Return flow characteristics
   Complexity of aquifer

5. Source of Irrigation Water

   GW: Ground Water
   SW: Surface Water
   Can: Canal Delivery System
   Pres: Pressurized Delivery System

II. Institutional Characteristics of Irrigated Regions.

6. Water Delivery Organization

   USBR: Most irrigation on lands within USBR project that receive water from delivery organization
   Non-USBR: Most irrigation on lands outside of USBR projects that receive water from delivery organization
   Mix: Mix of delivery organizations and independent irrigators
   Indep: Mostly independent irrigators

7. Local Awareness of Water Conservation in the Area

Active, Moderate, or Little depending on:

The level of water conservation activity in area
Awareness of irrigators in the area

8. Competition for Water

High, Moderate, or Low depending on:

Adequacy (relative to demand) of water supply
Potential for additional uses
Existence of water right conflicts
Extent of water markets

9. Cost per Unit of Water and Energy (to irrigator)

	Water	Energy
Low	<$12/ac-ft	<$15/ac-ft pumped
Moderate	$12 to $20/ac-ft	$15 to $50/ac-ft
High	>$20/ac-ft	>$50/ac-ft

III. Summary of Potential for Further Study.

10. Potential for State-Wide Application

High, Moderate or Low depending on:

Existence of a variety of critical water issues
Potential for successful study
Fundability under Ref 38
Impact on agricultural economic base

11. Potential for Improving Water Use Efficiency

High, Moderate, or Low depending on:

Level of on-farm water management
Type of on-farm irrigation system
Amount of irrigation water use relative to irrigation requirement
Level of local awareness
Rate structure for water/electricity
Delivery system efficiency

12. Potential for Benefits from Improved Water Use Efficiency

High, Moderate, or Low depending on:

Potential for additional irrigation
Impact on municipal, industrial and other consumptive uses
Impact on in-stream uses
Impact on water quality and other environmental concerns
Impact on wetlands
Impact on other critical water issues

13. Score = SA + WUE + PB

where,
SA = Value from the following table that depends on the rating in Table 5 for potential for state-wide application
WUE = Value from the following table that depends on the rating in Table 5 for potential fro improving water use efficiency
PB = Value from the following table that depends on the rating in Table 5 for potential for benefits from improved water use efficiency

Rating	SA	WUE	PB
Poor	5	10	10
Moderate	12	25	25
Good	20	40	40

APPENDIX C

DETAILED INFORMATION FOR MAJOR IRRIGATED AREAS IN WASHINGTON

Irrigated Region #1: Columbia Basin Project
Location: Central Washington
Adams, Franklin, Grant Counties

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

There were an estimated 505,616 acres of cropland irrigated on the Columbia Basin Project in 1987 (ref 13).

Irrigation District	Irrigated Acres(1987)
Quincy	206,499
East	111,171
South	187,946

2. On-Farm Irrigation System Type

Percent of total irrigated land with surface, sprinkle, and trickle irrigation systems (ref 3).

County	Surface	Sprinkle	Trickle
Adams	28.7%	71.2%	0.1%
Franklin	13.4%	86.1%	0.5%
Grant	31.0%	68.9%	0.0%

3. Diversity of Crops Irrigated

Crops grown on project lands in 1987 (ref 13).

Crops	Acres
Forage	163,658
Cereals	131,498
Field Crops	34,452
Vegetables	83,193
Seeds	41,050
Fruit	26,155

4. Hydrology of the Region

Due to the dry climate of this region, water is pumped from the Columbia River at Grand Coulee Dam. In 1987, 3,197,120 ac-ft of water was pumped from Grand Coulee Dam to the Project (ref 13). This water flows south through a vast network of canals and reservoirs back to the Columbia River. Major reservoirs are Banks Lake (761,800 ac-ft active storage), and Potholes Reservoir (379,500 ac-ft active storage). The Project has developed into an outstanding recreational, fishing and hunting region.

There are a total of 67,433 acres of lakes and impoundments and 20,993 acres of wetlands in Grant County. On an acreage basis, lakes are 12.2% private, 3.9% state and 83.9% federal. Wetland acreage was 44.6% private, 23.2% state and 32.2% federal. Considering both lakes and wetlands, 83.4% of the acreage was judged as high in waterfowl value for either breeding or wintering, 13.7% as moderate, and 2.9% as low (ref 1.3).

5. Source of Irrigation Water

Surface water from the Columbia River provides the primary source of water for this region. Project irrigation districts use earth and lined canal deliveries. In 1987 the Project water losses were reported at 357,690 ac-ft for operational spill and 813,480 ac-ft due to transport losses (ref 13). The Black Sands Irrigation District pumps groundwater recharged from losses from Project canals and reservoirs.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

Water is diverted through three Project irrigation districts: East, Quincy and South District. Also located within project lands is the Black Sands Irrigation District, formed in 1973 by individual irrigators.

7. Local Awareness of Water Conservation in the Region

A draft EIS prepared by the Bureau of Reclamation was released in September 1989. The abundance of available water and inexpensive energy relegate water management to low priority on most farms.

8. Competition for Water

There is little competition between irrigators for water in this region because water is pumped from the Columbia River by the USBR and distributed by the USBR. However Crab Creek between Moses Lake and the Columbia River was adjudicated in 5/5/24 before the Columbia Basin Project.

9. Cost of Water and Energy

The cost of water and energy for on-farm pumping for individual farmers is low.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the artificial nature by which this basin has been created, it is not seen as a good representation of many other basins in the state and therefore not a good study basin. The effects of water use efficiency on wetlands, however, does represent a major statewide issue.

11. Potential for Improving Water Use Efficiency

The efficiencies for the USBR irrigation districts are reported as: Quincy 72.2%, East 57% to 74%, and South 94% (due to return flows, the South Irrigation District has a very high efficiency rate) (ref 5).

12. Potential for Benefits from Improved Water Use Efficiency

Improving water use efficiency is seen as a negative effect on wetlands, because many wetlands have been created from canal losses. Additional lands could be irrigated using water saved from improved water use efficiency. The other benefit may be additional water for power production at Grand Coulee Dam, and the other ten downstream hydropower dams on the Columbia River.

Basin References

1.1 Black Sands Irrigation District. *Black Sands Irrigation District Position Paper USBR Contract Modification.*

1.2 Pacific Northwest River Basin Commission. *The Big Bend Basin Level B Study of the Water and Related Land Resources*. Dec 1976.

1.3 State of Washington Water Research Center. *Wetland Surveys of Skagit and Grant Counties, Washington: Inventory, Wildlife Values and Owner attitudes*. Report No. 29. Washington State University and University of Washington. May 1977.

1.4 Washington State, Legislative Budget Committee. *Report on Proposed Completion of the Columbia Basin Project: Policy Question and Findings*. Report No. 84-18. Dec 1984.

Irrigated Region #2: Yakima River
Location: Central Washington
Kittitas, Yakima, Benton Counties
WRIA 39, 38, 37

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Irrigated Area	Acres Irrigated (1975)
Kittitas Valley	106,800 (ref 24)
Naches Valley	37,000 (ref 24)
Mid and Lower Valley	364,845 (ref 24).

2. On-Farm Irrigation System Type

Percent of total irrigated land with surface, sprinkle, and trickle irrigation systems (ref 3).

County	Surface	Sprinkle	Trickle
Kittitas	78.7%	20.7%	0.6%
Yakima	42.4%	57.4%	0.3%
Benton	32.4%	66.5%	1.1%

3. Diversity of Crops Irrigated

In the Kittitas Valley crop production is mostly forage crops and some fruit crops. In the Naches Valley crop production is mostly fruit crops. In the Mid-Lower Valley production includes cereals, forage, field, vegetables, seed and fruit crops.

Crops grown on project lands in 1987 (ref 13).

Crops	Acres
Forage	135,010
Cereals	38,053
Field Crops	39,727
Vegetables	33,045
Seeds	470
Fruit	102,231

4. Hydrology of the Region

The principal streams draining the east slope of the Cascade Mountains in the northern portion of the Yakima Basin are the Yakima, Kachess, and Cle Elum Rivers. Farther south is the Naches River, whose main tributaries, American and Tieton Rivers, also drain the east slope of the Cascades. Issuing from the foothills of the Cascade Range, south of the Naches River, are the North and South Forks of Ahtanum Creek, Toppenish and Satus Creeks. The average annual outflow from the basin is about 2,300,000 ac-ft measured at Kiona (ref 2.3).

There are six reservoirs used for irrigation and recreation in the basin. Three large glacial mountain lakes form the mountain headwaters of the Yakima River in the northwestern corner of Kittitas Valley. These lakes are Keechelus Lake (157,800 ac-ft), the source for the Yakima River; Kachess Lake (239,000 ac-ft), the source for the Kachess River; and Cle Elum Lake (436,900 ac-ft), the source of the Cle Elum River. The three other mountain reservoir lakes are at the headwaters of the Tieton River and Bumping River in the Naches Valley. Clear Creek Lake (5,300 ac-ft) and Rimrock Lake (198,000 ac-ft) are the source of the Tieton River, and Bumping Lake (33,700 ac-ft) is the source of the Bumping River.

Groundwater outflow from the Kittitas Basin cannot be calculated accurately, although some water is leaving the basin through the sand and gravel beneath the river channel at Selah Gap. Groundwater discharge is considered small compared with surface outflow and evapotranspiration (ref 2.4).

5. Source of Irrigation Water

The main source of water in this basin is surface water. In 1975 an estimated 526,800 ac-ft of surface water was used in the Kittitas Valley, 127,946 ac-ft of surface water was used in the Naches Valley, and 1,636,540 ac-ft of surface water was used in the Mid-Lower Valley (ref 24). Short water years in 1977, 1979, and 1988 prompted the installation of numerous wells for supplemental water.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

Most of the land in the region receives its water from USBR projects or water contracted from the USBR and delivered through irrigation districts. There are twenty four irrigation districts in the Yakima Basin (ref 5).

7. Local Awareness of Water Conservation in the Region

Water use is a big issue in the Yakima Basin because of the lack of adequate water supply in dry summers, and competing demands for minimum instream flows for fisheries enhancement and possible expansion of irrigation on the Yakima Indian Nation reservation lands. Water use efficiency is addressed as part of the Yakima Enhancement Project.

8. Competition for Water

Water rights are a complicated issue in the Yakima Basin. There is great competition between irrigation districts, the Yakima Indian Reservation, instream flows, individual irrigators, municipal and industrial uses. The lack of adjudicated streams and unclear US documents regarding federal land reservations bordering water systems complicates this area. The Wenas and Ahtanum Creeks were adjudicated on 2/23/21 and 5/7/25 respectively.

9. Cost of Water and Energy

Water costs are moderate, while on-farm pumping costs are low to moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The Yakima River basin, or one of its subbasins has good potential for a statewide study area due to the number of organized irrigation districts; amount of irrigated land; ability for funding of districts under Ref. 38; water quality, fisheries and recreational issues.

11. Potential for Improving Water Use Efficiency

Some of the largest and oldest irrigation districts have poor or unknown efficiencies because of their seniority rights to water, lack of water measurement records, and aging facilities.

12. Potential for Benefits from Improved Water Use Efficiency

Improved water use efficiency would benefit the Naches and Mid-Lower Valley's junior irrigation districts that have shortages of water in dry seasons. Increased instream flow in these valleys would benefit water quality, fish and recreation. Improved water use efficiency in the Kittitas Valley may have a negative effect on groundwater recharge flows that are assumed to benefit the Mid-Lower Valley. Improvements in efficiency early in the season would reduce this groundwater recharge. Mid and late season efficiency improvements, however, would stretch the available water supply in this area, much of which is served by a junior water right district(KRD).

Basin References

2.1 Copp, Howard D., Higgins, David T. *Model Development and Systems Analysis of the Yakima River Basin, Hydraulics of Surface Water Runoff*. Report No. 17B, Washington State Water Research Center, Washington State University. Nov 1974.

2.2 Dawson, Robert H. *Onfarm Conservation Practices in the Yakima Basin--Phase II, Volume II General Assumptions, Linear Programming Solutions, and Appendix Tables*. 6-PG-10-06680 and 6-PG-10-11240. Submitted to: US Bureau of Reclamation. July 1986.

2.3 Pacific Northwest River Basin Commission. *The Yakima Basin Level B Study*. May 1977.

2.4 Pearson, H.E. *Hydrology of the Upper Yakima River Basin, Washington*. Water Supply Bulletin No. 52, Washington State Department of Ecology. 1985.

2.5 Thompson, Gene T. *Model Development and Systems Analysis of the Yakima River Basin, Irrigated Agriculture Water Use*. Report No. 17C, Washington State Water Resources Center, Washington State University. Sept 1974.

2.6 US Bureau of Reclamation. *Yakima Project*. 1984-778-293. Pacific Northwest Region. Oct 1983.

2.7 Washington State University. *Irrigation Development Potential and Economic Impacts Related to Water Use for the Yakima River Basin*. Agricultural Research Center. April 1972.

Irrigated Region #3: Snake River
Location: Southwestern Washington
Asotin, Columbia, Garfield, Walla Walla, Whitman, Franklin Counties
WRIA 33, 35

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975, 60,705 acres were estimated to be irrigated in the Snake River Basin., This includes lands irrigated from small streams in the eastern counties and private developments along the Snake River in Franklin and Walla Walla Counties just east of Pasco.

2. On-Farm Irrigation System Type

Almost all of the Snake River Region has sprinkle irrigation.

3. Diversity of Crops Irrigated

Forages, fruits and vegetables are major crops grown in the Snake River Region.

4. Hydrology of the Region

This region includes the Snake River drainage area from the river mouth at Pasco upstream to the Idaho border. The area consists of the Palouse, Asotin and Tucannon River subbasins. Three dams on the Snake River in this region have created reservoirs: Ice Harbor (1,433,000 ac-ft active storage), Lower Monumental (20,000 ac-ft active storage), and Lower Granite (44,000 ac-ft active storage).

5. Source of Irrigation Water

In 1975 the Snake River Basin used an estimated 191,880 ac-ft of surface water and 5,300 ac-ft of groundwater. Major sources of water are the Tucannon River, Pataha Creek, Palouse River and Snake River (ref 23).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in this region. Existing irrigation has been accomplished through private development.

7. Local Awareness of Water Conservation in the Region

Many of the large private developments along the Snake River have high pump lifts, and thus are concerned about good water management to reduce costs.

8. Competition for Water

Navigation and hydroelectric power are a high priority for this region. The U.S Fish and Wildlife Service indicates that resident fisheries could be developed. Several of the dams and reservoirs have recreation potential. The City of Pullman and Washington State University have shown interest in obtaining a municipal and industrial water supply (ref 25).

9. Cost of Water and Energy

Due to high pump lifts from the Snake River, energy cost are high for parts of this basin, while the water is essentially free once the diversions have been developed. The cost to develop diversions is $10 to $15 per ac-ft.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

This would be a poor basin to study because of the scattered areas of irrigation and lack of delivery organizations. This area does not face many of the major water issues of other basins.

11. Potential for Improving Water Use Efficiency

Due to the high cost of pumping this area is expected to have higher than average water use efficiencies.

12. Potential for Benefits from Improved Water Use Efficiency

This area includes a number of small to moderate size land areas that could be served by pumping from the Snake River reservoirs. The largest area is the Eureka Flats (ref 25). 1,360,000 ac-ft of water from the John Day/McNary pools reach of the Columbia River have been reserved for projected additional irrigation development of 340,000 acres. 20,000 ac-ft are reserved for future municipal supply (ref 3.2).

Basin References

3.1 US Bureau of Reclamation. *Eureka Flat Project, Le Grow Division, Washington(status report)*. Region 1, Boise Idaho. June 1966.

3.2 Washington State Department of Ecology. *John Day & McNary Pools - Columbia River*. Basin Program Series 8, Water Resources Management Program. Oct 1978.

Irrigated Region #4: Walla Walla Basin
Location: Southeastern Washington
Walla Walla, Columbia Counties
WRIA 32

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

There are approximately 105,000 acres irrigated in this basin (ref 4.3).

2. On-Farm Irrigation System Type

In Walla Walla County 99.7 percent of the irrigated land is sprinkle irrigated and 0.4 percent is drip irrigated (ref 3).

3. Diversity of Crops Irrigated

Cropping is diverse in this area, crops grown in this area include cereals, forage, vegetable, fruit and seed crops.

4. Hydrology of the Region

Water within this 1,758 sq-mi basin originates in the Blue Mountains of Oregon and Washington. Most of the water flows through the Walla Walla River, Mill Creek and Touchet River. The gravel aquifer, which underlies approximately 120,000 acres of the Walla Walla-Milton-Freewater area, is recharged from surface streams, precipitation and the basalt aquifer. The primary basalt aquifer, which underlies the entire basin is recharged primarily from the Blue Mountains (ref 4.1).

The Walla Walla River flows from Oregon and is often dry at the state border during summer months. During these low flow periods, waters occurring in the Walla Walla River in Washington are due to irrigation runoff, springs and direct discharges from the gravel aquifer (ref 4.1).

5. Source of Irrigation Water

Surface water provides 93% of the water used for irrigation while the other 7% comes from groundwater (ref 3). Of the five irrigation districts used for agriculture all have open earth canal deliveries (ref 5).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

Five of the various irrigation districts in this basin are used for agriculture, diverting water from the Walla Walla river, Touchet River and Mill Creek. There are a handful of irrigation districts that pump groundwater for municipal water supplies in the Walla Walla and College Place areas (ref 5).

7. Local Awareness of Water Conservation in the Region

Awareness of water conservation is high due to generally short water supply and concerns for the underlying aquifer.

8. Competition for Water

The Walla Walla and Touchet River have been adjudicated in 8/12/28 and 9/12/29 respectively.

The city of Walla Walla is a large user of surface water. Mill Creek is the source of approximately 85% of the city's water supply. The city also has a right to 19,600 ac-ft of groundwater from the primary basalt aquifer under this basin (ref 4.1).

Heavy competition exists between agriculture, municipal, and industrial demands for groundwater, which is the only existing source of supply with a promise for future development (ref 4.1).

9. Cost of Water and Energy

Water and energy costs are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Some major water concerns exist in this area including: water quality, fisheries concerns, shortages of water supplies, and protection of the aquifers.

11. Potential for Improving Water Use Efficiency

The water supplied from the Walla Walla River is inadequate and about on third of the land irrigated south of the river receives 10% of the required supply (ref 4.1).

Improvements are possible in measuring diverted waters. None of the five irrigation districts knew how much water was diverted in 1974 (ref 5).

12. Potential for Benefits from Improved Water Use Efficiency

There is increasing municipal and industrial demand for water in the Walla Walla Basin. Irrigators would benefit from saved water.

Basin References

4.1 Hanson, Alferd L., Mitchell, Steve. *Walla Walla River Basin (WIRA #32)*. Basin Program Series No. 6, Water Resources Management Program, Washington State Department of Ecology. Dec 1977.

4.2 Mac Nish, R.D., Myers, D.A., Baker, R.A. *Appraisal of Groundwater Availability and Management Projections, Walla Walla River Basin, Washington and Oregon*. Water Supply Bulletin No. 37, Washington State Department of Ecology. 1973.

4.3 USDA. *Southeast Washington, Cooperative River Basin Study*. Soil Conservation Service, Forest Service, Economic Research Service. 1984.

4.4 Economic and Engineering Services, Inc. *Walla Walla/College Place Coordinated Water System Plan Regional Supplement*. Prepared for: Walla Walla/College Place Water Utility Coordinating Commitee. Jan 1984.

Irrigated Region #5: Horse Heaven Hills
Location: Central Washington
Benton, Klickitat Counties
WRIA 31

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1986 the landowners irrigated 86,476 acres (ref 5.3)

2. On-Farm Irrigation System Type

Sprinkle irrigation is the major method in this region, but up to 2000 acres of drip is used on wine grapes.

3. Diversity of Crops Irrigated

Cropping is diverse. Crops grown on the Horse Heaven Hills in 1986 are listed in the following table (ref 5.3).

Crops	Acres
Forage	44,233
Cereals	6,752
Field Crops	536
Vegetables	23,469
Seeds	152
Fruit	5,224

4. Hydrology of the Region

The Horse Heaven Hills is a semi-arid region with an average annual precipitation of 6 to 12 inches. The southern border of the Horse Heaven Hills is formed by the Columbia River. There is also a supply of groundwater within this region.

5. Source of Irrigation Water

The major source of irrigation water is the Columbia River. There is some pumping from groundwater in this region.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

Water is delivered by pumps owned by individual farms.

7. Local Awareness of Water Conservation in the Region

Many irrigators have implemented water conservation measures to reduce pumping costs.

8. Competition for Water

The McNary and John Day pools reach of the Columbia River has 1,360,000 ac-ft of water reserved for potential irrigation projects (ref 5.1).

9. Cost of Water and Energy

Cost of irrigation is high due to high pump lifts.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

This would be a poor study basin because it has an adequate supply of water from the Columbia River and no major water related problems similar to other basins.

11. Potential for Improving Water Use Efficiency

This basin is perceived as having high water use efficiencies because of the high cost of pumping.

12. Potential for Benefits from Improved Water Use Efficiency

Improving water use efficiency would further reduce pumping costs and provide additional water for hydropower.

Basin References

5.1 Washington State Department of Ecology. *John Day & McNary Pools - Columbia River*. Basin Program Series 8, Water Resources Management Program. Oct 1978.

5.2 Washington State University. *Horse Heaven Hills Irrigation and Development Potential*. College of Agriculture. Dec 1970.

5.3 Watson, Jack. *Irrigated Acres on Land on the Horse Heaven Hills*. Benton County Cooperative Extension. 1986.

Irrigated Region #6: Columbia Plateau
Location: Central Washington
Grant, Franklin, Adams, and Lincoln Counties

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Variable over the years depending upon commodity prices. It ranges from 50,000 to as much as 75,000 acres.

2. On-Farm Irrigation System Type

This basin has mainly sprinkle irrigation.

3. Diversity of Crops Irrigated

The crops are limited to forages and cereals.

4. Hydrology of the Region

The rainfall is low in this basin. There are no major surface water supplies.

5. Source of Irrigation Water

All irrigation water is supplied from groundwater.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

The Columbia Plateau is irrigated by independent, private irrigators.

7. Local Awareness of Water Conservation in the Region

Local awareness is moderate to high due to high pump lifts and pumping costs. Many practice deficit irrigation without realizing it. Some concern exists that the Odessa aquifer is being mined.

8. Competition for Water

There is some competition between irrigators for water because the aquifer is dropping.

9. Cost of Water and Energy

The cost of water is low, while the cost of energy is high.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The potential for statewide application is low due to the unique situation of this basin.

11. Potential for Improving Water Use Efficiency

There is high potential for improving water use efficiency as growers are mainly dryland farmers with little knowledge of irrigation. Systems and pumps used are in very poor repair or very out-of-date.

12. Potential for Benefits from Improved Water Use Efficiency

There is moderate potential for benefits to be gained from reducing irrigation costs and reducing aquifer mining.

Basin References

6.1 Luzier, J.E., Bingham, J.W., Burt, R.J., Barker, R.A. *Ground-Water Survey, Odessa-Lind Ares, Washington*. Water Supply Bulletin No. 36, Washington State Department of Water Resources. 1968.

Irrigated Region #7: Spokane Basin
Location: Central Eastern Washington
Spokane County
WRIA 55, 56, 57

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975 an estimated 28,400 acres was irrigated in this region (ref 24).

2. On-Farm Irrigation System Type

Spokane County is estimated as having 98.4% sprinkle systems and 1.6% trickle systems (ref 3).

3. Diversity of Crops Irrigated

Crops grown in the Spokane Basin on USBR project lands in 1987(ref 13).

Crops	Acres
Forage	3,150
Cereals	300
Field Crops	100
Vegetables	165
Fruit	110

The rest of the irrigated land in this basin is on small farms producing mostly forages.

4. Hydrology of the Region

The Little Spokane River flows south from Idaho into the Spokane River just northwest of Spokane. The Little Spokane River covers 701 sq-mi of land north of Spokane. Snow runoff provides a large spring runoff and low summer flows. The Little Spokane River discharges 226,000 ac-ft per year. A large part of this basin's precipitation soaks into the ground and moves downward to become part of the Little Spokane River groundwater reservoir. This reservoir provides for much of the summer flows in the lower reaches of the Little Spokane River. Recharge to this reservoir is estimated at 160,000 ac-ft per year (ref 7.1).

The Middle Spokane River is the reach of the Spokane River, east of the confluence with the Little Spokane River to the Idaho Border. The Spokane River flows from Lake Coeur d'Alene in Idaho west to the Columbia River. Upriver Dam east of Spokane generates hydropower from the river. Flowing under this region is the Spokane Valley Aquifer. Estimates by the USGS suggest that the aquifer flows 40 to 90 ft per day. The aquifer is recharged by various lakes in Idaho and Washington. The aquifer flows into the Spokane River in Idaho, then, because of backwater from Upriver Dam, the river flows back into the aquifer upstream of the Dam. In the reach downstream of Upriver Dam and above the falls in downtown Spokane, the aquifer discharges into the Spokane River and into the Little Spokane River north of Spokane (ref 7.2).

The Hangman Creek Basin covers 689 sq-mi of land south of Spokane. This area receives an estimated 20 inches of rain annually. The average annual discharge into the Spokane River from Hangman Creek is 182,600 ac-ft (ref 21).

5. Source of Irrigation Water

Sources of water include the Little Spokane River and its underlying aquifer, Spokane Valley Aquifer, and Hangman Creek. Small farms diverted an estimated 1,752 ac-ft of surface water and 5,596 ac-ft of groundwater in 1975 from the Little Spokane Basin (ref 24). Most of the land in the Spokane Basin is irrigated from the Spokane Valley Aquifer by pressurized systems that have storage tanks (ref 5). In the Spokane Valley, of the 37,416 ac-ft of water used in 1975, 99% was from groundwater (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

The Little Spokane River and Hangman Creek are irrigated by individual farmer deliveries. The Spokane Valley has ten irrigation districts, five of which deliver water soley for domestic use. There is USBR involvement in the Consolidated Irrigation District.

7. Local Awareness of Water Conservation in the Region

The Department of Ecology has developed a Water Resources Program in the Little Spokane River Basin under Chapter 173-555 of the Washington Administrative Code. Considerable concern exists for the preservation of the Spokane Valley Aquifer.

8. Competition for Water

Water rights total 66,087 ac-ft for municipal and industrial use, while farmers have rights for 28,345 ac-ft of groundwater and 16,850 ac-ft of surface water in the Little Spokane Basin (ref 7.1).

9. Cost of Water and Energy

The cost of water and energy is low.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The Little Spokane Basin has no organized irrigation, and only small urban farms. The Little Spokane Basin does have water shortages during the summer months.

The Spokane Valley irrigates small farms in an urban setting, with the water quality of the aquifer as the main water issue in this basin.

11. Potential for Improving Water Use Efficiency

The Spokane Valley is expected to have higher than average water use efficiencies because the irrigation districts in this basin pump from groundwater supplies and deliver water through metered pipe systems.

12. Potential for Benefits from Improved Water Use Efficiency

With increasing urban and industrial development, water needs will increase in the Spokane Basin.

Basin References

7.1 Cundg, Seung K. *Little Spokane River Basin (WIRA 55)*. Basin Program Series 1, Water Resources management Program, Washington State Department of Ecology. Aug 1975.

7.2 State of Washington Water Research Center. *Protection and Management of Aquifers with Emphasis on the Spokane-Rathrum Aquifer*. Report No. 62. Washington State University and University of Washington. April 1985..

Irrigated Region #8: Mid Columbia Mainstem
Location: North Central Washington along Columbia River between Moses Coulee and Pateros

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

There are an estimated 10,636 acres within the irrigation districts in this region (ref 5).

2. On-Farm Irrigation System Type

Most irrigation is accomplished with sprinkle systems, but there is some trickle irrigation.

3. Diversity of Crops Irrigated

This area is primarily orchards.

4. Hydrology of the Region

This region includes the Columbia River reservoirs created by Wanapum Dam, Rock Island Dam, Rocky Reach Dam and Wells Dam. Average annual flow of the Columbia River at Chief Joseph Dam is 83,000,700 ac-ft. Five major river basins Okanogan, Methow, Chelan, Entiat, and Wenatchee Rivers contribute to the Columbia River in this region. Annual outflow from the region is estimated at 88,300,800 ac-ft (ref 21). The active storage in the Columbia River reservoirs is: Wanapum 160,800 ac-ft, Rock Island 8,600 ac-ft, Entiat Lake(Rocky Reach) 64,300 ac-ft and Wells 70,700 ac-ft (ref 8).

5. Source of Irrigation Water

Water is pumped from the Columbia River reservoirs through piped delivery systems. Some of the irrigation districts have storage tanks used for handling water between pumping stations (ref 5).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are eight irrigation districts in this region (ref 5).

7. Local Awareness of Water Conservation in the Region

With a generally abundant water supply and inexpensive energy, on-farm water conservation is a low priority.

8. Competition for Water

Most of the water in this basin is used for hydropower production. The large lakes created by the dams also provide recreational opportunities, which have been developed by various state and county parks in this region.

9. Cost of Water and Energy

The cost of water and energy is moderate for this basin.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

This area is seen as a poor study area because it has no major water issues. The large irrigation districts, however, could provide organizational benefits to a study.

11. Potential for Improving Water Use Efficiency

With moderate pumping costs and pipe deliveries, this basin is expected to have higher than average irrigation efficiencies.

12. Potential for Benefits from Improved Water Use Efficiency

Water saved from this basin would increase water for hydropower and recreation.

Irrigated Region #9: Chelan Basin
Location: North Central Washington
Chelan County
WRIA 47

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

An estimated 8,034 acres were irrigated in 1975 (ref 24).

2. On-Farm Irrigation System Type

Irrigated lands in Chelan County are estimated to have 98.1% sprinkle systems and 1.8% trickle systems. The Chelan Basin is also mostly sprinkle irrigated.

3. Diversity of Crops Irrigated

In this basin irrigation is primarily in orchards.

4. Hydrology of the Region

Surrounding Lake Chelan in north central Washington, this basin covers 924 sq-mi. Lake Chelan is 33,104 acres in area with a maximum depth of 1,605 ft and total storage of 676,100 ac-ft. Lake Chelan releases approximately 1,500,000 ac-ft into the Columbia River annually. The basin receives an average 55.0 inches of precipitation annually.

5. Source of Irrigation Water

Most of the water in this region is pumped from Lake Chelan and delivered through piped systems. In 1975 an estimated 23,707 ac-ft of surface water was used for irrigation (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are four irrigation districts in this basin.

7. Local Awareness of Water Conservation in the Region

Local awareness of water conservation is low to moderate. There is some concern with hydropower.

8. Competition for Water

The town of Chelan receives its water supply form Lake Chelan. Lake Chelan is one of Washington's major recreation lakes. There is also hydropower at the lake's outlet to the Columbia River.

9. Cost of Water and Energy

Some high lift pumping from Lake Chelan causes moderate energy and water delivery costs.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the large water supply stored in Lake Chelan, there are not a lot of water issues in this basin.

11. Potential for Improving Water Use Efficiency

Water management practices are relatively poor because of abundant supply and moderate costs. The irrigation districts in this basin pump water through PVC pipe and farmers use sprinkle systems. Therefore water use efficiency is expected to be higher than average.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from water use efficiency include water for hydropower and recreation.

Basin References

9.1 Columbia Basin Inter-Agency Committee. *River Mile Index, Wenatchee River, Entiat River, Chelan River, Methow River*. Hydrology Subcommittee. Sept 1964.

9.2 Washington State Department of Ecology. *Status Summary of Potential Projects in the Wenatchee-Chelan-Entiat River Basins*. Project Summary No. 7. Water Resources Information System. Oct 1975.

9.3 Beck, R.W. and Associates. *Sewage Drainage Basin Plan Chelan County, Washington*. Analytical and Consulting Engineers, Seattle, Wa. June 1974.

9.4 Bagley, Charles M. *Nonpoint Pollution Originating from Main Irrigation Systems (final report). Chelan County Conservation District Wenatchee, Washington*. Washington State Conservation Commission Olympia, Washington. July 1988.

Irrigated Region #10: Entiat River Basin
Location: North Central Washington
Chelan County
WRIA 46

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975 an estimated 2,620 acres were irrigated (ref 24).

2. On-Farm Irrigation System Type

Most of the area is sprinkle irrigated, with some drip irrigation near the Columbia River.

3. Diversity of Crops Irrigated

This region raises mostly fruit and some forages.

4. Hydrology of the Region

The Entiat Basin, located in north central Washington, comprises 419 sq-mi of land, of which 92% is forest. The average annual rainfall is 45 inches in the Entiat River Basin. Entiat River annually discharges 367,100 ac-ft into the Columbia River. The Mad River's discharge is estimated at 99,800 ac-ft to the Entiat River.

5. Source of Irrigation Water

Water is diverted from the Mad River and Entiat River. In 1975 an estimated 10,480 ac-ft of surface water was used for irrigation (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

Most of the water is diverted by individual farmers.

7. Local Awareness of Water Conservation in the Region

There is moderate local awareness of water conservation due to water shortages during dry years.

8. Competition for Water

Competition for water is generally low. With no hydropower or municipal demand there is an adequate supply of water.

9. Cost of Water and Energy

Cost of water is low, pumping costs are low to moderate due to pump lifts.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

There is very little data about this basin for a study. This basin, however, is typical of the small drainage areas of the state with high spring freshet flows, low summer flows, and no reservoir storage.

11. Potential for Improving Water Use Efficiency

The upper Entiat and Mad River diversions have potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

During dry summers improved water use efficiency would be beneficial to farmers lower in the basin near Entiat.

Basin References

10.1 Columbia Basin Inter-Agency Committee. *River Mile Index, Wenatchee River, Entiat River, Chelan River, Methow River.* Hydrology Subcommittee. Sept 1964.

10.2 Washington State Department of Ecology. *Status Summary of Potential Projects in the Wenatchee-Chelan-Entiat River Basins.* Project Summary No. 7. Water Resources Information System. Oct 1975.

10.3 Beck, R.W. and Associates. *Sewage Drainage Basin Plan Chelan County, Washington.* Analytical and Consulting Engineers, Seattle, Wa. June 1974.

10.4 Bagley, Charles M. *Nonpoint Pollution Originating from Main Irrigation Systems (final report)..Chelan County Conservation District Wenatchee, Washington.* Washington State Conservation Commission Olympia, Washington. July 1988.

Irrigated Region #11: Wenatchee Basin
Location: Central Washington
Chelan County
WRIA 45, 40

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

There are approximately 17,520 acres irrigated in the Wenatchee Basin (ref 11.5).

2. On-Farm Irrigation System Type

In Chelan County, 98.2% of the land is estimated to be sprinkle irrigated and 1.8% trickle irrigated.

3. Diversity of Crops Irrigated

Some forages are grown in the higher elevations of the basin, but most of the irrigated land is in fruit production.

4. Hydrology of the Region

This basin is approximately 1,310 sq-mi in area. The average annual precipitation ranges from 100 inches on the eastern slopes of the Cascade Range, to 9 inches at Wenatchee. The average annual discharge for the Wenatchee River is 2,379,000 ac-ft one mile north of Monitor (@6 mile north of the Columbia River).

5. Source of Irrigation Water

Surface water is the dominant source of irrigation water, diverted through lined and unlined canals, and piped systems. In 1975 an estimated 66,586 ac-ft of surface water was used for irrigation (ref 24). There are no reservoirs in this basin.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are ten major irrigation districts in this basin.

7. Local Awareness of Water Conservation in the Region

The interest in water conservation does not seem to be as high in this basin as the interest in other issues related to fruit production.

8. Competition for Water

The Wenatchee River is a valuable recreation resource. Some municipal water is diverted from the Wenatchee River, but the majority of municipal water supplies are pumped from groundwater.

The following streams within the Wenatchee Basin are adjudicated: Icicle Creek (10/28/29), Chumstick Creek (4/12/83), Stemilt Creek (1/22/26), and Squilchuck Creek (6/14/28) (ref 17). Ecology's policies to manage the basin's water resources are established in Chapter 173-545 of the Washington Administration Code(WAC), Instream Resources Protection Program -- Wenatchee River Basin.

9. Cost of Water and Energy

Costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The Wenatchee Basin has several irrigation districts that are eligible for referendum 38 funds, instream flow concerns, and some irrigation shortages during dry summer years. The upper basin area is seeing increasing urban development due to the aesthetic and scenic values of this region.

11. Potential for Improving Water Use Efficiency

The irrigation districts in this basin have conveyance efficiencies ranging from 80% to 31% (ref 11.6), with a mean of 60% efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

Improved water use efficiencies would provide water for instream flows, recreation, meet urban demands and irrigation shortages.

Basin References

11.1 Columbia Basin Inter-Agency Committee. *River Mile Index, Wenatchee River, Entiat River, Chelan River, Methow River*. Hydrology Subcommittee. Sept 1964.

11.2 Washington State Department of Ecology. *Status Summary of Potential Projects in the Wenatchee-Chelan-Entiat River Basins*. Project Summary No. 7. Water Resources Information System. Oct 1975.

11.3 Washington State Department of Ecology. *Wenatchee River Basin Instream Recourses Protection Program*. WIRPP Series-No. 26. State Water Program. Dec 1982.

11.4 Beck, R.W. and Associates. *Sewage Drainage Basin Plan Chelan County, Washington*. Analytical and Consulting Engineers, Seattle, Wa. June 1974.

11.5 Sorlie, Greg. *A Review of the Water Resources of the Wenatchee Basin.* Office Report No. 40. Water Resources Analysis and Information Section, Water Resources Management Division, Washington State Department of Ecology. Jan 1976.

11.6 Bagley, Charles M. *Nonpoint Pollution Originating from Main Irrigation Systems (final report). Chelan County Conservation District Wenatchee, Washington.* Washington State Conservation Commission Olympia, Washington. July 1988.

Irrigated Region #12: Methow River Basin
Location: North Central Washington
Okanogan County
WRIA 48

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975 an estimated 15,328 acres were irrigated in this basin (ref 24).

2. On-Farm Irrigation System Type

Most of the irrigation is by sprinkle systems, but some is by surface systems.

3. Diversity of Crops Irrigated

Forages and fruit production dominate the crops grown in this region.

4. Hydrology of the Region

This basin drains approximately 1,794 sq-mi of area. Precipitation ranges from 80 inches at the crest of the Cascade Range to 10 inches at Pateros. Most of the water is provided by mountain runoff. The mean annual precipitation is 32.1 inches or about 3,000,000 ac-ft of water. Outflow from the Methow River to the Columbia River is 1,200,000 ac-ft at Pateros. An average evapotranspiration rate of 20 inches per year for irrigated and 12 inches for nonirrigated land gives a total evapotranspiration of 1,160,000 ac-ft. This leaves an estimated 740,000 ac-ft of water for groundwater outflow from the basin (ref 12.3).

5. Source of Irrigation Water

The rivers of the basin provide 96% of the irrigation water in this basin and groundwater provides 4% of the irrigation water (ref 24). Surface water is delivered to farms through mostly unlined canals (ref 12.4). In 1975 an estimated 54,660 ac-ft of water was used for irrigation, of which 52,615 ac-ft was surface water and the rest groundwater (ref 24). Three lakes are used for storage: Patterson Lake (20 feet of control), Pearrygin Lake (6.5 ft of control, 1,800 ac-ft of storage), Davis Lake.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are two irrigation districts, 14 ditch companies, in addition to individual farm delivery systems in this basin (ref 12.4).

7. Local Awareness of Water Conservation in the Region

Local awareness of water issues is high in this basin with increasing development of the upper basin into small lots, instream flow requirements, and inadequate water for lower irrigated areas.

8. Competition for Water

Competition for water for a proposed ski area, mining development, irrigation, instream flows, and recreation exist in the Methow Basin. The following streams are adjudicated: Beaver Creek (9/20/21), Libby Creek (11/18/21), McFarland Creek (11/10/22), Gold Creek (5/7/29), Black Canyon Creek (6/20/29), Bear Creek and Davis Lake (5/14/30), and Wolf Creek (3/13/84). Ecology's policies to manage the basin's water are established in Chapter 173-548 of the Washington Administration Code(WAC), Water Resources Program in the Methow River Basin.

9. Cost of Water and Energy

Cost of water and energy is moderate in the Methow Basin.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

This basin is faced with instream flow issues, short water supplies and water quality issues. The irrigation districts are available for funding under referendum 38. This basin also has new data that would be useful in a study project.

11. Potential for Improving Water Use Efficiency

Although systems of conveyance of irrigation water vary in degree of efficiency, it is reported that the loss by leakage from earth canals and ditches in the Methow River Basin was 35,735 ac-ft (45%) of 79,348 ac-ft entering that system in 1971 (ref 12.6).

12. Potential for Benefits from Improved Water Use Efficiency

As many of the other small basins with no reservoir storage the water saved form improved water use efficiency would benefit instream flow requirements and recreation. Land in the lower portions of the Methow Basin would benefit from increased reliable water supplies.

Basin References

12.1 Columbia Basin Inter-Agency Committee. *River Mile Index, Wenatchee River, Entiat River, Chelan River, Methow River.* Hydrology Subcommittee. Sept 1964.

12.2 Orsborn, John F. *Technical Supplement to the Hydrographic Atlas, Okanogan-Methow River Basins Study Area.* Washington State Water Research Center. Dec 1973.

12.3 Pacific Northwest River Basin Commission. *The Methow Basin Level B Study of the Water and Related Land Resources*. April 1977.

12.4 US Bureau of Reclamation. *Methow Division, Chief Joseph Dam Project, Washington, (reconnaissance report)*. Region 1, Boise Idaho. Nov. 1961.

12.5 USDA Forest Service. *Twisp-Winthrop-Conconully planning Unit Land-Use Plan, Environmental Statement (final)*. USDA-FS-R6-FES(Adm.)-76-5. Okanogan National Forest.

12.6 Walters, Kenneth L., and Nassar, E.G. *Water in the Methow River Basin, Washington*. Water Supply Bulletin No. 38, Washington State Department of Ecology. 1974

12.7 Washington State Department of Ecology. *Status Summary of Potential Projects in the Okanogan-Methow Study Area*. Project Summary No. 3. Water Resources Information System. Oct 1975.

12.8 Leonoff, Klohn. *Water Management Plan for Methow Valley Irrigation District (draft)*. Consulting Engineers. Contract No. PW166 0101 with WDOE. Nov 1989.

12.9 Kauffman, Kris G. *Methow River Basin (WRIA NO. 48)*. Basin Program Series 4, Water Resources management Program, Washington State Department of Ecology. June 1977.

Irrigated Region #13: Okanogan River Basin
Location: North Central Washington
Okanogan County
WRIA 49

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975, 32,289 acres were irrigated (ref 24) in the Okanogan Basin.

2. On-Farm Irrigation System Type

In Okanogan County 95% of the on farm systems are sprinkle systems, 3% are trickle systems, and 2% are surface systems (ref 3).

3. Diversity of Crops Irrigated

Forages and fruit crops are the main crops grown in this basin (ref 13).

4. Hydrology of the Region

This basin is approximately 3,100 sq-mi in area. Annual precipitation ranges from 49 inches in the mountains to 10 inches near the Columbia River. The estimated mean annual precipitation in the Okanogan River Basin is 17.5 inches or about 2,000,000 ac-ft of water. Most of this precipitation falls during the winter months, resulting in snow accumulation. The melting snow then releases water to the stream in late spring and summer. Also, 2,100,000 ac-ft enters the basin as stream flow from Canada. Approximately 2,200,000 ac-ft leaves the basin as stream flow and an estimated 1,900,000 leaves as evapotranspiration annually.

5. Source of Irrigation Water

In 1975, an estimated 119,059 ac-ft of water was used for irrigation. Surface water was the source of 99% of the irrigation water (ref 24). The delivery systems in the basin's irrigation districts are lined canals or piped systems (ref 5).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are six irrigation districts in the Okanogan Basin. The Oroville-Tonasket, Whitestone, and Okanogan Irrigation Districts are USBR Projects.

7. Local Awareness of Water Conservation in the Region

There is moderate local awareness of water conservation due to water shortages during dry years.

8. Competition for Water

Competition exists between instream flows, recreation, and irrigation for water within this basin. This basin also has a small water dependence on Canadian influences. Chapter 173-549 of the Washington Administration Code(WAC), Water Resources Program in the Okanogan River Basin, establishes Ecology's policies to manage the basin's water resources. Adjudicated streams in this basin include the Similkameen River (11/26/18), Salmon Creek, North Fork (4/6/26), Johnson Creek (5/20/26), Lower Antoine Creek (7/9/28), Sinlahekin Creek (5/20/30), Whitestone Lake (5/21/56), Chiliwist Creek (5/16/67), and Boneparte Creek and Lake (12/14/79).

9. Cost of Water and Energy

Costs of water and energy are moderate in this basin.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The recent rehabilitation of one irrigation project by the USBR make this basin less urgent of a region for study. The basin, however, faces the same water issues of instream flows, water quality and irrigation shortages as other basins.

11. Potential for Improving Water Use Efficiency

With the pressurization of the Oroville-Tonasket Irrigation District, and because other districts have lined canals or piped systems, irrigation efficiency is expected to be higher than average. Water management at the farm level could see considerable improvement.

12. Potential for Benefits from Improved Water Use Efficiency

The largest benefit from improved water use efficiency is instream flows and recreation.

Basin References

13.1 Kauffman, Kris G. *Okanogan River Basin (WIRA 49)*. Basin Program Series 3, Water Resources management Program, Washington State Department of Ecology. June 1976.

13.2 Pacific Northwest River Basin Commission. *The Okanogan River Basin Level B Study of the Water and Related Land Resources (revised)*. Dec 1977.

13.3 US Bureau of Reclamation. *Colville Indian Reservation and Adjacent Areas Chief Joseph Dam Project Washington(appraisal report)*. July 1979.

13.4 Orsborn, John F. *Technical Supplement to the Hydrographic Atlas, Okanogan-Methow River Basins Study Area*. Washington State Water Research Center. Dec 1973.

13.5 Washington State Department of Ecology. *Status Summary of Potential Projects in the Okanogan-Methow Study Area*. Project Summary No. 3. Water Resources Information System. Oct 1975.

Irrigated Region #14a: Kettle River
Location: North Eastern Washington
Ferry County
WRIA 60

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

An estimated 3,650 acres were irrigated in 1975 (ref 24).

2. On-Farm Irrigation System Type

It is estimated that 98% of irrigation in Ferry County is sprinkle irrigated and 2% surface irrigated (ref 3).

3. Diversity of Crops Irrigated

Most of the land in this region produce forages.

4. Hydrology of the Region

The Kettle River snakes its way east to drain 3,800 sq-mi in Canada and Washington. The Kettle River annually discharges 2,090,000 ac-ft of water into the Columbia River near Boyds. Approximately 1,090,000 ac-ft of water comes from an annual average of 27 inches of precipitation that fall on 2,220 sq-mi in Canada.

5. Source of Irrigation Water

In 1975, an estimated 7,221 ac-ft of water was used for irrigation. Surface water provided 96% of the water for irrigation to this region in 1975 (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in this basin.

7. Local Awareness of Water Conservation in the Region

There is little local awareness of water conservation.

8. Competition for Water

There is little competition for water. Colville Indian Reservation has interest in the water in this area.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the small land base in irrigation and the limited irrigation entities, this basin is a poor choice for a study area. The lack of data for a study is also limiting for this basin.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Irrigated Region #14b: Pend Oreille River
Location: North Eastern Washington
Pend Oreille County
WRIA 62

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

An estimated 7,000 acres were irrigated in 1975 (ref 24).

2. On-Farm Irrigation System Type

Essentially all of the farms in this basin use sprinkle systems (ref 3).

3. Diversity of Crops Irrigated

Most of the land produces forages (ref 14b.1).

4. Hydrology of the Region

The Pend Oreille River is an extension of the Clark Fork River, flowing from Lake Pend Oreille in Idaho north to the Columbia River in Canada via Washington. Because the Pend Oreille River is a continuation of the Clark Fork River, the average annual runoff totals 19,140,000 ac-ft near the International Boundary. Although the combined drainage area for the Pend Oreille - Clark Fork is 25,960 sq-mi, the Pend Oreille drains only about 3,700 sq-mi of which 600 sq-mi is in Canada. The average annual precipitation at Metaline Falls is 28.4 inches (ref 14b.1).

5. Source of Irrigation Water

In 1975, an estimated 7,000 ac-ft of water was used for irrigation. Surface water is used to irrigate 75% of the irrigated land (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in this basin.

7. Local Awareness of Water Conservation in the Region

There is little local awareness of water conservation.

8. Competition for Water

Three dams on the mainstem of the Pend Oreille River generate hydropower from the river: Albeni Falls Dam in Idaho, Box Canyon Dam in Washington, and a Dam in Canada.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

There are few irrigation related water issues in this basin.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin Reference

14b.1 US Bureau of Reclamation. *Pend Oreille River Basin, Idaho-Washington (reconnaissance report)*. Region 1, Boise, Idaho. Jan 1964.

Irrigated Region #14c: Colville River Basin
Location: North Eastern Washington
Stevens County
WRIA 59

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975 an estimated 7,500 acres were irrigated (ref 24).

2. On-Farm Irrigation System Type

In Stevens County, 1.5% of land is surface irrigated, 98.4% is sprinkle irrigated and 0.1% is trickle irrigated (ref 3).

3. Diversity of Crops Irrigated

Forages are grown on 85% of the land with the rest in cereal crops (ref 14c.1).

4. Hydrology of the Region

The Colville River Basin, located in central Stevens County, drains approximately 1,000 sq-mi northward from the Selkirk Mountains to the Columbia River. The average annual precipitation ranges from less than 15 inches near Arden to 40 inches near Calispell Peak. The Colville River discharges an average 223,500 ac-ft annually near Kettle Falls (ref 14c.1).

Three lakes at the head waters of the Colville River are used for Recreation: Loon, Deer, and Waits Lake. Waits Lake, which is controlled by a low dam, is also used for hydropower and irrigation (ref 14c.1).

5. Source of Irrigation Water

In 1975, an estimated 13,680 ac-ft of water was used for irrigation. Surface water provided 95% of the irrigation water used in 1975 (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in the Colville River Basin.

7. Local Awareness of Water Conservation in the Region

The Stevens County Conservation District is active. Local awareness of water conservation is moderate due to the conservation districts activities.

8. Competition for Water

Ecology's policies to mange the basin's water resources are established in Chapter 173-559 of the Washington Administration Code(WAC), Water Resources Program for the Colville River Basin.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the small land base in irrigation and the limited irrigation entities, this basin is a poor choice for a study area. The lack of data for a study is also limiting for this basin.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin References

14c.1 Chung, Seung K., Slattery, Kenneth O. *Colville River Basin*. Basin Program Series 5, Water Resources Management Program, Washington State Department of Ecology. . Dec 1977.

14c.2 Mix, Theodore J. *Colville River Basin (technical report)*. Basin Program Series 5, Water Resources management Program, Washington State Department of Ecology. May 1977.

Irrigated Region #14b: Sanpoil River
Location: North Central Washington
Ferry and Okanogan County
WRIA 52

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Irrigated lands are centered in two locations: 1) the valley surrounding the town of Republic, 2) on the Colville Indian reservation near Keller, along the shores of Lake Roosevelt (ref 23). In 1975 an estimated 2,600 acres were irrigated (ref 24).

2. On-Farm Irrigation System Type

Most irrigation is sprinkle systems, but there is some surface irrigation.

3. Diversity of Crops Irrigated

Land in the Republic area is mostly in forage production and land along Lake Roosevelt is also in fruit production.

4. Hydrology of the Region

Located in north central Washington in Ferry and Okanogan Counties, the Sanpoil River drains 928 sq-mi into the Columbia River at Keller. Most of this area is forest land located within the Colville National Forest and the Colville Indian Reservation. An average 20 inches of precipitation occurs each year in this basin. Curlew Lake at the head waters of the Sanpoil provides a natural stored supply of water for the Sanpoil River.

5. Source of Irrigation Water

In 1975 an estimated 5,200 ac-ft was used for irrigation. Surface water provided for 98% of the water used in 1975 (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in this region.

7. Local Awareness of Water Conservation in the Region

The local awareness of water conservation is moderate.

8. Competition for Water

There is some competition for water by the Colville Indian Nation.

9. Cost of Water and Energy

The cost of water and energy is moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the small land base in irrigation and the limited irrigation entities, this basin is a poor choice for a study area. The lack of data for a study is also limiting for this basin.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin Reference

14b.1 US Bureau of Reclamation. *Colville Indian Reservation and Adjacent Areas Chief Joseph Dam Project Washington(appraisal report)*. July 1979.

Irrigated Region #15a: Klickitat River
Location: South Central Washington
Klickitat, Yakima County
WRIA 30

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975, an estimated 13,565 acres were irrigated in the Klickitat River Basin (ref 24).

2. On-Farm Irrigation System Type

On-farm irrigation systems for Klickitat County based on irrigated acres are 10.0% surface systems, 89.8% sprinkle systems and 0.2% trickle systems (ref 3).

3. Diversity of Crops Irrigated

Irrigated lands are primarily in forage and fruit production in the Klickitat basin.

4. Hydrology of the Region

The Klickitat River drains 1,170,000 ac-ft of water annually into the Columbia River from 1,297 sq-mi of land southwest of Mt. Adams. This area receives an average 26 inches of rain annually (ref 21).

5. Source of Irrigation Water

In 1975, an estimated 15,481 ac-ft of surface water and 15,530 ac-ft of groundwater were used in the Klickitat basin for irrigation (ref 24). Major areas of irrigation are centered around Outlet Creek near Glenwood, and around Goldendale (ref 23).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in this basin.

7. Local Awareness of Water Conservation in the Region

The local awareness of water conservation is moderate.

8. Competition for Water

There is some competition for water.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Because of the small land base in irrigation and the limited irrigation entities, this basin is a poor choice for a study area. The lack of data for a study is also limiting for this basin.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Irrigated Region #15b: White Salmon River
Location: South Central Washington
Klickitat, Skamania County
WRIA 29

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

In 1975, an estimated 6,200 acres was irrigated in the White Salmon Basin (ref 24).

2. On-Farm Irrigation System Type

The White Salmon Basin is irrigated mainly with surface and sprinkle systems with a few trickle irrigation systems.

3. Diversity of Crops Irrigated

Most of the upper White Salmon Basin produces forages, while the lower White Salmon Basin produces fruit (ref 15b.1).

4. Hydrology of the Region

The White Salmon River drains an area of about 400 sq-mi, and carries an average annual runoff of 804,600 ac-ft. The White Salmon River is formed from glaciers on Mount Adams (ref 15b.1).

There is a small amount of regulation of the White Salmon River by Condit Dam located on the mainstem about 3 miles upstream from its mouth on the Columbia River. Condit Dam's reservoir has 1,080 ac-ft of active storage.

5. Source of Irrigation Water

In 1975, an estimated 14,105 ac-ft of surface water was used for irrigation in the White Salmon Basin (ref 24)

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

The White Salmon Irrigation District irrigates about 600 acres near Husum using water diverted from Buck Creek. There are a number of individual farms irrigating near the town of Trout Lake (ref 15b.1).

7. Local Awareness of Water Conservation in the Region

Local awareness is moderate due to urban development.

8. Competition for Water

The White Salmon Irrigation District has two water rights: a 1923 right to 4.5 cfs and a 1960 right to 2.0 cfs from Buck Creek. The town of White Salmon also has a 1923 right to divert water from Buck Creek at 2.0 cfs (ref 15b.1).

The Pacific Power and Light Company has a right for 1,200 cfs of water from the White Salmon River for hydropower production at Condit Dam (ref 15b.1).

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The water issues in this basin include water quality concern around the town of Trout Lake. This basin is a poor choice of a statewide application because of its small irrigated land base.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin Reference

15b.1 US Bureau of Reclamation. *White Salmon Division Columbia North Side Project Washington (appraisal report)*. Feb 1974.

Irrigated Region #16a: Dungeness River
Location: Sequim-Dungeness Peninsula in Western Washington
Clallam County
WRIA 18

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Irrigated land is estimated at 15,100 acres (ref 16a.1).

2. On-Farm Irrigation System Type

In Clallam County 99.7% of the irrigated land is under sprinkle systems and 0.3% under trickle systems (ref 3).

3. Diversity of Crops Irrigated

Most of the land produces forages and fruit.

4. Hydrology of the Region

The Dungeness River drains 197 sq-mi from the Olympic Mountains into the Strait of Juan de Fuca. An average discharge of 282,600 ac-ft annually drains from the Dungeness River (ref 21). The Dungeness Basin is in the rain shadow of the Olympic Mountains and receives only 12 to 14 inches annual rainfall.

5. Source of Irrigation Water

An estimated 55,260 ac-ft is diverted through nine major irrigation systems (ref 16a.1).

The delivery systems within the four irrigation districts are earth canals and laterals (ref 5).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are four irrigation districts that are reported to divert water year round from the Dungeness Basin.

7. Local Awareness of Water Conservation in the Region

Local awareness is moderate. There is some concern over water quality in this basin.

8. Competition for Water

Competition for water in this basin includes water for instream flows, the City of Sequim, and irrigation.

9. Cost of Water and Energy

The cost of water and energy is moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

The farmed land base is shrinking in this basin, because of urban development. Water issues in this basin include instream flows, water quality and Indian issues. There are a number of irrigation districts that are eligible for Referendum 38 funding.

11. Potential for Improving Water Use Efficiency

The irrigation districts have potential for improving water use efficiency through management practices and by reducing canal loses.

12. Potential for Benefits from Improved Water Use Efficiency

Benefits from conserved water would be useful in meeting dry summer flow requirements, instream flow requirements and increased population demands.

Basin References

16a.1 Dorst, B.W. *Water Recourses of Clallam County, Washington: Phase 1 Report*. US Geological Survey. Water-Resource Investigation Report 83-4227. 1986.

16a.2 Pacific Northwest River Basins Commission. *River Mile Index, Elwha River, Dungeness River, Little Quilcene River, Big Quilcene River, Dosewallips River, Duckabush River, Hamma Hamma River, Skokomish River*. Hydrology and Hydraulics Committee. Sept 1969.

Irrigated Region #16b: Chehalis River
Location: South Western Washington
Grays Harbor, Lewis, Thurston Counties
WRIA 22, 23

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

An estimated 18,400 acres were irrigated from both ground and surface water in 1970 (ref 16b.1).

2. On-Farm Irrigation System Type

In the three counties of this basin, 99.9% of the irrigation is by sprinkle system and 0.1% is trickle system (ref 3).

3. Diversity of Crops Irrigated

Primary crops grown in this basin are: forages, cereals, vegetables, and fruit (ref 16b.1).

4. Hydrology of the Region

The Chehalis River Basin lies between the Deschutes and Cowlitz River Basins on the east and south, respectively, and the Olympic Range on the north. The total drainage area of the basin is 2,680 sq-mi, of which approximately 84% is forest land. The Chehalis River's average annual discharge from the basin is 8,120,000 ac-ft (ref 16b.1).

5. Source of Irrigation Water

Water use in the Chehalis Basin was approximately 125,000 ac-ft in 1970; of this total about 25,000 ac-ft were actually depleted from the basin supply. Approximately 66% of the water use in the basin is by industry, 23% by agriculture, and 11% by municipalities (ref 16b.1).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in the Chehalis Basin.

7. Local Awareness of Water Conservation in the Region

Local awareness of water conservation is moderate.

8. Competition for Water

There is some competition for water for hydropower and municipal and industrial use.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Water issues include instream flows for fish production and water quality problems.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin Reference

16b.1 Mahlum, Stanley E. *Chehalis River Basin (WIRA 22, 23)*. Basin Program Series 2, Water Resources management Program, Washington State Department of Ecology. Nov 1975.

Irrigated Region #16c: Willapa River
Location: South Western Washington
Pacific County
WRIA 24

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Irrigated acres in 1975 totaled 1,500 acres (ref 24).

2. On-Farm Irrigation System Type

All of the land in Pacific County was estimated to use sprinkle irrigation (ref 3).

3. Diversity of Crops Irrigated

Crops grown in this basin include forages and small fruits.

4. Hydrology of the Region

The Willapa drains 130 sq-mi west into Willapa Bay. The average annual rainfall of 87.0 inches produces an annual average discharge near Willapa of 470,000 ac-ft of water (ref 21).

5. Source of Irrigation Water

In 1975, an estimated 3,150 ac-ft of surface water was used for irrigation (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts in the Willapa Basin.

7. Local Awareness of Water Conservation in the Region

Local awareness is moderate. There are concerns over instream flows and water quality.

8. Competition for Water

There is some competition for water in this basin.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

This is a poor basin to study because it is very small and has little irrigated land.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Irrigated Region #16d: Nooksack River
Location: North Western Washington
Whatcom County
WRIA 1

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

Approximately 30,000 acres are irrigated in the Nooksack Basin.

2. On-Farm Irrigation System Type

Of the irrigated land in Whatcom County, 99.7% use sprinkle systems and 0.3% use trickle systems (ref 3).

3. Diversity of Crops Irrigated

Most of the crops grown in the Nooksack Basin are in forage and fruit, but there is some vegetable and cereal crop production as well.

4. Hydrology of the Region

The Nooksack River annually drains 2,970,000 ac-ft from 826 sq-mi of land west of Mt. Baker to the Strait of Georgia. There are approximately 14,748 acres of wetland in Whatcom County. An important wetland is located at the mouth of the Nooksack River (ref 16d.1).

5. Source of Irrigation Water

In 1975, an estimated 11,150 ac-ft of surface water and 26,028 ac-ft of groundwater was used for irrigation in the Nooksack Basin (ref 24).

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are no irrigation districts or ditch companies used for water delivery. However, drainage districts have been formed to take care of excess water in the basin (ref 16d.1).

7. Local Awareness of Water Conservation in the Region

There are moderate concerns for water quality, instream flows, and storage of water.

8. Competition for Water

Numerous hydroelectric projects have been proposed within the Nooksack River Basin. However only two of these projects were working as of 1984 (ref 16d.1).

A large part of the Nooksack River is used for industrial and municipal water supplies. The largest water user is the city of Bellingham, using between 67,000 and 112,000 ac-ft annually. The city has a right to divert 125 cfs from the Middle Fork of the Nooksack River and store 20,000 ac-ft of water in Lake Whatcom. Other smaller cities and industry use about 27,000 ac-ft annually from the Nooksack River (ref 16d.1).

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Due to the number of water related issues and the size of the irrigated land base, this basin has moderate potential for statewide application.

11. Potential for Improving Water Use Efficiency

There is moderate potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are moderate.

Basin Reference

16d.1 Washington State Department of Ecology. *Nooksack Instream Resources Protection Program (WIRA 1)*. W.W.I.R.P.P. Series - No. 11, State Water Program. Nov 1985.

Irrigated Region #16e: Skagit River
Location: North Western Washington
Skagit County
WRIA 3

I. Physical Characteristics of Irrigated Regions.

1. Amount of Irrigation

There are approximately 6,000 to 7,000 acres irrigated in this basin.

2. On-Farm Irrigation System Type

Most of the irrigated land is irrigated by sprinkle and trickle systems, while there is some surface irrigation.

3. Diversity of Crops Irrigated

Crops grown in this basin include cereals, vegetables, fruit, and forages.

4. Hydrology of the Region

The Skagit River drains 3,093 sq-mi. The average annual rainfall of 97 inches produces an annual average discharge of 12,195,000 ac-ft.

A total of 35,865 acres of inland standing water and coastal wetlands, and 391 miles of streams were inventoried in Skagit County. About 75% of all wetlands are protected under the Shorelines Management Act of 1971 (ref 16e.1).

5. Source of Irrigation Water

The main water source is the Skagit River.

II. Institutional Characteristics of Irrigation Regions.

6. Water Delivery Organization

There are some water districts and private wells.

7. Local Awareness of Water Conservation in the Region

Local awareness of water conservation is moderate.

8. Competition for Water

There is competition for water for hydropower, instream flows, wetlands and municipal and industrial uses.

9. Cost of Water and Energy

The costs of water and energy are moderate.

III. Summary of Potential for Further Study.

10. Potential for Statewide Application

Due to the amount of wetlands and water quality, this has moderate potential for statewide application.

11. Potential for Improving Water Use Efficiency

There is poor potential for improving water use efficiency.

12. Potential for Benefits from Improved Water Use Efficiency

The benefits from improved water use efficiency are poor to moderate.

Basin Reference

16e.1 State of Washington Water Research Center. *Wetland Surveys of Skagit and Grant Counties, Washington: Inventory, Wildlife Values and Owner attitudes*. Report No. 29. Washington State University and University of Washington. May 1977.

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APPENDIX D

EXPANDED INFORMATION CATEGORIES USED IN DETAILED EVALUATION OF FIVE AREAS

1.0 Area description data
- 1.1 Physical setting within state
  - 1.1.1. Geographical description
  - 1.1.2. Boundaries
    - 1.1.2.1. Physical
    - 1.1.2.2. Hydrologic
- 1.2 Hydrology
  - 1.2.1. Inflows
    - 1.2.1.1. Surface and groundwater
    - 1.2.1.2. Precipitation
  - 1.2.2. Instream flows
  - 1.2.3. Wetlands (created and natural)
  - 1.2.4. Outflows
    - 1.2.4.1. Surface return flows
    - 1.2.4.2. Subsurface return flows
- 1.3 Cropping data
  - 1.3.1. Growing season (frost-free days)
  - 1.3.2. Irrigated crops grown
    - 1.3.2.1. Irrigated acreage
    - 1.3.2.2. Distinct cropping patterns
- 1.4 Electric utility(s) serving area

2.0 Water data
- 2.1 Water sources
  - 2.1.1. Irrigated acres served by surface water
  - 2.1.2. Irrigated acres served by groundwater
- 2.2. Institutional/organizational assessment
  - 2.2.1. Water delivery/distribution
    - 2.2.1.1. Federal involvement
    - 2.2.1.2. Irrigation districts
    - 2.2.1.4. Informal
    - 2.2.1.5. Private individual
  - 2.2.2. Water costs (delivery cost)
    - 2.2.2.1. Surface water
      - 2.2.2.1.1. Organizational costs
      - 2.2.2.1.2. Pumping costs (if pumped)
      - 2.2.2.1.3. Pump lifts
    - 2.2.2.2. Groundwater
      - 2.2.2.2.1. Organizational costs
      - 2.2.2.2.2. Pumping costs (if pumped)
      - 2.2.2.1.3. Pump lifts
- 2.3. Water rights
  - 2.3.1. Amount/priority
  - 2.3.2. Ownership
  - 2.3.3. Transferrability
  - 2.3.4. Adjudication

2.4 Demand for water
- 2.4.1. Irrigation demand
- 2.4.2. Competing uses
- 2.4.3. Future demand

2.5 Adequacy of supply
- 2.5.1. Against current demand
- 2.5.2. Against projected demand
- 2.5.3. Enhanced supply--storage alternatives

2.6 Water quality assessment
- 2.6.1. Impact of irrigated agriculture
  - 2.6.1.1. Surface water
  - 2.6.1.2. Groundwater

3.0 Irrigation system data

3.1 Water delivery/distribution
- 3.1.1. Method(s) of diversion
- 3.1.2. Conveyance system(s)
  - 3.1.2.1. Type(s)
  - 3.1.2.2. Age
  - 3.1.2.3. Condition
  - 3.1.2.4. Efficiency

3.2 Water application systems
- 3.2.1. Type(s)
  - 3.2.1.1. Surface/gravity
  - 3.2.1.2. Sprinkle
    - 3.2.1.2.1. Continuous move
    - 3.2.1.2.2. Set-move
    - 3.2.1.2.3. Permanent
  - 3.2.1.3. Drip/trickle
- 3.2.2. Age
- 3.2.3. Condition
- 3.2.4. Efficiency

3.3 Water management practices

4.0 Current activities related to irrigation efficiency

4.1 Water resources data availability
- 4.1.1. Type
- 4.1.2. Quantity
- 4.1.3. Quality

4.2 Assistance programs and studies
- 4.2.1. Federal programs
- 4.2.2. State programs
- 4.2.3. Local programs
  - 4.2.3.1. Conservation districts

5.0 Potential irrigation efficiency improvements
- 5.1 Irrigation system
  - 5.1.1. Water delivery/distribution/conveyance
    - 5.1.1.1. Potential measures
    - 5.1.1.2. Estimated or relative costs
    - 5.1.1.3. Potential benefits and impacts
      - 5.1.2.3.1. Water saved
      - 5.1.2.3.2. Water quality impacts
      - 5.1.2.3.3. Instream flow and other hydrologic impacts
      - 5.1.2.3.4. Impacts on alternative uses/competing demands
    - 5.1.2.4. Statewide educational potential (applicability)
  - 5.1.2. Water application systems
    - 5.1.2.1. Potential measures
    - 5.1.2.2. Estimated or relative costs
    - 5.1.2.3. Potential benefits and impacts
      - 5.1.2.3.1. Water saved
      - 5.1.2.3.2. Water quality impacts
      - 5.1.2.3.3. Instream flow and other hydrologic impacts
      - 5.1.2.3.4. Impacts on alternative uses/ competing demands
    - 5.1.3.4. Statewide educational potential (applicability)
- 5.2 Assessment of local interest
- 5.3 Potential conflicts

APPENDIX E

INFORMATION FOR FIVE AREAS SELECTED FOR DETAILED STUDY

IRRIGATION EFFICIENCY ASSESSMENT

DUNGENESS RIVER

1.0. Area Description

The Dungeness River Study Area is located in western Washington on the northeast tip of the Olympic Peninsula in eastern Clallam County. The area is bounded by the Olympic Mountains on the south, the Port Angeles-Elwha River Basin area on the west, Sequim Bay on the east, and the Strait of Juan de Fuca on the north. The town of Sequim is centrally located in the Dungeness Basin. The Dungeness River Basin is located in Water Resource Inventory Area 18.

The Dungeness River Basin drains 197 sq-mi from the Olympic Mountains into the Strait of Juan de Fuca. An average discharge of 282,600 ac-ft annually drains from the Dungeness River. Estimated 1978 water use was near 310 ac-ft of surface water for the Sequim Water Department, and 55,260 ac-ft of surface water for irrigation. Adequate groundwater for individual domestic use is available in almost all of the developed areas. A small number of private wells (4% of the total) in the area supply water for irrigation.

Climate in Clallam County is characteristically maritime with cool, dry summers and mild, wet winters. The Dungeness Basin is in the rain shadow of the Olympic Mountains and receives about 16 inches of annual rainfall. The average length of the growing season (28°F) in the basin is around 180 days. The average date for the last 32°F spring frost is in mid-April. The first fall frost usually occurs about November 1. Table E1 is a summary of the long term average monthly temperatures, rainfall and grass reference crop evapotranspiration at Sequim.

Table E1. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Sequim.

Month	Temperature (°F)	Precipitation (in)	Grass Reference ET_O (in)
Jan	38.3	2.37	0.19
Feb	41.6	1.37	0.66
Mar	43.3	1.31	1.43
Apr	47.6	1.06	2.64
May	53.3	0.94	3.92
Jun	57.7	1.03	4.48
Jul	61.4	0.49	5.37
Aug	61.5	0.78	4.28
Sep	58.4	0.97	3.06
Oct	50.9	1.37	1.38
Nov	43.5	2.20	0.35
Dec	40.2	2.50	0.08
Total		16.39	27.83

Agricultural land is declining in Clallam County and estimated to have declined from 45,000 acres to 20,000 acres between 1966 and 1982. Irrigated land is estimated at 15,100 acres in the Dungeness Valley. Most of the land is in forage (alfalfa and pasture), turf and vegetable seed crops, and small fruit production.

There are an estimated 120 acres of wetlands on the Dungeness River. Most of this land is at the mouth of the river.

The area is served by Clallam County Public Utility District.

2.0. Water Data

The primary source of irrigation water is the Dungeness River. Approximately 95% of the water used in irrigation is from surface sources.

There are four irrigation districts and five irrigation companies which divert water year round from the Dungeness River. Water is diverted into McDonald Creek from the Dungeness River and then diverted farther downstream from McDonald Creek for irrigation and other uses. Water delivery costs are not known, but estimated to be in the range of $12 to $20 per ac-ft. Irrigation pumping costs are also estimated to be moderate and in the range of $20 per ac-ft pumped.

The Dungeness River was adjudicated on 3/7/24. Competition for water in the basin includes water for instream flows, municipal use by the City of Sequim, and irrigation. Water for irrigation is usually adequate, however, in dry years irrigation districts are not able to divert water to on-farm ponds. These ponds are apparently not used as a source of irrigation water. Districts and Companies have also been asked to cut back their intake rates so enough water remains in the Dungeness River for fish. A USGS study indicates a significant portion of existing well water in the Sequim-Dungeness Valley is attributable to the leaking main ditches and laterals.

Water quality is an important issue in the area and the Puget Sound Region. Several BMPs have been implemented in this basin to protect the river from agricultural wastes. The development of an instream protection plan has been proposed by the Department of Ecology.

3.0. Irrigation System Data

The delivery systems within these four irrigation districts and five companies are open earthen canals and laterals. The districts utilize flow measurement weirs at the Dungeness River headgates and ditch riders to control water. The age, condition and conveyance efficiency of the canals are unknown but assumed below average. Some improvements have been made by the Agnew ID with the replacement of two wooden siphons by concrete pipe, and currently the Highland ID is in the process of replacing a wooden siphon. Poor management exists on some districts due to the lack of adjustable and lockable weirs

A 1983 WSU Cooperative Extension irrigation survey determined that 99% of the on-farm irrigation systems in Clallam County were sprinkle systems and 1% were drip systems. Most if not all of the irrigation in the county is in the Sequim area. About half of the sprinkle system acreage uses hand-line systems and the other half uses sideroll or wheel-line systems.

The age, condition and efficiency of these systems are variable. Some systems are well maintained and are very efficient while others are in poor condition and may be overapplying excessive amounts of water. Many sprinkler systems in the Dungeness Basin have the wrong nozzle sizes in their sprinklers. Because many small farms require the owners to work at another job it is not uncommon to see sprinklers set in the same place for 12 hours or more instead of 7 or 8 hours as originally designed.

4.0. Current activities related to irrigation efficiency

Local awareness of water conservation and water quality maintenance is moderate to very active. There are particular concerns over water quality in the basin, Sequim Bay, and the Puget Sound as a whole.

5.0. Potential irrigation efficiency improvements

The farmed land base is shrinking in this basin because of urban development. Water issues in this basin include instream flows, water quality and Indian tribal issues.

There are a number of irrigation districts that are eligible for referendum 38 funding. The irrigation districts have potential for improving water use efficiency through improved management practices and by reducing canal losses.

On-farm irrigation management can be improved and water saved by evaluating and improving the sprinkler and pump systems in the area to be sure they are operating with adequate pressure and good pressure distribution to achieve acceptable application uniformities. Water quality concerns will require that irrigation return flows (deep percolation and runoff of applied water) be minimized to avoid carrying contaminants into the water supply.

Benefits from conserved water would be useful in meeting dry summer flow requirements, instream flow requirements and increased population demands.

IRRIGATION EFFICIENCY ASSESSMENT

KITTITAS VALLEY

1.0. Area Description

The Kittitas Valley Study Area is located in the Upper Yakima River Basin in Central Washington and is entirely located within Kittitas County. The Valley is bounded on the West by the Cascade Mountains, the North by Teanaway and Mission Ridges, on the East by Ryegrass and Boylston Mountains, and on the South by Manastash Ridge. The city of Ellensburg, centrally located in the Kittitas Valley, is the principal municipality in the region. The Kittitas Valley is located in Washington Department of Ecology Water Resource Inventory Area 39.

The Yakima River has its origin in the eastern slopes of the Cascade Mountains northwest of Ellensburg. The 2,135 sq-mi Upper Yakima River Basin has an average annual precipitation of 3.75 million ac-ft of water. Total evapotranspiration on agricultural and nonagricultural land is estimated to be 1.6 million ac-ft of water. The Yakima River has an annual average discharge of 2.16 million ac-ft at Selah Gap. Groundwater outflow from the basin cannot be calculated accurately, although some water is leaving the Upper Basin through the sand and gravel beneath the river channel at Selah Gap.

Three large natural lakes have been augmented with dams to increase storage capacity for irrigation water and are located at the headwaters of the Yakima River. Water from these lakes is used for irrigation in the Kittitas Valley and the Mid and Lower Yakima Valley. Keechelus Lake has an average annual inflow of 258,700 ac-ft with an active storage of 158,000 ac-ft. Kachess Lake has an average inflow of 221,400 ac-ft with an active storage of 239,000 ac-ft. Cle Elum Lake has an average inflow of 700,600 ac-ft with an active storage of 437,000 ac-ft. Cle Elum and Kachess Lake have heavy recreational use. Keechelus Lake is also used for power generation.

In 1975 an estimated 526,800 ac-ft of surface water was diverted to 106,800 irrigated acres in the Upper Basin. Municipal and industrial water use totaled 6,260 ac-ft in 1975. The Ellensburg Water Department was the largest user of ground water, using 3,470 ac-ft.

Climate varies greatly over the Upper Yakima Basin watershed and is generally affected by geographical influences. Annual precipitation at the crest of the Cascades ranges between 80 and 140 inches, while the lower southeastern elevation area receives 10 inches or less. The growing season (28^{0}F) for the cropland areas varies from 140 days to 180 days. The average date of the last 32^{0}F temperature in the spring ranges from mid-April to mid-May, and the first in the fall is during the first half of October. Table E2 summarizes the long term average monthly temperatures, rainfall and grass reference crop evapotranspiration at Ellensburg.

In the Kittitas Valley total irrigated acreage is near 100,000 acres. Irrigated crop production is primarily forage crops such as Timothy hay, alfalfa hay and pasture (75-80%). Other crops produced include small grains (10-11%), vegetables and tree fruits.

Table E2. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Ellensburg.

Month	Temperature (°F)	Precipitation(in)	Grass Reference ET_0(in)
Jan	26.2	1.20	0.00
Feb	33.0	1.14	0.15
Mar	40.9	0.67	1.82
Apr	47.0	0.51	4.00
May	54.5	0.54	6.14
Jun	61.8	0.59	7.31
Jul	67.1	0.34	9.66
Aug	67.6	0.61	7.98
Sep	58.3	0.64	4.70
Oct	46.9	0.54	1.21
Nov	34.5	1.21	0.00
Dec	26.1	1.59	0.00
Total		9.58	43.63

Electric utilities serving the area include Puget Sound Power and Light Co. and Kittitas Co. PUD.

2.0. Water Data

Ninety-nine percent of the irrigation in the Kittitas Valley is from surface water sources. The primary source is the Yakima River and its tributaries. Diversions by the Kittitas Reclamation District (KRD), Cascade Irrigation District, and Westside Irrigation District provide water to 75% of the Valley's irrigated land. The KRD accounts for 60% of the irrigation in the Valley and is the only junior water district. These three organizations receive water under contract from the USBR. Several small ditch companies and private operations also divert water from the Yakima and smaller tributaries.

Water delivery costs charged by the KRD are in the range of $20-25 per acre. Where on-farm pumping is used (sprinkler and drip systems) pumping costs are low to moderate in the range of $15-$20 per ac-ft.

Settlement and irrigation development began in the Upper Yakima Basin in the 1860's. Excellent cattle range, completion of the railroad and coal mining in the region stimulated development and agricultural activity. The Cascade Canal was completed in 1904, and the KRD Highline Canal in 1930.

In 1945, a federal district court judgment was handed down that defined the quantities of water to which each of several of the irrigation districts, companies, and individuals is entitled; defined certain quantities which were excluded from pro-ration in years of shortages; and acknowledged the use of flood water diversions by the United States for water user groups. This judgment involved all the major irrigation systems in the Yakima Basin, with the exception of the Kennewick and other lower Yakima River diversions.

The water supply for irrigation districts not having adequate natural flow rights is obtained through contract with the Bureau of Reclamation. The Bureau of Reclamation provides the irrigation districts with water from reservoir storage and natural flows. Those districts without natural flow rights contract for their water supply and pay their proportionate share of the dam and reservoir costs. Supplemental water supplies are provided to districts under similar dam and reservoir cost-sharing repayment contracts.

Completed water right adjudications in the Kittitas Valley area are the Teanaway River (06/16/21), Cooke Creek (08/12/25), and Big Creek (3/27/24). Due to the vast area of the Yakima River Drainage Basin, (9.2% of the state's land area) and the large number of claimants (approximately 2,000), it has been necessary to approach adjudication in the Basin with a totally different perspective. The Referee is attempting to expedite the procedural method of evaluating claims by dividing them into the four discrete, manageable groups as follows:

a. Federal reserved rights for Indian claims,
b. Federal reserved rights for non-Indian claims,
c. State-based rights of major claimants,
d. State-based rights for other claimants, by subbasin.

Existing water rights have fully subscribed the water supplies and any additional water yield to the system would require additional reservoir storage. Irrigation is the single largest water use in the Kittitas Valley study area and the Yakima Basin as a whole.

Water rights are a complicated issue in the entire Yakima Basin. There is large competition between irrigation districts, the Yakima Indian Reservation, water for instream flows and fisheries development, individual irrigators, municipal and industrial uses. The lack of adjudicated streams and unclear U.S. documents regarding federal reservations bordering water systems complicates the water right issue.

3.0. Irrigation System Data

Irrigation delivery systems in the Kittitas Valley operated by the 3 major irrigation districts are open earth channels. Water is measured on the KRD using Cipoletti weirs at farm turnouts. Water is not measured on the Cascade ID. Water measurement on the Westside ID is variable. Transmission losses on the KRD are estimated around 30%. The age of the canals ranges from 60 to 90 years. The condition of the canals is variable, with some areas experiencing very high seepage losses. Control structures on the canals are estimated to be in poor condition or non-existent.

A 1983 survey by WSU Cooperative Extension in Kittitas County found an estimated 78.7% of the irrigated acreage is by surface gravity-flow systems, 20.7% by sprinkler systems and 0.6% by drip systems. See Table E3.

The large percentage of surface irrigation systems coincide with the large acreage of forage crop production, particularly Timothy and alfalfa hay. Growers prefer to irrigate these crops without wetting the foliage indicating better quality is obtained this way. A large percentage of the surface irrigated acreage has had improvements made with on-farm conveyance through the use of gated pipe. A large number of acres are still served by open earth ditches. Very little water control exists within fields. While the system used is called rill irrigation, it is actually closer to wild flooding. Field slopes are undulating and lengths of run are not set out according to design principles. Surface irrigation efficiencies are judged to average anywhere from 30% to 50% on average.

Table E3. Summary of on-farm irrigation systems used in Kittitas Co. in 1983.

Method	Acres
Surface irrigation:	
Gated Pipe	28,000
Open Ditch w/Siphons	34,070
Buried Pipe w/risers	10,000
Flooding from Ditches	3,000
Sprinkle irrigation:	
Center Pivot	3,000
Hand Move	7,480
Sideroll/Towline	8,650
Solid Set	100
Gun/Traveler	500
Micro-irrigation:	
Drip/Trickle	600

Sprinkle and trickle irrigation systems in the Valley are judged to be average in terms of efficiency, in the range from 60% to 70% for sprinkle systems and from 85% to 90% for drip systems.

Water management practices in the Valley could see considerable improvement. An evaporation pan station has been operated in the Valley for several years with the daily readings being published in the newspaper. It is unknown how many growers use this information to help with irrigation scheduling.

Typically low efficiencies on surface irrigated fields result from poor system layouts on coarse-textured soils. Large heads of water are required to irrigate the fields adequately.

4.0. Current activities related to irrigation efficiency

Water use is a big issue in the entire Yakima Basin because of the lack of adequate water supply in dry years, and competing demands for minimum instream flows for fisheries enhancement and possible expansion of irrigation on the Yakima Indian Nation reservation lands. Water use efficiency is addressed as part of the Yakima River Basin Enhancement Project which is looking at combinations of on-farm conservation, delivery system improvements and additional storage to enhance water supplies.

Recent demonstration projects promoting improved on-farm systems and on-farm water management include surge flow irrigation demonstrations and scientific irrigation scheduling.

5.0. Potential irrigation efficiency improvements

Potential irrigation efficiency improvements in the Kittitas Valley include improvements to the irrigation district delivery systems and on-farm irrigation system improvements. Canal improvements to consider include lining or use of closed pipe in high seepage loss reaches, improvement or addition of canal water level control structures, on-line re-regulating reservoirs, and water measurement structures at all farm gate turnouts.

The largest gains in on-farm irrigation efficiencies can be made by reducing on-farm conveyance losses by lining irrigation ditches or using closed pipe and/or gated pipe; using improved field layouts with better in-field water control based on design principles which consider soil types and slopes; using improved surface irrigation methods such as surge flow irrigation.

Irrigation management practices can be improved by educating more growers on the use of scientific irrigation scheduling. A WSU Public Agriculture Weather System remote weather station is located in the Kittitas Valley from which real-time estimates of crop evapotranspiration may be determined.

Improved water use efficiency in the Kittitas Valley may have a negative effect on ground water recharge flows that are assumed to benefit the Mid and Lower Yakima Valley as return flow. Improvements in canal conveyance efficiency and early season on-farm irrigation efficiency would reduce this groundwater recharge, however, mid and late season efficiency improvements would stretch the available water supply to this area (assuming it remains in storage), much of it served by a junior water right district (KRD).

Due to organized water delivery; the large amount of irrigated land; the ability for funding of districts under Referendum 38; inadequate water supplies; and water quality, instream flows, fisheries and recreational issues affecting the entire Yakima Basin, the Kittitas Valley would be an excellent candidate for the conservation assessment study area. Interest in water resources problems in the area is very high.

IRRIGATION EFFICIENCY ASSESSMENT

METHOW RIVER BASIN

1.0. Area Description

The Methow River Basin Study Area lies in north central Washington in the western part of Okanogan County. It is bordered on the north by the Pasayten Wilderness, on the east by the Buckhorn Mountains and the Okanogan River Basin, on the south by the Columbia River and Sawtooth Ridge, and on the west by the Cascade Mountains. The communities of Mazama, Winthrop, Twisp and Methow are the main urban areas in the basin. The Methow River Basin is in Water Resource Inventory Area #48.

Visually, the Methow River Basin is an impressive sight, surrounded by forests and mountains, with an occasional snowcapped peak standing stoically remote. It is a popular recreation area. A cross section of the Methow Basin from west to east is characterized by the Cascade Mountain Range at the western boundary of the basin, then the Methow Valley with the Methow River flowing through it, and on the east, the Central Okanogan Highlands which separate the Methow Basin from the Okanogan Basin. Elevations range from 775 ft at Pateros near the confluence of the Methow and Columbia Rivers to the mountains along the western boundary that are 7,000 to 9,000 ft above mean sea level.

The Methow Basin is a closed basin with no significant surface or ground water inflows. This basin drains approximately 1,794 sq-mi of area. The mean annual precipitation over the Methow River Basin, based on records for 1930-57, is estimated to be 32.1 inches or about 3 million acre-feet of water. The mountain regions of the basin receive more of their precipitation as snow, which remains on the ground until late spring before melting. Thus, the mountain regions contribute a major part of the water for the growing season.

Water leaves the Methow River Basin in three ways; surface (Methow River) water, subsurface (ground-water) flow, and by evapotranspiration. The average annual surface outflow is measured by a gage near the Methow River mouth at about 1,200,000 acre-feet. With an average evapotranspiration rate of 20 inches per year for irrigated and 12 inches for nonirrigated areas, the total evapotranspiration for the basin amounts to about 1,160,000 acre-feet per year. The amount of water that leaves the basin as subsurface flow is estimated at 740,000 acre-feet per year. The materials underlying the lower end of the Methow River Basin do not appear to be able to transmit such a volume, which suggests mean annual precipitation may actually be less than estimated or evapotranspiration may be greater than was estimated. Municipal ground water use was estimated at 460 ac-ft in 1975.

The Methow River Basin is composed of three major sub-areas; the Chewack River drainage, the Methow River upstream from Winthrop, and the southern drainage. The average annual flow of the Methow River is 1,555 cfs at Pateros.

The Chewack River drainage contains the Chewack River and its tributaries, which drain the northeastern portion of the basin. Average annual flow is 430 cfs. In the drainage there are 61 lakes and ponds with a total surface area of 581.2 acres.

The Methow River drainage upstream from Winthrop drains most of the northwestern part of the basin from the crest of the Cascade Range to Winthrop. Average annual flow is 700 cfs. The drainage also contains 36 lakes and ponds which have a total surface area of 157.4 acres.

The southern drainage includes the Twisp River (300 cfs average annual flow), Beaver Creek, Libby Creek, and Gold Creek which drain most of the southern part of the basin from Winthrop to near Pateros. This drainage contains 87 lakes and ponds which have a total surface area of 1,027.5 acres.

Ground-water supplies sufficient for domestic use can be obtained from sand and gravel only along major streams, and in areas where saturated deposits are sufficiently thick and permeable. Ground-water supplies are adequate for irrigation. In the bedrock outcrops along slopes and in the uplands, ground-water supplies are meager and generally inadequate even for domestic or stock use.

The climate of the Methow Basin is characterized by great variations in temperature and precipitation. In general, the highest precipitation and lowest temperatures occur in the higher mountains. Some locations near the crest of the Cascade Range receive more than 80 inches of precipitation a year, while the valley floor near Pateros receives only about 10 inches a year. The average precipitation during the growing season (April-Sept.) for the period 1931-60, is 4.57 inches near Winthrop and 5.20 inches near Twisp. The growing season (28°F) in the central part of the Methow River Valley ranges from 130 to 150 days. The average last 32°F spring temperature occurs from May 15 to June 1. The first fall frost occurs during the latter half of September. Table E4 gives long term average monthly temperatures, rainfall and grass reference crop evapotranspiration at Methow.

Table E4. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Methow.

Month	Temperature (°F)	Precipitation (in)	Grass Reference ET_O (in)
Jan	23.2	1.49	0.00
Feb	30.9	1.69	0.08
Mar	40.2	1.07	1.65
Apr	47.4	1.11	3.59
May	55.7	1.09	5.41
Jun	63.3	0.80	7.02
Jul	69.6	0.29	7.98
Aug	69.6	1.08	6.15
Sep	60.2	0.64	4.02
Oct	48.0	0.80	1.87
Nov	33.7	2.15	0.00
Dec	21.9	2.12	0.00
Total		14.33	37.76

There are approximately 15,300 irrigated acres in the Methow River Basin lying in three areas of agricultural land use in the valley. Beginning at the mouth of the Methow River, practically all of the irrigated land is in apple production upstream to Carlton. From Carlton to Twisp, land use is about

IRRIGATION EFFICIENCY ASSESSMENT

METHOW RIVER BASIN

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The climate of the Methow Basin is characterized by great variations in temperature and precipitation. In general, the highest precipitation and lowest temperatures occur in the higher mountains. Some locations near the crest of the Cascade Range receive more than 80 inches of precipitation a year, while the valley floor near Pateros receives only about 10 inches a year. The average precipitation during the growing season (April-Sept.) for the period 1931-60, is 4.57 inches near Winthrop and 5.20 inches near Twisp. The growing season (28°F) in the central part of the Methow River Valley ranges from 130 to 150 days. The average last 32°F spring temperature occurs from May 15 to June 1. The first fall frost occurs during the latter half of September. Table E5 gives long term average monthly temperatures, rainfall and grass reference crop evapotranspiration at Methow.

Table E5. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Methow.

Month	Temperature (°F)	Precipitation (in)	Grass Reference ET_0 (in)
Jan	23.2	1.49	0.00
Feb	30.9	1.69	0.08
Mar	40.2	1.07	1.65
Apr	47.4	1.11	3.59
May	55.7	1.09	5.41
Jun	63.3	0.80	7.02
Jul	69.6	0.29	7.98
Aug	69.6	1.08	6.15
Sep	60.2	0.64	4.02
Oct	48.0	0.80	1.87
Nov	33.7	2.15	0.00
Dec	21.9	2.12	0.00
Total		14.33	37.76

There are approximately 15,300 irrigated acres in the Methow River Basin lying in three areas of agricultural land use in the valley. Beginning at the mouth of the Methow River, practically all of the irrigated land is in apple production upstream to Carlton. From Carlton to Twisp, land use is about equally divided between orchards and forage crops. The orchards in this area are subject to severe winter kill and frost damage. From Twisp to the upper end of the valley, most of the irrigated lands are in forage crops, such as alfalfa, with a small percentage in small grains to fit crop rotations.

Electric utilities serving the area include the Okanogan Co. PUD and the Okanogan Co. Electric Cooperative.

2.0. Water Data

In 1975 irrigation used 54,660 ac-ft of water, of which 52,615 ac-ft was surface water and the rest from ground water. This water was used on approximately 15,300 acres of land. The rivers of the basin provide 96% of the irrigation water in this basin and ground water provides 4% of the irrigation water. Surface water is delivered to farms through mostly unlined canals.

There are two irrigation districts and fourteen ditch companies, plus individual farm delivery systems in this basin.

Cost of water delivery is estimated to be in the range of $12-$20 per ac-ft. Where on-farm pumping is used, pumping costs are estimated in the range of $15-$20 per ac-ft.

Most diversions from the Chewack River are below the confluence with Boulder Creek (87.11 cfs, 1971) and are used to irrigate farms south of Winthrop. Some of the water diverted from the Chewack River is delivered to Pearrygin Lake. Six and one-half feet of control on the lake provides 1,800 acre-feet of storage water. Upstream from Winthrop, as of 1971, six ditches carried the bulk of water (93.77 cfs). However, this water is used to irrigate land both upstream and downstream from Winthrop. In the southern drainage are four small diversions from the Twisp River and one from the Methow River supplying the irrigation needs in the Twisp River Basin (61.5 cfs, 1971). Water from Beaver Creek, which drains the area northeast of Twisp, is also used for irrigation, but the total amount of diversion is not known. There are two diversions south of Carlton from Gold and Libby Creeks, with a combined total of 5.78 cfs in 1971.

Methow Basin irrigation districts are the Methow Valley ID with diversions on the Twisp and Methow Rivers, and the Wolf Creek Reclamation District with diversions on Wolf Creek, Little Wolf Creek and Patterson Lake. Patterson Lake has 20 feet of possible storage control.

Competition for water for a proposed ski area, mining development, irrigation, instream flows and recreation exist in the Methow Basin. Large quantities of fresh water are available from both surface and ground water sources in the Methow River Basin but some problems on availability do exist. Irrigation diversions may literally dry up some stream reaches in years of below average summer flows.

Beaver Creek is entirely diverted during the late summer months, and some water users are unable to obtain sufficient amounts for irrigation. There is a potential for similar results in other tributary streams as irrigation, recreation, mining, and domestic development continue.

Currently there exists enough water to irrigate additional irrigable lands north of Carlton. However, problems arise in providing adequate systems. The arable lands, especially the acreage not now irrigated are located in small scattered tracts, most ranging from 300 to 500 feet above the water source.

The basin below Carlton has many arable lands scattered in small parcels along terraces adjacent to the Methow River. These parcels are potentially prime areas for orchards, but are scattered and located well above a reliable water source.

Table E6. Maximum surface water available for future allocation from the indicated reach and watercourse is as follows (all figures in cfs):

Month	Lower Methow	Middle Methow	Methow Upper Methow	Early Head-waters	Winters Creek	Chewack River	Twisp River
Oct	95	50	44	15	29	09	14
Nov	116	101	46	06	21	10	15
Dec	112	99	44	17	26	10	15
Jan	50	36	26	08	19	03	09
Feb	51	37	29	09	19	04	10
Mar	147	139	80	38	19	24	18
Apr	565	590	273	336	35	118	148
May	2,922	2,927	784	412	403	809	703
Jun	3,116	2,853	1,017	1,249	294	1,292	890
Jul	965	877	583	608	189	308	298
Aug	214	192	203	109	94	70	70
Sep	62	55	76	33	47	23	26

Adjudications have been completed on the following watercourses:

Name of watercourse	Date of Decree	County
Beaver Creek	09/20/21	Okanogan
Libby Creek	11/18/21	Okanogan
McFarland Creek	11/16/22	Okanogan
Gold Creek	05/07/29	Okanogan
Black Canyon Creek	06/20/29	Okanogan
Bear Creek & Davis Lake	05/14/30	Okanogan
Wolf Creek	03/13/84	Okanogan

3.0. Irrigation System Data

The two irrigation districts in the basin use open earthen canals with some pipeline deliveries. Deliveries are not measured. Although irrigation water conveyance systems vary in degree of efficiency, it is reported that the loss by leakage from earth canals and ditches in the Methow River basin was 35,735 ac-ft (45%) of 79,348 ac-ft entering the system in 1971.

Irrigation in Okanogan County is 95% by sprinkle systems, 3% by drip systems and 2% by surface systems. This trend is expected to be the same in the Methow Basin. Sprinkle systems are mostly hand-lines and some permanent solid set. Average application efficiency is expected to be around 60% to 65%. Surface system efficiencies are low in the range from 40% to 50%.

The age and condition of on-farm systems in the Methow Basin is unknown. Since the basin is somewhat outside of the main irrigated areas in Washington it is possible systems are not in good operating condition.

Grower's water management practices result in considerable overirrigation in the spring and fall (when water supplies are adequate). It is generally assumed this overirrigation results in groundwater recharge in the basin.

4.0. Current activities related to irrigation efficiency

Chapter 173-548 of the Washington Administration Code (WAC), Water Resources Program in the Methow River Basin, establishes WA DOE policies to manage the basin's water. Fourteen streams have full or partial year closures. Seventeen lakes have also been closed to appropriation.

Local awareness of water issues is high in this basin with increasing development of the upper basin into small lots, instream flow requirements, and inadequate water for lower basin irrigated areas.

5.0. Potential irrigation efficiency improvements

The individual farmer and irrigation districts must first recognize the need to conserve water. The irrigation districts should consider the use of pipelines and/or line ditches where large volumes of water are lost.

Another means of providing additional water for late season use, would be from construction of small reservoirs on some of the tributary streams of the Methow. The use of selected small reservoirs to augment future domestic and industrial requirements should be investigated.

On-farm sprinkle irrigation systems can be improved through system evaluation for nozzle wear, poor pressure distribution, and too-wide spacings, all of which lead to poor application uniformity and low efficiencies. On-farm pumping systems should be evaluated for appropriate sizing as well as pressure losses around the pump itself.

Irrigation management practices early and late in the season can be improved through better understanding by growers of soil-water-plant relationships. Better timing and duration of irrigation late in the season will help to stretch water supplies during this part of the year during low flow years.

Certain selected watershed management practices could have a beneficial impact on providing more water. One such practice might be the thinning of timber on north slopes to allow snow cover to accumulate on the ground to help prolong runoff and increase groundwater reservoirs.

Most watersheds are located on National Forest lands, and therefore practices carried out by the Forest Service can have a significant impact. Their management of vegetative cover and construction of small check dams will help to control erosion, prolong water runoff, and improve water quality.

A streamlining of the state's water rights adjudication procedures would help to assure completion of the adjudication of the surface and ground waters in the Methow Basin. This would help to assure a more equitable use and help to prevent indiscriminate use of badly needed water.

This basin is faced with instream flow issues, short water supplies and water quality issues. The irrigation districts are eligible for funding under Referendum 38. This basin also has new water resources data that would be useful in a study project.

As in many of the other small basins with no reservoir storage the water saved from improved water use efficiency would benefit the instream flow requirements and recreation. Land in the lower portions of the Methow Basin would benefit from increased reliable water supplies.

IRRIGATION EFFICIENCY ASSESSMENT

WALLA WALLA BASIN

1.0. Area Description

The Walla Walla Basin Study Area straddles Washington's border with Oregon east of the mainstem of the Columbia River in southeastern Washington. It is bounded by the Snake River Basin on the North, the Blue Mountains to the East and South, the Umatilla River Basin on the South, and the mainstem of the Columbia River to the West. The basin includes parts of Walla Walla and Columbia Counties in Washington and part of Umatilla County in Oregon. The cities of Walla Walla and Milton-Freewater, OR are the principal urban areas in the Basin. The Washington portion has been designated Water Resource Inventory Area (WRIA) 32.

The Walla Walla Basin is divided into two physiographic areas: the Walla Walla section and the Blue Mountain Section.

The Walla Walla section is situated on the upper eastern edge of the central Columbia Basin. It consists of rolling, treeless upland, deeply mantled by fine, windborne deposits of silt which overlie the previously eroded and incised Columbia River basalt. Thick lake and stream terraced deposits occur in the valley.

The Blue Mountain section consists of the extremely northern extension of the Blue Mountains of Oregon and the long, tilted plateau that extends northward into Columbia River basalt. This topography is largely the result of erosion and stream cutting in the basalt. Flat-topped ridges, steep-walled canyons, and mountain slopes characterize this area of the basin.

Total drainage area of the basin is 1,758 sq-mi of which 1,275 sq-mi or 73% lies in Washington. Of the total basin area, 273 sq-mi or 15% is forest land. Approximately 952,217 acres (1,488 sq-mi) or 82% of the basin is in agriculture.

A gravel aquifer underlies approximately 120,000 acres of the Walla Walla-Milton-Freewater area and is recharged from surface streams, precipitation and the basalt aquifer. The primary basalt aquifer, which underlies the entire basin is recharged primarily from the Blue Mountains.

The primary source of runoff in the Walla Walla Basin is rainfall and snow melt from the Blue Mountains. Precipitation in the basin ranges from about 7 inches near the western edge at Wallula to over 40 inches in the Blue Mountains. Maximum flows occur in the spring when snow melt combines with the spring rainy season. Minimum flows and dry stream beds occur in the late summer due to low precipitation and high irrigation demands. Table E7 summarizes long term average monthly temperatures, precipitation and grass reference crop evapotranspiration at Walla Walla.

Much of the Walla Walla Basin enjoys an average growing season (28^{o}F) of between 180 and 210 days. The average date of the last spring frost (32^{o}F) is around May 1, while the average data of the first 32^{o}F temperature in the fall is in mid to late October.

Table E7. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Walla Walla.

Month	Temperature (^oF)	Precipitation (in)	Grass Reference ET_0 (in)
Jan	34.3	2.12	0.00
Feb	40.7	1.40	0.74
Mar	45.8	1.41	2.27
Apr	52.3	1.35	4.11
May	60.1	1.40	6.14
Jun	67.6	0.93	7.64
Jul	75.5	0.35	10.62
Aug	73.6	0.71	8.63
Sep	65.5	0.83	5.63
Oct	54.3	1.40	2.49
Nov	42.5	1.87	0.42
Dec	37.2	2.19	0.00
Total		15.96	48.69

A 1983 WSU Cooperative Extension survey of irrigated acreage in each county indicated there were approximately 76,000 acres of irrigated land in Walla Walla county in the Walla Walla Basin (another 40,000 acres of irrigated land lies in the western part of the county and receives water from the Snake and Columbia Rivers), and about 5,000 acres in Columbia county in the basin (another 1,150 irrigated acres in Columbia county lies on the Tucannon River drainage). Many of the Walla Walla Basin irrigated acres are receiving only a partial irrigation supply. Vegetables (24%), small grains (29%), alfalfa hay and other forages (28%), seed crops (18%) and tree fruits and grapes are the major irrigated crops.

Electric utilities serving the area include Pacific Power and Light Co. and Columbia REA.

2.0. Water Data

Surface water provides approximately 90% of the water used for irrigation while the other 10% comes from ground water. Groundwater pumping lifts are estimated to average around 300 ft.

Fourteen irrigation districts or water delivery organizations exist in the Walla Walla Basin. There is no federal involvement. Water costs are in the range of $12 to $20 per ac-ft. On-farm pumping of irrigation water is estimated to occur on 95% of the irrigated acres. Irrigation pumping costs are estimated to be in the range of $20 to $40 per ac-ft depending on the lift.

Heavy competition exists between agriculture, municipal, and industrial demand for ground water, which is the only existing source of supply with a promise for future development. There is sufficient water on an annual basis to satisfy most existing and future needs, provided seasonal distribution problems are resolved and provided that conjunctive use patterns for surface and ground water sources are instituted.

Total water use from all sources in the Washington portion of the Walla Walla Basin was approximately 400,000 ac-ft in 1974; of this total approximately 228,000 ac-ft was actually depleted from the basin's supply. About 69% of this use was by irrigation, 22% by municipal, and 9% by industry.

Current records indicate that approximately 50,000 acres of irrigable land could receive a full irrigation supply, provided existing surface and groundwater supplies are conjunctively managed to optimize their use.

The gravel aquifer, which underlies approximately 120,000 acres in the Walla Walla-Milton Freewater area, is recharged from surface streams, precipitation and the basalt aquifer. Annual recharge amounts to 177,000 ac-ft. Of this total, 10,000 ac-ft is lost through direct evapotranspiration, 113,000 ac-ft returns to streams, and 25,000 ac-ft was pumped to the land surface in 1975.

The primary basalt aquifer, which underlies the entire basin, is recharged primarily from the Blue Mountains. Annual recharge of this aquifer amounts to 132,000 ac-ft. Of this total, 97,500 ac-ft discharges laterally to the Columbia and Snake Rivers, 12,000 ac-ft to the gravel aquifer, and 22,500 ac-ft was pumped to the land surface in 1975.

It would appear that this source has a potential for substantially greater development; however, water levels have shown alarming declines in some areas, especially in the Walla Walla urbanized area.

Total storage capacity of the two ground water aquifers is estimated at nearly 7 million ac-ft with 3 million ac-ft of the total being in the gravel aquifer. Approximately 2.6 million ac-ft in the basalt and 1 million ac-ft in the gravel aquifer have a potential for active use.

Principal industrial use of water in the basin is for the processing and canning of vegetables. Food processors use approximately 20,000 ac-ft annually. Walla Walla's water system supplies water for a portion of this industrial use. The City's source of supply comes from both ground water and surface water via Mill Creek. Some industrial users also have their own water rights in the ground water aquifers.

All streams in the basin are administratively closed to further appropriation during the irrigation season. Existing rights are adjudicated for even the "wet year" high flows. Completed adjudications in the basin are:

Name of watercourse	Date of Decree	County
Upper Stone Creek	07/10/23	Walla Walla
Doan Creek	11/01/23	Walla Walla
Walla Walla River	08/12/28	Walla Walla
Touchet River	09/19/29	Columbia/Walla Walla
Dry Creek	05/20/52	Walla Walla

The Walla Walla River is totally appropriated in Oregon during the dry season, and the river is dry at the State border. During these low flow periods, waters occurring in the river in Washington are due to irrigation runoff, springs, and direct discharges from the gravel aquifer.

The gravel aquifer straddles the border between Washington and Oregon and extends from north of Walla Walla to south of Milton-Freewater. Existing evidence indicates that the gravel aquifer will withstand substantially greater pumping. Overflow from each years' recharge provides stream flow in the lower reaches of the Walla Walla River and is tributaries.

Mill Creek Drainage

Mill Creek originates in the Blue Mountains in Washington's Columbia County. It dips south into Oregon and then flows northwest through the city of Walla Walla, and enters the Walla Walla River just west of the city. Mill Creek and its tributary Blue Creek drain an area of approximately 100 sq-mi, with an average annual flow of 91 cfs.

A small dam off Mill Creek is used to divert flood flows. Water is also diverted from Mill Creek to provide a municipal and industrial supply for the city of Walla Walla. This source represents approximately 85% of the city's water supply.

Walla Walla depends for water supply on two sources, (1) it has an adjudicated water right of 28 cfs on Mill Creek with a priority date of 1866, and (2) rights to withdraw 19,600 ac-ft from the primary basalt aquifer. Due to the declining water levels in the aquifer and providing growth, the city has proposed a dam and reservoir on Mill Creek which would store water between November 1 and June 1. For this purpose the City has a water right permit from Washington State on Mill Creek for 20 cfs and Oregon legislative consent (ORS 537.835) for the appropriation, impoundment, and diversion of Mill Creek water.

Irrigation in the Mill Creek subbasin totals approximately 4,000 acres, 3,000 acres being irrigated from surface waters and the remainder from ground water sources. The potential for additional irrigation in this area appears slight, with only 300 acres being identified as having an irrigation potential.

Touchet River Drainage

The Touchet River originates in the Blue Mountains in the southwest corner of Columbia County and flows west through the cities of Dayton and Waitsburg, emptying into the Walla Walla River near Touchet. The Touchet River drains an area of approximately 739 sq-mi, with an average annual discharge of 220 cfs not including diversions. Dayton has a surface water right on the Touchet for 1000 ac-ft per year. Although it appears that an adequate ground-water supply does exist in the subbasin, little of present irrigation uses this source due to the pumping lifts involved.

Lower Walla Walla Drainage

The Lower Walla Walla River from the Oregon border to its confluence with the Columbia River near Wallula drains an area of approximately 771 sq-mi. Major tributary drainages of this subbasin, excluding the Touchet River and Mill Creek, are Pine Creek, Dry Creek, Yellowhawk Creek, and Cottonwood Creek. Average annual discharge near the mouth is 573 cfs.

This part of the basin encompasses the low lying areas of the valley floor. Approximately 62,000 acres are presently irrigated; however, of this total only about 24,000 acres enjoy a firm supply of water. The remainder receive as little as ten percent of the required supply.

The river is completely appropriated during the irrigation season, and the resulting stream flows are very low during periods of low precipitation and runoff. This also results in very low water quality and a subsequent loss of sport fisheries. Base flow levels will not be imposed unless instream storage is provided to augment present flow levels.

The largest portion of the gravel aquifer lies in this subbasin. Yields from this source have historically ranged up to 300 gpm; however, the potential exists for greater yields with improved well location and drilling techniques. To date, approximately 25,000 ac-ft per year is withdrawn from this source. This represents 13% of the average annual recharge to the aquifer. Annual recharge of this aquifer from all sources averages 177,000 ac-ft.

3.0. Irrigation System Data

Five of the 14 irrigation districts (listed below in Table E8) in this basin are used for agriculture, diverting water from the Walla Walla River, Touchet River and Mill Creek. There are a handful of irrigation districts that pump ground water for municipal water supplies in the Walla Walla and College Place areas. Of the five irrigation districts used for agriculture all have open earth channel deliveries.

Table E8. Irrigation Districts in the Walla Walla Basin.

Irrigation District	Delivery System
Artesia ID #8	all pipe system 35 psi to each house
Blalock ID #3	all pipe system measuring device at beginning of each lateral
Blalock Orchard ID	all pipe system from well
Consolidated ID #14	pipe system with valves and unused meters
East Side ID #6	open canal unread weir deliveries
Gardena Farms ID#13	open canal Cipolletti weir deliveries
Green Tank ID #11	well delivery to closed system
Hydro ID #9	closed system pumped from well
Lowden ID #2	open ditch with diversions to farmers
Mud Creek ID #7	open ditch with diversions to farmers
Touchet Valley ID	
West Side ID #5	open canal weir deliveries no records
Hearn ID	pipeline
West End ID	open ditch diversion from Touchet River

The age condition and efficiencies of these systems, particularly the open earth canals is unknown.

The 1983 WSU Cooperative Extension irrigation survey determined 97%-99% of the irrigation in both Walla Walla and Columbia counties was accomplished using sprinkle irrigation. The remaining acreage is irrigated with drip systems. A small percentage of irrigated land in Walla Walla county is irrigated with surface systems. See Table E9.

Table E9. Irrigation systems and irrigated acreage in Walla Walla and Columbia counties.

Method	Walla Walla (area in acres)	Columbia (area in acres)
Gated Pipe	0	0
Open Ditch w/siphons	0	0
Buried Pipe w/risers	200	0
Flooding from ditches	200	0
Center Pivot (see note)	47,000	300
Hand Move	44,600	1,700
Sideroll/Towline	17,000	3,680
Solid Set	6,000	0
Linear Move	500	0
Gun/Traveler	0	320
Drip/Trickle	500	150

Note: Approximately 40,000 acres of center pivot irrigation in the western part of Walla Walla Co., and 1,150 acres of handmove and sideroll sprinkle systems in Columbia Co., are outside the study basin.

The age and condition of these on-farm systems is unknown. Limited irrigation system testing has revealed sprinkler and pumping systems of higher than average efficiency (wheel line sprinkle system with flow control nozzles with efficiency in the range of 70%-75%). Poorly designed pump systems with a high degree of friction losses resulting in poor pressure at the sprinkler nozzles have also been found. Efficiencies could be expected to be in the range of 50% to 60% due to poor application uniformities in this situation.

Water management practices, particularly determining when and how much to irrigate, could be substantially improved. The short water supplies in much of the lower valley areas have caused growers to adopt irrigation practices in which there is considerable overirrigation early in the season. This is done on the precept of filling the soil profile to field capacity. However, enough water is applied early in the year when water is available to bring the soil profile to field capacity to depths of 15 to 20 ft. Some of this deep wetting may help later in the season, however, most is below the active water uptake part of the crop root zone. Groundwater is probably being recharged, however, groundwater quality problems may be accumulating. A firmer water supply which stretches late into the growing season would help this situation.

4.0. Current activities related to irrigation efficiency

Awareness of water conservation in the basin is high due to the generally short water supply and concerns for the underlying aquifer. Other issues include the re-establishment of steelhead runs, minimum instream flows, and water quality.

There are no known active irrigation water conservation activities in the basin. The National Weather Service operates an evaporation pan station at the Whitman Mission. WSU has established an automated remote weather station near Touchet as part of the PAWS network. These both provide information useful in improving irrigation management.

5.0. Potential irrigation efficiency improvements

Improvements are possible in measuring diverted waters. None of the five irrigation districts delivering water to irrigated crop land knew how much water was diverted in 1974.

Seepage losses on the open earth canals are unknown. Lining of high loss reaches would save water.

On-farm pump system evaluation and improvement and concurrent evaluation and improvement of sprinkle systems results in improved pressure distribution throughout a system and improved application uniformity. This can result in water savings.

Deep percolation losses of applied irrigation water can be considerably reduced through improved irrigation scheduling and education of growers on soil-water-plant relationships. Little progress will be made, however, without a firmer supply of water throughout the entire irrigation season.

The Walla Walla Basin would be a good conservation assessment study area. The problems are similar to the other major irrigated areas, particularly on those lands which are receiving a full supply. However, the development of a well-managed conjunctive use plan for surface and groundwater resources seems to be the major need. Considerable but wise development of groundwater would appear to solve much of the basin's problems.

IRRIGATION EFFICIENCY ASSESSMENT

WENATCHEE RIVER BASIN

1.0. Area Description

The Wenatchee River Basin Study Area is located in the southwest portion of Chelan County in central Washington. It is bounded by the Cascade Mountains to the west and northwest, the Wenatchee Mountains on the south, the mainstem of the Columbia River on the east, and the Entiat Mountains on the north. The City of Wenatchee, located at the confluence of the Wenatchee River with the Columbia River, is the primary urban area. Several smaller communities including Cashmere and Leavenworth are located in the central part of the basin. The Wenatchee River Basin is located in Water Resource Inventory Area 45.

This basin is approximately 1,310 sq-mi in area. The principal source of water for the basin is snowmelt and runoff from the surrounding mountains. By late summer or early fall, receding snowpacks and off-stream uses reduce instream flows to critical levels. The average annual discharge for the Wenatchee River is 2,379,000 ac-ft one mile north of Monitor (about 6 mile northwest of the confluence with the Columbia River). A 1976 DOE report estimated that 61,800 ac-ft of water was used for irrigation in 1970. Industry and municipal use was estimated to be 30,220 ac-ft. Irrigation and industrial uses were primarily from surface water sources, while municipal use was primarily from groundwater.

A total of 205 natural lakes have been identified in the Wenatchee Basin. These lakes act as natural reservoirs, storing some water during high runoff periods and releasing it over an extended time period. Lake Wenatchee is the largest in the basin, and is a popular recreation attraction.

Climate in the basin is variable depending on elevation and proximity to the mountains. The average annual precipitation ranges from 100 inches in the eastern slopes of the Cascade Range to less than 9 inches at Wenatchee. The growing season (28°F) in the main agricultural area, the narrow river valley between Leavenworth and Wenatchee, ranges from 150 to 180 days. The average date of the last 32°F temperature in spring is May 15, and the first 32°F occurrence in the fall is about October 1. Table E10 summarizes long term mean monthly temperature, rainfall and grass reference crop evapotranspiration at Wenatchee.

A 1983 WSU Cooperative Extension survey of irrigation in each county determined there were a total of 34,100 irrigated acres in Chelan County. This acreage lies in the Chelan Basin, the Entiat Basin, along the west bank of the mainstem of the Columbia River, and in the Wenatchee Basin. It is estimated there are approximately 17,520 acres irrigated in the Wenatchee Basin. Most of this land is in tree fruit production. Some forage crops are grown in the higher elevations of the western part of the basin near Plain.

Table E10. Average monthly temperature, precipitation and grass reference crop evapotranspiration at Wenatchee.

Month	Temperature (°F)	Precipitation (in)	Grass Reference ET_0 (in)
Jan	27.7	1.37	0.00
Feb	35.0	0.85	0.32
Mar	42.7	0.60	1.88
Apr	51.7	0.62	4.09
May	60.2	0.55	5.99
Jun	67.4	0.53	7.57
Jul	73.8	0.15	8.55
Aug	72.3	0.66	6.45
Sep	63.7	0.35	4.38
Oct	51.2	0.57	2.14
Nov	38.8	1.15	0.24
Dec	31.6	1.45	0.00
Total		8.85	41.62

The Wenatchee River Basin is served by Chelan County Public Utility District.

2.0. Water Data

Surface water is the dominant source of irrigation water (95% to 96% of the total supply), being diverted through lined and unlined canals, and piped systems.

There are ten major irrigation districts in this basin. Those serving the largest areas are the Wenatchee Reclamation District (39-40%), the Icicle Irrigation District (22-23%), the Peshashtin Irrigation District (20-22%).

Water delivery costs are moderate ranging between $45 to $60 per acre. Some water districts deliver water pressurized in closed pipelines. Where on-farm pumping is used, costs for pumping are less than $15 per ac-ft pumped.

The water resources in the Wenatchee Basin are used in a variety of ways, including instream recreation, fisheries development and enhancement, sports fisheries, private domestic water and stock watering, irrigation, and municipal and industrial supplies.

Some municipal water (i.e., Leavenworth) is diverted from the Wenatchee River or its tributaries. The majority of municipal water supplies in the basin are pumped from ground water. The City of Wenatchee obtains most of its water from the Columbia River. Industrial water supplies for fruit packing, processing and warehouse operations are obtained mostly from groundwater.

The anadramous and native fisheries are important in the Wenatchee Basin. The maintenance of adequate instream flows for spawning, rearing and migration is required. Natural summer low flows further reduced by withdrawals for irrigation are at critically low levels in some areas of the watershed, especially during dry years. The Wenatchee River is a popular destination for white water rafting and float trips. Adequate flows and water quality are concerns for these recreation uses.

Irrigation began in the Wenatchee River Valley in the 1890's. The Peshashtin Ditch was constructed in 1898. The Wenatchee Reclamation District was formed in 1915. Water is diverted above Dryden and carried down the north bank of the river to near the mouth, where the canal splits. One branch carries water up the west bank of the Columbia. The other branch extends down the Columbia and then crosses it to the east side in Douglas County.

The following streams within the Wenatchee Basin are adjudicated: Mission Creek (5/22/13), Brender Creek (8/26/36), Icicle Creek (10/28/29), Chumstick Creek (4/12/83), Stemilt Creek (1/22/26), and Squilchuck Creek (6/14/28).

3.0. Irrigation System Data

There are 10 major irrigation districts in this basin with conveyance efficiencies ranging from 31% to 80%. The districts with high efficiencies are piped deliveries (PVC, concrete) and those with the lowest efficiencies have several miles of earthen channel, wood stave pipe or clay pipe. The age of the systems range from a few years for those newly rehabilitated to 75 to 90 years for the earthen channels and wood stave pipe.

In 1983, 98.2% of the irrigated land in Chelan County was estimated to be sprinkler irrigated and 1.8% drip irrigated. The condition of on-farm systems is generally fair to good. Some sprinkler and pump systems have poor pressure distribution characteristics and consequently application uniformity and efficiency is lower than acceptable, potentially in the 50% to 60% range.

Grower's water management practices have been found to result in considerable overirrigation in the spring and fall (when water supplies are adequate) and about right in the mid-summer. It is generally assumed this overirrigation results in groundwater recharge in the basin.

4.0. Current activities related to irrigation efficiency

Proposed administrative rules (Chapter 173-545 of the Washington Administration Code: Instream Resources Protection Program -- Wenatchee River Basin) and a supplemental environmental impact statement were issued by WA DOE in July 1983. Policies to manage the basin's water resources, in particular the establishment of minimum instream flows on several watercourses in the basin, were set forth.

The Chelan County Conservation District performed a study of the irrigation delivery systems in the county as part of a grant from the Washington Conservation Commission to study non-point sources of water pollution. The 10 irrigation districts in the Wenatchee Basin were included. Conveyance efficiencies were estimated, areas of high seepage losses noted, and some rehabilitation work identified and implemented.

The Chelan Co. Soil Conservation Service and WSU Chelan Co. Cooperative Extension have undertaken several studies to determine on-farm irrigation management and irrigation system problems. Water management practices of growers were evaluated. Educational programs to help growers better determine irrigation application rates and timing have been conducted.

5.0. Potential irrigation efficiency improvements

The irrigation districts in this basin have conveyance efficiencies ranging from 31% to 80%. Canal lining in high loss areas, and replacement of wood stave and clay pipe will reduce considerable conveyance losses.

On-farm sprinkle irrigation systems can be improved through system evaluation for nozzle wear, poor pressure distribution and too wide spacings, all of which lead to poor application uniformity and low efficiencies. On-farm pumping systems should be evaluated for appropriate sizing as well as pressure losses around the pump itself.

Irrigation management practices early and late in the season can be improved through better understanding by growers of soil-water-plant relationships. Better timing and duration of irrigation late in the season will help to stretch water supplies during this part of the year during low flow years.

The Wenatchee Basin has several irrigation districts that are eligible for referendum 38 funds. Instream flows are of concern for recreational, fisheries and aesthetic interests. Some irrigation shortages occur during dry summer years. The upper basin area is seeing increasing urban development due to the aesthetic and scenic values of this region.

Improved conveyance and irrigation efficiencies would help to leave more water for instream flows, fisheries and in-stream recreation; and stretch water to help meet municipal, industrial and irrigation demand during shortages. The instream flows set in the basin do not seem to concern the growers in the basin. There is a general feeling that water saved simply will flow into the Columbia River, because there is no reservoir storage in the basin to hold the saved water for later use. Water conservation and water management generally are low priority issues in this basin compared to the emphasis growers place on other issues related to fruit production.

Increased urban and recreational demands for water in the future will probably create problems for water resources management in the Wenatchee Basin. As far as irrigation water conservation is concerned, the opportunity exists to make efficiency improvements in the basin, however, the interest in doing so does not seem to be strong at this point in time.

APPENDIX F

REVIEWERS OF INFORMATION FOR FIVE AREAS SELECTED FOR DETAILED STUDY

Dungeness River

Jack Waud
Cooperative Extension
Clallum County

Kerry W. Perkins
Clallam County District Conservationist

Kittitas Basin

Charles H. McKinney
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Kittitas County

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Walla Walla County District Conservationist

Wenatchee Basin

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APPENDIX G

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