DESCHUTES RIVER BASIN

STATE WATER RESOURCES BOARD
SALEM, OREGON
January 1961

SUPERVISORY STAFF

E. J. Watson	Chief Engineer
M. H. Karr	Chief, Basin Investigations
A. Brandstetter	Basin Engineer
G. N. Holman	Chief Draftsman
F. P. Hopkins	Data Engineer

FIELD REPRESENTATIVE

Q. G. Bowman

COVER PICTURE

Metolius River, Deschutes County.
Three Fingered Jack in background.
U. S. Department of Agriculture,
Soil Conservation Service photo.

Price $2.50

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF PLATES

Note: Plates appear at the back of the report.

PURPOSE AND INTRODUCTION

The purpose of this report is to set forth in a condensed form the major items considered by the State Water Resources Board in its formulation of an integrated, coordinated program of use and control of the water resources of the Deschutes River Basin in Oregon.

The board's investigation activities were completed in late 1960. The study was made in conformity with ORS 536.300(1) which states:

> "The board shall proceed as rapidly as possible to study: existing water resources of this state; means and methods of conserving and augmenting such water resources; existing and contemplated needs and uses of water for domestic, municipal, irrigation, power development, industrial, mining, recreation, wildlife, and fish life uses and for pollution abatement, all of which are declared to be beneficial uses, and all other related subjects, including drainage and reclamation."

Having completed the study necessary to formulate and implement an integrated, coordinated water resources program, the board proposes to adopt a program for the Deschutes River Basin. This program will fulfill the requirements of ORS 536.300(2) which states:

> "Based upon said studies and after an opportunity to be heard has been given to all other state agencies which may be concerned, the board shall progressively formulate an integrated, coordinated program for the use and control of all the water resources of this state and issue statements thereof."

The program will be based on the standards outlined in ORS 536.310 and the data obtained in the basin investigation. This program will supplement the program previously adopted by the State Water Resources Board for the Lower Deschutes Basin on November 25, 1959. A summary of basic data and factors examined in the study are contained in the report. Detailed information is available for examination in the files of the board in Salem, Oregon.

Data for study and evaluation were made available through (1) physical field activity, (2) review of available reports and data, (3) extensive personal contact, (4) hearing on the basin's water needs and problems (Redmond, March 1, 1960), (5) extensive hearings on applications for a preliminary permit and a license for the Round Butte Project of Portland General Electric Company before the Hydroelectric Commission and the State Water Resources Board (Portland, October 12-16, 1959; Salem, November 19, 1959; and Portland, September 9, 1960), and (6) data supplied by the Department of Agriculture (Soil Conservation Service, Forest Service, and Agricultural Research Service) through a cooperative program with the State Water Resources Board, and (7) submission of data to the board, at its request, by local, state, and federal agencies and other groups.

GENERAL CONCLUSIONS

1. *Water is a controlling factor in resource development. Future economic and and population growth will depend primarily upon the quantity of water available for development use.*

2. *The total basin yield is adequate to supply all existing and contemplated future needs of water, but serious shortages exist in many areas due to the seasonal and geographical pattern of distribution of the yield.*

3. *Flows are not sufficient on many streams under present stream regulation during summer months of average water years to supply existing and future demands.*

4. *Simultaneous use of any major portion of existing rights results in flows at or near the zero level in many streams during the summer months.*

5. *Augmentation of the water resource in periods of need can come through storage of surplus winter and spring runoff and more efficient use of presently appropriated water.*

6. *There are substantial quantities of unappropriated water that are subject to the jurisdiction of the State Water Resources Board.*

7. *Unappropriated waters of the Deschutes River and its tributaries above Bend, Tumalo Creek above Columbia-Southern Canal, Crooked River, Ochoco Creek, and White River and its tributaries have been withdrawn by the State Engineer or Legislature for special uses.*

8. *Waters within the Warm Springs Indian Reservation are not considered to be solely under the jurisdiction of the State of Oregon.*

9. *There are nonconsumptive rights with early priorities which limit upstream use of water for consumptive purposes.*

10. *Use of the waters of certain major streams, or sections of these streams, and numerous lakes and minor streams is limited due to physiography, location, land ownership, or economic potential.*

11. *There are limited-purpose storage developments that restrict multiple beneficial use of the water resources.*

12. *Ground water is generally of good quality and represents a potential source of water in portions of the basin. Extensive ground water surveys are needed to fully determine the amount and distribution of water available from this source.*

GENERAL CONCLUSIONS

13. *Domestic, municipal, livestock, and wildlife uses of water, while important, represent minor quantities in existing and contemplated future water use.*

14. *Irrigation is presently and will continue to be the major consumptive water use in the basin.*

15. *Adequately irrigated agricultural lands represent only a small portion of the total irrigated area.*

16. *The existing irrigated acreage could be more than doubled provided an adequate supply of water were available. Extensive studies are required to determine the feasibility of providing new storage, reducing existing stream channel and irrigation water losses, and developing ground water for increased irrigation use.*

17. *The basin has potential for industrial developments. Sufficient water will not be available at many locations for major water-using industries without provision for seasonal storage or, in some areas, developing the ground water resources.*

18. *The basin has potential for the development of hydroelectric energy. Studies are in progress to resolve the conflict between major dam projects and fish life on the Lower Deschutes River.*

19. *Mining and the use of water for mining purposes is slight and is not expected to increase materially in the foreseeable future.*

20. *Recreation is a major factor in the economy of the basin. There is an abundance of reservoirs, lakes, and streams available for water-based recreation in the western portion of the basin, especially in the Upper Deschutes sub-basin.*

21. *There is potential for more extensive use of existing facilities and development of new recreational facilities.*

22. *A major conflict exists between irrigation and fish life use of water.*

23. *Reduction of present reservoir and stream level fluctuations and maintenance of minimum reservoir levels and perennial streamflows would enhance fish life and recreation.*

24. *Desirable base flows suggested by fisheries agencies are substantially higher at many locations than the flow levels that can be committed during an average water year under current stream regimen and existing water rights and priorities.*

25. *Storage and scheduled releases of excess winter and spring runoff, purchase of some existing water rights, or acquisition of water saved by reducing irrigation transmission losses would be necessary to attain the flows recommended by fishery agencies. The economic relationships between costs and benefits related to base flow improvement have not been established.*

26. *Establishment of restrictions on further appropriations would aid in maintaining minimum flows in streams that are not now appropriated beyond their natural capacity at critical periods, and in streams that are now appropriated beyond their natural capacity at critical periods but where actual diversions of water are below the legal appropriations.*

27. *Pollution of surface and ground water is not a problem at present.*

28. *Flood, drainage, and streambank erosion are not major problems.*

29. *Small reservoirs on minor tributaries would reduce flash floods and streambank erosion and provide late season irrigation water. Most of these are not economically feasible at present.*

DESCHUTES RIVER BASIN STUDY

CHAPTER I THE BASIN

GENERAL

Sub-basin Divisions

Because of the differences in physical characteristics, needs and uses of water, and levels of economic development from area to area, the basin has been divided into sub-basins to facilitate the analysis of these differences.

Chapters I and II are devoted to a discussion of water resources and related items for the entire Deschutes Basin. Chapter III is an inventory of each sub-basin covering the same items as preceding chapters but in much greater detail.

To permit direct comparison of some items and also for added clarity, many of the tables and figures present their information by sub-basins, particularly in Chapter III, and reference to the various sub-basins is made throughout the narrative.

Delineation of the sub-basin divisions is shown in Plate 1: Sub-basin 1, Upper Deschutes, comprises all of the Deschutes River drainage from its headwaters to Benham Falls; Sub-basin 2, Middle Deschutes, from Benham Falls to Mecca excluding Crooked River drainage; Sub-basin 3, Lower Deschutes, the remaining Deschutes drainage from Mecca to its mouth plus small streams in the lower part of the basin draining directly into the Columbia River; Sub-basin 4, Upper Crooked, covers all of the Crooked River drainage from its headwaters to mile 66, which is a few miles below Prineville Reservoir; and Sub-basin 5, Lower Crooked, the remainder of Crooked River drainage from mile 66 to its mouth.

Location and Size

The drainage basin key map of Plate 1 shows the Deschutes River Basin to be located in the north central part of the State of Oregon. This stream system drains an area of approximately 10,400 square miles (6,650,000 acres), which is nearly 11 percent of the area of the state.

Basin boundaries consist of the high Cascade Mountains on the west, lava plateaus to the south, the Ochoco Mountains and the plateau between the Deschutes and John Day Rivers on the east, and the Columbia River to the north. One hundred and seventy miles long in a north-south direction and 125 miles at its longest east-west extension, the basin narrows to only a few miles at its northern boundary.

THE BASIN

As shown by Table 1, the Deschutes Basin includes nearly all of Crook, Deschutes, and Jefferson Counties, 70 percent of Wasco County, nearly half of Sherman County, a small portion of Klamath County, and only a few square miles each of Wheeler, Grant, Lake, Hood River, and Harney Counties.

TABLE 1

AREAS OF COUNTIES LYING WITHIN THE DESCHUTES RIVER BASIN

COUNTY	TOTAL AREA Sq. Mi.	*AREA WITHIN DESCHUTES RIVER BASIN Sq. Mi.	Acres	% of County	% of Basin
Crook	2,980	2,865	1,833,600	96.1	27.6
Deschutes	3,027	2,738	1,752,320	90.5	26.3
Wasco	2,387	1,677	1,073,280	70.3	16.0
Jefferson	1,794	1,584	1,013,760	88.3	15.2
Klamath	5,973	765	489,600	12.8	7.4
Sherman	830	372	238,080	44.8	3.6
Lake	8,270	116	74,240	1.4	1.1
Wheeler	1,707	92	58,880	5.4	0.9
Grant	4,532	67	42,880	1.5	0.7
Harney	10,132	67	42,880	0.7	0.7
Hood River	529	47	30,080	8.9	0.5
TOTALS		10,390	6,649,600		100.0

*Determined from SWRB Map No. 5.701

Stream System

Major tributaries of the Deschutes River, from the headwaters downstream to the mouth, are the Little Deschutes River, Tumalo Creek, Squaw Creek, Crooked River, Metolius River, Shitike Creek, Trout Creek, Warm Springs River, and White River. Stream miles at the confluences of these tributaries with the Deschutes River can be determined from Plate 1. It will be noted that of the major tributaries only the Crooked River and Trout Creek have headwaters in the eastern portion of the basin. All of the remainder head in the high Cascades to the west. While the Little Deschutes River enters the Deschutes on the latter's east bank, it too heads in the Cascade Mountains at a point south of the origin of the Deschutes River.

Named streams total about 570 and there are an additional 1,350 unnamed streams in the basin. All streams total approximately 6,800 miles in length, of which only 1,980 miles are perennial in nature. Included in these figures are the 252 miles of Deschutes River main stem, 97 miles of Little Deschutes River, 130 miles of Crooked River, 41 miles of Metolius River, and 48 miles of White River.

A further indication of the extent of perennial and intermittent streams in the Deschutes River Basin is given by Table 2 which lists this information by sub-basins.

Determination of stream elevations at any point and stream gradients for any section

can be made from Plate 2, a profile of most of the important streams in the Deschutes

TABLE 2

MILES OF STREAMS
IN THE DESCHUTES RIVER BASIN

SUB-BASIN Name	Area in Sq. Mi.	*MILES OF STREAMS Perennial	Intermittent	Total
Upper Deschutes	1,710	310	440	750
Middle Deschutes	1,850	330	580	910
Lower Deschutes	2,690	760	1,440	2,200
Upper Crooked	2,480	330	1,650	1,980
Lower Crooked	1,660	250	710	960
TOTALS	10,390	1,980	4,820	6,800

*Determined from SWRB Map No. 5.701

system. Reference is made throughout the report to many items of significance that are shown by, or can be inferred from, Plate 2.

Climate

Although the climate of the Deschutes Basin is continental, moderating affects of the Pacific Ocean are not entirely shut off by the Cascade Mountains. Average annual precipitation is as high as 100 inches in some areas in the Cascade Range but drops to between 9 and 14 inches in the Deschutes Valley and on the eastern plateaus, and increases to above 20 inches in some areas in the Ochoco Mountains. Only about 25 percent of the average annual precipitation occurs during the main irrigation season between May 1 and September 30.

The effect of elevation is also apparent with annual snowfall which averages 295 inches at Cascade Summit and decreases with lower elevation to 39 inches at Bend, 17 inches at Redmond, and 14 inches at Prineville and increases again in the Ochoco Mountains where it is about 72 inches at the Ochoco Ranger Station.

Recorded temperature extremes have varied from minus 45 degrees Fahrenheit to 119 degrees above zero. Average annual temperatures at various locations in the valleys range between 40 degrees in the upper regions of the Deschutes River and 51 degrees near its mouth.

The average number of days without killing frost at lower elevations in the agricultural areas averages between 80 days in the Upper Deschutes and southern lava plateaus of the basin to about 170 days on the plateaus near Wasco. However, frosts can occur in any month of the year in the entire watershed south of Madras.

Growing seasons average about 90 days at Bend, 100 at Madras, 112 at Prineville, 130 at Antelope, and 170 at Wasco. Hydrological stations are shown on Plate 14, and listed in a summary available in the office of the State Water Resources Board.

Population

Table 3 shows the population distribution in the basin by counties and sub-basins, as estimated from U. S. Bureau of the Census data. Total population of the Deschutes River Basin estimated for 1960 was 44,080, which is approximately 2.5 percent of the total population of the state. Sixty-five percent of the population of the basin is concentrated in the Middle Deschutes sub-basin while 52 percent is located in Deschutes County. Populations for 1960 were, Bend - 11,940, Redmond - 3,340, Prineville - 3,260, and Madras - 1,520. The remaining six incorporated cities in the basin all have populations below 1,000. There are an additional 62 unincorporated communities in the basin having populations ranging from 500 downward with the majority having populations less than 50.

TABLE 3

POPULATION DISTRIBUTION
BY COUNTIES AND SUB-BASINS
1960

SUB-BASIN	COUNTY									TOTAL SUB-BASIN
	Crook	Deschutes	Grant	Harney	Hood River	Jefferson	Klamath	Sherman	Wasco	
Upper Deschutes	0	560	0	0	0	0	1,190	0	0	1,750
Middle Deschutes	0	22,350	0	0	0	6,390	0	0	0	28,740
Lower Deschutes	0	0	0	0	20	280	0	1,140	2,100	3,540
Upper Crooked	420	50	30	10	0	0	0	0	0	510
Lower Crooked	9,010	110	0	0	0	420	0	0	0	9,540
TOTAL POPULATION WITHIN DESCHUTES BASIN	9,430	23,070	30	10	20	7,090	1,190	1,140	2,100	44,080

Note: The portions of Lake and Wheeler Counties within the Basin are uninhabited.

Trends in population are illustrated in Figure 1. All of the counties in the basin exhibited a fairly sharp rate of growth from 1940 to 1950 except Sherman which had a slight decline. The succeeding 10 years, 1950-1960, brought a continued growth but at a lesser rate for all counties except Wasco which continued to grow at an accelerated rate. Much of Wasco County's growth occurred in The Dalles area which is outside of the Deschutes Basin.

Of the major cities, those above 1,000 population, Bend has shown a very high rate of growth, particularly in the early 1900's. A leveling off in rate of growth is apparent for all major cities in the last 10 years with Prineville showing a decline.

Other incorporated cities, those below 1,000 population, exhibit quite variable growth patterns. Metolius has maintained a high rate of growth since 1940 while Sisters shows an appreciable drop for the last 10 years. Wasco's population in 1940 was less than half

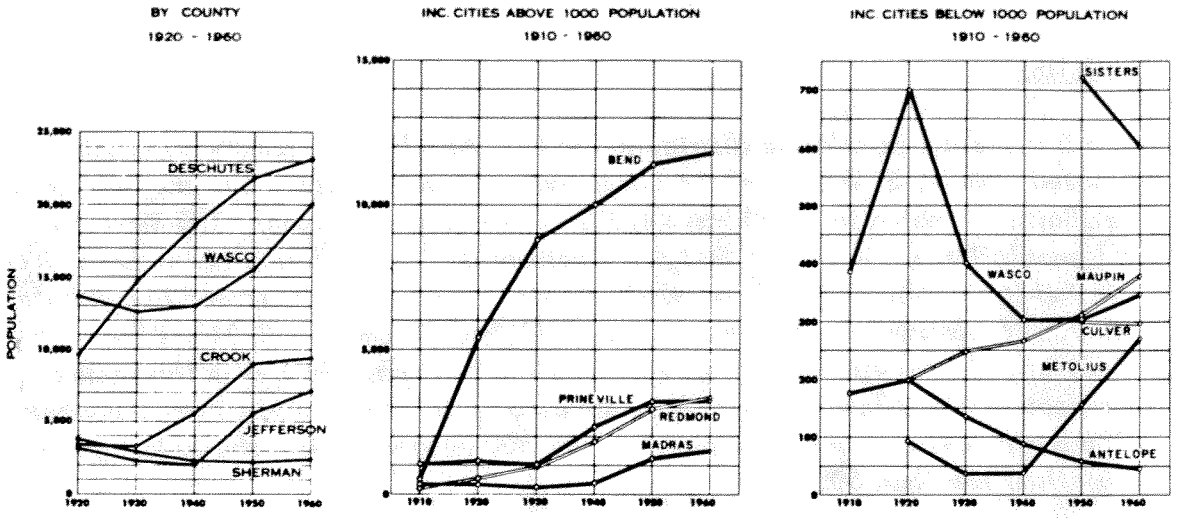


FIGURE 1. Trend in population.

that of 1920 but is now on the upswing. Antelope has been declining steadily in population since 1920. Maupin has had a steady increase in population at nearly a uniform rate since 1920.

ECONOMY AND LAND USE

Land Ownership

A detailed breakdown of federal, state, and private land ownership by sub-basins is given in Table 4. Of the total basin area, 10,390 square miles, 55 percent is federally owned or administered, 1 percent is state land, and the remaining 44 percent is predominantly privately owned.

This ownership distribution has a direct bearing on the economy of the area. That nearly one-third of the basin is U. S. Forest Service land is of importance in the utilization of the area timber resources. Uses made of the large areas of private land and management practices prevalent in those areas are important factors in water resources and basin economy. This relationship between land ownership and use and basin economy is brought out in the following paragraphs.

Timber

The importance of the timber resource in the Deschutes Basin is indicated by the fact that

approximately four million acres of land, which is nearly 60 percent of the basin area, is forest land and nearly two-thirds of that is classed as commercial, which are lands available for and capable of producing marketable timber.

TABLE 4

LAND OWNERSHIP OR ADMINISTRATION

SUB-BASIN Name	Total Area Sq.Mi.	U. S. FOREST SERVICE Area Sq.Mi.	% of Total	BLM-PUBLIC DOMAIN Area Sq.Mi.	% of Total	BUREAU OF INDIAN AFFAIRS Area Sq.Mi.	% of Total	OTHER FEDERAL Area Sq.Mi.	% of Total	STATE Area Sq.Mi.	% of Total	PRIVATE & OTHERS Area Sq.Mi.	% of Total
Upper Deschutes	1,710	1,330	78	65	4	0	0	5	0	5	0	305	18
Middle Deschutes	1,850	645	35	125	7	320	17	15	1	10	0	735	40
Lower Deschutes	2,690	370	14	65	2	560	21	35	1	10	0	1,645	62
Upper Crooked	2,480	505	20	765	31	0	0	20	1	45	2	1,145	46
Lower Crooked	1,660	475	29	420	25	0	0	5	0	25	2	735	44
DESCHUTES BASIN TOTAL	10,390	3,325	32	1,440	14	880	8	80	1	95	1	4,565	44

Note: Areas are shown to the nearest five square miles.

Source: U. S.; Forest Service, Bureau of Land Management, Bureau of Indian Affairs
State; Land Board, Highway Department, Game Commission

Forest land areas and predominant wood species as determined from data supplied by the U. S. Forest Service are shown by counties in Table 5.

TABLE 5

FOREST AREAS AND PREDOMINANT WOOD SPECIES
WITHIN THE DESCHUTES RIVER BASIN

COUNTY	COMMERCIAL FORESTS Acres	*Major Wood Species % of total volume PP	DF	LP	FS	NONCOMMERCIAL FORESTS Acres	*Major Wood Species % of total volume J	OM	TOTAL Acres
Crook	429,000	87	8			562,000	98		991,000
Deschutes	918,000	64		25		371,000	71		1,289,000
Jefferson	376,000	88				262,000	91		638,000
Klamath	467,000		Unknown			22,000	Unknown		489,000
Wasco	381,000	53	32		9	74,000	54	38	455,000
TOTALS	2,571,000					1,291,000			3,862,000

*PP, Ponderosa Pine; DF, Douglas-fir; LP, Lodgepole Pine; FS, fir-spruce; J, juniper; OM, oak-madrona

Source: U. S. Forest Service

Ponderosa pine is the predominant wood species in the basin and constitutes about 75 percent of the commercial acreage, and about 60 percent of the commercial sawtimber volume. Most of the remaining area consists of lodgepole pine and Douglas fir and, of lesser importance, larch, hemlock, cedar, black cottonwood, and other fir and pine species.

Of the noncommercial timber land, juniper covers 91 percent, oak-madrona 3 percent, 4 percent is classed as sub-alpine, and the remaining 2 percent as noncommercial - rocky.

Commercial forests in the basin extend over most of the slopes of the Cascades, east to the Paulina Mountains and Walker Rim, and cover a large portion of Ochoco and Maury Mountains. There are areas of noncommercial forests scattered over most of the remainder of the basin with the exception of Sherman and the portion of Wasco County lying east of the Deschutes River.

Annual log production and the major timber producing areas of the basin have varied appreciably over the years. The trend by counties from 1949 through 1958 can be seen in Figure 2.

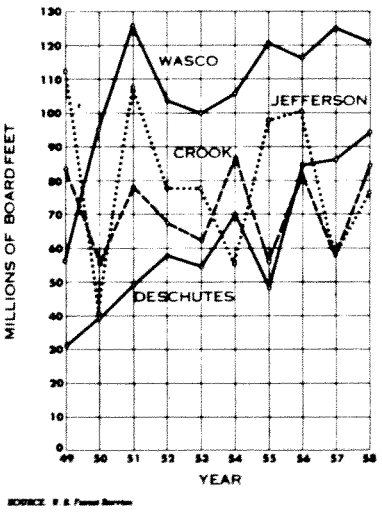


FIGURE 2. Trend in log production, by counties.

Deschutes County averaged over 200 million board feet annually from 1936 through 1943 followed by a tremendous drop to a low of less than 14 million in 1947. This drop resulted from cessation of operations in that area of a major timber company. Since then, log production in that county has gradually increased, with a temporary setback in 1955, and is now approaching 100 million board feet annually.

Crook County production reached a high of 100 million board feet in 1941, but in recent years has varied between 50 and 80 million annually.

Jefferson County production now runs between 60 and 100 million board feet annually, which also is below the maximum of nearly 160 million reached in 1947.

The general production trend in Wasco County has been towards an increase reaching a high in 1951, which has pretty much held since then, near 120 million board feet annually.

Data from the Department of Employment indicates that of all of the covered employes in Crook County, 63 percent are in the lumber and wood products industry. Comparable figures for Deschutes County are 28 percent, Jefferson 17 percent, and Wasco 13 percent. In terms of the numbers of covered employes in the lumber industry in all of the counties of the state, Crook County ranks 14th, Deschutes 15th, Wasco 30th, and Jefferson 32nd.

An indication of the extent of logging on U. S. Forest Service land is given by Table 6

which shows annual log production and annual stumpage value of timber sales for national forests within the Deschutes Basin.

It is important to note that stumpage values and log production figures cannot be compared directly for any given year since timber sold in one year usually is logged over a period of several years following the sale. Further, stumpage figures are not true indicators of timber value because of a number of factors that influence the difference between sale price and market value of timber.

TABLE 6

LOG PRODUCTION AND STUMPAGE VALUE
NATIONAL FORESTS WITHIN THE DESCHUTES RIVER BASIN

YEAR	NATIONAL FOREST ANNUAL CUT						TOTAL	
	MT. HOOD		OCHOCO		DESCHUTES			
	Million BM	*Stumpage $ Value	Million BM	*Stumpage $ Value	Million BM	*Stumpage $ Value	Million BM	*Stumpage $ Value
1955	48	1,034,000	39	874,000	79	1,681,000	166	3,589,000
1956	47	1,220,000	57	1,302,000	109	2,808,000	213	5,330,000
1957	31	448,000	31	625,000	102	2,282,000	164	3,355,000
1958	49	578,000	51	1,354,000	113	1,962,000	213	3,894,000
1959	43	767,000	85	1,619,000	153	2,805,000	281	5,191,000
ALLOWABLE	37		55		118		210	

*Stumpage value and log production cannot be compared directly for the same year. See text.

Source: U. S. Forest Service

For example, timber that is over-ripe, low-grade, or diseased may not have a high stumpage value but, if utilized in pulp and paper production, will yield an end product of high value.

On the other hand, high-grade timber that brings premium prices at the mill may also have a relatively low sale price on the stump because of high road-building and logging costs resulting from difficult terrain.

A third situation would be a good grade of timber having high value both on the stump and at the market.

These and many other factors influence the relationship between stumpage value and true market value of timber so the values cited in Table 6 should only be used to indicate the relative magnitude of timber sales in national forests.

Average log production on national forests within the Deschutes Basin averaged 207 million board feet annually for the period 1955-1959 which compares favorably with the allowable cut of 210 million. It is Forest Service policy to allow the cut to fluctuate above and below allowable as long as the long-term average does not vary appreciably from the estimated sustained yield. This practice permits more efficient and more economical logging operations and insures maximum yield from the forests.

Agriculture

The first white settlers in the Deschutes Basin located along Hay Creek east of Madras in 1863 and herded cattle in the surrounding hills. Within the next few years other settlers located on Trout Creek, Willow Creek, and Squaw Creek. Agriculture at first consisted mainly of raising cattle, sheep, and horses.

Large areas in Jefferson, Wasco, and Sherman Counties, devoted in the early days almost exclusively to grazing, were gradually replaced by dry wheat farming. Precipitation in Jefferson County is marginal for dry land wheat production and operations on many dry wheat farms established in Jefferson County during wet years were subsequently discontinued during dry years.

Irrigation in the area started first on Squaw Creek near Sisters around 1871. Homesteading started in 1898 and irrigation was begun on a large scale in about 1900. Several small irrigation companies were formed about this time. Most of these companies were short-lived and were merged into larger ones which were in turn taken over by landowners who organized irrigation districts. Most of the irrigable land in the basin was occupied, although not all irrigated, by 1920.

Construction of storage facilities began in the mid-20's when it became apparent that the flow of streams was not large enough to supply all projects at the time the water was needed. Construction on the Bureau of Reclamation's Deschutes projects began in 1921.

Today about 42 percent of the total basin area is occupied by farm land. Of the nearly 2,800,000 acres of farm land, 425,000 acres are in crops, 521,000 acres in woodland, and the remainder in pasture and other uses. Details of agricultural land use and farms within the basin for the five major counties are shown in Table 7.

More than half of the approximately 2,500 farms in the basin are located in the Middle Deschutes sub-basin and most of the remainder are divided about equally between the Lower Deschutes and Lower Crooked sub-basins with a few farms located in the Upper Crooked and Upper Deschutes sub-basins. Agricultural Census data shows that for the period 1930 through 1954 the number of farms decreased approximately 25 percent in Crook, Sherman, and Wasco Counties, but increased 30 percent in Deschutes County and 75 percent in Jefferson County.

At the same time, the total land in farms has increased resulting in a larger average size of farms in all counties with the exception of Jefferson. In the latter case, the average size of farms has been greatly reduced due in part to the division of lands of this county in the 1940's after the introduction of irrigation through the North Unit Irrigation District.

The physical and economic environment in the Deschutes Basin has resulted in the development of three general types of agriculture: (1) general irrigated farming, (2) dry land farming, and (3) range livestock. Many farms in the basin are a combination of two or all three of these types.

TABLE 7

AGRICULTURAL LAND AND FARMS
WITHIN THE DESCHUTES RIVER BASIN
1954

ITEM	COUNTY					TOTAL
	Crook	Deschutes	Jefferson	Sherman	Wasco	
Area in Deschutes Basin	1,833,600	1,752,320	1,013,760	238,080	1,073,280	5,911,040
Land in farms	1,037,174	337,810	539,985	218,000	635,000	2,767,969
Number of farms	393	1,067	590	110	225	2,385
Average farm size	2,639	317	915	1,980	2,822	1,369
Cropland	72,863	48,515	96,904	116,000	90,300	424,582
Cropland harvested	49,005	33,838	69,906	55,700	47,000	255,449
Land pastured	960,393	274,032	427,624	74,700	568,000	2,304,749
Woodland	209,664	109,549	29,748	600	171,700	521,261
Other land	9,432	15,831	18,190	4,100	15,300	62,853
Irrigated land	45,818	44,424	54,789	0	5,000	150,031

Note: All areas are in acres.

Source: Agricultural Research Service

General irrigated farming is concentrated in Jefferson and Deschutes Counties and is also intermixed with range type of agriculture in Crook County below Prineville.

Plate 3 was prepared to give an indication of the location of irrigation lands, both existing and potential. Information was lacking with which to delineate the lands that are presently being irrigated outside of the major irrigation districts. Also the pattern of irrigation varies from year to year. Therefore Plate 3 shows the lands which hold water rights for irrigation. Present rights are for 270,000 acres as compared to the 180,000 acres estimated to have been irrigated in 1959. Thus an appreciable portion of the nonirrigated lands holding water rights could also be classed as potentially irrigable lands.

This is also brought out by the fact that although more than 80 percent of the farms in the basin irrigate, only 8 percent of the agricultural lands receive irrigation water and only a small fraction of the irrigated lands receive an adequate supply of water.

Most irrigated farm land receives water from gravity irrigation systems and 75 percent of the irrigated lands lie within the irrigation districts of the Deschutes and Crooked River projects. Most irrigated land outside of districts lies along or near streams. These lands are dependent on natural streamflow which results in shortages during the summer low flow season, particularly in the arid areas east of the Deschutes River.

The present level of irrigation development and proposals for future developments are delineated in Plate 4. This includes irrigation districts, Bureau of Reclamation projects, irrigation dams and reservoirs, and major irrigation canals and ditches. This also serves to illustrate the lack of facilities in many areas of the basin.

Range livestock farms include irrigated land for the production of winter feed. This type is located principally in Crook County along Crooked River and near tributary streams in Wasco County.

In addition to livestock farms, about 925,000 acres of public domain land administered by the Bureau of Land Management are used primarily for grazing and national forest lands also provide some grazing.

Dry land farming is dominant in the northern portion of the basin, primarily in Sherman and Wasco Counties with wheat being the principal crop.

Data from the Agricultural Census shows that in the tri-county area of Crook, Deschutes, and Jefferson Counties, 67 percent of the approximately 2,000 farms are classed as commercial, 11 percent as part time, and 22 percent as residential farms. In this area, which contains about 94 percent of the total area irrigated in the basin, 45 percent of the commercial farms reported a gross value of all farm products sold in 1958 of less than $5,000, while 24 percent show less than $2,500.

Total gross agricultural income in the Deschutes Basin in 1958, exclusive of forest and forest products, is estimated at 32.5 million dollars with crops accounting for 15.5 million or about 48 percent of the total. Wheat was the most valuable crop followed by potatoes and alfalfa. These three together accounted for 75 percent of the total estimated gross income from crops.

Livestock products and poultry accounted for 17 million dollars or 52 percent of the total agricultural income. Beef alone accounted for 12.1 million followed by dairy 2.2 million and poultry 1.1 million.

The trend in the value of farm products sold in the tri-county area of the basin is shown in Figure 3. Sales in Jefferson County have increased steadily from less than 1 million dollars in 1939 to nearly 11 million dollars in 1958. Sales dropped off in both Crook and Deschutes Counties from 1949 to 1954, but since then have shown a steady increase and in 1958 amounted to nearly 9 million dollars in Crook County and over 5 million dollars in Deschutes County.

The trend in acres of irrigated land in the same tri-county area is shown in Figure 4. It will be noted that the rate of increase or decrease in acres of irrigated land from the

period 1944 through 1958 is very similar to the increase or decrease in the value of farm products sold during the same period. This gives some indication of the importance

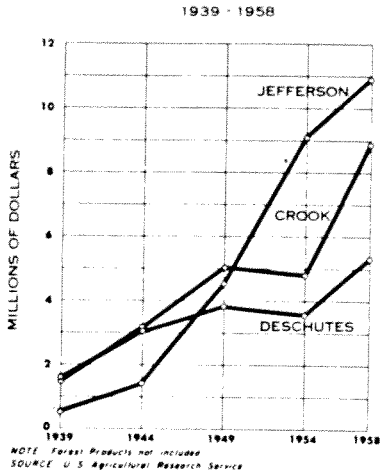


FIGURE 3. Trend in dollar value of farm products sold, by counties.

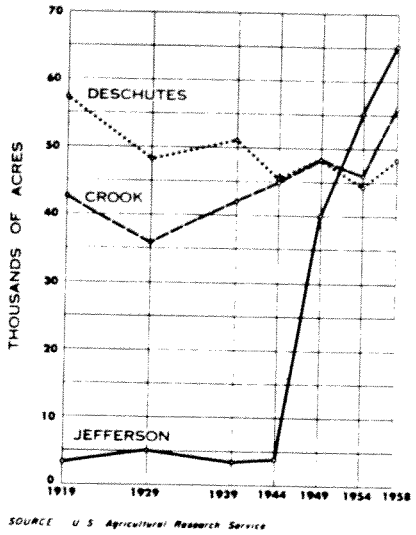


FIGURE 4. Trend in irrigated acreage, by counties.

of irrigation on some aspects of the agricultural economy of the basin. This is particularly evident in the large increase in both acres of irrigated land and agricultural income in Jefferson County with the advent of the North Unit Irrigation District in the middle 1940's.

Recreation

Recreation is very important to the economy of the basin. The Deschutes stream system has a nationwide reputation for excellent trout and salmon fishing. Each year there is a large influx of people to the basin during the hunting season. Thousands of visitors each year enjoy the scenic attractions of the basin; the Lower Crooked River and Deschutes River canyons, the Ochoco Mountains, and the Cascades with their many lakes.

The many and varied recreation areas in the basin including forest camps, wilderness areas, state parks, roadside rest areas, resorts, boat landings, and others are located on Plate 5. A detailed summary of the facilities available at each of these areas has been compiled and is available at the office of the State Water Resources Board.

One hundred and thirty-eight forest camps are scattered throughout the basin in the Deschutes, Mt. Hood, and Ochoco National Forests in the Cascade, Paulina, Ochoco,

and Maury Mountains. Recreational use of national forest land in the basin has been increasing steadily in the past few years and reached an estimated total of 1,318,400 man days in 1959 according to U. S. Forest Service data. In addition, six privately-owned and two forest service-owned organization sites in the national forests receive approximately 34,200 man days of use each year. Ten privately-owned resorts on national forest land in the basin receive about 93,300 man days of use each year. Also, six summer home areas on national forest land, with a total of 297 homes, receive approximately 35,600 visitor days per year.

Twenty-two resorts are scattered throughout the basin. Bachelor Butte ski area near Bend had 29,000 visitors who enjoyed 24,000 ski days in its first season of operation, the winter of 1958-59.

Seventeen state parks and roadside rest areas can be found in the basin, most of them along the Deschutes and Crooked Rivers. As with other recreation areas, the popularity of state parks has increased steadily over the years. This is indicated by Figure 5 which shows the annual use of state parks by day visitors and overnight campers since 1953.

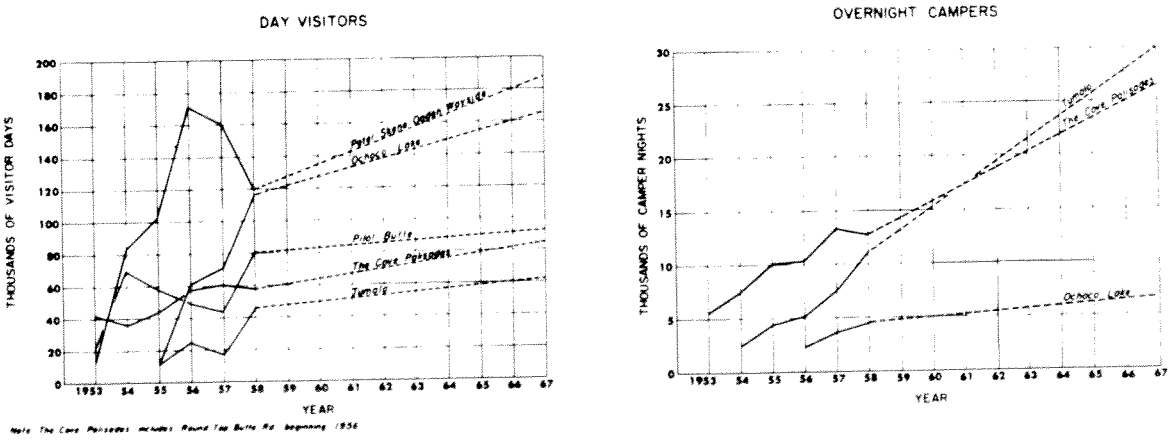


FIGURE 5. Trend in annual use of state parks projected to 1967 by the Parks Division of the Oregon State Highway Commission.

Those parks shown having day visitors were selected as being representative of all parks in the basin. All parks having overnight camping facilities are shown in Figure 5. Counts taken in state parks in the basin totaled 622,900 visitor days and 28,600 camper nights for 1958. These figures do not include roadside rest areas. Traffic counts taken in 1958 showed that approximately 45 percent of the cars at overnight camping grounds came from out of state.

It can be noted in Figure 5 that both Peter Skene Ogden Wayside and Ochoco Lake had approximately twice the number of day visitors in 1958 as Cove Palisades. This

reflects both accessibility and recreational features.

Peter Skene Ogden Wayside is located at the Crooked River crossing of U. S. 97, the main north-south arterial of the basin, thus offering easy access to a large number of travelers. Likewise, Ochoco Lake is located on U. S. 26, a main east-west arterial. In contrast, Cove Palisades State Park is located several miles from the main highway at the bottom of the canyon and is accessible by a relatively steep and winding road.

The major attraction at Peter Skene Ogden Wayside is a spectacular view from the rim of the Crooked River canyon, at Ochoco Lake is reservoir type of activity such as boating and fishing, and at Cove Palisades is both scenic and stream fishing.

The State Parks and Recreation Division projected state parks' use to 1967, as also shown in Figure 5. These projections reflect physical capabilities of the parks as well as anticipated future demands. For example, the relatively low rate of increase in annual use of Ochoco Lake State Park is not because of lack of popularity but rather due to limited space for expansion and the restrictions imposed on recreation through operation of the reservoir for irrigation purposes. Therefore, future recreation demands will be higher than the projected use of state parks indicates.

It is difficult to assign dollar values to recreation due to a number of intangible factors such as the value of the pleasure and health benefits derived from recreation. Evaluation of recreation has been made in a number of ways but the dollar values derived are only a partial measure of the full benefit of recreation. Examples are cited below.

The Parks Division of the Oregon State Highway Department reports that revenue at existing state parks in the basin which provide overnight camping averages about 30 cents per camper night. Out-of-state, three-day tourists spent an average of $5.20 per day for food, lodging, travel expenses, and miscellaneous items in 1957.

In 1956 average expenditure per person per day for campers in Washington was estimated at $7.43 by the Washington State Parks and Recreation Commission.

For the purpose of determining the economic benefits to an area from recreation, the Department of Natural Resources of Oregon State College has estimated that average daily expenditures in the proposed Oregon dunes park area will be $2.00 for day visitors and $6.50 for overnight campers in 1990.

As a guide to capital investment justification, the National Parks Service uses a figure of $1.61 per tourist day in their study of proposed recreation areas.

None of the dollar values cited include expenditures for recreation equipment such as boats, fishing gear, camping items, trailer houses, etc.

Minerals

Mining activity in the basin is associated almost entirely with stone, sand and gravel, and related building materials. In addition, small quantities of mercury are mined and exploratory work has recently been completed on uranium deposits. The approximate location of active mining operations and known mineral deposits is shown in Plate 6.

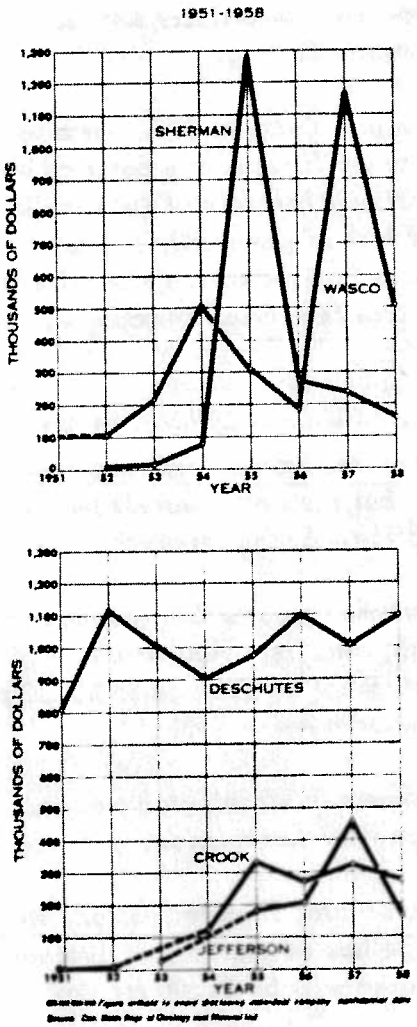


FIGURE 6. Trend in dollar value of mineral production, by counties.

In 1959 there were 14 active mineral industry establishments in the basin including mercury, pumice, tuff, diatomite, bentonite, cinders, and stone operations. In addition there are many sand and gravel operations scattered throughout the basin. Other known mineral deposits of economic significance which are not being mined at present include gold, gypsum, obsidian, perlite, semi-precious gems, and uranium.

The annual value of the total mineral production of Crook, Deschutes, Jefferson, Sherman, and Wasco Counties averages about $2,500,000 for the years 1954-1958. Mineral production from 1951 to 1958 for Crook, Deschutes, and Jefferson Counties, which contain nearly all of the active operations in the basin, is shown in Figure 6. Crook, Deschutes, and Jefferson Counties show a normal up-and-down pattern of production with the overall trend in recent years being slightly upwards. This is also true of Sherman and Wasco Counties with the exception of tremendous production increases in Sherman County in 1955 and in Wasco County in 1957. These peaks in production were both due to increased demands on sand and gravel operations from heavy construction taking place in those areas. In fact, the majority of production shown for these counties is from sand and gravel operations. These operations have about doubled in output in the past 10 years.

Transportation Media

The existing system of state and federal highways makes most areas of the basin readily accessible. Federal highways completely cross the basin in both north-south and east-west directions connecting all of the major towns.

State highways link the important population centers with each other and with the federal system. In addition, many improved and unimproved roads give access to other remote areas.

Regular bus and freight service both are available on five federal and one state highways while irregular freight service can be secured to nearly all points in the basin.

Railroad lines also cross the basin in a north-south direction through Maupin, Madras, Redmond, and Bend providing links with market areas outside the basin such as Portland, Eugene, and Klamath Falls. Prineville and Redmond are connected by a city-owned spur line.

Commercial airline service is available at Roberts Field near Redmond with connections at Portland, Klamath Falls, and Eugene. In addition, there are a number of fields and landing strips in the basin equipped to handle light planes. Charter flight service is available from the airport at Bend.

CHAPTER II WATER SUPPLY, USE, AND CONTROL

GENERAL

That nearly all types of human endeavor are either directly or indirectly dependent upon water is an amply illustrated fact in the Deschutes River Basin. The most evident item is water need for human consumption which, while extremely important, involves a very small quantity in comparison with many other needs and uses. For example, the dependency of agriculture upon irrigation water in the arid regions of the basin represents a very large annual consumptive use of water. Nonconsumptive requirements, such as water to maintain and enhance fish life, also involves large quantities of water at many locations. An important distinction between nonconsumptive and consumptive use is that most water diverted in the former case becomes available for other purposes at downstream locations but only part of that diverted in the latter case is later available for other uses.

SURFACE WATER SUPPLY

Yield

A great difference in yields can be observed between streams that originate in the Cascades and western parts of the basin and those originating in the Ochoco Mountains and eastern plateaus.

For example, the annual yield of Ochoco Creek below Ochoco Reservoir (drainage area about 300 square miles) varied between 1,340 and 68,480 acre-feet and averaged 18,570 acre-feet (62 acre-feet per square mile) for the years 1920 to 1958.

By contrast, the annual yield of Squaw Creek above Sisters (drainage area about 55 square miles) has varied between 48,330 and 118,860 acre-feet and averaged 77,140 acre-feet (1,400 acre-feet per square mile) for the years 1907 to 1958.

This pattern of high yields per square mile for Cascade streams is largely due to relatively high precipitation as compared to eastern streams.

Annual yields for the Deschutes River near its confluence with the Columbia are shown in Figure 7. These vary between 3,030,000 and 5,700,000 acre-feet and average 4,213,000 acre-feet for the years 1907 to 1958. This represents the water leaving the stream system after consumptive use has taken place.

The pattern of yields shown in Figure 7 is characteristic of nearly all streams in the basin. Dry years, such as the early 1930's and 40's, are evident as well as the relatively good water years of the past decade.

Distribution

Most of the Deschutes stream system is characterized by low flows in the late summer, fall, and winter and high flows in the spring and early summer under natural conditions.

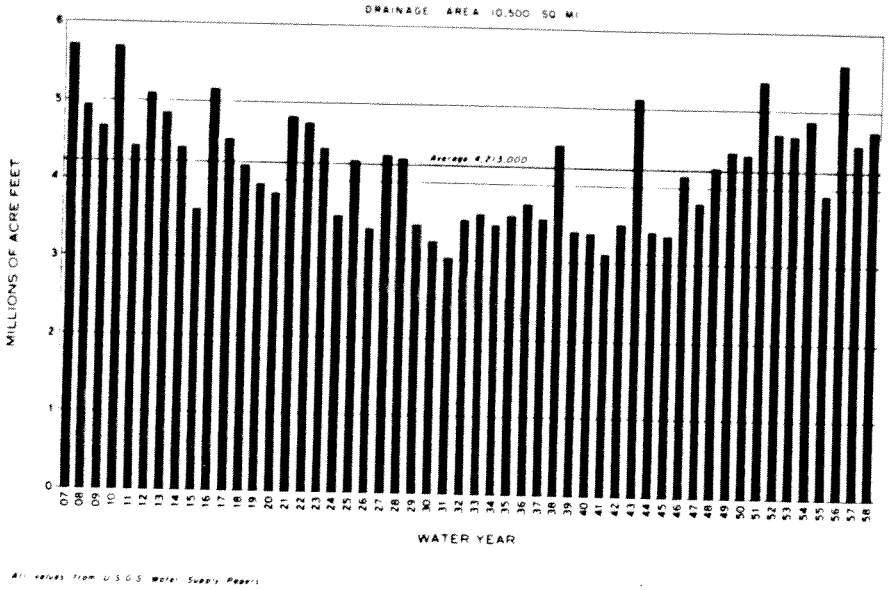


FIGURE 7. Annual yield of the Deschutes River near its mouth, 1907-1958.

This is illustrated by average monthly flows of the Little Deschutes River near Lapine, Figure 8, which closely approximate unregulated flows. Here peak flows occur in May from spring runoff with the lowest flows being in September and October. Of major significance is that summer periods of low flow coincide with periods of low precipitation which is also the time of maximum demand for water. Therefore, even with annual yields adequate to satisfy needs, the pattern of runoff distribution at many locations is such that seasonal requirements cannot be met from utilization of natural flow alone. Satisfaction of needs when and where they occur is dependent in part upon regulation of streamflow through controlled storage. If yields are inadequate, even this is not a complete solution in all cases.

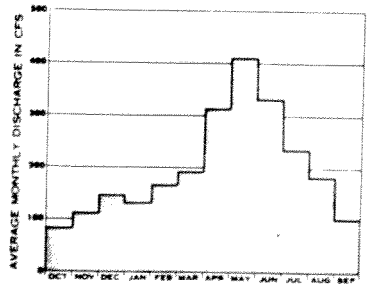


FIGURE 8. Average monthly discharges of the Little Deschutes River near Lapine, 1925-1958.

Fluctuation between low and high flows and the time of occurrence of such flows varies considerably among the different tributaries. Peak flows in the Crooked River and its tributaries occur in March and April while glacial-fed streams originating in the Cascades usually reach

their peaks in May and June. Base flows in streams originating in the Cascades are relatively stable due to the regulatory effect of ground water storage. Streams in the arid Crooked River watershed are characterized by considerably lower flows in the summer and comparatively high flood periods during the spring runoff.

The most even flows are in the Metolius River where average monthly discharges near Grandview (drainage area 324 square miles) vary between 1,330 cubic feet per second (cfs) in October and 1,620 cfs in June. This is in contrast to the widely varying flows of the Crooked River above Hoffman Dam near Prineville (drainage area 2,760 square miles) where average monthly discharges vary between 8 cfs in August and 1,200 cfs in April. Part of the difference between low and high flows in the Crooked River is the result of extensive irrigation diversions in the summer.

Extremes

Differences between discharge patterns of streams originating in the Cascades and those in the eastern portion of the basin are demonstrated more drastically by comparing extreme flows. Minimum discharges and yields at selected stations in the basin are listed in Table 8.

The minimum recorded flow of the Metolius River near Grandview was 1,080 cfs compared to a maximum of 5,780 cfs while the minimum of the Crooked River above Hoffman Dam was zero a number of times compared to a maximum of 8,410 cfs. Thus the more uniform flows of Cascade streams are also illustrated by the smaller differences between extreme flows.

Recorded discharges of the Deschutes River at its confluence with the Columbia River, which is the composite flow of the entire stream system, have varied between 3,380 and 43,600 cfs. The mean discharge at this location is 5,590 cfs.

Depletions

The location of each of the approximately 1,350 water rights existing in the Deschutes stream system is shown on the basin stream map in Plate 7. Each water right number is located on the map at its approximate point of diversion. From this, areas with a concentration of rights can be noted but the quantity of water involved is not apparent. For the latter purpose, a 102-page water rights summary has been prepared listing each right and its location, priority date, purpose, quantity, and stream. A limited number of summaries is available at cost through the State Water Resources Board.

The compilation of water rights for the Deschutes River Basin does not include water

rights on the Warm Springs Indian Reservation. Water rights on the reservation are a part of the Indian Treaty of 1855. The Indians have use of all the water in the creeks

TABLE 8

MINIMUM DISCHARGE AND YIELD
AT SELECTED STREAM GAGING STATIONS

GAGING STATION	COMPLETE WATER YEARS OF RECORD	WATER YEAR OF MINIMUM DISCHARGE	MINIMUM DISCHARGE CFS	WATER YEAR OF MINIMUM YIELD	MINIMUM YIELD ACRE-FEET
Beaver Creek near Paulina	1943-58	1946	0	1944	17,970
Big Marsh Creek at Hoey Ranch	1913, 1929-30, 1932-58	1935	0	1941	22,600
Crescent Creek at Crescent Lake	1913-14, 1929-58	In several years	0	1931	5,900
Crooked River above Hoffman Dam	1910-14, 1942-58	1955	0.5	1944	100,700
Crooked River near Culver	1918-58	1945	920	1931	894,000
Crooked River near Post	1910, 1941-58	1909, 1953	4	1944	93,860
Deschutes River at Benham Falls	1907-13, 1925-58	1950	448	1931	667,000
Deschutes River at Cline Falls	1935-46	1931	0	1942	238,900
Deschutes River at Mecca	1912-26	1920	3,170	1926	3,010,000
Deschutes River at Moody	1898-99, 1907-58	1931	3,380	1931	3,030,000
Deschutes River at Pringle Falls	1916-17, 1923-52	1952	27	1931	392,000
Deschutes River below Bend	1915-58	1930	1	1945	218,000
Deschutes River below Crane Prairie Reservoir	1914-17, 1923-58	1941, 1943, 1948	2	1941	72,990
Deschutes River above Lava Island	1915-16, 1944-50	1948	414	1945	700,800
Deschutes River below Lava Island	1927-58	1950	416	1931	601,000
Deschutes River below Wickiup Reservoir	1939-58	1948	6	1942	397,100
Deschutes River near Culver	1952-58	1955	446	1955	629,200
Deschutes River near Madras	1924-58	1942	2,940	1931	2,600,000
Fall River near Lapine	1939-58	1942	68	1942	59,020
Lake Creek near Sisters	1916-58	1941	1	1941	19,800
Little Deschutes River near Lapine	1925-58	1931	8	1931	47,700
Metolius River near Grandview	1913, 1922-58	1932, 1943	1,080	1941	844,900
Ochoco Creek below Ochoco Reservoir	1920-37, 1939-56, 1958	In several years	0	1930	1,340
Odell Creek near Crescent	1934-58	1934	9	1941	33,820
Shitike Creek at Warm Springs	1912-16, 1924-28	1924	32	1926	51,400
Squaw Creek near Sisters	1907-18, 1920, 1923, 1926-58	1923	19	1941	48,330
Tumalo Creek near Bend	1914-21, 1924-58	1940	1	1939	39,230
Warm Springs River near Warm Springs	1913, 1915-19	1915	166	1915	219,000
White River below Tygh Valley	1918-58	1920, 1931	10	1941	130,000

Source: U. S. Geological Survey, State Engineer

but it is allocated on Indian lands by the riparian doctrine. Therefore, the State Water Resources Board does not have jurisdiction over the waters of the reservation.

Legal depletion rights by stream mile indicating the maximum rate of diversion which could legally occur above each point along the Deschutes River are shown in Figure 9.

This diagram does not illustrate the actual or seasonal pattern of water use in the basin.

Consumptive rights are shown separately on the plot for comparative purposes and the major blocks of rights on tributary streams are also indicated. More than one-third of the total rights are for water diverted from the Deschutes River in the vicinity of Bend. Nearly one-third are located along the Crooked River and the remainder are scattered throughout the rest of the stream system.

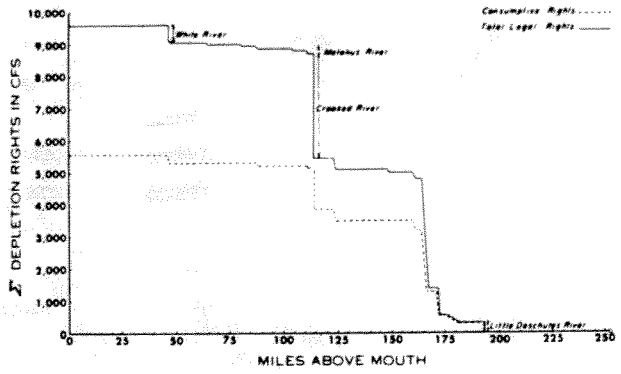


FIGURE 9. Legal depletion rights by stream miles of the Deschutes River as of January 1960.

Surface water rights in the Deschutes River Basin total 9,800 cfs of which 5,540 cfs are consumptive and 4,260 cfs nonconsumptive in nature. The largest group of water rights in the basin is formed by irrigation rights which total 5,452 cfs for the irrigation of 259,469 acres. Other consumptive water rights consist of 62 cfs for municipal, 16 cfs for domestic, and 10 cfs for industrial. The largest group of nonconsumptive water rights is formed by power rights which total 3,873 cfs. Other nonconsumptive water rights consist of 200 cfs for industrial, 135 cfs for fish, 51 cfs for mining, and 1 cfs for recreational use.

Assuming that all consumptive surface water rights are used to their maximum legal extent, approximately 1,600,000 acre-feet of water could be diverted each year from the streams of the Deschutes River system. Records exist only for the diversions of the major irrigation districts and municipalities. Smaller diversions for irrigation, industrial, domestic, and stock purposes can only be estimated. Some water rights are not being utilized and many others are not used every year. A number of rights cannot be fully exercised due to seasonal deficiencies in water supply, particularly in low flow years. These factors indicate that the actual annual diversion is much less than the maximum legal amount. The maximum rate of diversion may, in some instances, exceed the legal rate, particularly early in the irrigation season when there is an abundance of water.

Only a part of the water diverted for consumptive purposes is consumed, the remainder reappearing as return flow in the streams or as ground water. A USGS survey points out that, on a national average, only 60 percent of water diverted for irrigation is used consumptively by evapo-transpiration, the remaining 40 percent returning to the ground water and streams. This situation is even more pronounced in the Deschutes

Basin because diversion allowances are large in order to offset high transmission losses which exist in a number of major canals. The USGS survey further states that only two percent of water diverted for industrial purposes and eight percent of that for public use is consumed, again the remainder returning to the streams and ground water.

Using a consumptive requirement of two acre-feet per acre for the 180,000 acres irrigated in the Deschutes Basin in 1958, and a conservative 10 percent consumption for other diversions, the actual annual consumption of water in the basin is currently in the neighborhood of 400,000 acre-feet. Comparing this with actual diversions, which probably do not exceed 1,300,000 acre-feet annually, and the yield of the stream system, it is evident that approximately 30 percent of the total natural yield is diverted but less than 10 percent is consumed.

This leads to the conclusion that the Deschutes stream system yields sufficient water to satisfy existing and future demands. Taking the stream system as a whole, this is a true statement. In considering the basin area by area, it is evident that water shortages now exist and will continue to exist because of the aforementioned maldistribution. The most notable areas where the water supply is adequate are the Metolius River, the lower few miles of the Crooked River, and the Deschutes River below the Metolius. Specific areas of shortages and the nature and extent of such shortages are discussed in detail in Chapter III.

GROUND WATER SUPPLY

General

Detailed studies of the ground water resources of the basin have been conducted only in the vicinity of Madras and Prineville. Geological surveys have been conducted only in a few areas and topographic mapping is not complete. Both are prerequisites for ground water investigations. Conclusions on the occurrence of ground water therefore have to be drawn from the few well records available and from the geologic and engineering reports that contain incidental references to ground water. Adequate information to furnish a complete picture of the ground water resources of the basin can be obtained only by a long-term investigation which would include an expensive test drilling program.

The following discussion of the occurrence and movement of ground water in the basin is, of necessity, general in nature. Most of this discussion and the accompanying diagrams are based upon an unpublished report prepared for the board by Mr. Jack Sceva, geologist for the State Engineer.

Geology

A generalized geologic cross section taken along the Deschutes River is shown in Figure 10. Indicated here are the major formations and key locations along the river. This plot is in the form of a river profile in order to indicate approximate elevation relationships.

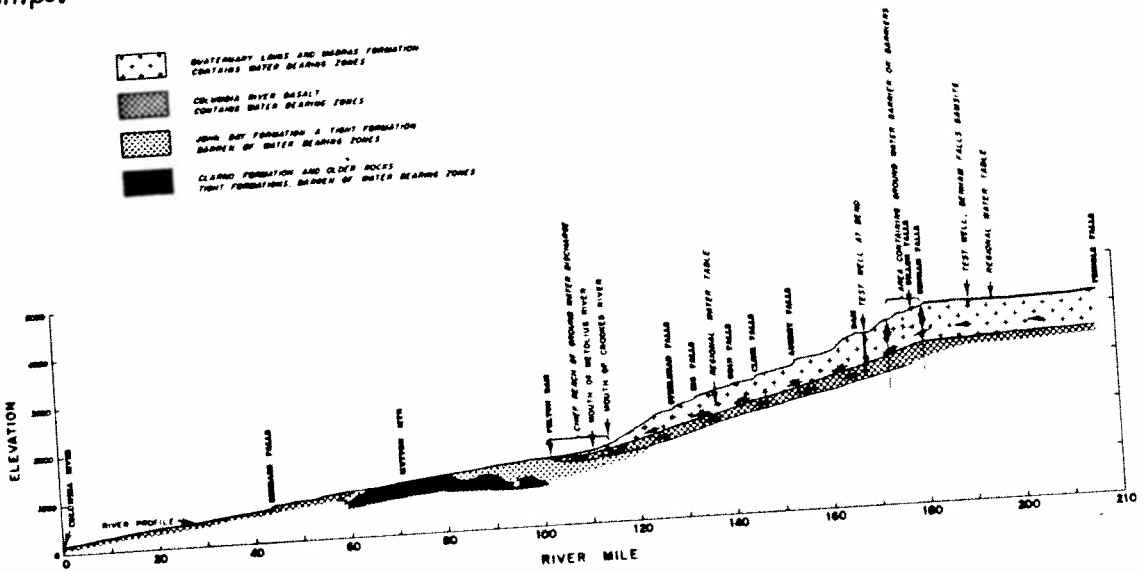


FIGURE 10. Generalized geologic cross section along the Deschutes River.

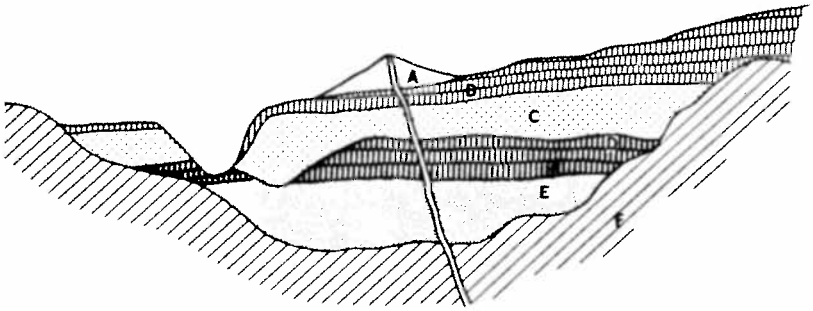
A diagrammatic section of the major formations in the basin is shown in Figure 11 along with a table listing the nature and water-bearing characteristics of those formations.

The geology of the Deschutes River Basin consists mainly of various layers of sedimentary formations and lava flows. Permeability of these formations varies greatly and largely depends on the grain size of the rock particles, the degree of sedimentation, and the degree of fracturing.

The older rock formations are relatively dense and impermeable and should not be considered as potential sources of large ground water supplies in the Deschutes River Basin. More recent formations and lavas contain permeable zones which are generally capable of yielding moderate to large supplies of ground water where they lie below the regional water table.

In some locations two and three separate water tables have been encountered because of sequences of permeable and impermeable rock formations. In some areas ground water is pumped from the valley alluvium along streams. Confined water is sometimes

found in both rock formations and recent alluvium. Artesian pressure occasionally is sufficient to raise the water above land surface.



Designation in Figure	Unit Name	Character	Water-bearing Characteristics
A	Quaternary pyroclastic deposits	Chiefly cinders associated with cinder cones.	Rocks of this unit are generally well drained and not sources of ground water. Where saturated they are capable of yielding large supplies of ground water.
B	Quaternary lavas	Chiefly basaltic lava flows associated with Newberry Crater, and volcanic eruptions in the Cascade Range.	Contains numerous porous lava flows. At most places are well drained and are unproductive. Where they are saturated, they are capable of yielding moderate to large supplies of ground water.
C	Madras formation	Chiefly stratified layers of sand, silt, ash, pumice with some gravel lenses. Contains some interbedded lava flows.	This formation is in large part fine grained and not a productive aquifer. At places it contains permeable lenses of gravel that are capable of yielding moderate supplies of ground water. Some of the interbedded volcanic rocks are permeable and are capable of yielding large supplies of ground water.
D	Columbia River basalt	Series of basaltic lava flows.	Contact zones between individual lava flows serve as aquifers. This formation is generally capable of yielding moderate to large supplies of ground water.
E	John Day formation	A sedimentary formation composed of silt, sand, and volcanic ash.	The fine grained character of this formation precludes it from being a productive source of ground water.
F	Clarno formation and older rocks undifferentiated	Chiefly consolidated sedimentary rocks, volcanic rocks and associated pyroclastics.	All of these rocks are believed to be of low permeability and not capable of furnishing more than meager supplies of ground water.

FIGURE 11. Diagrammatic section showing the major rock units of the Deschutes River Basin.

Yield and Distribution

Plate 8 was developed to graphically illustrate what is presently known concerning the occurrence and movement of ground water in the Deschutes Basin.

A large regional water table seems to exist in the area encompassing Hampton, Brothers, Millican, Bend, Redmond, and Madras. Ground water is available in moderate to large quantities in this area but the depth to the regional water table and the resulting high pumping lift are presently a deterrent to its development for many uses. Ground water has recently been found at shallower depths in the Hampton area and quite probably will be used extensively for irrigation.

WATER SUPPLY, USE, AND CONTROL

The southwestern and western parts of the Deschutes River Basin contain large amounts of ground water in subsurface storage. The uniform flow of the Deschutes River can be largely attributed to the equalizing effect of this ground water reservoir. Areas of ground water discharge in the form of springs occur along the lower reaches of the Crooked and Metolius Rivers and in the adjacent stretch of the Deschutes River, in the headwaters of the Metolius River, and above Benham Falls on the Deschutes River and its tributaries.

The Upper Crooked River Basin, which includes a large part of the Ochoco Mountains, contains some water-bearing formations but the occurrence and magnitude of the ground water resources of this area are largely unknown.

More information is available on ground water in the vicinity of Prineville but the actual extent of this supply is yet unknown. Water in this area is found in sand and gravel alluvium and is used extensively for domestic, municipal, and industrial purposes. Water in the older alluvium is confined and, when tapped, flows freely to the surface in some places.

Very little is known about ground water resources in the northern part of the basin. The only information available is from well logs but is inadequate to permit even general conclusions on the availability, movement, and quantity of ground water in this area.

Depletions

Ground water rights total 90 cfs, which constitute only a small fraction of the total water rights in the Deschutes Basin. All ground water rights are consumptive in nature. The largest group is for 53 cfs for the irrigation of 4,896 acres. Other consumptive ground water rights consist of 29 cfs for industrial and 7 cfs for municipal purposes. If all of these rights were used to their maximum legal extent, the annual depletion of ground water would be 41,400 acre-feet.

It can be seen, then, that ground water is presently used to a limited extent in the basin with the exception of areas like the Prineville Valley. However, shortages in surface water supplies might lead to more extensive ground water development in the future once this resource is better defined. Probably the most desirable place to initiate a ground water study program would be in the western and southwestern parts of the basin. Water from this area could be used to serve the central part of the basin, which is the area with the heaviest population concentration.

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

Statutory

ORS 449.545 prohibits the deposit in the Deschutes River, its tributaries, or artificial canals or ditches in which the waters of the Deschutes River run, any sewage effluents, wastes, or polluting water or any matter which will corrupt or impair the quality of the water of the river for domestic or municipal purposes.

ORS 538.110 prohibits the diversion of waters of Tumalo Creek above a point one-half mile above the intake of Columbia Southern Canal in Section 2, Township 18 South, Range 10 East, except for domestic, municipal and stock use.

ORS 538.440 rules that the City of Bend may take water from the direct flow of Tumalo Creek after it has acquired the rights to appropriate 11 cfs from the Deschutes River and delivers it to the Deschutes County Municipal Improvement District Feed Canal.

State Engineer

In 1913 the State Engineer withdrew and withheld from appropriation all unappropriated waters of the regular flow of the Deschutes River and its tributaries above Bend for irrigation, domestic, and power purposes (Application 2802). At the same time he withdrew 900,000 acre-feet for storage in the proposed Benham Falls Reservoir for the Deschutes River Project and for the same purposes (Application R-2803). Later in the same year he withdrew 187,000 acre-feet for storage of irrigation water in the then proposed Crane Prairie Reservoir (Application R-3261). In 1934 the State Engineer extended these withdrawals to any storage site or sites found feasible and practical by the investigations of the U. S. Bureau of Reclamation (Application R-15631).

In 1914 the State Engineer withdrew and withheld 50,000 acre-feet for storage of irrigation water in the then proposed Ochoco Creek Reservoir on Ochoco Creek (Application R-3587) and 300,000 acre-feet for storage of irrigation water in the then proposed Crooked River Reservoir on Crooked River (Application R-3589).

In 1915 the State Engineer withdrew and withheld from appropriation all unappropriated water of Threemile and Gate Creeks, tributaries of White River, for irrigation (Application 4073). Later in the same year he withdrew and withheld from appropriation all unappropriated water of White River and its tributaries for irrigation, power, and domestic purposes (Application 4624). At the same time he withdrew 12,000 acre-feet for storage in a proposed Clear Lake Reservoir for the same purposes (Application R-4625).

In 1921 the State Water Board adopted recommendations of the Board of Engineers as

set forth in a report to the Federal Power Commission on uses of Deschutes River. These were that rights to storage in the Upper Deschutes River be held withdrawn and be dedicated to irrigation. A continuous flow of 200 cfs past Bend shall be reserved from allotment to irrigation projects, however, to take care of fish ladders, domestic, municipal, power, and industrial requirements, and 18,000 acre-feet of water to be used during the nonirrigation season for domestic and other uses. The Deschutes Decree of 1928 confirmed the reservation of a continuous flow of 200 cfs past Bend out of the withdrawal of 1913 for domestic, municipal, and industrial use. This limitation does not apply to rights with priorities earlier than the 1913 withdrawal of the Deschutes River and its tributaries above Bend.

In 1955 the State Engineer ordered that the flow of the Deschutes River at the gaging station below Wickiup Dam shall never be less than 20 cfs and that the rates of opening and closing the outlet gate shall be such that they will prevent a rise or fall of the water surface in the river at this gaging station at a rate greater than one foot per hour.

State Water Resources Board

In its program of 1959 for the Lower Deschutes Basin, the Oregon State Water Resources Board reserved the unappropriated waters of the main stem of the Deschutes River from its confluence with the Columbia River to mile 100 for domestic, livestock, recreation, fish, and wildlife purposes. Also in that program, unappropriated waters of the main stem of the Deschutes River from mile 100 to mile 120, the main stem of the Metolius River from its confluence with the Deschutes to mile 13, and the main stem of the Crooked River from its confluence with the Deschutes to mile 6.5 are reserved for domestic, livestock, hydroelectric power, fish, wildlife, and recreation purposes. Water rights acquired in this section for hydroelectric purposes shall be subordinate to all present and future upstream beneficial uses of water except for hydroelectric power.

On January 4, 1961, the State Water Resources Board issued an order in the matter of the application of Portland General Electric Company for a license for Round Butte project on the Deschutes River. It includes the provision that water rights acquired for the project shall be subordinate to the use of water for all present and future upstream beneficial uses of water except for hydroelectric power. It orders the licensee to replace existing recreation facilities in agreement with the State Highway Commission and to provide fish facilities in agreement with the State Fish and Game Commissions. The reservoir pool shall not fluctuate more than one foot daily, weekly, monthly, or per season from June 15 to September 15 of each year. It shall not inundate or cause detrimental effects to Opal Springs. A minimum flow of 3,000 cfs for protection and utilization of fish spawning areas shall be maintained at river mile 100. Portland General Electric Company shall also reach agreements with the U. S. Bureau of Reclamation and Pacific Power and Light Company relating to the

settlement of rights and interests involved in the inundation of the Cove Hydroelectric Plant on the Crooked River.

Federal Power Commission

September 12, 1960 the Federal Power Commission issued a joint license for Pelton and Round Butte Projects on the Deschutes River. The license states that these two projects of Portland General Electric Company will be operated as a unit and that the project works of each development will constitute parts of a project best adapted to a comprehensive plan for improving and developing the Deschutes River for the improvement and utilization of water power development and other beneficial public uses, including recreational purposes.

Portland General Electric Company shall construct, maintain, and operate fish handling facilities and fish protective devices, including artificial propagation facilities, for the purposes of conserving the fishery resources affected by the project and shall comply with reasonable modifications recommended by the Federal Power Commission, the Secretary of the Interior, the Oregon State Game Commission, and the Fish Commission of Oregon.

Any rights to the use of waters in the Deschutes River and its tributaries in connection with the project, shall be subordinate to:

1. All existing rights, whether or not perfected, to the waters of the Deschutes River and its tributaries for domestic, stock, municipal, and irrigation purposes, including the rights to store any such waters in the proposed Benham Falls, Post, and Prineville Reservoirs and in the existing Crane Prairie, Crescent Lake, and Wickiup Reservoirs; and

2. The use of additional flows of the Deschutes River and its tributaries pursuant to rights which may be initiated hereafter for the diversion and storage of waters for domestic, municipal, stock, and irrigation purposes in connection with any reclamation projects undertaken pursuant to the Federal Reclamation Laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory thereof or supplementary thereto), the amounts of water to be used under the additional rights together with the uses under existing rights whatever they may be, not, by reason of the additional right, to exceed these quantities:

    a. Deschutes River and its tributaries above Cline Falls - entire flow;

b. Squaw Creek - all flows during the nonirrigation season;

c. Lake Creek - 20,000 acre-feet annually;

d. Crooked River and its tributaries - all the flows above the Highway Bridge at the place where U. S. Highway 97 crosses the Crooked River Canyon;

e. Crooked River below the Highway Bridge - not to exceed 2,500 acre-feet annually for the proposed Deschutes project domestic water system; and

f. An additional 400 second feet that may be taken above the licensee's project either from the Deschutes River below Cline Falls or the Crooked River below the Highway Bridge during the irrigation season.

During construction and the first two years of operation of the Round Butte development, a minimum streamflow in the amount of 3,500 cfs or the inflow to the Round Butte and Pelton Reservoirs, whichever is less, shall be maintained at river mile 100.0 during the months of March, April, May, and June for fish spawning habitat and passage. Such minimum streamflows shall be maintained thereafter during those months until such time as this condition is modified or eliminated by the Federal Power Commission upon consideration of the recommendations of the Secretary of the Interior, the State Water Resources Board, the Oregon State Game Commission, and the Fish Commission of Oregon.

In order to secure maximum recreational benefits the water surface of the Round Butte Reservoir shall be maintained at the highest level practicable from June 15 to September 15 of each year as is consistent with the primary purpose of the reservoir to provide pondage for the daily, weekly, monthly, or seasonal power requirements.

Portland General Electric Company shall prior to commencement of construction of the Round Butte development enter into agreements with Pacific Power and Light Company and the Bureau of Reclamation of the United States Department of the Interior relating to the settlement of rights and interests involved in the inundation of the Cove Hydroelectric Plant on the Crooked River and with the State Highway Commission of Oregon for the replacement of inundated facilities in Cove Palisades State Park with lakeside facilities, including suitable access roads, bridges, etc. The licensee shall also cooperate with the University of Oregon, Department of Anthropology, in arranging for an archeological survey and in the salvage of archeological and paleontological values prior to flooding of the Round Butte Reservoir area.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Domestic supplies in the basin are obtained from ground water, natural streams and springs, and irrigation canals. Surface water rights total only 16 cfs which represents a maximum annual consumption of 11,400 acre-feet. These rights, scattered throughout the basin, are intended for stock, camps, park, and household uses. Many rights for household and stock use from irrigation ditches are classified under irrigation rather than domestic and therefore do not appear as part of this total.

Shortages often occur in many parts of the basin because of the large number of streams that are dry in the summer months in combination with many wells having a rate of recharge less than the rate of use. In some parts of the basin surface waters are not available and ground water lies only at great depths.

Ground water in the Deschutes Basin is generally of good quality and can be used for domestic supplies without treatment. Domestic and stock water from natural streams and springs is also of good quality and is used without special treatment. Many farms which use their water directly as obtained from irrigation canals probably should subject such supplies to one or more of the many effective treatment methods available.

Municipal

Sources of municipal water supply are the same as those for domestic purposes; streams, springs, ground water, and irrigation canals. Surface water rights for municipal use total 62 cfs which if used to the maximum extent possible would consume 27,700 acre-feet each year. Some municipal rights are transferred irrigation rights and are subject to the applicable seasonal restrictions of the original rights. As with domestic rights, municipal use from irrigation canals is sometimes classified under irrigation and not included in the total cited above.

Ground water rights for municipal purposes total seven cfs which represents a maximum annual depletion of about 5,070 acre-feet.

The quantity of water available for municipal purposes is adequate for both present and immediate future needs. However, some communities may have shortages in the future because either the present distribution system or the available supply is too small to meet long-range demands, particularly if any large industrial developments take place. A few communities dependent upon ground water supplies receive supplemental water from irrigation canals during periods of high use.

Well water quality is such that it can be used without treatment or, at most, requires only chlorination. Most surface water supplies also require only chlorination. Municipal water obtained from irrigation canals usually has to be treated by chlorination, chemical flocculation, sedimentation, and filtration to remove or reduce bacteria, algae, turbidity, and color. In nearly every instance, treatment practices presently being used produces water of acceptable quality.

Irrigation

Surface water rights for irrigation represent the largest consumptive group in the basin, totaling 5,452 cfs for the irrigation of 259,469 acres. In addition, ground water rights total 53 cfs for the irrigation of 4,896 acres. If all these rights were used to their maximum legal limit, approximately 1,500,000 acre-feet of irrigation water would be diverted each year. However, only about 180,000 acres were irrigated in the basin in 1959, which is less than 70 percent of the lands holding rights for this purpose. Also, few lands in the basin receive an adequate supply of irrigation water. Therefore, water consumed by irrigation use is probably considerably less than that indicated by the total water rights for that purpose. Also, in many areas of the basin an appreciable portion of the water diverted for irrigation reappears in the streams as return flow. This, of course, varies considerably from area to area.

Irrigation development shown in Plate 3 includes Bureau of Reclamation projects, both existing and proposed, irrigation districts, storage and diversion dams, and major irrigation canals and ditches. The highest level of irrigation development exists in the valleys and on the plateaus in the vicinity of Bend, Sisters, Madras, and Prineville. Most of these lands are included in the Deschutes and Crooked River Projects of the Bureau of Reclamation. Several thousand acres of new land will be brought under irrigation after completion of Prineville Reservoir. Other Bureau project areas are located on the Upper Crooked River and White River watersheds.

Average rainfall in most agricultural areas during the summer months ranges from one to five inches. Irrigation agriculture, therefore, is largely dependent upon storage projects for water. Low precipitation during the period when irrigation water is most urgently needed, combined with low streamflow, many streams being dry at that time, results in most agricultural lands having shortages of irrigation water during low flow years. This situation will be improved somewhat upon completion of the Prineville Reservoir which will supply supplemental water to 10,220 acres of land and will bring 9,990 acres of new land under irrigation production. Also, a portion of the reservoir space is as yet unallocated and might possibly serve to irrigate additional acreage.

Water shortages on Deschutes project lands could be substantially reduced by sealing leaks in storage reservoirs and by elimination of the existing transmission losses in

canals and ditches for which investigations are needed to determine the physical and economic practicability of such measures. Allowances for transmission losses for Deschutes project canals and ditches, between the point of diversion and the farmer's ditch, vary between 35 and 65 percent.

The average annual diversion from Deschutes River and Tumalo Creek for the Deschutes Project was 847,000 acre-feet during 1950-1959. Estimates made by the State Water Resources Board indicate that only 184,000 acre-feet or 22 percent of the total diversion were consumptively used (evapo-transpiration) on the farm lands. The remainder of 663,000 acre-feet or 78 percent of the diversion were wastes and losses. These losses include 94,000 acre-feet of main canal and lateral waste, 279,000 acre-feet of main canal and lateral losses and 290,000 acre-feet of farm wastes and losses. The greatest portion of these losses is seepage in the distribution system and deep percolation on the farm lands. Small amounts of water could be saved by increasing distribution - operational efficiency and by increasing irrigation efficiency on the farms. The greatest amount of water could be saved by reducing seepage losses in the canals themselves.

Water quality data have been collected by the Bureau of Reclamation for all major irrigation projects in the basin. These data indicate that the quality of water in the Deschutes stream system is excellent for irrigation purposes. This is illustrated by the following excerpts taken from various Bureau reports.

"Water from the Deschutes River and tributaries has been used for irrigation for more than 50 years without apparent deleterious effect on soils or crop production. Glacier and volcanic materials covering the watersheds do not contain soluble salts to any material degree. Chemical analyses of water samples taken at Wickiup Dam outlet show the water to be of excellent quality for irrigation."

"Water of the Crooked River has been used for irrigation for over 70 years without observable ill effects."

"Water from Clear Creek on the Wapinitia Project has been used for irrigation for more than 35 years without deleterious effect on crop production. Glacial and volcanic materials covering the watersheds do not contain soluble salts to any material degree."

Other water quality data from USGS publications and State Water Resources Board's files for the Deschutes River at Bend and Moody, Crooked River near Prineville, and White River at Tygh Valley for the years 1911 and 1912 and 1951 through 1956 also indicate the water quality at those locations to be very constant and well within the standards for irrigation water.

Power

Power rights total 3,873 cfs which is 40 percent of the total water rights in the Deschutes River Basin. Seventy-seven percent of all power rights are for plants at Bend, Cline Falls, Cove, and Tygh Valley. Most of the remainder are for only a few cfs and are used to a large extent for pumping irrigation water rather than for the generation of electric power.

Installed capacity of the major power plants in the Deschutes River Basin is 126,860 KW of which 120,000 KW is at the Pelton Project of Portland General Electric Company. This project has not been licensed by the State of Oregon and consequently does not have a water right.

Major hydroelectric developments in the basin are listed in Table 9. The location of the existing developments listed in this table and all major potential dam and reservoir sites which have been studied, proposed, recommended, or suggested for power and other purposes is shown in Plate 9.

TABLE 9

EXISTING MAJOR HYDROELECTRIC DEVELOPMENTS

NAME	OWNER	STREAM	INSTALLED CAPACITY Kilowatts	AVERAGE ANNUAL GENERATION 1000 kilowatt-hours
Tygh Valley	Pacific Power & Light Co.	White River	2,250	13,000
Cline Falls	Pacific Power & Light Co.	Deschutes River	750	4,600
Bend	Pacific Power & Light Co.	Deschutes River	1,110	5,600
Cove		Crooked River		
Nos. 1 & 2	Pacific Power & Light Co.		1,250	11,000
No. 3	Bureau of Reclamation		1,500	11,000
Pelton	Portland General Electric Co.	Deschutes River	120,000	396,000
		TOTALS	126,860	441,200

Source: Oregon State Engineer

Water quality does not present any problems to existing power installations in the basin.

Industrial

Industrial rights total 210 cfs from surface water and 29 cfs from ground water supplies. They are scattered throughout the basin and are used by various industries, mainly lumber and food processing plants, sand and gravel operations, and railroads. Many industrial plants receive water from municipal supply systems and do not hold individual water rights. If all industrial rights were used to their maximum legal extent, 7,000 acre-feet could be diverted for consumptive purposes from surface waters and 21,000

acre-feet could be pumped from ground water each year.

Water supply for industries seems to be adequate at present, but additional sources will have to be found if new major water-using industries should locate in the basin. Most water supplies in the basin are of good quality for present industrial purposes.

Mining

Mining does not play a large part in the economy of the basin except for the production of sand and gravel and related building materials, and these usually obtain industrial water rights. There are only three water rights for a total of 51 cfs from surface water for mining purposes in the Deschutes Basin; one for a mercury mine and two for the processing of volcanic glass. These operations are intermittent in nature and seem to receive an adequate supply of water. New operations might face problems depending on the locality of the development and the amount of water needed. Water quality does not present a problem to the mining industry in the basin at the present.

Recreation

Water rights for recreation were issued in the past only for swimming pools and related purposes at resorts. They total only one cfs in the entire Deschutes Basin. Water for drinking, cooking, and other purposes in camps and parks was not normally classified as recreational usage and obtained domestic rights or no water rights at all.

Restrictions on the use of water are sometimes given in connection with the issuance of other water rights. Minimum flows have to be maintained in the Deschutes River below Wickiup Dam and below Bend at all times of the year to preserve aquatic life and scenic attractions of the stream, among other purposes.

Most of the recreational areas in the basin are located on streams, lakes, and reservoirs and their value and attractiveness depend directly on water. There are more than 430 lakes and reservoirs in the basin with a total surface area of approximately 69 square miles. Eleven lakes and reservoirs have a surface area of more than one square mile, the largest being Wickiup Reservoir with a surface area of 14 square miles or 9,000 acres. A summary of the approximate surface areas of lakes and reservoirs of more than one acre in size has been prepared by sub-basins and is available at the office of the State Water Resources Board.

A factor limiting recreation in the Deschutes Basin is the highly fluctuating water levels in reservoirs and rivers which are caused by storage of winter flows and high summer

releases for irrigation. There are no known water quality conditions harmful to the present recreational use in the basin.

Wildlife

Past practices have not included reservation of water specifically for wildlife use.

The Deschutes Basin has excellent populations of mule deer and limited numbers of blacktail deer, Rocky Mountain elk, and antelope. Deschutes and Crook Counties are among the more popular hunting areas of the state. Approximately 227,200 man days are spent afield by big game hunters each hunting season, mainly for deer. The average annual kill of deer is approximately 12,000 animals. Mule deer have shown a steady increase in population due to larger areas of improved habitat created by logging operations with some increases noted adjacent to irrigated lands, and due to a great reduction of predators. The population of mule and blacktail deer in the Deschutes National Forest was estimated at 1,200 in 1924 and 62,000 in 1960.

Excellent populations of valley quail and chukar partridges and limited numbers of pheasant, grouse, sage grouse, doves, and Hungarian partridges are found in the basin. An average of 120,000 hunter days afield are spent each year in search of small game. A remarkable increase in the population of game birds has taken place on irrigated lands in the basin, particularly on those of the North Unit Irrigation District.

Waterfowl use in the basin is not as extensive as other game species. Some local nesting takes place along the streams and lakes, especially in the lower reaches of the Little Deschutes River. Waterfowl hunting is more limited than in many other areas of the state. An annual average of about 20,400 hunter days is spent in pursuit of waterfowl.

Furbearers in the basin include beaver, muskrat, mink, marten, and otter. Beaver and muskrat are the most important species in the trapping industry with both being dependent on aquatic habitat.

Table 10 shows the 1957 kill of game and fur animals by species in Crook, Deschutes, Jefferson, Sherman, and Wasco Counties.

Highly fluctuating reservoir levels and river flows inflict some damage to waterfowl nesting along rivers and reservoirs and to muskrat dens. Waters available for wildlife in the Deschutes Basin are generally of good quality and no problems are evident in this respect.

Fish Life

The Deschutes Basin is one of the most popular recreational areas of the state, and fishing is one of its major attractions. It supports approximately 600,000 angler days

TABLE 10

GAME AND FUR ANIMAL KILL
1957

SPECIES	COUNTY Crook	Deschutes	Jefferson	Sherman	Wasco	TOTAL	NOTES
Deer	2,893 6,862	8,187 18,090	1,369 2,964	565 1,008	2,389 5,099	15,403 34,023	1,8
Elk	20 339				2 66	22 405	1,8
Antelope						120 192	1,2,8
Quail and partridge	23 7		32 35	23 65	23 60	101 167	1,3
Pheasant						25 37	1,4
Dove	165 23	513 73	603 95		98 19	1,379 210	1,5,8
Beaver	203	94	49	25	112	483	6
Marten		5				5	6
Mink	16	102	23		77	218	6
Muskrat	182	1,053	3		65	1,303	6
Otter		3	1		2	6	6
Weasel					1	1	6
Wildcat	1	88	1			90	6
Badger	61	42	9	17	29	158	7
Coyote	266	170	81	7	111	635	7
Porcupine	64	68	54	111	122	419	7
Racoon	5	4	3	33	60	105	7
Skunk		1		6	17	24	7
No. trappers' reports	9	18	8	1	11	47	6

Note: 1) Top line = number of kill
Bottom line = number of hunters
2) Deschutes - Lake area
3) Opening weekend
4) First two days of season
5) Hunters checked
6) Number reported during 1957-58 season
7) Number reported from May 1, 1957 through April 5, 1958
8) 1957 total

Source: Oregon State Game Commission

of recreation annually. Approximately 754 miles of streams, 44,000 acres of lakes and reservoirs, and 350 acres of farm ponds are considered suitable for game fish habitat.

Water rights for fish life have been appropriated in the past only for the propagation of fish in hatcheries. They total 135 cfs in the Deschutes Basin and are issued to the Oregon State Game Commission and the Fish Commission of Oregon. Fish hatcheries are operated at present by the Fish Commission on the Metolius River and by the Game Commission on Fall River, Metolius River, and Oak Springs on the Lower Deschutes. Maintenance of minimum flows for the preservation of fish life are required

on the Deschutes River between Wickiup Dam and the mouth of Crooked River at the rate of 20 cfs below Wickiup and 50 cfs below Bend. Installation of fish ladders at dams and fish screens at diversions are required for projects before they are approved.

A considerable number of species of fish are found in the Deschutes River Basin. Adult steelhead trout and spring chinook salmon using the basin total 15,000 to 20,000 fish annually. Spring chinook salmon normally enter the river in April and May and the peak of their spawning activity occurs in September. Steelhead enter the river in numbers in May to September, but some entry is made every month of the year, and their principal spawning period is the following March and April. Downstream movement of seaward migrants is heaviest from April through July.

Areas in the basin in which chinook salmon have been observed spawning are indicated as present spawning areas on Plate 10. The narrow bands are for areas considered fair by the Oregon Game Commission while the wide bands cover areas considered good. Present spawning areas for chinook salmon include all of the lower Deschutes below Pelton Dam and an additional 20 miles above the reservoir. There are short stretches included which are not suitable for spawning but cannot be distinguished due to the small scale of the plot. Other important spawning waters exist in the Metolius and Warm Springs Rivers and in Mill and Squaw Creeks. The best spawning areas are found in the Upper Metolius River, the middle reaches of Mill Creek, and the lower miles of Squaw Creek.

Plate 10 also shows potential spawning areas, which are discussed later.

Similar information relative to steelhead trout is shown in Plate 11. Steelhead utilize the same stretches of the Deschutes and Warm Springs Rivers and Mill Creek for spawning as do chinook. In addition, Trout Creek and its headwater tributaries and Bakeoven, Buck Hollow, Squaw, and Beaver Creeks are important steelhead spawning areas. Some spawning activity also takes place in Nena Creek and in McKay and Ochoco Creeks in the Crooked River drainage.

Rainbow, eastern brook, brown, golden, lake and Dolly Varden trout are well distributed in the lakes and streams of the basin. Trout spawning areas are shown on Plate 12. High elevation streams and lakes as well as the Deschutes and most of the major tributaries are important to the trout population.

Warm water game fish such as bass, bluegill, crappie, and pumpkinseed as well as coarse fish including squawfish, suckers, chiselmouth, roach, and goldfish are found in some waters of the basin.

Resident fish spawn at various times of the year depending on the variety. Several species make limited intra-stream migrations to their spawning areas.

Whitefish frequent the entire length of the Deschutes and Metolius Rivers and portions of Crooked, Warm Springs, and Little Deschutes Rivers. Whitefish are also found in a number of high elevation lakes and reservoirs and their tributaries. These same high level lakes and reservoirs support a small population of kokanee.

Blueback salmon have recently been introduced on an experimental basis to a few small areas in the vicinity of Suttle Lake.

From the foregoing, it is evident that the Deschutes stream system is an important producer of both resident and anadromous fish. This production is largely dependent upon adequate streamflow in respect to both quantity and quality. The Oregon Game Commission has recommended flows both to maintain fish production and to permit ideal fish production. These recommendations are shown by sub-basins in Table 11.

The recommended desirable minimum flows are based in part upon a survey conducted by the Game Commission during 1959-60. Thirty-two measurement stations were established for the survey and data collected at the stations included streamflow, velocity and depth, air and water temperature, food producing area, and spawning area exposed. The stations were located to cover all of the basin except the Lower Deschutes River. Currently, the Game Commission is in the process of establishing a study program for the lower river which will relate various levels of streamflow to spawning, habitat, rearing, and passage with resultant effects on water quality and maintenance and enhancement of the fishery resources.

Desirable minimum flows cited in Table 11 are based on what has been natural flow during the low flow period in normal water years. For this purpose the Game Commission has averaged the recorded flows for the 10-year period 1948-1957 since these are the flows that have created the natural fish production levels that currently exist. However, this period was relatively wet, as was shown in Figure 7. If a dry cycle such as the early 1930's and 40's were to re-occur, available flows would become far less than desirable at most locations and fish production would be reduced because of natural conditions alone.

Table 11 also lists desirable minimum flows to permit ideal fish production again considering available natural flows, using the period 1948-1957 as a base, if no conflicting uses of water exist. This potential for enhancement of the fishery resource will be discussed later.

To illustrate the significance of Table 11, the desirable flow recommended for the Deschutes River below Wickiup Reservoir during the winter low flow period is 200 cfs. The water right for storage in Wickiup Reservoir issued by the State Engineer requires a conservation release of only 20 cfs. Studies conducted by the U. S. Bureau of Reclamation indicate that increasing the conservation flow from 20 to 200 cfs would increase

the average annual irrigation shortages at Bend for the Deschutes Project by 19,600 acre-feet and the maximum shortage occurring during 1931 by 29,900 acre-feet.

TABLE 11

DESIRABLE MINIMUM FLOWS FOR FISH LIFE
RECOMMENDED BY OREGON GAME COMMISSION

STREAM	DESIRABLE MINIMUM FLOW, cfs to Maintain Fish Production (1)	DESIRABLE MINIMUM FLOW, cfs for Ideal Fish Production (2)
UPPER DESCHUTES SUB-BASIN		
Deschutes River		
below Crane Prairie Dam	80	200
below Wickiup Dam	200	500
below Fall River	375	750
below L. Deschutes River	450	825
at Benham Falls	660	1,030
Big Marsh Creek	17	30
Crescent Creek		
below dam	30	55
at mouth	40	75
Cultus Creek	5	5
Little Deschutes River		
at Highway 58	38	38
at Crescent	34	40
near Lapine	76	150
at mouth	76	150
MIDDLE DESCHUTES SUB-BASIN		
Deschutes River		
below Bend	Nov.-Mar. 300 200	1,000
at Cline Falls	Nov.-Mar. 300 200	1,000
at Lower Bridge	Nov.-Mar. 300 200	1,000
Squaw Creek		
at Highway 20 Bridge	15	50
at Camp Polk	25	70
at Shumway Corrals	25	70
Tumalo Creek		
at Shevlin Bridge	12	70
at mouth	10	70
Indian Ford Creek		
at Highway 20	2	10
at mouth	4	15
Lake Creek		
at Suttle Lake	20	60
at Camp Sherman Road	20	60
at mouth	20	60
LOWER DESCHUTES SUB-BASIN		
Trout Creek		
at Ashwood	10	35
at Highway 97	10	35
at mouth	10	35
Foley Creek	5	10
White River		
at Emigrant Crossing	75	(3)
at Highway 197 Bridge	150	(3)
at mouth	150	(3)
Tygh Creek	6	(3)
Badger Creek	10	(3)
Little Badger Creek	5	(3)
Buck Hollow Creek	5	15
Bakeoven Creek	5	15
UPPER CROOKED SUB-BASIN		
Crooked River		
below North Fork	30	50
below Prineville Dam	May-Feb. 50 Mar.-Apr. 100	100 150
North Fork Crooked River		
above Deep Creek	1	20
below Deep Creek	8	30
at mouth	10	15
Deep Creek	7	10
Beaver Creek	10	20
South Fork Crooked River	10	15
LOWER CROOKED SUB-BASIN		
Crooked River near Prineville	May-Feb. 50 Mar.-Apr. 100	100 150
Ochoco Creek below dam	10	20
Mill Creek	5	10
McKay Creek	5	10
Marks Creek	5	10

(1) Flows needed to maintain fish production considering available natural flows in normal water years.
(2) Flows needed for the best fish production assuming normal available water with no conflicting uses.
(3) Presently unknown.

Source: Oregon State Game Commission

The desirable minimum flow recommended for the Deschutes River below Bend during the summer low-flow period is 200 cfs. Present control over flows at this point is in the form of a provision established by the State Engineer for a minimum flow of 50 cfs.

Maintaining a conservation flow of 50 cfs reduces the amount available for irrigation diversions near Bend by 21,200 acre-feet compared to a reduction of 84,900 acre-feet under a conservation flow of 200 cfs.

Summer flows in this stretch of the river at times drop below this conservation level. This means that under current practices the desirable minimum flow to maintain fish production cannot be met. To establish such desirable flows without additional stream regulation would infringe upon existing rights to the use of water. This situation is repeated at many other locations in the basin.

High flows also create problems by washing eggs out of the gravel and by depositing silt on rearing areas thereby smothering eggs and food organisms. Siltation problems are also created at times by unused water from irrigation ditches returning to the river.

Water temperature extremes can also create problems. High temperatures over a sustained period act detrimentally by reducing the oxygen content of the water, by causing poor egg development, and by providing an environment favorable to warm water disease. Low temperatures reduce the activity and hence the growth of fish and also cause poor egg development and permit the existence of cold water disease.

The most favorable water temperature for salmonids is in the range of 55 to 60° F. If stream temperatures could be maintained in this range the year around the result would be maximum development and production of fish consistent with streamflow. Since this is not practical, the desirable range of water temperature for salmonids is from 45 to 65° F. While fish can live in temperatures outside of this range, if such extreme temperatures were sustained over a long period of time the stream would no longer be able to support a good salmonoid population. Also, near the limits of this desirable range of water temperature, egg development is slow and there is less resistance to disease.

Temperatures in major streams generally lie within the desirable range as shown by Figure 12 which is a plot of 1953 water temperatures of the Deschutes River near both Culver and Madras. The Culver location is above the confluences of the Metolius and Crooked Rivers so the water temperature is not influenced by those streams. Here the water temperature sometimes exceeds 65° F., usually in July and August, and minimums go below 40° F., usually in December, January, and February.

Water temperature near Madras is influenced by the colder water of the Metolius and the warmer water of the Crooked River. The net effect is for Deschutes River temperatures to stay below 60° F. during the summer, when the Metolius River contribution is greatest, and above 40° F. in the winter, when the Crooked River contribution is greatest. Therefore the influence of these two major tributaries is such that water temperature conditions are improved in the Deschutes River below their confluences.

Water temperatures for the same year, 1953, for the Metolius near Grandview and Crooked River near Culver, which would be the temperature of these waters when they

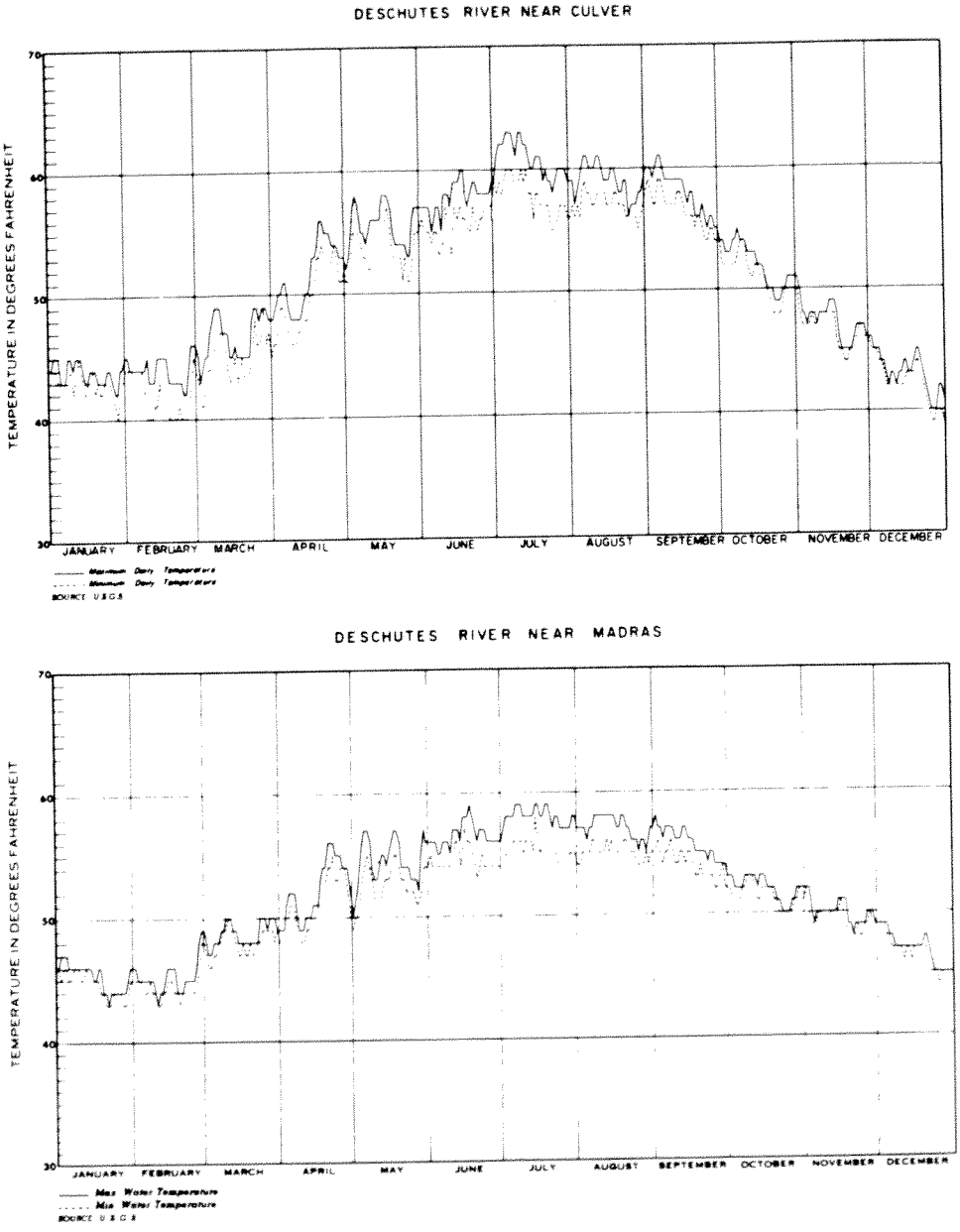


FIGURE 12. Seasonal pattern of water temperature of the Deschutes River near Culver and Madras, 1953.

enter the Deschutes, are shown for comparative purposes in Figure 13. During that year Metolius River temperatures ranged from about 39 to 52° F. while Crooked River temperatures ranged from 44 to 63° F.

Pollution Abatement

A state law prohibits the discharge of wastes into any stream in the Deschutes Basin

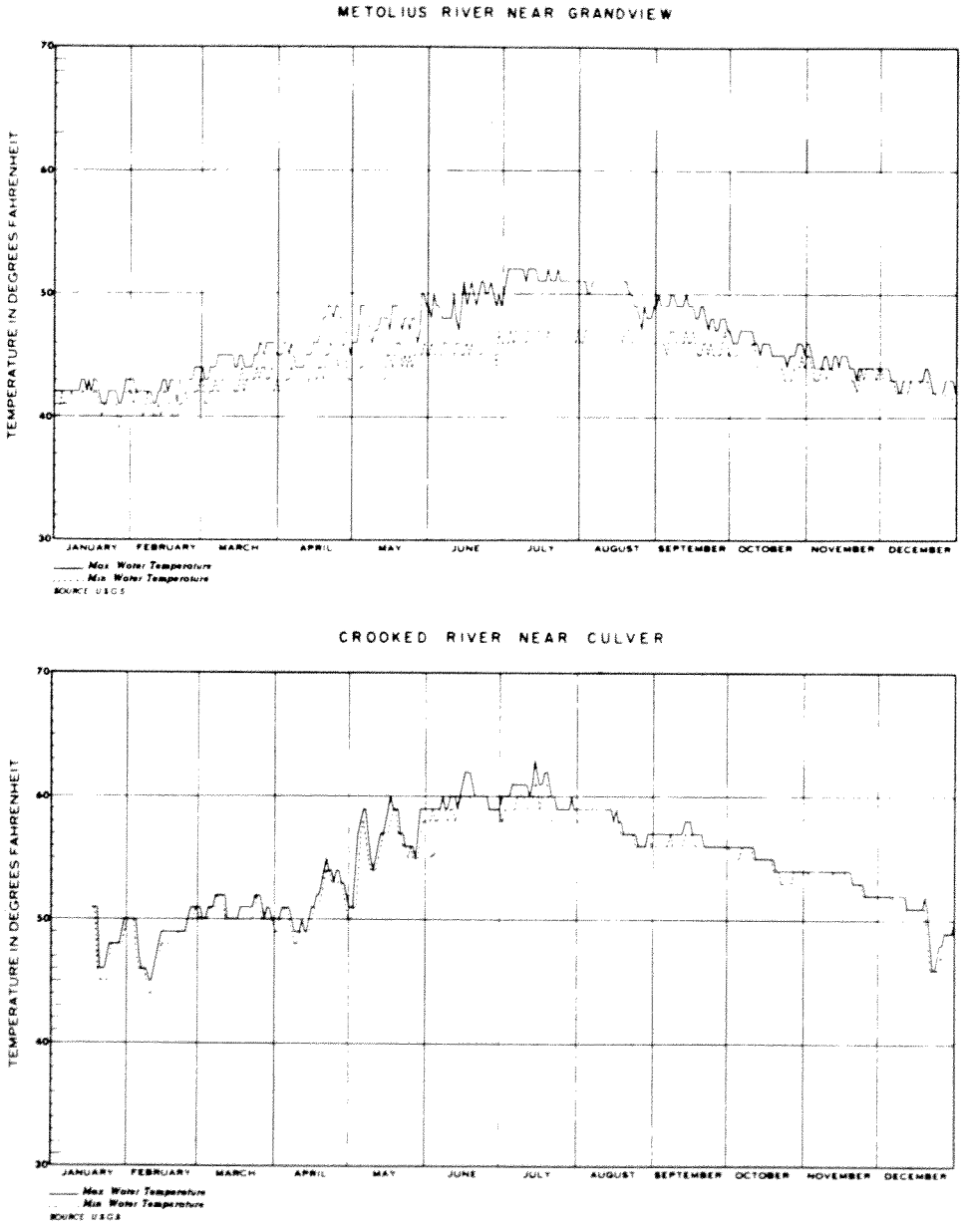


FIGURE 13. Seasonal pattern of water temperature of the Metolius and Crooked Rivers near their mouths, 1953.

unless such wastes are treated and disinfected so they do not impair or corrupt the quality of water in the receiving stream. This ruling has kept the streams in the

Deschutes Basin of comparatively good quality and no serious problems exist concerning the pollution of streams.

Water samples taken by the State Sanitary Authority in the Deschutes, Crooked, and Metolius Rivers show relatively low counts of coliform bacteria and appear encouraging as far as gross pollution of the rivers is concerned. An odor and taste problem is sometimes created by algae originating in Upper Deschutes reservoirs which are carried downstream into irrigation ditches serving as sources for domestic and municipal water supplies in some parts of the basin. These waters usually require chlorination, flocculation, and sedimentation before they can be used for domestic purposes.

A predominant method of disposing of sewage in the Deschutes Basin is by discharge of untreated or treated wastes underground through sink holes and seepage pits. No pollution of streams or ground waters as a result of this kind of disposal of waste has been detected so far. However, disposal of large quantities of industrial or chemical wastes by this method could cause changes in the chemical quality of streams. Household detergents, which are relatively new additions to sanitary waste, are difficult to remove and may eventually be detected in the waters of the Deschutes River.

WATER CONTROL

General

Water control problems in the basin consist of flooding, drainage, and erosion. Plate 13 is a generalized map showing the major problem areas. These are discussed below.

Flood Control

Major floods occur primarily in the arid regions of the Crooked River watershed, particularly in the valley between Post and Prineville, and below Prineville, and on Bear Creek. The greatest historical flood occurred in 1890 and the highest recent flood in 1952. Damages in the Prineville area are primarily to agricultural lands but also to some extent to urban and suburban areas. Corps of Engineers' estimates place average annual flood damages at $63,600 in the Crooked River Basin.

Flooding also occurs in the Trout Creek and Upper Crooked River watersheds and other isolated sections but is much less severe in those areas. The Trout Creek Soil Conservation District has applied for federal assistance in order to reduce flooding and bank erosion and to provide late season irrigation water.

Ochoco Reservoir, built in 1920, is the only major flood control project in the basin.

Prineville Reservoir, now under construction by the Bureau of Reclamation, will be operated in conjunction with Ochoco Reservoir to reduce floods on Ochoco Creek and Crooked River.

Indirect flood control is maintained by reservoirs which store winter and spring flows for summer irrigation thereby reducing the high flows during snowmelt periods.

Drainage

Serious drainage problems exist for the most part within the confines of the areas outlined on Plate 13. The problem in the Crooked River Valley near and below Prineville is in the nature of a high water table created by flooding. Elsewhere the problem is also in the nature of a high water table but caused by irrigation.

In most developed areas of the basin, natural drainage channels and land slope are adequate to provide good surface drainage. Most soils in the basin are of a texture providing good internal drainage and the underlying rock formations are usually sufficiently creviced or porous to allow deep percolation of water thus preventing the occurrence of high water tables. However, new areas with drainage problems may arise in the future when more lands are brought under irrigation and supplemental water is provided for presently irrigated lands.

Erosion

Severe water erosion occurs in the Bear Creek and Lower Deschutes watersheds. Such erosion usually results from one or more of the following: steep slopes; shallow, rocky soil; lack of vegetative cover; too intensive cropping practices. In many cases the erosion could be reduced or eliminated by changing the land use to a type that would provide the vegetative cover necessary to hold the soil in place. In some instances, particularly where steep slopes are involved, it is difficult to economically justify the necessary remedial measures.

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic

The location and expansion of rural population is in part dependent upon the availability of water for domestic purposes. Abundant and good quality water stimulates while limited or expensive supplies and poor quality restricts population growth.

Water quality does not represent a major problem but water quantity is a decisive factor in the population pattern of the Deschutes Basin. There are large areas in the basin that do not have any significant surface water supplies and ground water has been found only at great depths. Some of these areas presently receive domestic water from irrigation canals. Others are too far from surface water sources and expansion of rural population in these areas will depend largely on the economic aspects of developing ground water.

Municipal

The establishment and growth of communities depend largely on the adequacy and quality of water supply available. Sometimes water has to be brought from long distances and adverse quality requires large expenditures for treatment. In many cases industrial needs have to be met by municipal systems.

The communities in the Deschutes Basin feel that they can meet the immediate future demands for municipal water but additional storage, larger distribution facilities and new sources of supply will be necessary if major water-using industries should locate in the communities. Water quality does not present a major problem at present and no significant changes in this respect are expected in the near future.

Irrigation

The Deschutes Basin is located in the rain shadow of the high Cascades and therefore its precipitation is low. For this reason, the agricultural economy of the basin depends largely upon irrigation. Agricultural production could be greatly increased if all irrigated lands received an adequate water supply and if all potentially irrigable lands were irrigated.

However, less than 10 percent of the present crop and pasture land in the basin is irrigated. Many dry farmed lands in the basin are potentially irrigable, but water could be made available in sufficient quantities in most instances only by the provision of storage or by development of ground water supplies.

Power

Studies conducted by the State Water Resources Board determined the undeveloped power potential of the Deschutes River Basin using all proposed power sites located on the Deschutes River below the Pelton Project and on the Metolius River that are not in conflict with each other or with existing developments. Only those sites which had

previously been studied by a group or agency were considered. Computations were based upon mean monthly flows for the power years July 1928 to June 1948 in accordance with the base period used in Columbia River Basin power studies, an overall plant efficiency of 80.8 percent, 100 cfs allowance for fish facilities, and run-of-river projects which disregarded storage and variations in demand.

Results of the study are indicated by Figure 14 which shows the power potential in the form of a duration curve. The total basin potential is 319,000 kilowatts 90 percent of the time and 545,000 kilowatts 10 percent of the time. The median power that can be developed is 403,000 kilowatts, which represents an average annual energy production of 3.53 billion kilowatt hours.

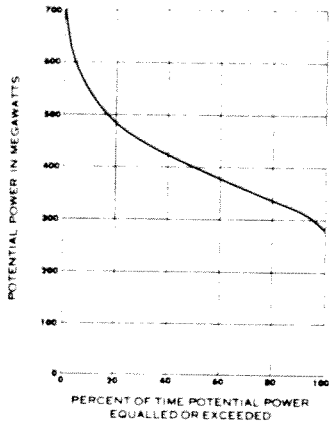


FIGURE 14. Undeveloped power potential of the Deschutes River Basin.

The State Water Resources Board ruled in November 1959 that development of hydroelectric power shall be excluded from the uses of the Deschutes River main stem between its confluence with the Columbia and mile 110. Potential power sites located in this section have a median power potential of 342,000 kilowatts which represents an average annual energy production of approximately three billion kilowatt hours.

These figures do not include the proposed Round Butte Project which would have an installed capacity of 275,000 kilowatts and an average annual energy production of 975 million kilowatt hours.

Industrial

Industrial expansion in the Deschutes River Basin is expected mainly in the field of food and secondary wood processing. The most likely locations for new industries of this type are in the vicinity of Bend, Redmond, Prineville, and Madras.

Plans have been considered for the construction of a pulp and paper mill in the Bend area which would use wood wastes. The minimum capacity would be 250 to 300 tons using wastes from the immediate vicinity and it is estimated that the resource could support a capacity of 800 tons per day in addition to sawtimber capacity by importing wastes from other areas. Such an operation could require up to 10 cfs per 100-ton capacity, the exact amount depending upon the type and efficiency of the process.

This, and all other new major water-using industries, are faced with the problem of

securing adequate water supplies. All easily obtainable water has been appropriated for other uses, mainly irrigation. Securing of adequate water supplies for new industries could, therefore, require high expenditures. Industrial water probably will have to be diverted over long distances or be pumped from ground water.

Waste disposal could also create a major problem for major water-using industries, particularly in view of the statute prohibiting the deposit in the stream system of any matter which will corrupt or impair the water quality.

Mining

The Deschutes Basin has not been studied intensively from an economic geology standpoint. Parts of the basin are not mapped topographically and geological mapping is largely of the reconnaissance type. Any discussion of the mineral potential of the area must be confined to surface exposures of presently useful minerals and rocks since what lies below the layers of lava which covers most of the region is largely unknown. The approximate location of known mineral deposits of economic importance are shown in Plate 6.

At the present time the amount of water required by the mining industry in the basin is small since mining is presently limited mainly to building materials and related minerals. Future requirements will probably be greater but, based upon present knowledge, the total amount will still be comparatively small.

Recreation

The Deschutes Basin includes some of the most popular recreation areas in the State of Oregon. A great attraction to tourists is exercised by the lake areas in the Cascades, by the Deschutes and Crooked River Canyons, and by the Metolius River and many other clear water streams. Many of these areas depend upon water directly for campground uses and for recreational purposes such as boating, swimming, water skiing, and fishing. Therefore, the economic importance of recreation in the basin will continue to depend a great deal on the maintenance of minimum lake and reservoir levels and streamflows.

The Parks Division of the Oregon State Highway Department estimates an increase of 50 percent in the day use of state parks in the Deschutes Basin between 1958 and 1968 and an increase of 135 percent in the use of existing overnight camping areas in the same 10-year period. This agency listed 11 potential non-urban recreation areas in the basin of which two are presently suitable for state park sites and are currently being studied. In addition, the Parks Division plans to improve or add new facilities to all existing state parks in the basin in succeeding years.

The U. S. Forest Service estimates that recreational use of national forests in the Deschutes Basin in the year 2000 will be six times greater than in 1959. This agency has approved plans for eight new forest camps in the basin and increasing the number of developed family units in all camp areas from 1,378 to 2,230.

The Oregon State Game Commission estimates an increase in the recreational use of the Deschutes Basin in 1975 to four times, and in the year 2000 to eleven times, the present number of visitors.

Wildlife

Mule deer are the principal big game in the Deschutes Basin. Some increase in deer population can be expected in the future due to increased habitat areas as a result of logging operations and possibly also adjacent to new irrigated lands.

An increase in the number of game birds can generally be observed when new lands are brought under irrigation.

No appreciable change is expected in the population of waterfowl and furbearers that are dependent upon an aquatic habitat unless highly fluctuating reservoir levels and river flows are stabilized.

Fish Life

The Oregon State Game Commission estimates that the known spawning and rearing areas currently available in the streams and lakes of the Deschutes River system are capable of producing approximately 10 times the number of fish now existing if adequate streamflows and other desirable habitat conditions are provided. Substantial production increases in anadromous fish can be expected only if passage facilities at existing and planned main stem dams prove efficient in handling migrant fish.

Deschutes salmon and steelhead provide considerable recreational and commercial values to other areas of the state in addition to those received in this basin. This is substantiated by the Fish Commission of Oregon's estimate that an annual returning run of 5,000 spring chinook salmon to the Deschutes River contributes fish having a first wholesale value of about $125,000 to the commercial gillnet fishery in the Columbia and to the ocean troll fishery. Developing the large potential for enhancement that exists would increase this dollar value proportionately.

Streamflows necessary to develop the full fishery potential were listed in Table 11 as

desirable minimum flow for ideal fish production. The recommended flows at many locations, particularly along the Deschutes main stem, cannot be obtained under natural conditions because of other conflicting uses of water that presently exist. Realization of the full fishery potential is not practical and appreciable enhancement of the fishery resource will require storage releases specifically for fish life.

CHAPTER III SUB-BASIN INVENTORY

SUB-BASIN 1 UPPER DESCHUTES RIVER

GENERAL

Location and Size

The Upper Deschutes sub-basin includes all of the Deschutes watershed above Benham Falls or river mile 181. Containing 1,710 square miles, which is about 16 percent of the total area of the Deschutes Basin, it ranks fourth in size among the five sub-basins.

The sub-basin is bounded on the west by the Cascade Range, on the south by the divide between the Deschutes and Klamath Basins, on the east by the Walker Rim, Crater Buttes, and Paulina Mountains, and on the north by the arbitrary divide which extends from the Paulina Mountains through Benham Falls to the Three Sisters in the Cascades.

Fifty-two percent of the sub-basin area lies in Deschutes County, 45 percent in Klamath County, and the remaining 3 percent in Lake County.

Stream System

All major streams in this sub-basin originate in the Cascade Mountains. Paulina Creek, which originates at Paulina Lake, is the only stream of significance that heads to the east of the Deschutes River. The drainage area of the Little Deschutes River, which is the main tributary of the Deschutes in this sub-basin, comprises about 60 percent of the total sub-basin area. Crescent Creek, which is an important tributary of the Little Deschutes River, contains about 11.5 percent of the sub-basin area.

There are more than 750 miles of streams in this sub-basin of which only 310 miles are perennial in nature. Included in these figures are 71 miles of the Deschutes main stem, 97 miles of the Little Deschutes River, and 30 miles of Crescent Creek.

Profiles of these streams showing elevations versus stream miles are shown in Plate 2. The Deschutes River travels on an average gradient of only 8.5 feet of drop per mile in the 71-mile course through the sub-basin from Lava Lake to Benham Falls. The Little Deschutes drops 350 feet in its upper 3 miles but averages only 9 feet per mile in its lower 95 miles to the confluence with the Deschutes main stem. Crescent Creek has an average gradient of about 15 feet per mile between Crescent Lake and its confluence with the Little Deschutes River.

Climate

Climatological data are available only for the lower elevations between 4,000 and

4,800 feet. Average annual precipitation is estimated as high as 80 inches near the Three Sisters in the high Cascades, but decreases at lower elevations to 59 inches at Odell Lake, 50 inches at Cascade Summit, 19 inches at Crescent, and 14 inches at Lapine. Annual precipitation near Cascade Summit and Odell Lake has varied between 30 and 77 inches and in the area between Crescent and Benham Falls, between 11 and 30 inches. Precipitation averages 4.21 inches at Lapine and 4.14 inches at Crescent Lake between May 1 and September 30.

Precipitation averages by months are shown in Figure 15 for two representative stations, Crescent Lake and Lapine. Although the record at Lapine is relatively short, it is the only station located in the agricultural areas of the sub-basin and is shown for this reason. Peak precipitation at this location occurs during the months of November through February with a second, lesser peak during the spring rains of May and June. Precipitation at Crescent Lake, which is at a higher elevation, is highest during the months of November through January.

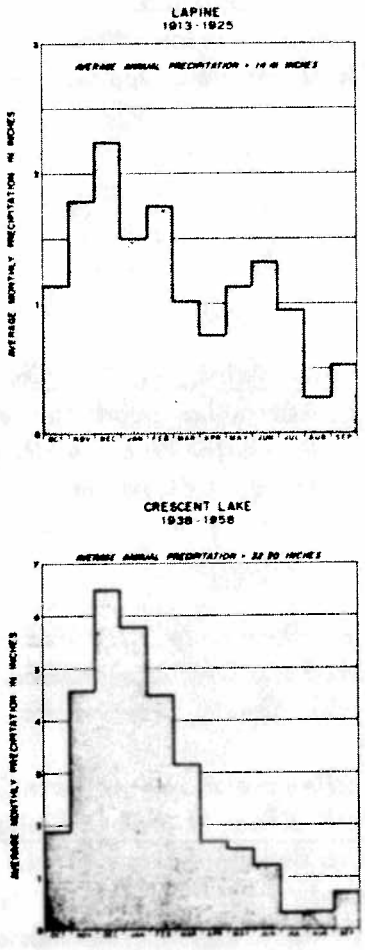


FIGURE 15. Average monthly precipitation at representative stations in the Upper Deschutes sub-basin.

Snowfall varies greatly with elevations with annual averages of 295 inches at Cascade Summit, 165 at Chemult, 87 at Crescent, and 63 at Lapine.

Temperatures at the lower elevations have ranged between extremes of minus 40 and plus 107° F. Average annual temperatures in the valley locations range between 40 and 43° F.

Frosts can occur in any month of the year in this sub-basin. The average period without killing frost is 80 days at lower elevations.

Population

This is a sparsely settled area having an estimated population of 1,750 in 1960. There are no incorporated cities in this sub-basin. Gilchrist and Lapine are the largest towns each having populations of about 500. There are several small towns scattered throughout the sub-basin, nearly all having populations of less than 100 persons.

ECONOMY AND LAND USE

Land Ownership

Of the total sub-basin area, 1,710 square miles, 82 percent is federally owned or administered, less than 1 percent is owned by the State of Oregon, and the remaining land is predominantly under private ownership.

The largest portion of the sub-basin is timber land within the Deschutes and Fremont National Forests, small parts are agricultural lands, and most of the remainder is waste land.

Timber

Timber and recreation are the most important resources to the economy of this sub-basin. About 78 percent of the sub-basin area is U. S. Forest Service land, most of it is within the Deschutes National Forest. Most areas are classed as commercial forests and a large portion is still in sawtimber stands.

Timber industries of major importance are concentrated near Gilchrist and Lapine. No figures are available for the timber cut in this sub-basin. Much of the log production in this sub-basin is transported to mills in surrounding areas for processing.

Agriculture

Agriculture plays a minor part in the economy of this sub-basin. There are about 40 farms in the area located mainly along the lower Little Deschutes and Paulina Creek. They are engaged primarily in raising beef cows and sheep with barley being the principal field crop. No major expansion of agricultural lands is anticipated due to rugged topography and unfavorable climate.

Recreation

Recreation plays an important role in the economy of this area. The Upper Deschutes sub-basin is one of the most popular recreation areas in Oregon. Thousands of tourists are attracted each year by unique scenery, many lakes and streams which provide fishing and boating, vast forests which provide big game hunting, and other types of recreational activities.

Resorts and forest camps are scattered all over the area mainly along the rivers, lakes,

and reservoirs. The gross income of the resorts in this area was estimated at $350,000 in 1959.

East and Paulina Lakes, long recognized as among the most popular fishing areas of the state, support over 55,000 angler days annually for a take of approximately 200,000 trout.

Transportation Media

The sub-basin is crossed by several major highways which connect it with other parts of the basin and the state. U. S. 97, known as The Dalles-California Highway, crosses the sub-basin in a north-south direction and connects it with Bend and Klamath Falls. Oregon 58, known as the South Willamette Highway, runs to Eugene in the west and Oregon 31 to Lakeview in the southeast. A secondary oiled highway makes Paulina and East Lakes easily accessible. Many parts of the eastern slopes of the Cascades are accessible over a network of forest roads.

Regular bus service is available on U. S. 97 and Oregon 58 and regular freight truck service on these and on Oregon 31. Irregular freight truck service is available to almost all points in the sub-basin.

There are two major railroads crossing the sub-basin. The Southern Pacific main line between Portland and San Francisco enters the sub-basin at Cascade Summit and continues south through Chemult. The Great Northern runs north from Chemult to Bend and the Columbia River. Passenger service is available only on the Southern Pacific. A lumber railroad connects Gilchrist with the Southern Pacific at Mowich.

The State Board of Aeronautics maintains landing strips near Crescent Lake and Lapine, the State Game Commission at the Fall River Fish Hatchery, and a privately-owned landing strip is located near the confluence of the Deschutes and Little Deschutes Rivers. No commercial airline service is available in this sub-basin.

SURFACE WATER SUPPLY

Yield

The annual yield of the Upper Deschutes sub-basin, 1907-1958, as determined at the gaging station on the Deschutes River at Benham Falls, is shown in Figure 16. The yield pattern here is similar to other stations in the sub-basin which show the relatively dry cycle of the 1930's and early 1940's and the relatively wet cycle of recent years. The average annual yield at this location is 1,024,700 acre-feet and much of this

water is in the form of releases for irrigation diversion at downstream locations. This is further illustrated by the yield of the Deschutes River below Bend, discussed in the next section, which averages 430,500 acre-feet annually.

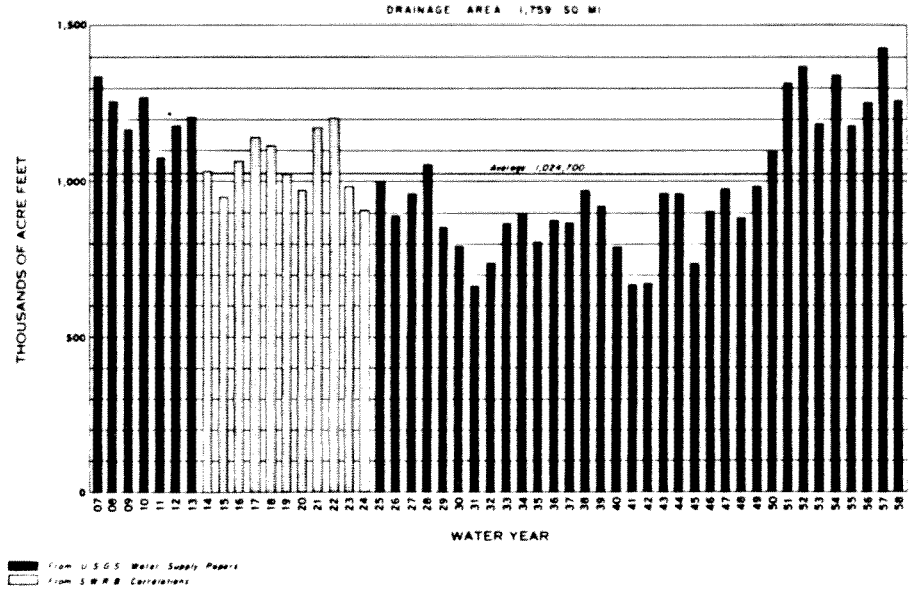


FIGURE 16. Annual yield of the Deschutes River at Benham Falls, near Bend, 1907-1958.

Contributions to Deschutes River yields made by the Little Deschutes for the period 1925-1958 are shown in Figure 17. Here again the same wet and dry cycles are evident. The average annual yield of this stream system, which has a drainage area of 859 square miles compared to 1,759 square miles for the Deschutes at Benham Falls, is 145,400 acre-feet.

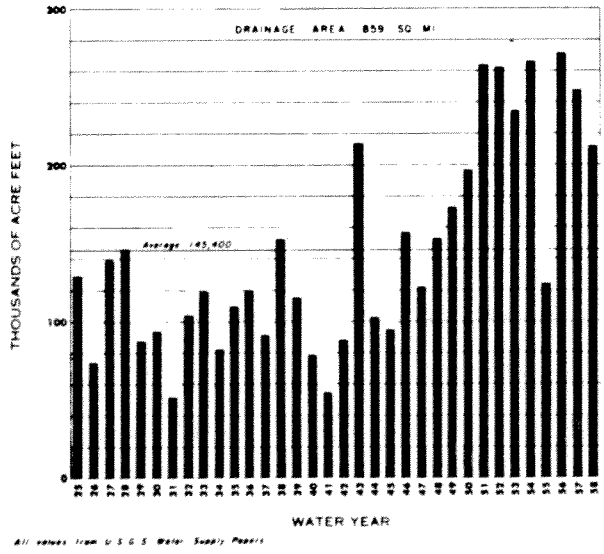


FIGURE 17. Annual yield of the Little Deschutes River near Lapine, 1925-1958.

Yield diagrams were prepared for other locations in the Upper Deschutes Basin and are available at the office of the State Water Resources Board. Average annual yields at these other locations are: Crescent Creek at Crescent Lake 40,860 acre-feet; Deschutes River below Crane Prairie Reservoir 147,570 acre-feet; and Deschutes River below Wickiup Reservoir 536,030 acre-feet. These diagrams indicate

large differences in annual yields of the smaller tributaries but quite even flows from year to year in the Deschutes River below Wickiup Reservoir as well as at Benham Falls.

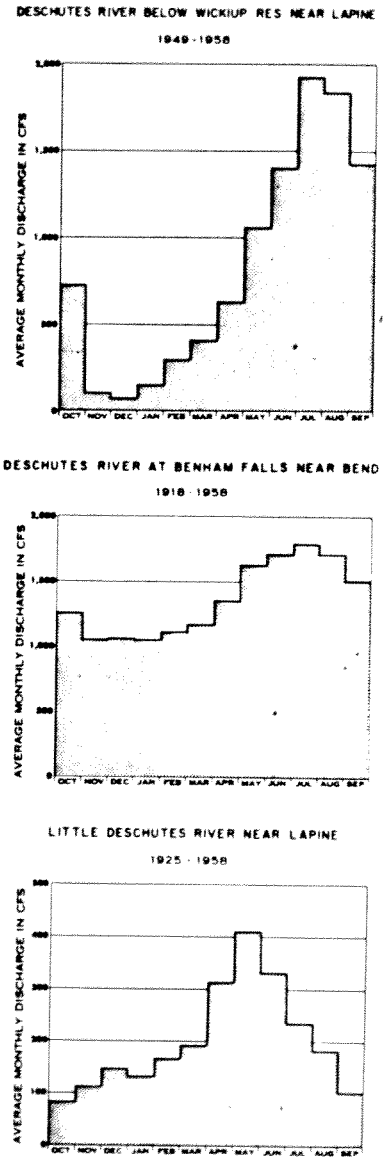


FIGURE 18. Average monthly discharges at representative stations in the Upper Deschutes sub-basin.

Distribution

Average monthly discharges were computed for the same locations as the yield diagrams, and representative stations are shown in Figure 18. Discharges of the Deschutes River below Wickiup Reservoir reflect storage regulation as indicated by low flows during winter and spring runoff, the reservoir filling period, and high summer flows as a result of irrigation releases.

This same pattern is evident in Deschutes flows at Benham Falls but is much less pronounced because Wickiup Reservoir effects only those flows since 1949 and flows at Benham Falls were averaged for the period 1918-1958. Without regulation the Deschutes River flows would be even more uniform than the Benham Falls hydrograph indicates.

Discharges of the Little Deschutes River more closely approximate natural flows for that drainage area and illustrate the peak that occurs during spring snowmelt and the relatively low late summer and early fall flows.

Extremes

The effect of storage regulation on streamflow is even more pronounced in Figure 19 which shows the average daily discharges at two representative stations for the water years having the minimum daily flow of record.

The flows of the Little Deschutes near Lapine for 1931 show a peak occurring in early April and the extreme low flow of eight cfs occurring the first part of September. These flows are regulated to some extent by storage in Crescent Lake, but releases occurred in 1931 only during July and August. By contrast, as a result of reservoir regulation the hydrograph of the Deschutes at Benham Falls is nearly reversed with peak flows occurring in July, August, and September and the extreme low flow of 448 cfs taking place in late January.

Similar extreme hydrographs were developed for the Deschutes below both Crane Prairie

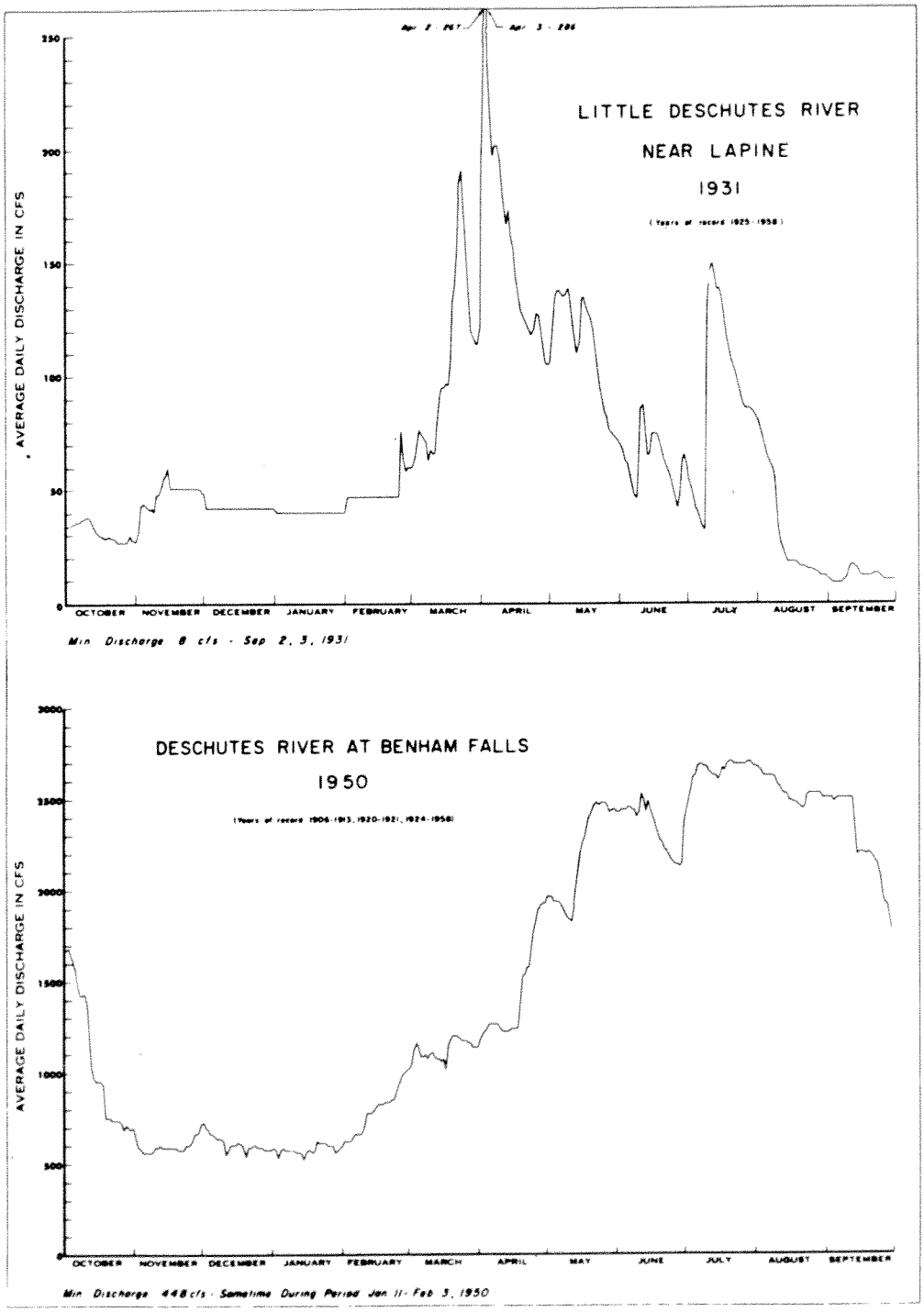


FIGURE 19. Discharge pattern for the water year having the minimum instantaneous flow of record at representative stations in the Upper Deschutes sub-basin.

and Wickiup Reservoirs and these show the same general pattern. The minimum below Crane Prairie was 2 cfs in December 1940 and below Wickiup, 10 cfs in January 1952.

Table 8 summarized critical yield and discharge conditions at selected stations throughout the basin.

Depletions

Water rights in the Deschutes Basin at their points of diversion are shown in Plate 7. Most of the rights in the Upper Deschutes sub-basin lie along the Little Deschutes and in the Odell Lake area. These rights are summarized by use and stream in Table 12.

TABLE 12

SURFACE WATER RIGHTS SUMMARY
SUB-BASIN 1 - UPPER DESCHUTES RIVER

USE	STREAM	CFS	TOTAL RIGHTS
Domestic	Crescent Creek	0.3	
	Deschutes River	0.1	
	Little Deschutes River	0.4	
	Odell Lake	0.9	
	Paulina Lake and Creek	0.1	
	TOTAL		1.8
Irrigation	Crescent Creek	22.9	
	Davis Lake	6.0	
	Deschutes River	243.6	
	Little Deschutes River	37.0	
	Paulina Lake and Creek	7.6	
	TOTAL		317.1
Municipal	Little Deschutes River	2.0	
	TOTAL		2.0
Industrial	Little Deschutes River	2.0	
	Odell Lake	1.4	
	TOTAL		3.4
Power	Fall River	1.5	
	Odell Lake	0.2	
	TOTAL		1.7
Fish	Davis Lake	8.0	
	Fall River	3.0	
	TOTAL		11.0
	GRAND TOTAL		337.0

Of the total, 337 cfs, 324 cfs are consumptive and 13 cfs nonconsumptive in nature. The largest group is 317 cfs for the irrigation of 13,835 acres. Other consumptive rights total 1.8 cfs for domestic, 2 cfs for municipal, and 3.4 cfs for industrial purposes. Nonconsumptive rights total 1.7 cfs for power and 11 cfs for fish.

The pattern of legal rights to use water by stream miles for the entire Deschutes Basin was shown in Figure 9. The Upper Deschutes portion of this extends down to mile 181 and is comprised primarily of Little Deschutes River depletion. These latter depletions are shown separately in Figure 20. The large increase which takes place at mile 56 on the Little Deschutes River is due to a right of 241 cfs held by the Walker Basin Irrigation Company.

While these depletion diagrams show the total of all rights, they do not indicate actual water use for the following reasons:

1. Irrigation rights are seasonal in nature with actual use depending upon the pattern of rainfall occurring during the specific season in question, the availability of irrigation water during that season, and the pattern of rotation practiced by the individual water user.

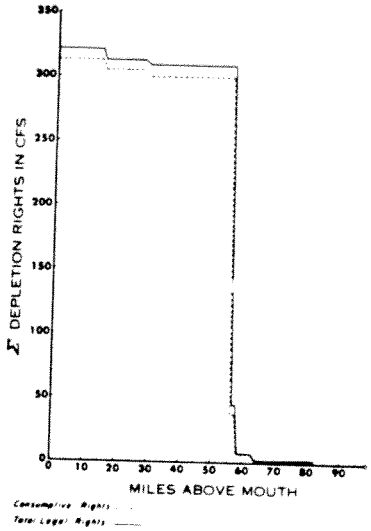


FIGURE 20. Legal depletion rights by stream mile of the Little Deschutes River as of January 1960.

2. Some irrigation rights are filed with the knowledge that low flows of the streams are fully appropriated and the right can be exercised only during higher flows occurring in the first and last parts of the season.

3. A portion of diverted water reappears in the streams as return flow.

4. Power, mining, and fish rights are non-consumptive in nature so that water for this purpose becomes available for other use at downstream locations.

Ordinate values on the depletion diagrams do not include supplemental irrigation rights and these are not part of Table 12. Supplemental rights permit alternate sources of supply but do not add to original rights.

If all consumptive water rights indicated by the depletion diagrams were used to the maximum legal extent, 53,800 acre-feet could be diverted from the streams in this sub-basin each year. This is only a small part of the average annual yield of 1,024,700 acre-feet of the sub-basin. However, all water available at Benham Falls is either withdrawn or appropriated for use at downstream points and no new permits will be issued in this sub-basin for diversions during the irrigation season, except in the special case of tributaries that do not contribute to the flow of the Deschutes River.

GROUND WATER SUPPLY Sub-basin 1.

Yield and Distribution

A large portion of this sub-basin is covered by pumice sand which is underlain by highly permeable basalt. Consequently, the area contains large amounts of ground water in subsurface storage. This accounts in part for the very uniform flows of the Deschutes River at Benham Falls. Detailed geologic and hydrologic studies, including a test well program, would be necessary to evaluate the feasibility of developing and utilizing this source of water.

The State Engineer has records for only 27 wells of known depth in this sub-basin. Twenty-six of these wells are less than 100 feet deep and encounter water usually in gravel beds close to the banks of the major lakes in this area. It is probable that the ground water in these wells is in connection with the adjoining lakes. Most of these wells tested yields between 10 and 40 gallons per minute at drawdowns up to 10 feet after two to four hours of pumping.

The remaining well is located near the town of Crescent on the Little Deschutes River and is 267 feet deep. Water was found in lava rock at a depth of 245 feet below the land surface. The static water level is 148 feet below the surface and the pump test yielded 117 gallons per minute at a drawdown of 8 feet after eight hours of pumping. To p. 60

Depletions

Ground water rights in this sub-basin total only 2.5 cfs of which 1 cfs is for the irrigation of 80 acres, 1.2 cfs for municipal, and 0.3 for industrial purposes.

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

In 1913 the State Engineer withdrew and withheld from appropriation all unappropriated waters of the Deschutes River and its tributaries above Bend for the Deschutes Project. This withdrawal included the regular flow of the Deschutes River including 900,000 acre-feet of storage in the proposed Benham Falls Reservoir for irrigation, domestic, and power purposes. In 1934 this withdrawal was extended to any storage site or sites found feasible and practical by investigations being made by the U. S. Bureau of Reclamation and 187,000 acre-feet were withdrawn for storage of irrigation water in the then proposed Crane Prairie Reservoir.

Later 200,000 acre-feet were appropriated for Wickiup Reservoir and 50,000 acre-feet for Crane Prairie Reservoir under these withdrawals. From this the North Unit Irrigation District has rights for 1,200 cfs for the irrigation of 50,000 acres. All the water appropriated under these withdrawals is used for irrigation in the Deschutes Project which lies outside the Upper Deschutes sub-basin.

In 1955 the State Engineer ordered that the minimum flow of the Deschutes River at the gaging station below Wickiup Dam shall not be less than 20 cfs for the maintenance of aquatic life. He also ordered that in the operation of Wickiup Dam and Reservoir, except in emergencies, the rate of opening and closing of the outlet gate shall be such that they will prevent a rise or fall of the water surface in the river at this gaging station at a rate greater than one foot per hour.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Most households use only small quantities of water. A few farms and resorts have rights for domestic water totaling two cfs for surface water from streams. No domestic rights for ground water exist. No quantity or quality problems have been reported in this sub-basin.

Municipal

There are only two cfs of municipal water rights for surface water and one cfs for ground water, all for the town of Gilchrist. The maximum capacity of the water system of Gilchrist is 900,000 gallons per day (1.4 cfs) and the average output 50,000 gallons per day. Only water from wells is used at the present and its quality is satisfactory without treatment. A population of 500 is served by the system.

Irrigation

Irrigation rights form the largest group in the sub-basin, totaling 317 cfs for the irrigation of 13,835 acres from surface waters of the streams. These figures include 241 cfs of rights for 9,646 acres granted to the Walker Basin Irrigation Company which is inactive at present. Other rights are scattered throughout the basin and are located mainly along the lower Little Deschutes River and Paulina Creek.

Irrigation rights for ground water total only one cfs for the irrigation of 80 acres.

Three large rights for storage of irrigation water exist in this area: 50,000 acre-feet in Crane Prairie Reservoir; 200,000 acre-feet in Wickiup Reservoir; and 86,050 acre-feet in Crescent Lake Reservoir. All of these reservoirs store water for irrigation use outside the Upper Deschutes sub-basin.

The only storage right for lands within this sub-basin is on Paulina Lake for 3,780 acre-feet supplying supplemental irrigation water to ranches along Paulina Creek.

Almost every large lake in the Upper Deschutes sub-basin has been considered a potential source of water, mainly for irrigation. Applications for water rights to store irrigation waters were filed in the State Engineer's office for Crescent Lake, Odell Lake, Davis Lake, Big Cultus Lake, Paulina Lake, and East Lake. Only Crescent Lake and Paulina Lake are presently used for storage. All other projects have been abandoned

because more economic storage sites for the Upper Deschutes water were found at the Crane Prairie, Wickiup, and Benham Falls Reservoir sites.

Crane Prairie and Wickiup Reservoirs have sufficient capacity to store the entire runoff of the main stem of the Deschutes River and seepage water from Odell and Davis Lakes, except in extremely high water years. Runoff from the Little Deschutes, smaller tributaries, and water not stored by the present reservoirs could be stored in the future more economically by the proposed Benham Falls Reservoir, rather than in the existing lakes. Past proposals for sites on Big Marsh and Crescent Creek have also been abandoned in favor of the Benham Falls Reservoir site.

Lands in the Deschutes Basin holding water rights for irrigation are shown in Plate 4. The large block of land shown south of Lapine is for rights held by the inactive Walker Basin Irrigation Company.

Only about 1,600 acres are estimated to be under irrigation in this sub-basin at present and no material increase is expected in the future due to relatively unfavorable climatic and soil conditions. Thus, only a small proportion of the existing irrigation rights are currently exercised and this situation will likely remain relatively stable.

Power

There are no major power plants in this sub-basin and existing power rights, totaling two cfs, are used mainly to pump water and produce electric power for small individual users.

Industrial

Logging and lumber operations are the only industrial establishments in this area. Industrial water rights total three cfs of which two cfs are used by a lumber mill at Gilchrist and the remainder at the railroad depot near Odell Lake.

Mining

There are no active mining operations and no water rights for mining exist in the sub-basin. As indicated by Plate 6, known mineral deposits in this area are few and consist of obsidian and scoria or cinders.

Recreation

There are no consumptive water rights for recreational purposes in the Upper Deschutes sub-basin but water does play an important part in the overall recreational resource of this area. There are about 240 lakes and reservoirs within this section, the largest being Wickiup Reservoir with a surface area of 9,000 acres. Others having important recreational value include Crane Prairie Reservoir and Odell, Crescent, Davis, Paulina, and East Lakes. All but Paulina and East Lakes are located on the eastern slopes of the Cascade Mountains.

Surveys show that Crane Prairie Reservoir had 20,000 day and 15,000 overnight visitors and Wickiup Reservoir 20,000 day and 5,000 overnight visitors in 1954. The U. S. Forest Service estimated 577,000 visitor days of recreation in 1959 in the Deschutes National Forest, which covers much of this sub-basin.

There are 54 forest camps in this area, the majority being located in the lake area between the headwaters of the Deschutes River and Crescent Creek. One state park is maintained at Lava River Caves. Counts at this park showed between 26,000 and 63,000 visitor days annually in the years 1953 to 1958. One wayside park is located south of Lapine.

Thirteen commercial resorts are operated in the sub-basin, nine of them located on lakes and reservoirs, two on rivers, and two are primarily skiing resorts. Bachelor Butte ski area west of Bend is becoming increasingly popular. It was enjoyed by 29,000 persons in the 1958-59 season, its first year of operation, and by 43,000 persons in the 1959-60 season.

Twelve public boat landings are available at the lakes and reservoirs and two on the Deschutes River itself. These recreation areas are located on Plate 5 and a summary of the facilities available at each area is on file at the office of the State Water Resources Board.

Wildlife

Mule deer is the most important game species in this region. There also are several species of upland game, waterfowl, and furbearers.

Water has not been reserved specifically for wildlife and wildlife consumption of water is of relatively small magnitude. However, water is exceedingly important and many problems in respect to habitat arise with artificially regulated streams and reservoirs.

Storage reservoirs in this sub-basin furnish considerable resting area for migratory

waterfowl but their fluctuating nature does not provide suitable nesting or food producing areas. Local ducks and geese nest along the Deschutes River but manipulation of flows often causes excessive losses of those nests. Northern flights of both ducks and geese utilize the river itself for resting during their migration but reduced winter flows, due to storage for irrigation, reduces the attraction of long stretches of the river and sometimes permits the lower portions to freeze over.

Muskrats suffer from artificially fluctuated waters of the Deschutes River when increased flows during the irrigation season flood their dens. Such fluctuations have reduced the muskrat population in the river to a point where their harvest is no longer profitable.

Fish Life

Water for fish has been appropriated in the past only for the propagation of fish in hatcheries. Eight cfs have been appropriated for this purpose on Davis Lake and three cfs on Fall River for fish hatcheries of the Oregon State Game Commission. Currently the Game Commission is operating the Fall River hatchery only.

Principal species of game fish in the Upper Deschutes sub-basin are rainbow, Dolly Varden, brown, eastern brook, and lake trout, whitefish, and kokanee and Atlantic salmon. There are no anadromous fish in this sub-basin, Big Falls on the Deschutes River near Lower Bridge (mile 132) being the upper limit of present anadromous fish migration.

Currently the Deschutes, Little Deschutes, and Fall Rivers receive plantings of hatchery-reared rainbow trout and all other streams are dependent upon wild fish. Atlantic salmon has been introduced recently and it is expected that Quinn Creek, a tributary to Mud Lake, will provide the required spawning grounds for natural production.

Trash fish problems exist in the reservoirs and in some of the lakes. Crane Prairie Reservoir originally had a large population of rainbow and brook trout. However, trash fish have increased in number from 2 percent of the total in 1948 to 87 percent in 1959.

The Upper Deschutes River was an excellent rainbow trout fishing stream prior to the construction of Wickiup Reservoir but rainbow fishing has since fallen off accompanied by an increase in trash fish. However, habitat conditions such as shallow water, non-turbid water, and excellent food for fish have proven to be good for brown trout which also feeds on trash fish. Crane Prairie Reservoir might also eventually go to a brown trout fishery.

Gillnet counts by the Oregon State Game Commission in 1959 showed a trash fish population of 87 percent in Crane Prairie Reservoir, 84 percent in Wickiup Reservoir, 96 percent in Crescent Lake, 72 percent in Davis Lake, 76 percent in Odell Lake, 74 percent in Little Lava Lake, and 35 percent in Big Lava Lake. All other lakes in the Upper Deschutes sub-basin where gillnet counts were conducted had trash fish populations below 5 percent.

Adequate streamflow to cover spawning gravel and to provide other favorable conditions for wildlife is also a problem. Comparison of desirable minimum flows recommended for fish life (Table 11) with flow records at various locations in the sub-basin indicates that, based on average monthly discharge, sufficient water is available throughout the year to satisfy requirements in the Deschutes River at Benham Falls and the Little Deschutes near Lapine. Although this long-term average is favorable, it should be recognized that flow conditions less than desirable have occurred many times in the past at these locations.

Again based on average monthly discharges, insufficient flows occur in the Deschutes River below Crane Prairie Reservoir in February and below Wickiup Reservoir during November, December, and January. This condition also exists in Crescent Creek at Crescent Lake from October through February. In fact, Crescent Creek is dry whenever no water is being released from Crescent Lake.

A conflict in water use exists between fish life and irrigation in the stretch of the Deschutes River below Wickiup Dam. The Game Commission recommends a desirable minimum flow for the Deschutes River below Wickiup Reservoir during the winter low-flow period of 200 cfs. The water right for storage in Wickiup Reservoir issued by the State Engineer requires a conservation release of only 20 cfs. In 1954 the U. S. Bureau of Reclamation conducted a study to determine the effect of bypassing 20, 50, or 200 cfs at Wickiup Dam throughout the storage season on irrigation water shortages of the Deschutes River Project. This study was based on existing irrigation storage practices and rights, the maintenance of a conservation flow of 50 cfs in the Deschutes River below Bend and hydrologic conditions of the years 1925 to 1953.

Water supplies for the Deschutes Irrigation and Reclamation Company (Swalley District) and Deschutes County Municipal Improvement District (Tumalo District) would not have been affected by changes in conservation releases past Wickiup Reservoir, according to the Bureau of Reclamation analysis, because Swalley has no storage right but was decreed the senior direct-flow right and Tumalo District storage at Crescent Lake is located on the Little Deschutes River, a tributary of the Deschutes River below Wickiup Reservoir.

Changes in conservation releases past Wickiup Reservoir would affect Arnold Irrigation

District, Crook County Improvement District No. 1 (Lone Pine District), Central Oregon Irrigation District, and North Unit Irrigation District. Average annual shortages at Bend under a conservation release of 20 cfs past Wickiup Dam would be increased by 2,900 acre-feet under a conservation release of 50 cfs and 19,600 acre-feet under a conservation release of 200 cfs. Maximum shortages occurring during 1931 would be increased 4,700 acre-feet under a conservation release of 50 cfs and 29,900 acre-feet under a conservation release of 200 cfs.

Desirable minimum flows were not established for small streams. This category includes small, spring-fed streams having little fluctuation which are considered important from a recreational standpoint. In many instances, it is recommended that the small streams be maintained in their present natural flow conditions. Although a large number of such streams go dry each year, it is considered by the Game Commission that the headwater lakes and drainages are more valuable, from a fishery and recreation standpoint, in their natural condition than they would be if they were dammed to provide storage for a better downstream flow.

The popularity of the Upper Deschutes sub-basin for fishing is indicated by the estimate that 500,000 angler days are spent in this and the Middle Deschutes sub-basin each year. More detailed statistics for East and Paulina Lakes showed that 55,000 angler days yielded 200,000 trout in 1958.

Pollution Abatement

There are no public sewerage systems in this sub-basin and most homes dispose of their sewage in lava sink holes, some after treatment in septic tanks or cesspools. No contamination of ground water or streams is evident.

WATER CONTROL

Flood Control, Drainage, and Erosion

Flood problems in the Upper Deschutes sub-basin are minor in nature. Storage in headwater reservoirs during the months of heavy runoff and the porosity of the basalt and lava in this area which absorb huge quantities of water in times of heavy precipitation and release it slowly throughout the year combine to greatly reduce potential flood peaks.

Some bank erosion is evident on streams in a few places but no major erosion problems exist.

There is very little evidence of drainage problems in this sub-basin.

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic and Municipal

The economy of this sub-basin is based on the natural assets of timber, agriculture, and recreation. Valley elevations range from 4,000 to 4,800 feet with a large portion of the sub-basin lying at higher elevations. The climate is adverse for agriculture and most of the timber harvested in the area can be processed economically outside the sub-basin. Therefore, the population increase in the future will probably be limited and depend to a large extent upon the expansion of tourism in this area. Thus, needs for domestic and municipal water will probably increase very slowly.

Irrigation

Only about 1,600 acres of the total of 13,835 acres of irrigation rights are estimated to be under irrigation in this area at the present time. Little increase in irrigated acreage is expected in the future due to unfavorable climatic and soil conditions. Existing irrigation diversions on Paulina Creek already use nearly all water available from that stream system.

A further change in the runoff pattern of the sub-basin might be caused by the development of new storage reservoirs for irrigation of lands outside the sub-basin, mainly the Deschutes Project near Bend. According to the Bureau of Reclamation, the only feasible major storage site left above Bend is located at Benham Falls, the northern boundary of the sub-basin. The Bureau has proposed a reservoir at Benham Falls with a usable capacity of 78,000 acre-feet to be used for storage of supplemental water for the Deschutes Project. In connection with this project, a coordinated operational schedule for all storage reservoirs in the Upper Deschutes sub-basin is recommended to develop the most advantageous use of the available water supply. This would change the pattern of streamflow in the sub-basin to some extent but would not make additional water available for use within the sub-basin.

Power

No hydroelectric power developments have been proposed in the Upper Deschutes sub-basin. Operation of future power plants in the area would depend upon the releases from reservoirs which store water exclusively for irrigation. Therefore, sufficient

water for power development would be available only during the irrigation season and not during the winter and spring storage months.

Industrial

The main industrial resource in this sub-basin is timber. Since most of it is processed at Gilchrist and Bend, no new major water-using industrial developments are expected in the foreseeable future.

Mining

Known mineral deposits of some value in this sub-basin are obsidian and scoria or cinders (Plate 6). These are not mined at present and no developments are anticipated in the near future due to economical active operations in other areas located closer to markets.

Recreation

This area is heavily frequented each year by tourists who are interested in the scenic and recreational attractions. There are no recreational water rights at present and new demands in the future will probably be confined to campground uses. Most of the best locations for camps on the larger lakes have already been developed but increasing pressure on these will require expansion of their facilities to the fullest potential.

A potential state park area in this sub-basin, listed by the State Parks Division, is located in the vicinity of Lava Caves 12 miles south of Bend off The Dalles-California Highway. The interest there would be limited primarily to geologic features and water would be needed only for campground use.

It is estimated that 1,600,000 man days of recreation were spent in the Upper and Middle Deschutes sub-basins in 1959 and that four times as many are to be expected in 1976 and eleven times as many in the year 2000.

Wildlife

No major changes in the needs of wildlife for water are expected in the near future unless the habitat is changed appreciably by new developments.

New developments could cause some damage to wildlife by inundating existing

waterfowl, furbearers, and deer habitat. For example, the Oregon State Game Commission estimated in 1955 that annual losses to wildlife, for the above reasons, as a result of constructing the proposed Benham Falls Reservoir would total $18,300.

Fish Life

Although not currently an anadromous fish area, the sub-basin has many miles of streams which are potential spawning grounds for salmon and steelhead providing water conditions were improved (Plates 10 and 11).

Improved fishing and spawning conditions could be created by increasing reservoir releases during the winter storage period thus maintaining higher minimum flows. Reducing water level fluctuations in lakes and reservoirs would also improve the habitat for fish life.

New developments could cause damages to fish life by inundating existing spawning areas and by changing downstream flow conditions. To illustrate, the Game Commission estimated in 1955 that construction of the proposed Benham Falls Reservoir would result in annual fishery damages amounting to $41,700.

Pollution Abatement

Requirements for pollution abatement will not increase much over the present level as a result of population, industrial, and mining expansion in this sub-basin. However, some increase in the pollution of streams and lakes can be expected from heavier recreational use in the future.

SUB-BASIN 2 MIDDLE DESCHUTES RIVER

GENERAL

Location and Size

The Middle Deschutes sub-basin (Plate 1) includes the Deschutes drainage between Mecca, mile 96, and Benham Falls, mile 181, with the exception of the Crooked River drainage which is treated separately. This is the third largest of the sub-basins containing 1,850 square miles which is 18 percent of the total Deschutes Basin area.

Fifty-one percent of the sub-basin area lies in Jefferson County, 48 percent in Deschutes County, and the remaining 1 percent in Crook County.

The western boundary of the sub-basin is formed by the Cascade Range, the southern boundary runs from the Three Sisters east, crosses the Deschutes River at Benham Falls, and continues towards the Paulina Mountains. The eastern boundary, which is not well defined topographically, runs north on the lava plateau between the Crooked River and Deschutes watersheds. The northern boundary runs west in the Mud Springs area, crosses the Deschutes River near Mecca, and continues on the divide between Shitike Creek and the Warm Springs River.

Stream System

All major streams in this sub-basin originate in the Cascade Mountains. Willow Creek is the only significant stream entering the Deschutes from the east. Major tributaries of the Deschutes River from the west are Tumalo Creek, Squaw Creek, Metolius River, and Shitike Creek.

There are about 910 miles of streams in this sub-basin (Table 2) of which only 330 miles are perennial in nature. These figures include 85 miles of the Deschutes main stem, 41 miles of the Metolius River, 41 miles of Squaw Creek, and 33 miles of Shitike Creek.

Profiles of these streams showing elevations versus stream miles are included in Plate 2. The gradient of the Upper Deschutes River is only 8.5 feet of drop per mile but it increases below Benham Falls to an average of 38 feet per mile to the confluence of the Metolius River and 13 feet per mile below that point to the northern boundary of the sub-basin. The Metolius River drops quite uniformly at a gradient of 35 feet per mile throughout its course.

Climate

Average annual precipitation along the Cascade Ridge is estimated to range from 80

inches near the Three Sisters to 100 inches near Mount Jefferson. Precipitation decreases rapidly towards the east and ranges from 4 to 27 inches per year in the area between Bend and Madras. Average annual precipitation at specific locations in this area is 17 inches at Sisters, 13 inches at Bend, and 9 inches at Redmond and Madras. Precipitation averages 3.17 inches at Bend and 2.32 inches at Madras between May 1 and September 30.

Average precipitation at Bend is shown by months in Figure 21. Peak precipitation occurs during the winter months, November, December, and January, with a second, lesser peak in May and June. August is the lowest month averaging about 0.4 inches for the period 1902-1958. Similar information developed for Sisters and Madras shows the same precipitation pattern with much higher November and January peaks occurring at Sisters.

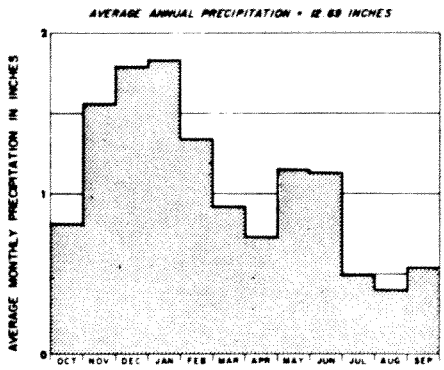


FIGURE 21. Average monthly precipitation at Bend, 1902-1958.

Annual snowfall averages 57 inches at Sisters, 39 inches at Bend, and 17 inches at Redmond.

Temperatures between minus 45 and plus 112 degrees Fahrenheit have been recorded at elevations between 1,300 and 4,000 feet. Average annual temperatures at these elevations lie between 45 and 49° F.

Frosts can occur in any month of the year in this sub-basin. The average length of season without killing frosts is 90 days at Bend and 100 days at Madras.

Population

The Middle Deschutes is the most heavily populated area in the basin with a 1960 estimated population of 28,740. Bend is the largest city in the sub-basin with a 1960 population of 11,940. The 1960 population of other incorporated cities was, Redmond 3,340, Madras 1,520, Sisters 600, and Metolius 270.

Three other towns in the sub-basin have a population above 100, and five a population of less than 100.

Population trends of incorporated cities, Figure 1, were discussed in Chapter I.

ECONOMY AND LAND USE

Land Ownership

As shown in Table 4, approximately 35 percent of the total area of 1,850 square miles of the Middle Deschutes sub-basin is national forest land within the Deschutes National Forest, 7 percent is public domain, and 1 percent is under other federal ownership. Seventeen percent of the sub-basin area lies within the Warm Springs Indian Reservation, less than 1 percent is owned by the State of Oregon, and the remainder, approximately 40 percent, is predominantly under private ownership.

Timber

Timber processing is considered to be the most important industry in this sub-basin. About 35 percent of the sub-basin area is within the Deschutes National Forest which still has extensive stands of uncut sawtimber. Log production in Deschutes County, whose forests are located mainly in this sub-basin, has climbed steadily since 1947 and reached 90 million board feet in 1958 (Figure 2). Uncut sawtimber in the county totaled 5,154 million board feet in 1953.

Bend, the home of several logging contractors and lumber processing mills, has the heaviest concentration of sawmill activity in the Deschutes Basin. Redmond and Sisters are also important centers of logging activity in this sub-basin.

Agriculture

Agriculture is considered second in importance in the economy of the sub-basin. Centers of agricultural production are Bend, Redmond, and Madras and several dairies and food processing plants operate in these cities.

There are approximately 1,230 farms in the sub-basin, which is more than half the total number of farms in the Deschutes Basin. Many farms irrigate and the Deschutes County Municipal Improvement District (Tumalo District), Snow Creek Irrigation District, Squaw Creek Irrigation District, Deschutes Reclamation and Irrigation Company (Swalley District), and parts of the Central Oregon Irrigation District and North Unit Irrigation District lie in this sub-basin.

Principal crops are wheat, potatoes, hay, including alfalfa, barley, and seeds. Livestock consists primarily of beef and milk cattle, poultry, sheep, and hogs.

Recreation

Many tourists are attracted to this region each year, mainly to the lake area west of Bend and to the Deschutes and Metolius River Canyons. Recreation presently ranks third in the income of the area but might well surpass agriculture in the future.

Mining

Mining in this sub-basin is limited mainly to sand and stone operations. There also are a few establishments processing diatomite, scoria or cinders, and pumice.

Transportation Media

This sub-basin has an excellent system of federal highways. U. S. 97 known as The Dalles-California Highway crosses the entire Deschutes Basin in a north-south direction through Bend, Redmond, and Madras. U. S. 20, 26, and 126 connect the sub-basin with points in the east and west.

There are numerous improved state and county roads connecting all populated areas with federal highways. An improved road, very popular with tourists, is the highway from Bend to Elk Lake known as Century Drive which leads to a network of forest roads along the east slope of the Cascades.

Regular bus service is available on U. S. 97 and 20. Regular freight truck services are maintained on U. S. 26, 97, and 126 and irregular service is available to most parts of the sub-basin.

The Oregon Trunk Railroad connects Bend with the Columbia River in the north and is continued to the south by the Great Northern Railroad which intersects with the Southern Pacific at Chemult. A city-owned railroad, the City of Prineville, connects Redmond and Prineville.

There are three publicly-owned airports in the area, the municipal airport near Bend, Roberts Field east of Redmond, and the municipal airport north of Madras. Commercial airlines land at Roberts Field near Redmond and provide service to Portland, Salem, and Klamath Falls. Emergency air strips are located at the Hudspeth Ranch between Redmond and Terrebonne, and at Barclay near Sisters.

SUB-BASIN INVENTORY - MIDDLE DESCHUTES

SURFACE WATER SUPPLY

Yield

The annual yield of the Upper Deschutes sub-basin was shown by Figure 16, Deschutes River at Benham Falls. This would also be the inflow to the Middle Deschutes sub-basin. Progressing downstream, Figure 22, the effect of irrigation diversions is apparent in the yield of the Deschutes River below Bend which averages 430,500 acre-feet annually as compared to the inflow of 1,024,700 acre-feet at Benham Falls.

Further downstream, near Culver, the yield has increased again to an annual average of 800,200 acre-feet. This increase can be attributed primarily to the contribution of Tumalo and Squaw Creeks and other small tributaries, inflow from springs, and return flow from irrigation.

At the Madras gage, the annual yield of the Deschutes jumps to an average of 3,341,000 acre-feet which is primarily due to the contribution of the two major tributaries, the Metolius and Crooked Rivers. This yield closely approximates the amount of water leaving the Middle Deschutes sub-basin.

Although the low yield years of the 1930's and 40's are evident in the diagram for Bend and Culver, the high yield years of the past decade are not as pronounced as they would be under natural flow conditions due to irrigation diversions which have been at their peak during the last 10 years. The effect of diversions is less pronounced in the diagram for Madras because large inflow from the Metolius and Crooked Rivers tends to overshadow these depletions.

Figure 23 shows the annual yield of the Metolius River near Grandview which averaged 1,065,090 acre-feet for the period 1922-1958. This location is about mile 12 on the Metolius so the yield at the mouth of the river would be a little higher than the values shown in Figure 23. Since the Metolius River has very little artificial regulation, this diagram is representative of the yield pattern for streams in the basin influenced by the Cascades.

Similar diagrams developed for smaller tributaries in this sub-basin show the same general pattern of yields although larger fluctuations from year to year as a result, in part, of regulation. Average annual yields in acre-feet for these streams are: Tumalo Creek near Bend 75,010; Squaw Creek near Sisters 77,140; Lake Creek near Sisters 37,740; and, Shitike Creek at Warm Springs 84,100.

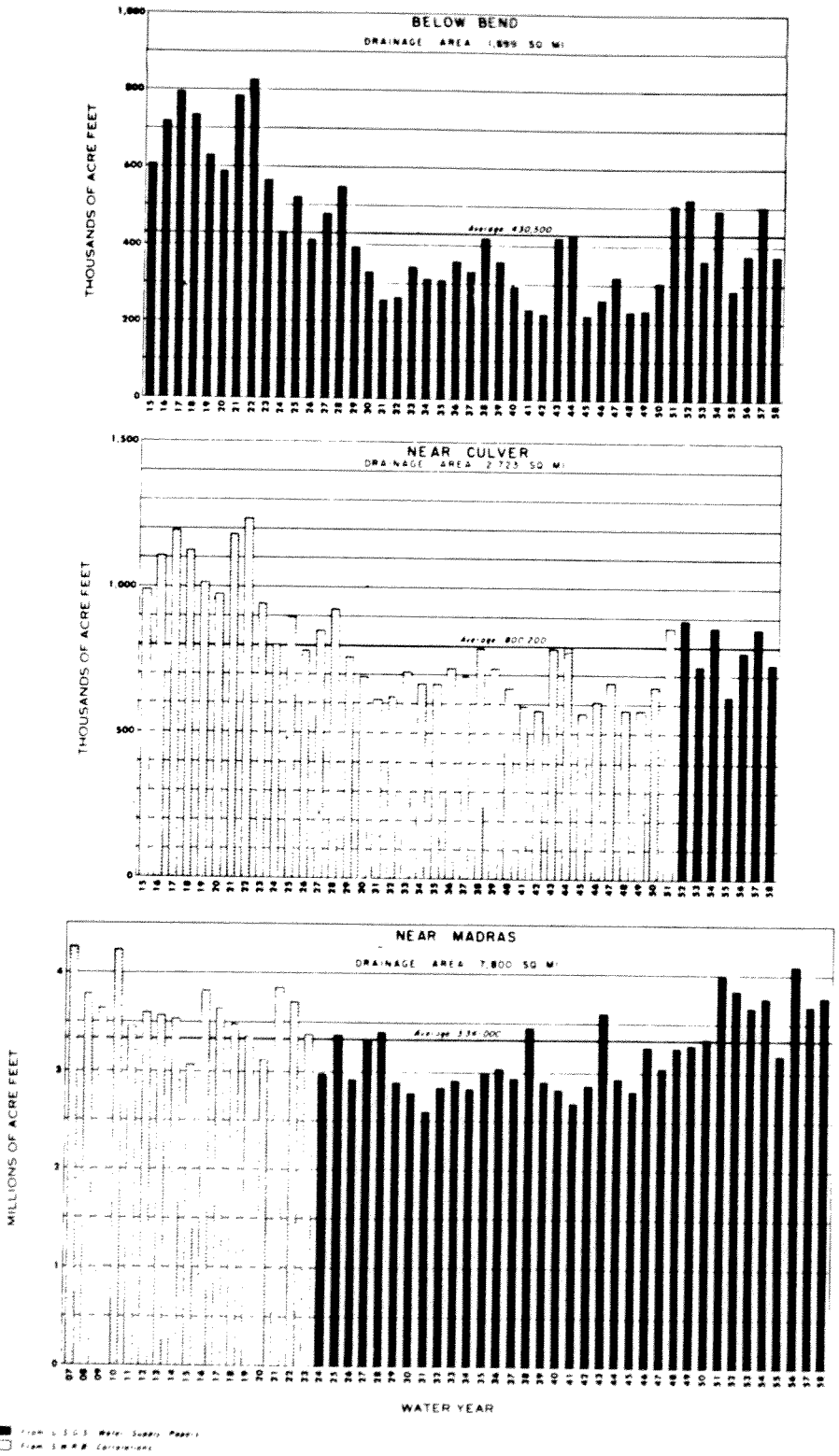


FIGURE 22. Annual yield of the Deschutes River at locations in the Middle Deschutes sub-basin.

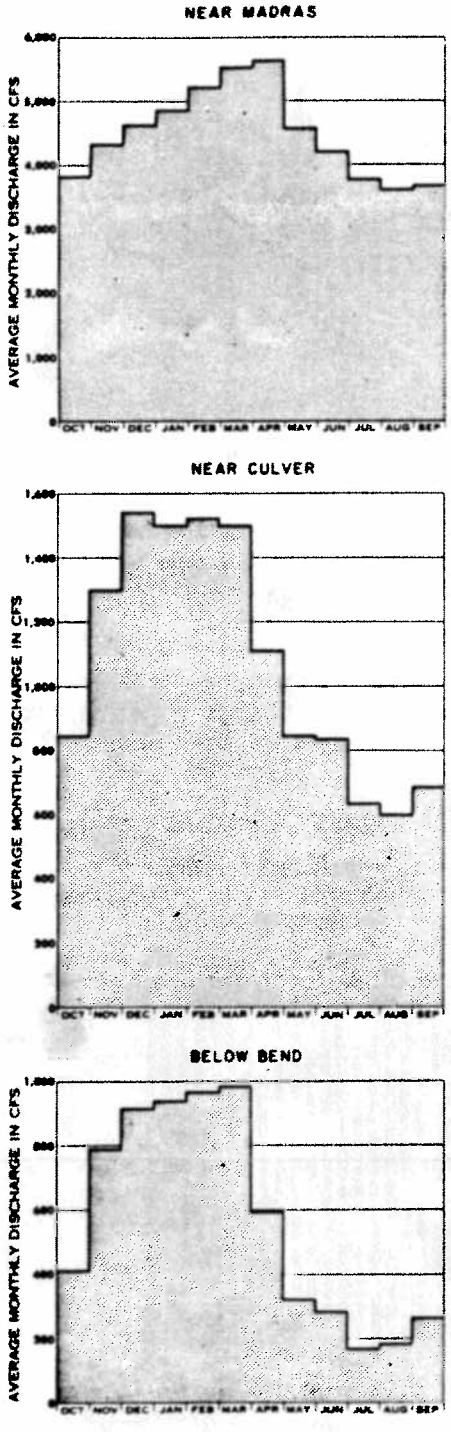


FIGURE 24. Average monthly discharge of the Deschutes River at locations in the Middle Deschutes sub-basin, 1918-1958.

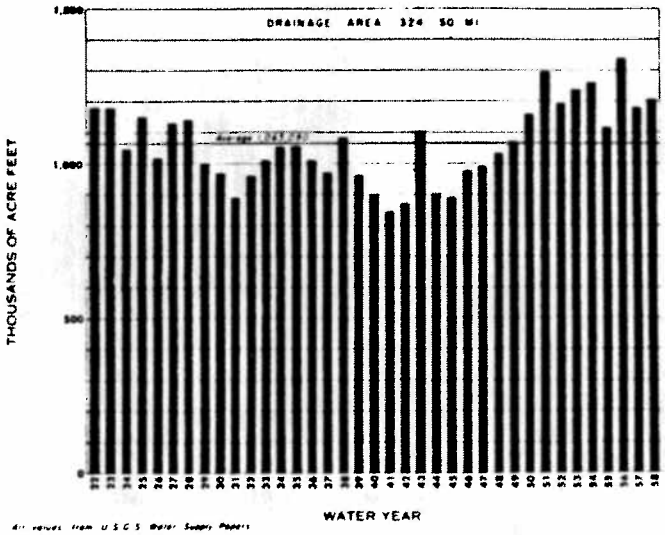


FIGURE 23. Annual yield of the Metolius River near Grandview, 1922-1958.

Distribution

Runoff distribution in terms of average monthly discharge was computed for the stations having annual yield diagrams. For locations on the Deschutes River, Figure 24, the highest flows at Bend and Culver are in the winter months, December through March, and the lowest flows in the summer, July and August, which again is a reflection of stream regulation. At Madras, the furthest downstream location, the pattern of discharge more closely represents natural conditions with peak runoff occurring during the snowmelt period and low flows in the late summer.

Comparison of the magnitude of average monthly flows illustrates the contribution of the major tributaries. High flows below Bend are less than 1,000 cubic feet per second (cfs), on a monthly average but are nearly 5,700 cfs at Madras. Likewise, low flows at Bend average less than 200 cfs for the month of July but are nearly 3,700 at Madras for August, the month of lowest average flow.

Average monthly flows of the Metolius River near Grandview are shown in Figure 25. Here, peak flows are not regulated and therefore occur during the snowmelt season. The influence of large springs is evidenced by the extremely uniform flows of the Metolius which vary between 1,300 and 1,650 cfs from the lowest to highest average month.

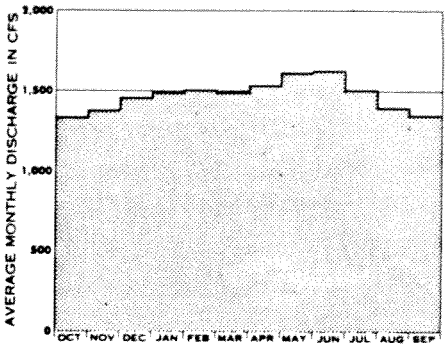


FIGURE 25. Average monthly discharge of the Metolius River near Grandview, 1922-1958.

Tumalo, Squaw, and Lake Creeks also exhibit high snowmelt runoff in May and June and low flows in the late summer.

Extremes

The daily pattern of runoff during an extreme low-flow year is shown for the Deschutes River in Figure 26. This is a plot of the average daily discharges for the water year having the minimum daily flow of record at the Bend and Madras gaging stations. Again the effect of regulation is evident at the station below Bend with low flows, as a result of upstream diversions, occurring during the six-month period from the middle of April to the middle of October. This plot is for a year prior to the existence of the North Unit Irrigation District so the pattern would be somewhat changed if a similar water year were to re-occur in the future.

A similar plot developed for the Metolius River near Grandview, Figure 27, illustrates the extreme uniformity of flow, even with average daily values, for nearly the entire year.

Minimum discharge and yield conditions at these, and other locations, in the Middle Deschutes sub-basin were summarized in Table 8. Minimum recorded discharges are: Deschutes River below Bend, 1 cfs in August 1930; Tumalo Creek near Bend, 1 cfs in June and July 1940; Lake Creek near Sisters, 1 cfs in November 1940; Squaw Creek near Sisters, 19 cfs in December 1922; Metolius River near Grandview, 1,080 cfs in February 1932 and October and November 1942; and Deschutes River near Madras, 2,940 cfs in September 1942.

Depletions

Water rights in the Deschutes Basin at their points of diversion are shown in Plate 7. A detailed summary of these rights listing number, location, use, quantity, stream, and priority date is available at the State Water Resources Board's office.

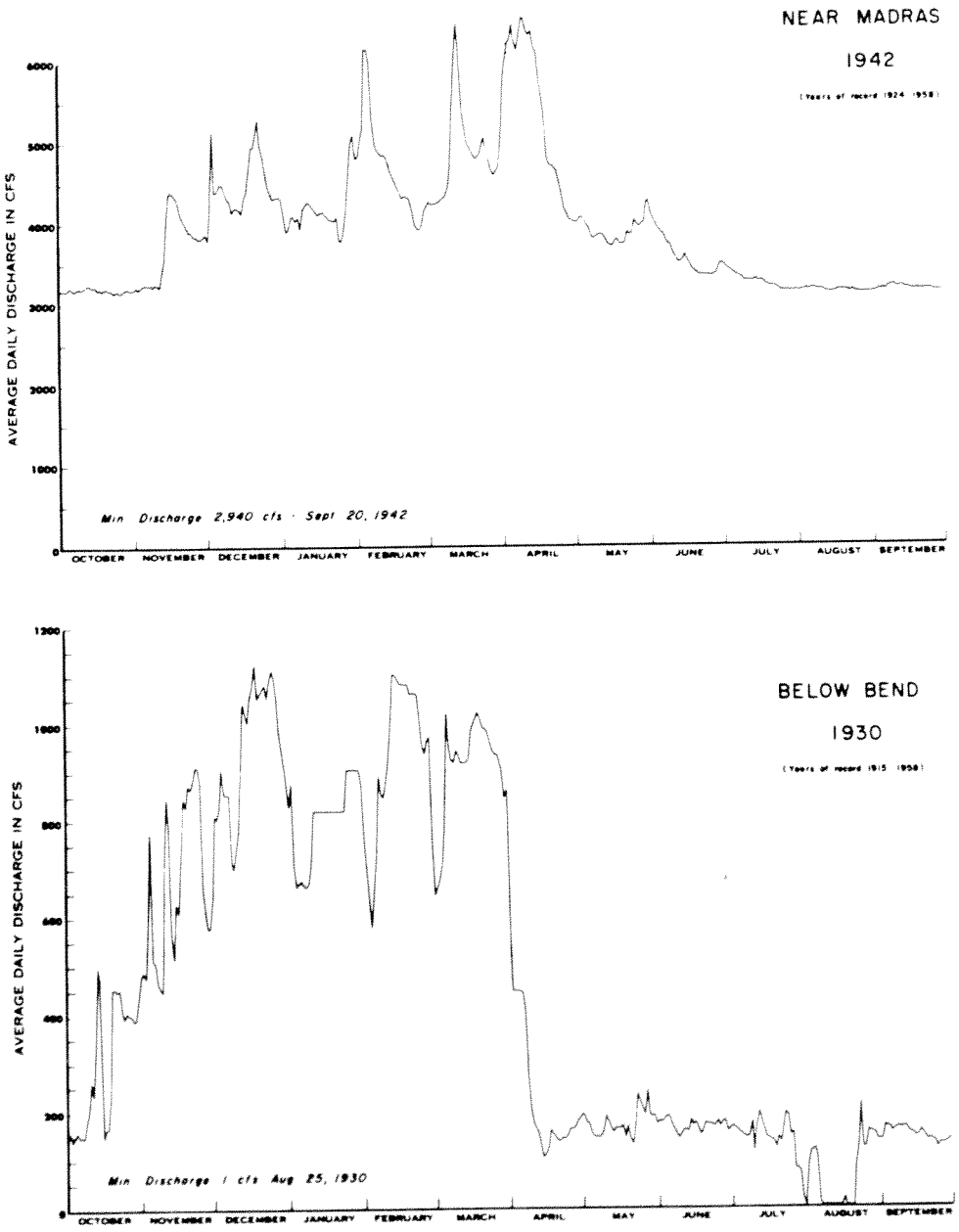


FIGURE 26. Discharge pattern of the Deschutes River for the water year having the minimum instantaneous flow of record at representative stations in the Middle Deschutes sub-basin.

SUB-BASIN INVENTORY - MIDDLE DESCHUTES

A concentration of water rights in the Middle Deschutes sub-basin is found along the Deschutes in the vicinity of Bend, on the middle portion of Tumalo Creek, along Squaw

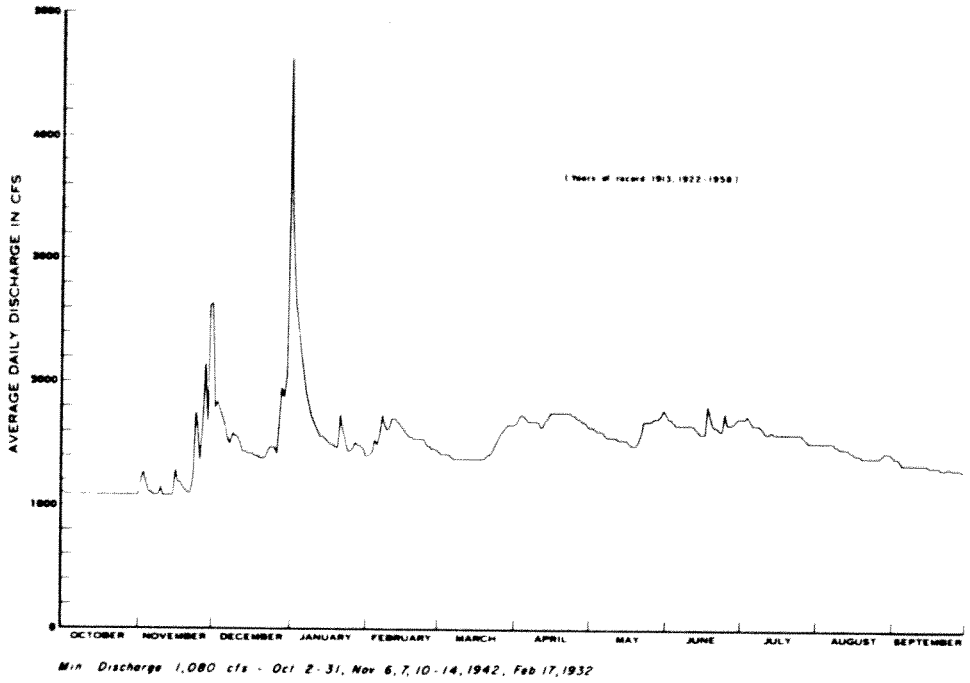


FIGURE 27. Discharge pattern of the Metolius River near Grandview for the water year having the minimum instantaneous flow of record, 1943.

Creek near Sisters, and on the Metolius River in the Camp Sherman area. These rights are summarized by use and stream in Table 13.

Of the total, 5,453 cfs, 3,559 cfs are consumptive and 1,894 cfs nonconsumptive in nature. The largest group is 3,505 cfs for the irrigation of 135,636 acres. Other consumptive rights include 6 cfs for domestic, 46 cfs for municipal, and 1 cfs for industrial purposes. Power is the largest nonconsumptive user with rights for 1,641 cfs, 200 cfs are for industrial, 53 cfs for fish life, and 1 cfs for recreational use.

The pattern of legal rights to use water by stream miles for the entire Deschutes Basin was shown in Figure 9. The Middle Deschutes' portion of this extends from mile 181 downstream to mile 196. It is evident from the plot that most of the depletions take place in the Deschutes River in the vicinity of Bend, mile 165, and in the Crooked River stream system. Those for the Crooked River are discussed later.

Irrigation diversions near Bend represent nearly 85 percent of all consumptive diversions in the Middle Deschutes sub-basin and over 56 percent of all water use in that area.

The growth of irrigation, as evidenced by diversions near Bend, is illustrated in Figure 28 which covers the period 1906-1958. In terms of annual depletion, diversions for the 10-year period 1949-1958 averaged 780, 800 acre-feet. This is representative of the present level of development and serves to further illustrate the reason for the large reduction in yield measured at the gage below Bend, Figure 22, as compared to yields entering the sub-basin at Benham Falls, Figure 16.

TABLE 13

SURFACE WATER RIGHTS SUMMARY
SUB-BASIN 2 - MIDDLE DESCHUTES RIVER

USE	STREAM	CFS	TOTAL RIGHTS
Domestic	Deschutes River	3.9	
	Juniper Creek	0.1	
	Lake Creek	0.3	
	Metolius River	0.8	
	Squaw Creek	0.6	
	Tumalo Creek	0.2	
	Willow Creek	0.3	
	TOTAL		6.2
Irrigation	Deschutes River	3,001.3	
	Fly Creek	0.4	
	Jack Creek	2.1	
	Lake Creek	7.5	
	Metolius River	7.5	
	Snow and Three Creeks	6.8	
	Squaw Creek	327.5	
	Tumalo Creek	133.4	
	Willow Creek	18.3	
	TOTAL		3,504.8
Municipal	Deschutes River	23.1	
	Squaw Creek	4.1	
	Tumalo Creek	19.1	
	TOTAL		46.3
Industrial	Deschutes River	201.3	
	Squaw Creek	0.1	
	TOTAL		201.4
Recreation	Jack Creek	0.2	
	Lake Creek	0.3	
	Metolius River	0.1	
	TOTAL		0.6
Power	Deschutes River	1,582.8	
	Jack Creek	39.1	
	Juniper Creek	0.5	
	Lake Creek	6.1	
	Squaw Creek	12.0	
	TOTAL		1,640.5
Fish	Metolius River	45.0	
	Tumalo Creek	8.0	
	TOTAL		53.0
	GRAND TOTAL		5,452.8

While the depletion diagram of Figure 9 shows the total of all rights, it does not indicate actual water use for the following reasons:

1. *Irrigation rights are seasonal in nature with actual use depending upon the pattern of rainfall occurring during the specific season in question, the availability of water during that season, and the pattern of rotation practiced by the individual water user.*

2. *Some irrigation rights are filed with the knowledge that low flows of the streams have already been appropriated and subsequent rights can be exercised only during the higher flow period at the first and last parts of the irrigation season.*

3. *A portion of diverted water reappears in the streams as return flow.*

4. *Power, mining, and fish life rights are almost entirely nonconsumptive in nature so that water diverted for these purposes becomes available for other uses at downstream locations.*

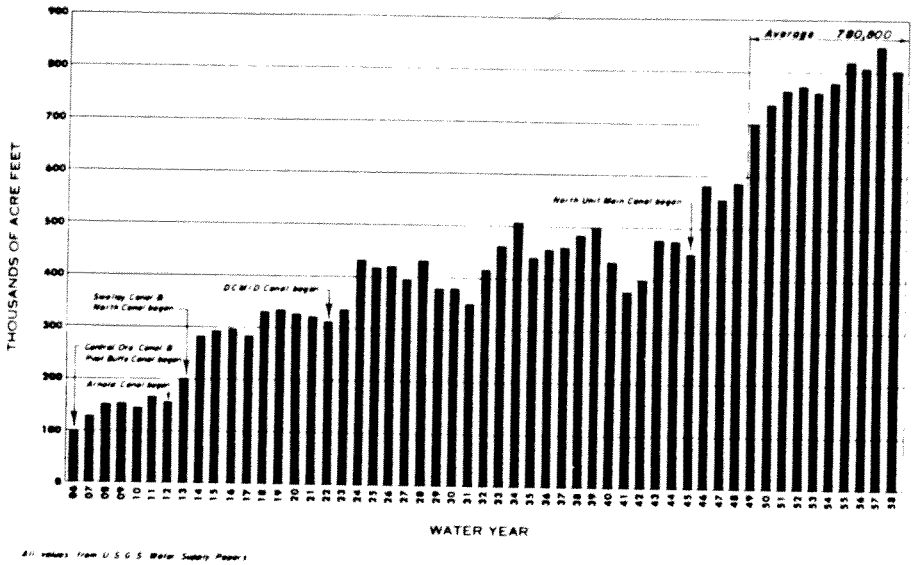


FIGURE 28. Annual irrigation diversions near Bend, 1906-1958.

Ordinate values on the depletion diagrams do not include supplemental irrigation rights and these are not part of Table 13. Supplemental rights permit alternate sources of supply but do not add to original rights.

If all consumptive water rights in the sub-basin would be used to the maximum legal extent, approximately 1,100,000 acre-feet could be diverted from the streams in this sub-basin each year which is about 70 percent of the total consumptive diversions in the basin. While this is less than the average annual yield of all the streams in the sub-basin, shortages exist at many locations because water is not always available at the times of heaviest use.

GROUND WATER SUPPLY Sub-basin 2

Yield and Distribution

Very little is known concerning the extent of the ground water resources of this sub-basin. Well logs and known water tables indicate that there is a general movement of ground water from the area encompassing Hampton, Brothers, and Millican northward towards Bend and the confluence of the Deschutes and Crooked Rivers. Large

springs in the canyon walls of the Crooked, Deschutes, and Metolius Rivers near their confluences tend to confirm this assumption.

Ground water development between Bend and Redmond has been restricted to some degree because of the depth at which water is found. A test well at the Brooks-Scanlon mill in Bend was drilled to a depth of 900 feet. The static water level, which is believed to represent the elevation of the regional water table, was 564 feet below land surface. This well was tested at 1,300 gallons per minute (gpm) with a 7-foot drawdown. In some areas, small supplies of water have been obtained from perched zones which lie higher than the regional water table.

Study of well logs shows the main regional water table to range in depth from 300 feet to more than 800 feet. Pump tests on these wells have varied from 3 to 1,300 gpm with the deeper wells generally showing the larger yields. Te p. 110

Depletions

Ground water rights in the Middle Deschutes River sub-basin total 28.3 cfs. The largest group, 27 cfs, is for industrial use while the remainder includes 1 cfs for the irrigation of 76 acres and 0.3 cfs for municipal purposes.

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

In addition to withdrawals of water for irrigation in the Upper Deschutes, which effect water use in the Middle Deschutes, the Deschutes Decree of 1928 reserves a continuous flow of 200 cfs past Bend for domestic, municipal, and industrial purposes.

In 1929 the Oregon Legislature declared that the waters of Tumalo Creek above a point one-half mile above the intake of Columbia Southern Canal shall not be diverted except for domestic, municipal, and stock use to preserve recreational values. Also, the City of Bend may take from the direct flow of Tumalo Creek after it has acquired the right to appropriate 11 cfs from the Deschutes and delivers it to the Deschutes County Municipal Improvement Feed Canal.

The unappropriated waters of the main stem of the Deschutes River between its confluence with the Columbia River and river mile 100 were reserved for domestic, livestock, recreation, fish, and wildlife purposes by the Oregon State Water Resources Board in 1959. At the same time it reserved the unappropriated waters of the main stem of the Deschutes River between river mile 100 and 120, and the main stem of the Metolius River between its confluence with the Deschutes and river mile 13 for domestic, livestock, hydroelectric power, recreation, fish, and wildlife purposes.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Most rural households in this sub-basin obtain their domestic and stock water from irrigation ditches. Use of irrigation water for domestic purposes is included in irrigation rights and is not filed separately as domestic rights. Individual domestic water rights, aside from the uses of irrigation water, total only six cfs for surface water from the streams in this sub-basin.

The Deschutes Decrees of 1928 and 1933, which determined the irrigation rights allotted to the irrigation districts within the Deschutes Project, also define the amount of domestic and stock water to be used by the farms within these districts. These decrees state that all parties allowed a right to the use of water for irrigation shall be entitled to use such water for stock and domestic purposes. During the irrigation season stock and domestic water shall be included as a part of, and not in addition to, irrigation water. Outside of the irrigation season water shall be diverted for stock and domestic use at the rate of 1/10 of one cfs for each 100 head of stock and 1/10 of one cfs for each family.

Irrigation districts are allowed certain maximum amounts for domestic and stock for the months outside the irrigation season, as listed below:

DISTRICT	CONTINUOUS FLOW cfs	PERIODIC FLOW cfs
Central Oregon Irrigation District	100	300
Arnold Irrigation Company	50	150
Deschutes Reclamation and Irrigation Company	50	150
*North Canal Company	75	225

*Now part of the Central Oregon Irrigation District

The decree also states that no two of these companies shall divert water for domestic and stock purposes at the same time. Diversion records indicate that an average of 100 cfs is diverted from the Deschutes River at Bend during the nonirrigation season.

The Tumalo Creek adjudication decreed that stock water shall be diverted at a rate not to exceed 1/40 of a cfs per 1,000 head of stock provided that the domestic water be included in the irrigation appropriation. Farms obtaining domestic and stock water

from irrigation canals usually store it in cisterns and farm ponds between the periodical deliveries.

Tumalo Irrigation District has a water right to divert 20 cfs from Tumalo Creek continuously or 60 cfs periodically for domestic and stock use during the nonirrigation season, November 1 to April 1.

The only rural water district, the Deschutes Valley Water District, is in the Madras area and supplies domestic water to farms within the North Unit Irrigation District and municipal water to the towns of Culver and Metolius and, in times of high demand, to Madras. Water is pumped from Opal Springs in the Crooked River Canyon.

Opal Springs discharge an average of 223 cfs. Of this, the Deschutes Valley Water District holds a right for 5 cfs (3.23 million gallons per day) but the capacity of its Opal Springs' pump station is only 1,000 gpm (1.44 million gpd). The average output is 450,000 gpd which serves 1,030 service connections. This amount includes approximately 160,000 gpd used for commercial and industrial purposes. This system has difficulty in meeting present demands, partly due to excessive leakage and to freezing temperatures in the winter. The Bureau of Reclamation has recommended a plan of replacing and extending the present distribution system and constructing additional storage reservoirs to meet existing and future demands.

Ground water in the Deschutes Basin is generally of good quality and can be used without treatment for domestic purposes. Water from irrigation ditches and natural streams is generally of good quality and is often used without special treatment although it probably should be subjected to one or more of the common effective treatment methods.

Municipal

Municipal water rights for surface water in this sub-basin total 46 cfs. There is only one ground water right for municipal purposes amounting to less than 1 cfs.

Bend, the largest city in the sub-basin and consequently the major municipal water user holds a total of 19 cfs (12.35 million gpd) of municipal water rights and obtains its water from the Bridge Creek branch of Tumalo Creek. Only 6 cfs (3.88 million gpd) of these rights can be used throughout the year since the remainder, 13 cfs, were obtained by purchasing irrigation rights on Tumalo Creek and their use is restricted to the irrigation season from April 15 to October 15. Some of these rights have later priorities than many others on Tumalo Creek and therefore cannot be fully exercised during those parts of the summer months when flows in Tumalo Creek fall below irrigation demands.

The Bend water system capacity is 11 million gpd and the peak demand is now about 10 million gpd. Consumption over the year now averages about 2.91 million gpd. Growth in demand on the Bend system has been a uniform five percent per year for many years and, on that basis, the present system and supply will be adequate for several more years. The Bend water system presently serves a population of approximately 13,500.

Tumalo Creek water requires only chlorination for domestic and municipal purposes.

Redmond holds municipal water rights totaling 18 cfs (11.35 million gpd), the second largest municipal water right in the sub-basin. The main source of Redmond's water supply is the Pilot Butte Irrigation Canal which diverts water from the Deschutes River near Bend. Water is pumped intermittently from the Deschutes River above Cline Falls during the nonirrigation season when canal deliveries occur only periodically. Redmond's system serves a population of about 5,000 and has a maximum capacity of 7.2 million gpd, with the average use being 1.2 million gpd. No water shortages are reported at present.

Redmond's water is treated by chlorination, chemical flocculation, and sedimentation. Algae growth in the shallow Upper Deschutes reservoirs sometimes causes a problem because of the resultant objectionable odor and taste.

Madras holds a water right for 0.33 cfs (213,000 gpd) from a 400-foot deep well and 5.20 cfs (3.36 million gpd) from Round Butte Springs in the Deschutes River Canyon. The latter right is not used at present. The present average annual output of this well is 23.8 million gallons (65,000 gpd). During the irrigation season, the city also obtains water from the North Unit Main Irrigation Canal under a right granting 1 cfs of domestic water to the irrigation district. In times of high usage, water is also obtained from the Deschutes Valley Water District.

Diversion of municipal water from the irrigation canal is limited by the 720,000 gpd capacity of the treatment plant. The maximum capacity of the city water system is 2,000,000 gpd and the average output presently is 274,000 gpd. Storage is available for 1,165,000 gallons and serves a population of about 1,600.

Water from the well does not require any treatment but the water from the irrigation canal requires treatment by chlorination, chemical flocculation, sedimentation, and filtration.

The towns of Culver and Metolius are served by the Deschutes Valley Water District which holds a water right for five cfs (3.23 million gpd) from Opal Springs in the Crooked River Canyon. As discussed above, it also supplies the rural areas of the North Unit Irrigation District with domestic water and the City of Madras in times of high water usage.

Sisters holds water rights for four cfs (2.65 million gpd) for water from Pole Creek, Squaw Creek, and several springs. The water system serves a population of 800 and its maximum capacity is 700,000 gpd. No shortages are reported at the present. The only treatment required is chlorination.

Irrigation

Irrigation rights form the largest group in this sub-basin. They total 3,505 cfs for the irrigation of 135,636 acres from surface water supplies and 1 cfs for the irrigation of 76 acres from ground water supplies. This is more than half of the total irrigation rights in the Deschutes Basin.

The majority of the irrigation rights in this sub-basin are held by irrigation districts in the area encompassing Bend, Sisters, and Madras. These districts receive water from the direct flow of the Deschutes River, Tumalo Creek, and Squaw Creek and from storage in Crescent Lake, Crane Prairie, and Wickiup Reservoirs.

The oldest decreed rights are held by the Deschutes Reclamation and Irrigation Company (Swalley District) totaling 4,522 acres. Water rights for the direct flow of the Deschutes River and storage in Crane Prairie Reservoir are held by the Arnold Irrigation District totaling 4,503 acres, by the Central Oregon Irrigation District totaling 45,122 acres, and by the Crook County Municipal Improvement District totaling 2,369 acres. The North Unit Irrigation District has rights for 50,000 acres from storage in Wickiup Reservoir.

The Deschutes County Municipal Improvement District (Tumalo District) serves primary rights totaling 6,574 acres from Tumalo Creek and has supplemental rights for these lands from storage in Crescent Lake. Squaw Creek Irrigation District has rights for 9,161 acres from Squaw Creek of which 5,981 acres have a fair water supply and 3,180 acres have only flood rights. Snow Creek Irrigation District has water rights for 756 acres from Snow and Three Creeks.

There are two water rights for large reservoirs in the sub-basin: One for the storage of 32,300 acre-feet in Tumalo Reservoir and the other for 6,000 acre-feet in Haystack Equalizing Reservoir. In addition, three small rights for irrigation reservoirs, totaling 2,100 acre-feet, exist in the sub-basin. Tumalo Reservoir, constructed in 1914, failed to hold water due to excessive leakage throughout the entire reservoir area. Subsequently, a smaller dam was constructed diking off only a small part of the reservoir which is used mainly to regulate the high diurnal fluctuations of Tumalo Creek.

Squaw Creek Irrigation District has applied for 6,000 acre-feet of supplemental water

from Lake Creek and for a storage right of 20,000 acre-feet from Squaw Creek to firm up its water supply but has not yet found feasible damsites.

Squaw Creek Irrigation District would need a minimum of 4,000 acre-feet of additional storage to firm up the late season water supply for presently irrigated lands and 4 acre-feet of storage for each acre of new irrigated land.

Irrigated lands in the Deschutes Project, which include the Arnold Irrigation District, Central Oregon Irrigation District, Crook County Improvement District No. 1, Deschutes County Municipal Improvement District, and the North Unit Irrigation District, have an average annual shortage at Bend of about 47,000 acre-feet for presently irrigated lands, or 110,000 acre-feet if all lands having irrigation rights were irrigated. These districts have a total of 107,922 acres of irrigation rights but only 99,250 acres were under irrigation in 1959. These districts are delineated in Plate 3 and the lands holding irrigation rights are shown in Plate 4.

It is estimated that the proposed Benham Falls Reservoir would reduce this shortage by 27,600 acre-feet. A coordinated operation between all reservoirs, including Crescent Lake, Crane Prairie, and Wickiup, would reduce the average annual shortage by an additional 4,500 acre-feet. The U. S. Bureau of Reclamation considers Benham Falls Reservoir, with an active capacity of 78,000 acre-feet, to be the last feasible storage site in the Deschutes Basin above Bend.

Another possibility of reducing irrigation shortages for these districts would be to eliminate seepage losses in the river bed of the Deschutes River in the eight-mile stretch between Benham Falls and Lava Island. It is estimated that water loss in this section averages about seven percent and occurs mainly at flows above 600 cfs. The Bureau of Reclamation prepared plans of bypassing this section with a concrete channel which could save more than 42,000 acre-feet annually. This water could be used to put new lands under irrigation or to supplement the water supply of presently irrigated areas.

Reduction of transmission losses in unlined irrigation canals, laterals, and farm ditches would also save appreciable quantities of water. The Deschutes Decree allows transmission losses from 35 to 65 percent of the diverted water for irrigation districts of the Deschutes Project.

Irrigation transmission losses will be reduced on the Arnold Irrigation District after completion of the rehabilitation of diversion works being carried out by the U. S. Bureau of Reclamation at present. The Bureau has received also requests for aid to rehabilitate transmission facilities of the Tumalo and Central Oregon Irrigation Districts.

The State Water Resources Board conducted a study to determine possibilities of saving water by means of lining irrigation canals, curtailment of stream channel losses in the

Deschutes River upstream of Bend or by improving operational efficiencies. The study was confined to the Deschutes Irrigation Project, the largest irrigation project and the major water user in the Deschutes Basin.

The Deschutes Irrigation Project, as defined by the U. S. Bureau of Reclamation, consists of Arnold Irrigation District, Central Oregon Irrigation District, Crook County Improvement District No. 1 (Lone Pine), North Unit Irrigation District, and Deschutes County Municipal Improvement District (Tumalo). This study includes also Deschutes Reclamation and Irrigation Company (Swalley) whose lands are located within the project area.

All districts divert water from the Deschutes River near Bend, Tumalo District also from Tumalo Creek. The irrigated lands are located in the area of Bend, Redmond, and Madras.

Project irrigation rights total 112,503 acres, of which 105,929 acres are entitled to divert water from Deschutes River only and 6,574 acres of Tumalo District are entitled to a primary supply from Tumalo Creek and a supplementary supply from Crescent Lake. Tumalo District has also a vested right of 9.5 cfs for the direct flow of Deschutes River.

Arnold, Central Oregon, and Lone Pine Districts have a right for supplementary water from storage in Crane Prairie Reservoir. North Unit Irrigation District receives its entire water supply from storage in Wickiup Reservoir. Swalley District has rights for the direct flow of Deschutes River only which are senior to the rights of the other districts.

All districts have rights for purposes other than irrigation totaling 555 acres of equivalent irrigation rights for diversion from the Deschutes River during the irrigation season and a total of 295 cfs for domestic and stock water during the nonirrigation season.

The preceding rights allow for a maximum diversion of 914,500 acre-feet from the Deschutes River and Tumalo Creek during the irrigation season and 1,021,000 acre-feet per year.

This study used average diversions for the years 1950-1959 as the basis for this study. This period was chosen because maximum development of irrigable acreages under project rights has probably been accomplished due to the pending action for final certification of water rights, above average water supplies, and weather conditions which generally ranged from very dry to very wet growing seasons. The diversions would probably be slightly smaller on a long-term basis under present irrigation and storage development.

Nonirrigation season diversions total less than five percent of the total annual diversion

and are not considered separately from irrigation diversions in the determination of diversion losses.

Project diversions averaged 812,900 acre-feet during the irrigation season and 847,000 acre-feet per year from Deschutes River and Tumalo Creek during 1950-1959. The maximum annual diversion from the Deschutes River was 850,100 acre-feet in 1957 and from Tumalo Creek 70,800 acre-feet in 1918. The maximum annual project diversion was 892,100 acre-feet in 1957.

Observations by the watermaster, studies by the Bureau of Reclamation, and streamflow measurements indicate considerable seepage losses in the channels of the Deschutes River above Bend, of Little Deschutes River, and Crescent Creek. Stream channel losses average 10 percent from Crane Prairie and Wickiup Reservoirs and 18 percent from Crescent Lake to the diversions near Bend. They average 7 percent in the Deschutes River between Benham Falls and the diversions near Bend.

Channel losses averaged approximately 89,000 acre-feet per year between Benham Falls and Bend during 1950-1959. The Bureau of Reclamation has considered a bypass channel to reduce channel losses in this section of Deschutes River. Diversion into this channel is planned during the irrigation season only. It would result in an average annual saving of approximately 42,000 acre-feet. No plans or possibilities of reducing stream channel losses above Benham Falls are known.

Losses of irrigation water within the project consist of transit losses, operational waste, and farm losses. Transit losses consist mainly of seepage losses in main canals and laterals. Operational waste consists mainly of water diverted in excess of farm diversion needs. Farm losses include seepage in farm ditches, percolation of water below the root zone on the fields, and surface runoff from fields. Only very little information is available about the extent of these various losses. Estimates were based on some figures of losses available for diversions of North Unit, Central Oregon, Lone Pine, Tumalo, and Arnold Irrigation Districts.

The average annual diversion of 1950-1959 from the Deschutes River near Bend and of Tumalo Creek for project lands totaled 847,000 acre-feet. Main canal and lateral waste was estimated to be 11 percent of the diversion or 94,000 acre-feet. Main canal and lateral losses were estimated to be 33 percent of the diversion or 279,000 acre-feet. Thus, about 44 percent of the diverted water or 373,000 acre-feet is lost before it reaches the farm weirs.

The remaining loss of 34 percent of the diversion or 290,000 acre-feet occurs in the farm ditches and fields. Thus, only 22 percent of the total diversion or 184,000 acre-feet are irrigation consumptive use (evapo-transpiration) on project lands. Total losses are therefore 663,000 acre-feet or 78 percent of the diversion. This means, that an

average of about 7.5 acre-feet per acre were diverted during 1950-1959 to satisfy an average project irrigation consumptive use of 1.65 acre-feet per acre.

A small amount of water could be saved by increasing operational efficiency, thus reducing the main canal and lateral wastes of 94,000 acre-feet per year. The greatest amount of water could be saved by lining main canals and laterals and replacing defective distribution structures, thus reducing the seepage losses of about 279,000 acre-feet per year. Lining farm ditches and improvement of water management practices on the farms themselves would result in a small reduction of the 290,000 acre-feet per year of farm waste and losses.

With a reduction of 10 percent of operational waste by improving distribution practices, a reduction of 75 percent of transit losses by lining canals and rehabilitating diversion structures and an increase of the farm irrigation efficiency from an estimated present 39 percent to 50 percent, an annual average saving of approximately 360,000 acre-feet available in Deschutes River at Bend, could be achieved. This amount is equivalent to a continuous flow of 500 cfs during the entire year or 850 cfs during the irrigation season from April through October.

A reduction of 25 percent of all transmission losses and wastes without any increase in farm efficiency would make available an additional flow of 220 cfs during the irrigation season and 130 cfs throughout the year in the Deschutes River at Bend, on the average, above those now experienced.

Evidence indicates that major conservation of water originating above Bend could be made by the reduction of river channel losses between Benham Falls and Bend and by the improvement of the irrigation systems, and system practices, using Upper Deschutes waters. It seems desirable that more detailed studies, and in some cases additional studies, be made to determine the economic practicality and timing of potential improvements.

Power

Power rights in this sub-basin total 1,641 cfs, most of them located on the Deschutes River main stem. The majority of these are at Bend, 1,425 cfs, and Cline Falls, 90 cfs. The remainder are small and are used to pump irrigation water and to produce electric power for individual users.

Also located in this sub-basin is the Pelton Project of Portland General Electric Company. This project on the Deschutes River near Madras has not been issued a license by the State of Oregon and therefore does not hold a water right.

SUB-BASIN INVENTORY - MIDDLE DESCHUTES

The present installed capacity of major hydroelectric powerplants in the Deschutes River Basin totals 126,860 KW (Table 9). Within this sub-basin are the Pelton Project with 120,000 KW, the Bend powerplant of Pacific Power and Light Company with 1,110 KW, and the Cline Falls powerplant of the same company with 750 KW.

Pacific Power and Light Company's right of 1,375 cfs at Bend is in excess of the normal direct flows of the river and is junior to many major direct flow irrigation rights but older than all storage rights on the Upper Deschutes River. This right includes 1,325 cfs for the development of power and 50 cfs for the removal of ice and debris from the dam during the nonirrigation season. To solve the conflict between direct flow and storage irrigation rights on one side and power rights on the other side, a contract was developed between the Bureau of Reclamation and Pacific Power and Light Company which relinquished power rights to all waters from the Deschutes River above Pringle Falls, thus assuring the water supply of Wickiup Reservoir, and retained power rights to all waters below Pringle Falls. In exchange for the power loss, the Bureau of Reclamation installed units at the Cove plant of the Pacific Power and Light Company on the Lower Crooked River where only about half of the available water supply was being used.

Benham Falls Reservoir, proposed by the Bureau of Reclamation to store supplemental irrigation water, could be built only if the power rights at Bend were relinquished to make the flows below Pringle Falls available for irrigation storage.

Industrial

Industrial rights for the use of surface water in this sub-basin total 201 cfs and for ground water 27 cfs. Some industries obtain water through city supplies and do not hold individual rights. Water-using industries in this section include lumber mills, dairies, bottling plants, food packing plants, railroads, and building material operations.

The largest right for surface water is for Brooks-Scanlon Lumber Company at Bend, which was awarded 3 cfs for steam generation, domestic, and sanitary purposes, 15 cfs for log washing and steam condensing, and 50 to 200 cfs including the above amounts for the maintenance of a log pond. The same company also holds a ground water right for 26.7 cfs for a proposed pulp and paper mill at Bend. Supplies seem to be adequate to satisfy present demands and no quality problems are evident.

Mining

There are no water rights for mining in this sub-basin. Existing mining operations are

confined to sand and gravel operations and a few establishments processing diatomite, cinders, and pumice whose demands for water are small.

Recreation

Water rights for recreational use are negligible and total less than one cfs in this sub-basin. However, water plays an important part in the overall recreation picture of this area. Many tourists are attracted to this area each year, mainly by the many lakes on the slopes of the Cascade Mountains and the scenic Metolius and Deschutes River Canyons.

There are approximately 90 lakes and reservoirs with a total surface area of 2,160 acres in this area, the largest being Lake Simtustus, behind Pelton Dam, with a surface area of 540 acres. Suttle Lake, with a surface area of 270 acres, is located in the center of another important recreation area.

There are eight state parks and one roadside rest area in the sub-basin. Peter Skene Ogden State Park had 120,000 visitor days in 1958, Cline Falls State Park 58,000, Pilot Butte State Park 80,000, and Cove Palisades State Park 47,000 visitor days and 13,000 camper nights. The trend in recreational use of some of these parks, starting with 1953 and projected to 1967, was shown in Figure 5.

Seven commercial resorts are operated in the sub-basin, four located on lakes, two on reservoirs, and one a ski area.

Other popular recreation spots include the park maintained by Portland General Electric Company on the shores of Lake Simtustus and Shevlin Park, owned by the City of Bend, on Tumalo Creek. Public boat landings are available on Lake Simtustus, Suttle Lake, Blue Lake, and Haystack Reservoir. Thirty-five forest camps are distributed over the Deschutes National Forest on the slopes of the Cascade Mountains. These recreation areas are located on Plate 5 and a summary of the facilities available at each area is available at the office of the State Water Resources Board.

Wildlife

Mule deer is the most important game species in this sub-basin and Deschutes and Jefferson Counties are among the most popular hunting areas in the state. In Deschutes County 14,640 hunters killed 5,170 deer and in Jefferson County 3,710 hunters killed 1,950 deer in the 1958 season. Several species of upland game, waterfowl, and furbearers are also found in this region.

Irrigation has had a considerable effect on the wildlife of the area, particularly upland game and waterfowl. Ringneck pheasants are probably the most important of the upland game species and they do best on farm land. Therefore, extension of the area utilized in diversified farming increases the potential of pheasant habitat. This was demonstrated by the advent of the North Unit Irrigation District which was followed by an increased pheasant population. A problem sometimes arises from crop damages by the birds and from sportsman-landowner relations.

Fish Life

Water rights for the propagation of fish total 53 cfs in this sub-basin. The Oregon State Game Commission holds a right for 8 cfs from Tumalo Creek and 10 cfs from the Metolius River and the Fish Commission a right for 35 cfs also from the Metolius River. Fish hatcheries are operated at present by the Game Commission near Wizard Falls and by the Fish Commission near Camp Sherman, both on the Metolius River.

The principal species of anadromous fish spawning in the Middle Deschutes sub-basin are chinook salmon and steelhead trout. Blueback have been recently introduced by the Fish Commission and results to date show promise.

The Metolius stream system, particularly in the Camp Sherman area, and the lower few miles of Squaw Creek provide important spawning grounds for chinook. The Deschutes River below Big Falls, mile 132, also serves, to a lesser degree, as spawning ground for chinook. These are indicated on Plate 10.

Spring chinook enter the Deschutes River in April and May and spawn in August and September. It is estimated from surveys that up to 5,000 spring chinook enter the Deschutes River in a single year. Recent counts at Pelton Dam have shown about 500 passing through the fishways each year on their way to upstream spawning areas.

Steelhead trout make heavy use of Squaw Creek for spawning purposes and, to a lesser extent, the Deschutes between Lake Simtustus, mile 112, and Big Falls, mile 132 (Plate 11).

Steelhead generally enter the river in May through September and spawn principally the following March and April. Counts of steelhead at Pelton Dam upstream fish facilities have been about 1,500 each year.

Blueback salmon spawn in Link Creek connecting Blue and Suttle Lakes, a few miles of Lake Creek below Suttle Lake, and lower Jack Creek.

SUB-BASIN INVENTORY - MIDDLE DESCHUTES

A small run of blueback salmon returns to the Metolius River system each year. Blueback enter the Deschutes River in July, August, and September and spawn in September, October, and November. Downstream migration from Suttle Lake occurs in April, May, and June.

The principal species of resident game fish in this sub-basin include rainbow, Dolly Varden, brown and eastern brook trout, land-locked blueback (kokanee), and whitefish.

Resident trout spawning areas are shown on Plate 12 which illustrates the importance of the Deschutes and Metolius Rivers and Squaw Creek in this respect as well as smaller tributaries such as Tumalo and Indian Ford Creeks.

Fishing pressure on the Metolius and Deschutes Rivers is so heavy that thousands of rainbow trout of legal length are stocked each year. Other streams in the sub-basin are dependent upon natural reproduction. Link and Lake Creeks are of special importance in the natural reproduction of kokanee salmon and brown trout for the Suttle Lake fishery.

Haystack Reservoir on the North Unit main canal is stocked with rainbow trout and has proven to be very popular for both fishing and boating. Lake Simtustus is not stocked by the Game Commission since fishing rights in this reservoir are the property of the Warm Springs Indians.

Low flows create a major problem in Squaw Creek, an important tributary, by trapping adult steelhead after they have ascended to spawn as a result of diversions below the spawning grounds.

Other fish problems in this sub-basin include the loss of fish through unscreened irrigation diversions and turbidity caused by irrigation return flows and high water temperatures created, in part, by inadequate streamflows during the irrigation season.

The Fish Commission of Oregon is currently evaluating the fish passage facilities of Pelton Dam but the full impact of this dam on anadromous fish will not be known for some time. The Fish Commission states, however, that less than the expected number of downstream migrants of chinook salmon and steelhead trout pass the dam and, to date, no downstream migrant blueback salmon fingerlings have been collected.

Squawfish, suckers, chiselmouths, and other coarse fish are native to the Deschutes River and, according to the Game Commission, are becoming more abundant in the relatively new reservoir behind Pelton Dam. Some of these species are predators on salmonids as well as competitors for food.

Adequate streamflow for both spawning and migratory purposes is often a problem in this sub-basin. Desirable minimum flows (Table 11) of 200 cfs during the irrigation season and 300 cfs for the remainder of the year in the Deschutes River between Bend and the mouth of Squaw Creek are recommended by the Oregon Game Commission for the maintenance of the present level of fish production. However, the State Engineer provides for a minimum flow of only 50 cfs below Bend and flows in this stretch of the Deschutes have been below this minimum level a number of times during extreme low flow periods.

No studies have been conducted to determine the effect of maintaining various conservation flows in the Deschutes River below Bend on irrigation shortages. Maintaining a conservation flow of 50 cfs in the Deschutes River below North Canal Dam near Bend during the irrigation season amounts to 21,200 acre-feet of water which cannot be used for irrigation diversions near Bend. Increasing this conservation flow to 200 cfs, as recommended by the Game Commission, would result in 84,900 acre-feet during the irrigation season which could not be used for irrigation diversions near Bend.

Anadromous steelhead, chinook, and resident trout pass Steelhead Falls during high flows, but Big Falls has become the upper limit of anadromous fish migration because ladders at this location and Cline Falls are nearly inoperative due to low flows during the period of fish migration combined with a state of disrepair. The rehabilitation of these ladders in connection with the provision of sufficient flows would greatly enhance fish populations, mainly resident trout and steelhead, in the Deschutes River between Steelhead Falls and Bend.

As shown in Figures 12 and 13 and discussed in Chapter II, water temperatures of the major streams are generally within the desirable range, 45 to 65° F., for salmonids. It is probable that extreme temperatures in smaller tributaries lie far outside this range and the current study being conducted by the Oregon Game Commission will establish whether or not that is the case.

Pollution Abatement

Public sewerage systems in this sub-basin are located at Bend and at the Warm Springs Indian Agency. Bend has a total population of about 12,000 but its sewerage system only serves the main business section of the city, a population of 1,300. This system disposes of sewage into lava sink holes after primary treatment. Other households dispose of their wastes into individual septic tanks and drilled lava sink holes. The method of disposing of sewage into lava sink holes is also used by other unsewered communities in the basin.

The sewerage system of the Warm Springs Indian Agency serves 500 people and disposes

of the wastes into Shitike Creek after secondary treatment in a trickling filter.

Industrial sources of pollution include dairies and food processing plants. Industrial waste in one case is discharged into seepage pits after treatment in a septic tank. In a few other cases, waste is discharged into seepage pits after treatment in lagoons.

During the latter part of 1958 a basic data survey of the ground and surface waters in the Bend-Redmond area of the Deschutes River Basin was started by the State Sanitary Authority in connection with a proposed location of a pulp mill in that region. This survey consists primarily of a study to establish the present quality of surface and ground water in the area to serve as a base for determining the effect, if any, of pulp and paper waste discharges on this quality in the advent that such a development takes place. It has been determined from this survey, which is still in progress, that surface and ground water in this area are generally of good quality, require a minimum of treatment for domestic purposes and, further, that there is little evidence of ground water pollution resulting from the practice of disposing of sewage into lava sink holes.

WATER CONTROL

Flood Control, Drainage, and Erosion

There are no major flood problems in the Middle Deschutes sub-basin. Small streams have high snowmelt runoff in the months April to June but peak flows are usually below the flood stage. Of the major streams, the Metolius River exhibits uniform flows throughout the year and Deschutes River flows are regulated by storage in headwater reservoirs and by irrigation diversions near Bend resulting in a reduction of flood danger.

Cloudbursts in the Upper Willow Creek watershed create severe erosion damage on dry crop lands and some flooding in the area of Madras. High flood flows are increasingly deepening and widening small stream channels and serious streambank erosion has occurred in parts of the Lower Willow Creek channel.

Drainage problems exist in a few areas, mainly within the irrigated lands between Bend and Redmond, below Tumalo Reservoir, and on Indian Ford Creek, where high water tables are created by excessive irrigation (Plate 13).

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic

Future domestic needs in the more populated parts of the sub-basin will have to be met

from surface water sources until the ground water resources are better defined and can be developed economically. Proposals have been made to reserve the total flow of Tumalo Creek for domestic, municipal, and industrial purposes and to transfer the irrigation rights on Tumalo Creek to the Deschutes River as soon as additional irrigation water can be made available on the Deschutes River, either by additional storage or by means of water savings. Proposals have also been made to reserve the total flow of Opal Springs in the Lower Crooked River Canyon, which averages 223 cfs, and 100 cfs of the Metolius River for the same purposes to assure adequate water supplies for future developments. Opal Springs discharges an average of 223 cfs but only 2 cfs are used at present under a water right of 5 cfs.

Municipal

All municipalities in this sub-basin recorded an increase in population and water use in the past years. The demand on the Bend water system has increased uniformly five percent per year for many years and, on that basis, the system will be adequate for several more years unless an industrial demand arises from a major water-using industry. Supplemental water from wells has been considered by the city but quality remains an unknown factor. The Deschutes River is a potential source of municipal water for Bend but objections arise in that respect because of the superior quality of Tumalo Creek water, the present source.

If the proposal to reserve all of the flow of Tumalo Creek for domestic, municipal, and industrial purposes were to take place, this source could also serve Redmond and other communities and rural households in this area. Redmond presently is served by the Pilot Butte Irrigation Canal and no shortages are expected within the next few years.

The City of Madras feels that its present system and supply is adequate for the immediate future.

Irrigation

Potentially irrigable lands in this sub-basin include many small individual tracts scattered among presently irrigated lands of the existing irrigation districts (Plate 4). The Bureau of Reclamation estimates that 10,700 acres are still potentially irrigable within the districts of the Deschutes Project. This figure includes 1,500 irrigable acres in the Arnold Irrigation District, 4,900 in the Central Oregon Irrigation District, 200 in the Crook County Improvement District No. 1, 600 in the Deschutes County Municipal Improvement District, and 3,500 in the North Unit Irrigation District. Irrigation of most of these lands would depend on water from the Deschutes River and consequently on developing new storage facilities or improving the efficiency of present systems.

SUB-BASIN INVENTORY - MIDDLE DESCHUTES

Storage investigations made in 1936 recommended various reservoir sites in the Upper Deschutes sub-basin which would store water for irrigation of lands below Bend. These investigations included storage in Davis Lake, Odell Lake, two reservoir sites on Crescent Creek, a reservoir site on Big Marsh Creek, and a transmountain diversion from Waldo Lake to the Deschutes Basin. These proposals were made before the construction of Wickiup Reservoir and the suggested projects are no longer considered feasible.

The only reservoir site on the Upper Deschutes River presently considered feasible by the Bureau of Reclamation is at Benham Falls. However, water stored in this reservoir would be sufficient only to reduce existing shortages and not to bring additional dry lands under irrigation.

Natural lakes considered as possible sources for irrigation water in this sub-basin include Suttle Lake, Blue Lake, and Big and Little Three Creek Lakes. Only Big and Little Three Creek Lakes have been developed for storage of irrigation water, totaling 1,600 acre-feet, for lands of the Snow Creek Irrigation District.

Suttle Lake was considered a possible source for irrigation water by the Bureau of Reclamation for irrigation of lands in the Plainview District, by the Squaw Creek Irrigation District for lands near Sisters, and by the Suttle Lake Irrigation District for lands near Grandview. All of these proposals have been abandoned because of the high costs of a canal to the distant lands and of the compensation of recreational developments on Suttle and Blue Lakes.

Squaw Creek Irrigation District in a recent application for Suttle Lake storage mentioned the Green Lakes as possible sources for irrigation water. These lakes are fed mainly by Prouty Glacier of the South Sister and drain into Sparks Lake which does not have a surface outlet.

Diversions to Suttle Lake appear to be possible from Big Lake on the west side of the Santiam Summit, from Square, Long, and Round Lake, and from First and Cache Creek, but no investigations have been conducted.

Several areas outside the existing irrigation districts are considered potentially irrigable. About 6,000 to 7,000 acres could be irrigated east of the Arnold Irrigation District and approximately 12,000 acres are considered potentially irrigable within the proposed West Side Unit of the Deschutes Project, located west of the Deschutes River between Cline Falls and Lower Bridge. These lands also would be dependent upon Deschutes River water.

Approximately 18,000 acres are considered potentially irrigable within the proposed Suttle Lake Irrigation District in the area of Grandview west of the Deschutes River

between the mouth of Squaw Creek and Metolius River. Plans for irrigation of these lands are based on diversion of water from Lake Creek and First Creek, tributaries of the Metolius River.

Approximately 1,500 acres of new land could be irrigated in the area of Grizzly on Willow Creek if an adequate supply of water were available.

Presently irrigated lands do not receive an adequate water supply with shortages up to 50 percent in some areas in dry years. Therefore, it is as much a problem to provide supplemental water for existing irrigated lands as it is to bring new lands under irrigation.

It has been estimated that the unallocated water of the Prineville Reservoir, now under construction on the Crooked River, could provide full supply to 10,500 acres of land within and adjacent to the North Unit Irrigation District.

Power

The undeveloped power potential of the sub-basin was computed using proposed potential power sites not in conflict with each other or with existing developments. Computations were based on monthly mean flows for the power years July 1928 to June 1948, an overall plant efficiency of 80.8 percent, a flow of 100 cfs for fish facilities, and run-of-river projects which disregarded storage and variations in demand.

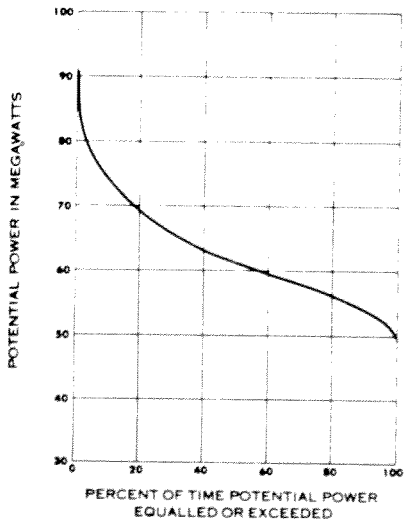


FIGURE 29. Undeveloped power potential of the Metolius River.

All major potential power sites in this sub-basin, with the exception of Round Butte on the Deschutes River above Pelton, are located on the Metolius River. Results of this study, as shown in Figure 29, indicate that the power potential of the Metolius River is equal to or higher than 53,000 kilowatts 90 percent of the time and 74,000 kilowatts 10 percent of the time. The median power that can be developed is 62,000 kilowatts which represent an average annual energy production of 543 million kilowatt hours. The proposed Round Butte project would have an installed capacity of 275,000 kilowatts and an average annual production of 975 million kilowatt hours.

An additional potential exists in the form of two powerplants proposed by the Bureau

of Reclamation to be installed on a channel bypassing the Deschutes between Benham Falls and Lava Island. The primary purpose of this channel would be to eliminate seepage losses from the bottom of the river that presently exist in this section. By using all available diverted flows, these two plants would produce 120 million kilowatt hours of energy during the seven-month irrigation season. This is based upon 75 percent plant efficiency and average monthly diversions.

Industrial

The Middle Deschutes sub-basin has considerable potential for future industrial development and industrial expansion can be expected, particularly in secondary timber processing.

Current consideration is being given to a plan to build a pulp mill in the vicinity of Bend. A capacity of 250 to 300 tons per day seems to be the minimum economic size for a pulp mill in this area and studies indicate that the area could supply a pulp mill of 800-ton capacity if the raw material could be hauled economically from longer distances. Such an installation could require up to 10 cfs of water per 100 tons of capacity depending upon the process and its efficiency.

The major cities, Bend, Redmond, and Madras, feel that they can supply needs for small industrial developments but major water-using industries probably would have to develop their own supplies of water unless additional municipal sources of water supply were developed.

Mining

This sub-basin has the heaviest concentration of mining activities but such activity is restricted primarily to building materials. No other mineral deposits of economic importance are known to exist in this area so increases in mining will be associated with building and related materials. There are no water rights for these purposes and future needs will be of minor significance.

Recreation

The Parks Division of the Oregon State Highway Department reports that facilities at state parks in the Deschutes Basin are keeping up with the demand. At present, overflows occur only on peak days such as the opening of fishing season and a few summer week ends.

However, the heavy pressure at many parks including Cove Palisades, Tumalo, and Cline Falls indicates that existing facilities will need expanding and new facilities will be needed within a few years.

The recreational use of the Upper and Middle Deschutes sub-basins was estimated at 1,600,000 man days in 1959. Four times that number are expected in 1976 and 11 times as many in the year 2000.

Potential recreation areas listed by the Parks Division include Redmond Caves, Tetherow Bridge, Odin Falls, Lake Simtustus, and the Haystack Reservoir area. All of these, with the exception of Redmond Caves and Haystack Reservoir, are located on the main stem of the Deschutes River and their attractiveness would depend upon the maintenance of minimum flows in the river. Haystack Reservoir is located on the North Unit main canal and could be developed for general recreation use.

Wildlife

The principal big game in the Deschutes Basin is mule deer and some increase in the deer population can be expected as a result of logging operations which increase the area of suitable habitat.

Some increase in the numbers of upland game is generally observed adjacent to new irrigated lands and this will continue in the future.

Water needs for wildlife will not change materially in the future unless their habitat is changed appreciably by new developments.

Fish Life

The Oregon State Game Commission and the Fish Commission of Oregon report that this sub-basin has sufficient spawning ground and rearing areas to handle many times the number of fish presently utilizing the area. Such an increase, as well as preservation of existing fish populations is largely dependent upon maintenance of desirable minimum flows. Flows of 1,000 cfs in the Deschutes River between Bend and the mouth of Squaw Creek are recommended by the Game Commission for ideal fish production (Table 11). In light of the present level of development in the Upper and Middle Deschutes, such flows are not attainable. Even to develop a part of the fishery potential of the middle river would require storage and releases from storage reserved specifically for fish life.

A major controversy exists between fish and power interests concerning the proposed Round Butte Project on the Deschutes River below the mouth of the Metolius River.

Objections from fishery interests are based, in part, upon the fact that the reservoir would inundate some 25 miles of streams, the dam of 450 feet in height would create a major hazard to migratory fish, and the pattern of streamflow below the project would be altered appreciably.

Minimum flows needed by fish life in the lower river have not been determined but a study to establish this factor is currently being conducted by the Game Commission and a preliminary figure has been provided in connection with Round Butte.

Pollution Abatement

Deschutes River water is of good quality due in part to a state law prohibiting discharge of untreated wastes into the Deschutes River or its tributaries. Problems may arise in the future as a result of sewage disposal into lava sink holes but there is as yet no evidence to indicate that this practice affects the quality of the streams.

At Bend, where only 1/10 of the present population is served by the existing sewerage system, extension of the sewers and adoption of secondary treatment is advisable. Madras and Redmond, which do not have sewerage systems, will probably have pollution problems to overcome in the future.

SUB-BASIN 3 LOWER DESCHUTES RIVER

GENERAL

Location and Size

The Lower Deschutes sub-basin includes all of the drainage of the Deschutes River and its tributaries between its confluence with the Columbia River and river mile 96 near Mecca. This is the largest sub-basin and contains 2,693 square miles which is 26 percent of the total area of the Deschutes Basin.

Sixty-two percent of the sub-basin area lies in Wasco County, 20 percent in Jefferson County, 14 percent in Sherman County, and 2 percent each in Hood River and Crook Counties.

The western boundary of the sub-basin is formed by the Cascade Range. The southern boundary runs along the divide between Warm Springs River and Shitike Creek, crosses the Deschutes River near Mecca, and continues east between Mud Spring and Willow Creeks to the Ochoco Mountains. The eastern boundary is formed by the plateau between the Deschutes and John Day River Basins and the northern boundary by the Columbia River.

This sub-basin also includes the streams flowing directly into the Columbia River between the mouths of the John Day and Deschutes Rivers.

Stream System

The two major tributary streams in this sub-basin, Warm Springs and White Rivers, originate in the Cascade Mountains. The only stream of significance originating to the east is Trout Creek which has its headwaters in the Ochoco Mountains and the plateau between the Deschutes and John Day Basins.

There are approximately 2,200 miles of streams in this sub-basin of which only 760 miles are perennial in nature. These figures include 96 miles of the Deschutes River main stem, 52 miles of Trout Creek, 50 miles of Warm Springs River, and 49 miles of White River.

Profiles of these streams showing elevations versus stream miles are shown in Plate 2. The gradient of the Deschutes River between its mouth and river mile 96 is a fairly uniform 13 feet of drop per mile. Trout Creek drops about 432 feet per mile in its upper four miles, averages 89 feet per mile between river mile 48 and 37, and 41 feet per mile between river mile 37 and its mouth. Warm Springs River has widely varying gradients which average 49 feet of drop per mile. White River drops about 830 feet per mile in its upper four miles, 96 feet per mile between miles 45 and 20, and averages 48 feet per mile between river mile 20 and its mouth.

Climate

Average annual precipitation in the Cascades is estimated to range between 60 inches near the headwaters of Warm Springs River and 130 inches on Mt. Hood. Precipitation decreases rapidly towards the east to between 8 and 23 inches annually in the White River Valley and between 4 and 18 inches in the area east of the Deschutes River. Precipitation averages 2.72 inches at Friend and 3.78 inches at Antelope between May 1 and September 30.

Precipitation averages by months are shown in Figure 30 for two representative stations, Antelope and Friend. The Friend station is west of the Deschutes on the divide between the Deschutes and Hood Basins (Plate 14) and is representative of precipitation in the White River watershed. The Antelope station is east of the Deschutes near its boundary with the John Day Basin and is representative of precipitation in the eastern portion of the sub-basin.

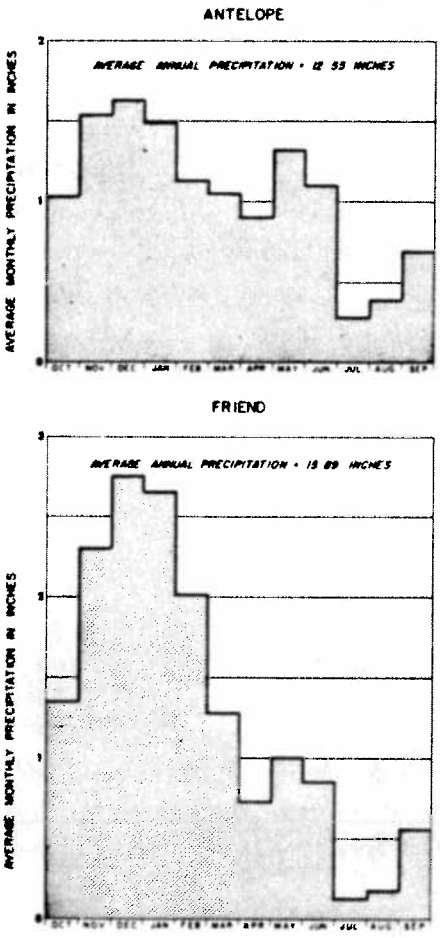


FIGURE 30. Average monthly precipitation at representative stations in the Lower Deschutes sub-basin, 1924-1958.

The seasonal pattern of precipitation is similar at both locations, high in the winter months and low in the summer, but the December-January peak is much more pronounced at Friend and represents a much larger percentage of the annual precipitation than at Antelope. Both stations exhibit a second, lesser peak during May and June and both have their extreme low precipitation, 0.5 inch or less, in July and August.

Annual snowfall in the sub-basin averages 50 inches between Wamic and Friend and 23 inches between Wasco and the headwaters of Hay Creek.

Temperatures from minus 34 to plus 113 degrees Fahrenheit have been recorded at elevations between 160 and 3,000 feet above mean sea level, and the average annual temperature ranges from 45 to 51° F. at those elevations.

The average number of days without killing frost is 110 days at Wamic, 130 at Antelope, and increases towards Wasco to 170 days.

Population

This sub-basin is comparatively sparsely populated with an estimated population of 3,540 in 1960. Incorporated cities and their 1960 populations include Maupin 380, Wasco 350, and Antelope 50. There are 29 other towns in the sub-basin of which only 4 have populations above 100.

ECONOMY AND LAND USE

Land Ownership

This sub-basin has the highest percentage of private lands of all sub-basins in the Deschutes Basin. Only about 14 percent of the total sub-basin area is national forest land, which lies within the Mt. Hood National Forest, 2 percent is public domain, and about 1 percent is under other federal ownership status. About 21 percent of the sub-basin area is within the Warm Springs Indian Reservation, less than 1 percent is owned by the State of Oregon, and the remaining 62 percent of the sub-basin area is largely under private ownership.

Timber

Timber and agriculture are considered to be the principal industries in this sub-basin. Most of the commercial forests are within either the Warm Springs Indian Reservation or the Mt. Hood National Forest. About 50 percent of the commercial forest area is in ponderosa pine, 30 percent in Douglas fir, and the remainder predominantly in hemlock and lodgepole pine.

Log production in the Deschutes Basin portion of the Mt. Hood National Forest in 1959 was 43 million board feet and the heaviest concentration of sawmill activity associated with this production is at Maupin.

Agriculture

The principal agricultural areas of the sub-basin are in the White River watershed west of the Deschutes River and the Trout Creek watershed and plateaus east of the Deschutes. Irrigation is practiced along White River and its main tributaries and along Trout, Hay, and Antelope Creeks.

There are approximately 620 farms in this sub-basin with wheat being the main field

crop which is raised primarily by dry farming methods. The principal livestock is beef cattle and sheep.

Recreation

Tourist trade ranks third in the economy of the area but plays only a minor role in the total income of the sub-basin. The main recreational areas are along the Deschutes River Canyon and in the Mt. Hood National Forest.

Mining

Mining in this sub-basin is limited mainly to sand and gravel operations although two operations mining tuff are presently active. Perlite or volcanic glass has been processed in the past but this operation is no longer active.

Transportation Media

This sub-basin is crossed by an excellent system of federal and state highways. The principal highway is U. S. 97, known as The Dalles-California Highway, which traverses the sub-basin from north to south and connects it with the Columbia River Highway, U. S. 30. U. S. 197 from The Dalles and U. S. 26 from Portland connect the sub-basin with other points of Oregon.

Oregon 216 connects Grass Valley and Maupin with U. S. 26 near Wapinitia Pass. Several improved roads intersect the main highways and serve other communities in the sub-basin.

Regular bus service is available on U. S. 30, 97, and 197. Regular freight truck service is maintained on U. S. 26 between Portland and Klamath Falls and irregular freight service is available to most points in the sub-basin.

The Oregon Trunk Railroad from Bend crosses the sub-basin and intersects with the Union Pacific Railroad on the Columbia River. A Union Pacific spur line runs from the Columbia River south to Kent on the eastern boundary of the sub-basin. Freight service only is maintained within the sub-basin on these lines.

The only airport in the sub-basin is an emergency field near Wasco and commercial airline service is not available.

SURFACE WATER SUPPLY

Yield

Water entering the sub-basin is indicated by the annual yield of the Deschutes River near Madras, shown in Figure 22 and discussed in the previous section, which averaged 3,341,000 acre-feet annually for the period 1907-1958. Water leaving the sub-basin, which is the unconsumed yield of the entire Deschutes stream system, is indicated by the annual yield of the Deschutes River at Moody, shown in Figure 7 and discussed in Chapter II, which averaged 4,213,000 acre-feet annually for the same period. The difference in yield between the two locations, 872,000 acre-feet annually, can be attributed largely to the contribution of the Warm Springs and White Rivers.

Annual yields of White River, Figure 31, average 315,230 acre-feet annually for the period 1918-1958. The characteristic pattern of yields for the Deschutes stream system showing both wet and dry cycles is also apparent in Figure 31 although differences between the yields of individual years is more pronounced.

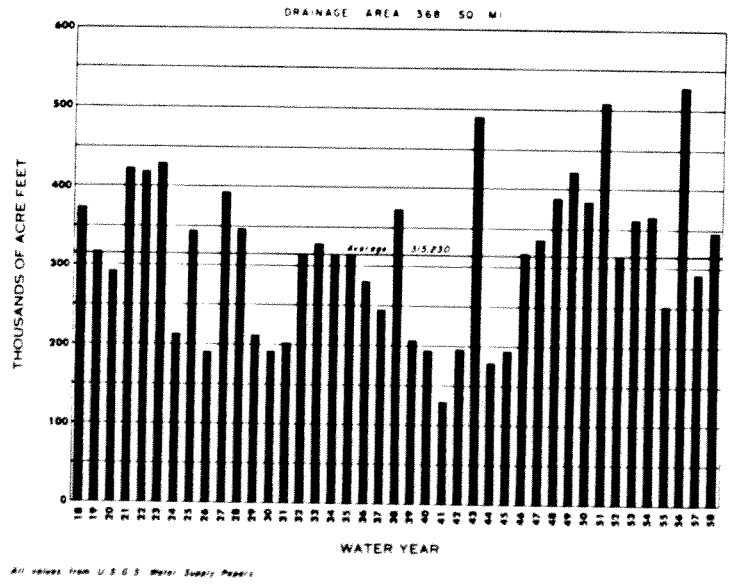


FIGURE 31. Annual yield of White River below Tygh Valley, 1918-1958.

Records available on Warm Springs River are inadequate for a similar representation of yields but, based upon such correlations as could be made, it is estimated that the average annual yield of this river for the same period is about 334,000 acre-feet.

Very few flow records are available on Trout Creek and precipitation data is also sketchy. This, combined with the fact that depletion of the streamflow is quite heavy but not measured, prevented determination of the yield although this stream is of major importance to the eastern portion of the sub-basin.

Distribution

Natural flow conditions in this sub-basin follow the general pattern of peaks during

spring rain and snowmelt and lows during late summer and early fall. This is illustrated in Figure 32 which shows the average monthly discharges of the Deschutes River at Moody and White River below Tygh Valley for the period 1918-1958. The pattern is similar except that the peak month is May on White River instead of April as on the Deschutes. Of particular significance is the high base flows in comparison to peak flows exhibited by the Deschutes in contrast to the very low base flows of White River. These high base flows are largely due to the effect of ground water storage which results in seasonal uniformity in the contribution of such streams as the Metolius River (Figure 25).

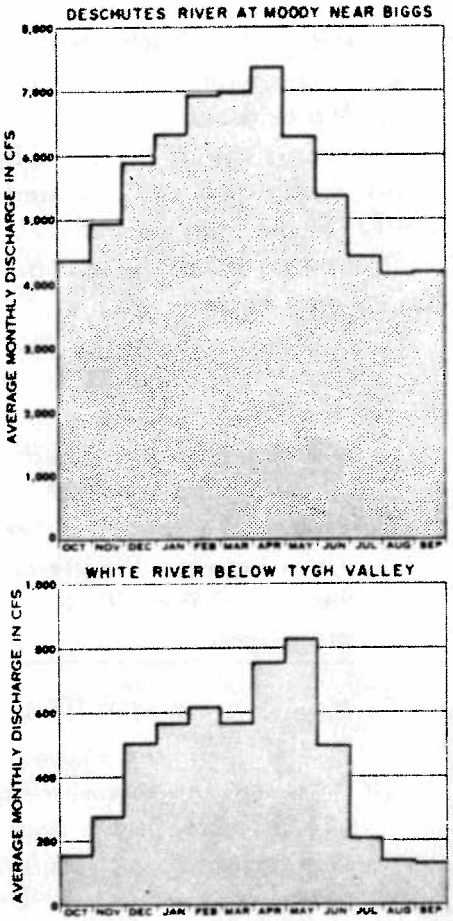


FIGURE 32. Average monthly discharges at representative stations in the Lower Deschutes sub-basin, 1918-1958.

Extremes

A further indication of the different characteristics in streamflow of the Deschutes and White Rivers is in comparison of average daily discharges for the water year having the minimum daily flow of record (Figure 33).

Even in a critical year, the uniformity of discharge and high base flow is evident in the Deschutes. The lowest flow of record at the Moody station was 3,380 cubic feet per second (cfs) on September 16-19, 1931 and flows were very uniform throughout the year with the exception of the first part of April.

In contrast, daily flows during the critical year for White River, 1920, varied appreciably with peaks of differing degrees occurring in November, December, January, February, April, and May and the lowest flow of 10 cfs also occurring in December. This low flow was repeated again on August 9, 1931.

Critical discharge and yield conditions at these and other stations throughout the basin were summarized in Table 8. The lowest annual yield of the Deschutes at Moody was also recorded in 1931 while that for White River occurred in 1941.

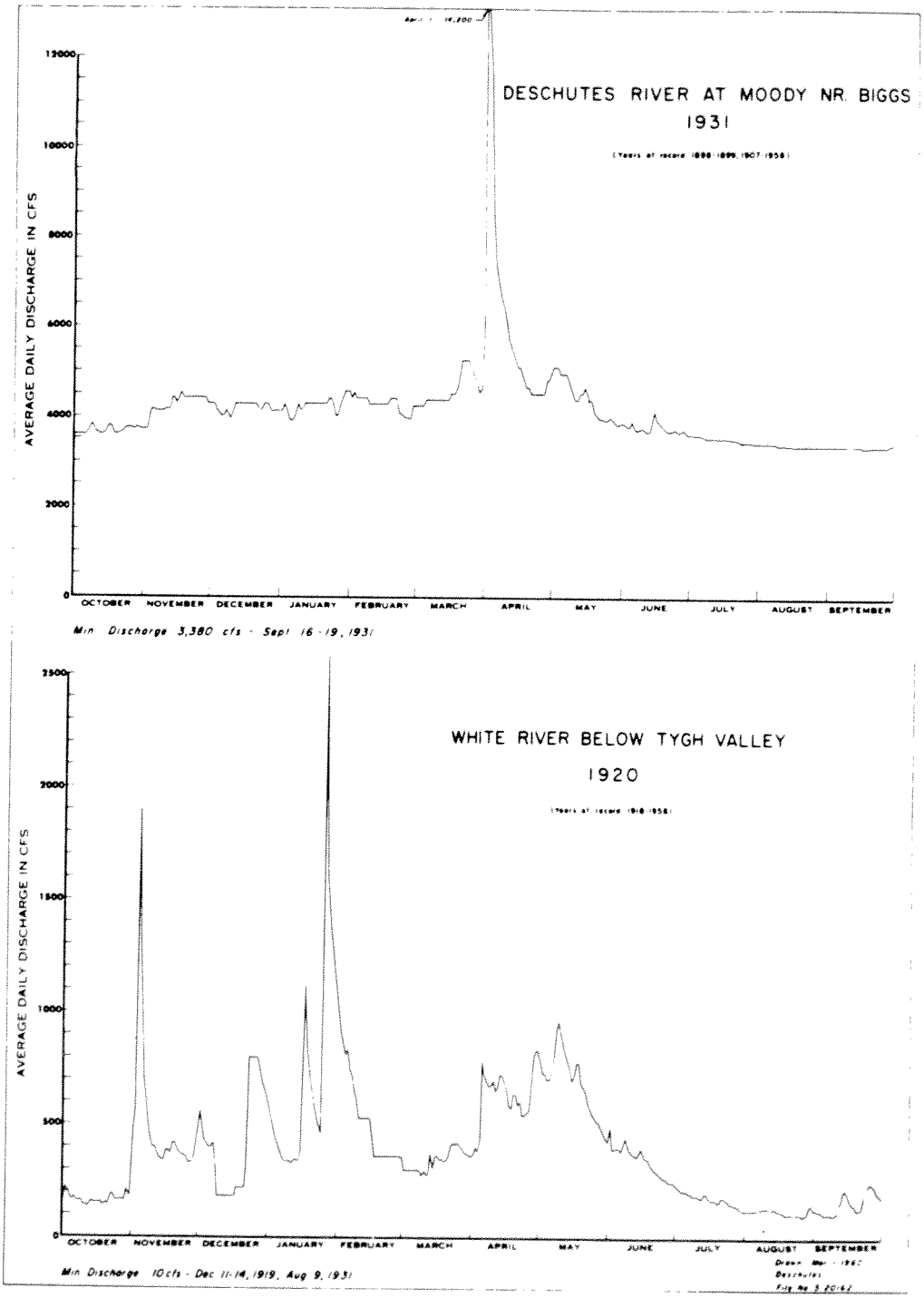


FIGURE 33. Discharge pattern for the water year having the minimum instantaneous flow of record at representative stations in the Lower Deschutes sub-basin.

Depletions

Water rights in the Deschutes Basin at their points of diversion are shown in Plate 7. Most rights in the Lower Deschutes sub-basin are on White River and its tributaries, Trout Creek and its tributaries, and along the Deschutes main stem. These rights are summarized by use and stream in Table 14.

TABLE 14

SURFACE WATER RIGHTS SUMMARY
SUB-BASIN 3 - LOWER DESCHUTES RIVER

USE	STREAM	CFS	TOTAL RIGHTS
Domestic	Antelope Creek	0.2	
	Badger Creek	0.4	
	Clear Creek	1.0	
	Deschutes River	1.2	
	Hay Creek	0.6	
	Rock Creek	0.1	
	Threemile Creek	0.2	
	Trout Creek	0.3	
	Tygh Creek	0.1	
	Wapinitia Creek	0.1	
	Warm Spring River	0.1	
	White River	0.3	
	TOTAL		4.6
Irrigation	Antelope Creek	6.2	
	Badger Creek	55.8	
	Buck Hollow Creek	1.6	
	Clear Creek	52.7	
	Columbia River	1.0	
	Deschutes River	8.1	
	Hay Creek	43.7	
	Rock Creek	12.0	
	Threemile Creek	26.6	
	Trout Creek	50.6	
	Tygh Creek	36.8	
	Wapinitia Creek	0.5	
	White River	42.6	
	TOTAL		338.2
Municipal	Antelope Creek	0.2	
	Badger Creek	1.0	
	Deschutes River	6.5	
	Threemile Creek	1.0	
	TOTAL		8.7
Industrial	Columbia River	0.1	
	Deschutes River	3.5	
	Tygh Creek	1.0	
	White River	0.2	
	TOTAL		4.8
Recreation	Warm Springs River	0.5	
	TOTAL		0.5
Power	Badger Creek	1.3	
	Clear Creek	0.1	
	Deschutes River	20.0	
	White River	262.0	
	TOTAL		283.4
Mining	Deschutes River	51.0	
	TOTAL		51.0
Fish	Deschutes River	71.4	
	TOTAL		71.4
	GRAND TOTAL		762.6

Irrigation rights form the largest group of surface water rights, totaling 338 cfs for the irrigation of 17,456 acres. Other consumptive rights include 5 cfs for domestic, 9 cfs for municipal, and 5 cfs for industrial purposes. Power rights, the second largest group, total 283 cfs, mining rights 51 cfs, fish rights 71 cfs, and 0.5 cfs are for recreational use. All water rights combined total 763 cfs, of which 357 cfs are consumptive and 406 cfs non-consumptive in nature.

The pattern of legal rights to use water by stream miles for the entire Deschutes Basin was shown in Figure 9. The Lower Deschutes portion of this extends from mile 96 to the mouth of the Deschutes and the largest block in this section is on White River.

Depletions along White River are shown in Figure 34. Total legal rights are nearly 500 cfs, 65 percent of the sub-basin total, and consumptive rights along White River add to about 230 cfs, also 65 percent of the sub-basin total.

While these depletion diagrams show the total of all rights, they do not indicate actual water use for the following reasons:

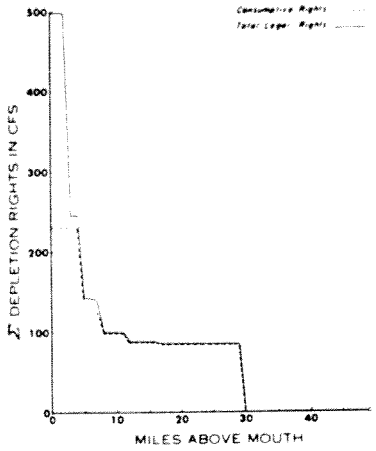


FIGURE 34. Legal depletion rights by stream mile of White River as of January 1960.

1. *Irrigation rights are seasonal in nature with actual use depending upon the pattern of rainfall occurring during the specific season in question, the availability of water during that season, and the pattern of rotation practiced by the individual water user.*

2. *Some irrigation rights are filed with the knowledge that low flows of the streams have already been appropriated and subsequent rights can be exercised only during the higher flow period at the first and last parts of the irrigation season.*

3. *A portion of diverted water reappears in the streams as return flow.*

4. *Power, mining, and fish life rights are almost entirely nonconsumptive in nature so that water diverted for these purposes becomes available for other uses at downstream locations.*

Ordinate values on the depletion diagrams do not include supplemental irrigation rights and these are not part of Table 14. Supplemental rights permit alternate sources of supply but do not add to original rights.

If all consumptive water rights in the sub-basin were used to the maximum legal extent, approximately 85,000 acre-feet could be diverted from the streams each year. This is far less than the average annual yield of all streams in the sub-basin, but shortages exist at many locations because of low flows at the times of heaviest use and lack of storage with which to regulate these flows.

GROUND WATER SUPPLY

Sub-basin 3

Yield and Distribution

Available data concerning the extent and movement of ground water in the Lower Deschutes sub-basin is limited in scope and much of it is incomplete. Therefore, only general conclusions can be drawn about the amount and distribution of ground water in this sub-basin.

Well logs in the Rufus area show the wells to be between 100 and 300 feet deep with water encountered in basalt. The static water levels vary from 40 to 200 feet below land surface.

An increasing use of ground water for irrigation is taking place in the Wasco area. One successful well was drilled to a depth of 712 feet with water encountered in basalt at a depth of 649 feet. The static water level is 14 inches below land surface and a pump test yielded 640 gallons per minute (gpm) with 77 feet of drawdown.

Three wells in the area between Buck Hollow and Bakeoven Creeks have depths ranging between 220 and 402 feet with water encountered in volcanic tuff, scoria, and basalt at depths between 188 and 330 feet below land surface. Bailer tests for these wells yielded 15 gpm at drawdowns up to 40 feet.

Two wells at Gateway, 229 and 300 feet deep, encountered water in sandstone at depths of 174 and 216 feet. Bailer tests yielded 7 and 10 gpm with drawdowns to the bottom of the wells.

A well near Ashwood, drilled 186 feet deep into andesite, with a static water level of 45 feet was bailed dry at 6 gpm.

Logs for wells along Mud Spring Creek indicate depths between 100 and 135 feet with water found between 90 and 125 feet in basalt. Bailer tests yielded between 5 and 10 gpm with drawdowns of 1 to 7 feet.

Higher yields are obtained from wells drilled in the area between Little Willow Creek and Aubrey Creek. These wells are from 535 to 550 feet deep and encountered water 412 feet below land surface in sand. Pump tests yielded from 1,125 gpm to 1,475 gpm at drawdowns from 155 to 235 feet.

Only a few logs are available for wells located west of the Deschutes River. Five wells near Tygh Valley, drilled to depths between 25 and 80 feet, found water between 8 and 40 feet below land surface. All these wells are located close to creeks and were drilled to gravel. Pump tests yielded between 10 and 50 gpm with drawdowns up to 11 feet.

A well on Juniper Flat, drilled to a depth of 234 feet, encountered water 229 feet below land surface in sand. The well was tested by the driller at 14 gpm with no apparent drawdown.

A well located a few miles north of Warm Springs was drilled to a depth of 300 feet and water was encountered 88 feet below land surface in soft lava rock. The sustained yield of this well is estimated to be two gpm.

To p. 35

Depletions

Ground water rights in the Lower Deschutes sub-basin total only 18 cfs. Seventeen cfs are for the irrigation of 1,482 acres and less than one cfs is for the municipal supply system of the town of Rufus.

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

In 1915 the State Engineer withdrew and withheld from appropriation all unappropriated water of Threemile and Gate Creeks, all tributaries of White River, for irrigation. He also withdrew and withheld from appropriation all unappropriated water of White River and its tributaries for irrigation, power, and domestic purposes. Twelve thousand acre-feet were withdrawn for storage in a proposed Clear Lake Reservoir for the same purposes. Under this withdrawal 11,660 acre-feet have been appropriated to the Juniper Division of the Wapinitia Irrigation Project for storage of irrigation water in Wasco Reservoir (Clear Lake) and 8,856 acre-feet of supplemental water for the irrigation of 2,208 acres.

In 1959 the Oregon State Water Resources Board reserved all unappropriated water of the main stem of the Deschutes River between its confluence and river mile 100 for domestic, livestock, recreation, fish, and wildlife purposes.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Domestic water in this sub-basin is obtained from wells, springs, streams, and irrigation ditches. Some farmers store water in farm ponds and cisterns which are filled from irrigation canals in the early spring and again filled after fall irrigation. Many domestic wells in the White River watershed are drilled to depths between 200 and 400 feet. Wells in the Mud Spring area, a tributary of Trout Creek, have been found fairly reliable when drilled to depths between 400 and 800 feet to the Columbia River basalt.

Domestic water obtained from irrigation canals is usually included with irrigation rights and not filed separately. Adjudicated irrigation rights in the White River watershed are entitled to domestic and stock water at the rate of 1/40 cfs per each 1,000 head of stock. The quantity diverted for irrigation shall include the amount for stock and domestic uses. Separate domestic rights in this sub-basin total only five cfs.

Municipal

Municipal water rights in this sub-basin total nine cfs of which seven cfs are held by the City of Maupin, one cfs each by Tygh Valley and Wamic, and less than one cfs each by Antelope and Rufus. Maupin, Tygh Valley, and Antelope obtain water from springs and Wasco and Rufus from wells. No municipal water right for Wasco has been recorded. The community of Pine Grove is interested in organizing a public corporation to establish a community water system using a nearby spring as its source of water. Currently, domestic water is taken from individual shallow wells which are recharged by irrigation seepage from the surface.

Water used for municipal purposes is of good quality in most cases and requires treatment by chlorination only. Adequate treatment is reported from all towns except Wamic which uses water without treatment from an irrigation ditch.

Irrigation

Irrigation rights, the largest group in the Lower Deschutes sub-basin, total 338 cfs for irrigation of 17,456 acres from surface water and 17 cfs for irrigation of 1,482 acres from ground water supplies. About 65 percent of these rights are located in the White River watershed and 30 percent in the Trout Creek watershed.

There is one major reservoir right for storage of 11,660 acre-feet in Wasco Reservoir, also known as Clear Lake, which will provide irrigation water for the Juniper Division of the Wapinitia Project of the Bureau of Reclamation. Construction of this project was completed in 1960 and irrigation deliveries will begin in 1961. This project will provide an adequate water supply for the irrigation of 2,108 acres.

The only other water right on a natural lake in this sub-basin is on Badger Lake for the storage of 660 acre-feet of irrigation water for the Badger Improvement District. Planning has started on a proposal to raise Badger Lake Dam 20 feet and thereby increase the storage approximately 1,100 acre-feet. Other storage rights in this sub-basin are for 13 smaller reservoirs totaling 4,835 acre-feet.

It was estimated that approximately 11,000 acres were under irrigation in the White River watershed in 1959. Only about 460 acres are irrigated directly from White River and these have a fairly adequate water supply through the entire irrigation season. The remaining lands have deficiencies amounting to 70 percent in dry years and 50 percent in an average water year. After completion of the Clear Lake Dam, it is expected that there will be no water deficiency for the 2,108 acres of irrigated land on Juniper Flat.

Irrigation water could be conserved by reducing transmission losses estimated to be as high as 50 percent in some cases, by improving water management within each farm unit, and by reconstructing distribution systems and structures.

The eastern part of the sub-basin is characterized by rather barren, arid, rolling terrain cut by deep rocky canyons. Portions of the ridges are dry farmed for the production of wheat and the less productive areas and canyons are used for grazing purposes only.

Irrigation east of the Deschutes River is limited primarily because of rugged topography and the pattern of streamflow - heavy floods in the spring and virtually dry creeks later in the season. Most of the irrigation takes place in the Trout Creek watershed and, in addition, about 160 acres are now irrigated with ground water in the Wasco area.

Power

Power rights, the second largest group in the sub-basin, total 283 cfs of which 260 cfs are held by Pacific Power and Light Company for the Tygh Valley plant on the White River. The remaining power rights are small and are for pumping of irrigation water and for the production of electric power for individual use.

Industrial

Industrial rights for the use of water are small and total only five cfs. They are scattered throughout the sub-basin and are for mining, milling, manufacturing, sawmills, sand and gravel plants, and railway use.

Mining

There are two mining rights in the sub-basin, one for 50 cfs and the other for 1 cfs, both issued for a volcanic glass or perlite processing plant on the Deschutes River main stem. This plant has not been in operation recently.

Recreation

Water rights for recreational use in this sub-basin are negligible, as with other sub-basins, and total only 0.5 cfs on Warm Springs River. Major recreational areas are the east slopes of the Cascade Mountains and the Deschutes River Canyon.

There are about 52 lakes and reservoirs in this sub-basin with a total surface area of approximately 1,860 acres, the largest being Clear Lake (Wasco Reservoir) with a surface area of 557 acres.

Recreation is not as important to the economy of this sub-basin as it is in some others which is indicated also by the smaller number of recreational facilities. About 29 forest camps are scattered over the slopes of the Cascade Mountains. There are no state parks in this sub-basin and only one roadside rest area, located on U. S. 97 in Cow Canyon. A private resort is maintained in the Deschutes Canyon south of Maupin and a public resort at Hot Springs in the Warm Springs Indian Reservation. There are seven public boat landings in the sub-basin, five on lakes and reservoirs, one on the Deschutes River, and one on the Columbia River.

Wildlife

Mule deer is the most important game animal found in this sub-basin. The Oregon State Game Commission purchased 7,673 acres of big game winter range in the White River area to accommodate herds which otherwise would inflict damage to crops on adjacent private land.

Game birds in the area include waterfowl, estimated at 3,000 to 5,000 by the Oregon State Game Commission, pheasants, quail, chukars, Hungarian partridge, and doves.

Furbearing animals in the area include beaver, muskrat, mink, otter, and martens.

No water problems in regard to wildlife are reported at the present.

Fish Life

Water rights for the propagation of fish in this sub-basin total 71 cfs and are held by the Oregon State Game Commission for the Oak Springs Fish Hatchery in the Deschutes River Canyon near Maupin.

Anadromous fish entering the Deschutes River include chinook salmon, steelhead trout, and blueback salmon. Chinook salmon spawn in this sub-basin on the main stem of the Deschutes River and on Warm Springs River and its tributaries (Plate 10). Steelhead trout spawn on the main stem of the Deschutes River, Bakeoven Creek, Buck Hollow Creek, Trout Creek and its tributaries, and Warm Springs River and its tributaries (Plate 11). Blueback salmon were introduced by the Oregon State Fish Commission on the Upper Metolius River and have not yet been found spawning in other areas.

Other important game fish in this sub-basin include rainbow, brown, eastern brook, and Dolly Varden trout. They spawn principally on the Deschutes River main stem, White River, Warm Springs River, Trout Creek and its tributaries, Buck Hollow Creek, and Bakeoven Creek (Plate 12).

A major problem in regard to the fishery resource in this sub-basin is that of inadequate flows in some of the streams. Bakeoven, Buck Hollow, and lower Trout Creek become completely dry and streamflows on White River at times fall below the desirable minimum (Table 11). Desirable minimum flows have not been established for the Lower Deschutes main stem and that is currently the subject of a study being conducted by the Oregon Game Commission.

Among other problems is the fact that both the Trout Creek and White River watershed contain irrigation diversions that should be screened in order to prevent fish losses in irrigation ditches.

Indians have conducted a dip-net fishery in the vicinity of Sherar Falls for years, taking as many as 1,000 salmon a season. This fishery has been increased since the Celilo Falls Indian Fishery was eliminated by construction of The Dalles Dam. Fish runs over Sherar Falls are maintained by a fish ladder constructed by the Oregon Fish Commission.

Water temperatures in the major streams in the sub-basin have been generally within the desirable range for salmonids, 45 to 65° F., except for lows occurring in December, January, and February, although they exceed the ideal range, 55 to 60° F. This situation also exists in the Lower Deschutes sub-basin as indicated by the 1953 water temperatures of the Warm Springs River at Hehe Mill, Figure 35. Maximum water

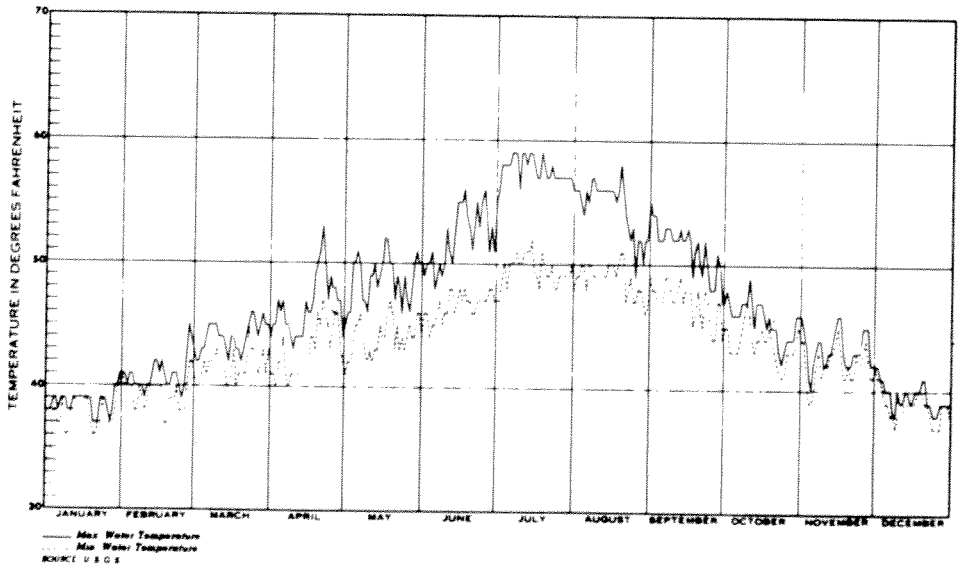


FIGURE 35. Seasonal pattern of water temperature of the Warm Springs River at Hehe Mill, 1953.

temperatures of 59° F. occurred at this location in the first half of July which corresponds to the time of peak temperatures on the Deschutes, Metolius, and Lower Crooked Rivers for the same year, Figures 12 and 13. During January of the same year a low of 34° F. was recorded in the Warm Springs River at Hehe Mill which also is similar to the temperature pattern in the other major streams.

While water temperatures do not create a major problem in these streams, it is very likely that extreme temperatures exist on most of the smaller tributaries, particularly those with a low base flow. Data being collected by the Game Commission for their current stream survey of the Deschutes system will show whether or not that is the case.

Pollution Abatement

Public sewerage systems in this sub-basin are located at Maupin and Wasco. The Maupin system serves a population of 200 and disposes of wastes, after treatment in septic tanks, into seepage pits and into the Deschutes River. This system is inadequate for present conditions which means that extension of the municipal sewer system and construction of a new treatment plant would be advisable. Wasco's system serves a population of 300 and disposes of wastes into Dry Creek after primary treatment in septic tanks.

Most homes outside of community systems dispose of wastes into septic tanks. No industrial sources of pollution are reported.

WATER CONTROL

Flood Control

Flood problems exist mainly in the Trout Creek watershed and other smaller watersheds east of the Deschutes River. Floods are flashy in nature and are caused by heavy spring rains combined with rapid snowmelt. An application for federal assistance under the Watershed Protection and Flood Prevention Act has been received by the State Engineer from the Trout Creek Soil Conservation District. The principal problems in this area are flooding and bank erosion combined with lack of late season flow for irrigation.

Some flood damage has been caused also in the Tygh Creek Valley, confined mostly to

soils, crops, and irrigation ditches. These floods are caused mainly by excessively rapid snowmelt in the higher reaches of the watershed.

Drainage and Erosion

No drainage problems of significance have been reported.

Severe water erosion occurs in the Lower Deschutes watershed as a result of one or more of the following: steep slopes; shallow, rocky soil; lack of vegetative cover; too intensive cropping practices. The areas involved are delineated on Plate 13. In many cases the erosion could be reduced or eliminated by changing the land use to a type that would provide the vegetative cover necessary to hold the soil in place. In some instances, particularly where steep slopes are involved, necessary remedial measures would be difficult to justify economically.

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic

Local opinion does not foresee an appreciable expansion in the population within the immediate future with the possible exception of new recreation facilities along the shores of the Deschutes River. Currently there is limited access to the river in this area so such a development, if it took place, would be very slow. Therefore, future domestic water requirements will increase slowly over the present level of needs.

Municipal

Population growth is expected to be very slow in this sub-basin so future demands for municipal water should not increase much over the present level.

Most communities in the sub-basin seem to have a water supply adequate to satisfy immediate future demands. Exceptions are Pine Grove and Tygh Valley which currently experience shortages and need an enlargement of existing facilities. Pine Grove does not have a community system as yet but attempts are being made to form a public corporation for that purpose. Wamic has adequate supplies at the present but would need additional water to satisfy future demands.

Irrigation

Only a small percentage of the lands presently farmed in this sub-basin are irrigated. Most potentially irrigable lands in this sub-basin lie in the White River watershed although there are smaller areas which could be irrigated on the plateaus between the Deschutes and John Day Rivers and in the Trout Creek watershed (Plate 4).

Since many of the streams east of the Deschutes go dry during the peak irrigation season, irrigation would be practical in this area only if low flows were supplemented. This might be accomplished by construction of small reservoirs to store heavy spring runoff for release later in the irrigation season. The Soil Conservation Service of the Department of Agriculture is currently conducting a field reconnaissance review of small watershed problems on eight areas in the Lower Deschutes sub-basin in order to determine the applicability of project action of the type and scope authorized by Public Law 566. This work is being carried out as part of the Department of Agriculture's cooperation with the State Water Resources Board in the Deschutes River Basin study.

The Lower Deschutes River flows in a deep canyon so that using this water for irrigation on surrounding plateaus would be expensive because of the high pumping lift.

About 11,000 acres are presently irrigated in the White River watershed and more than 30,000 additional acres of presently dry farmed lands are considered potentially irrigable. Since much of the presently irrigated land does not receive an adequate water supply, supplemental water is needed for these lands as well as water for new lands.

Two thousand one hundred and eight acres of land on Juniper Flat will receive an adequate water supply after completion of the Wasco Project of the Bureau of Reclamation. About 25,000 additional acres could be irrigated in this area if new sources of water could be developed. Similar conditions exist in other areas of the White River watershed where small tracts are irrigated within larger tracts that are dry farmed but potentially irrigable.

Irrigation has been applied to about 290 acres in the Antelope Creek watershed and there is an additional 580 acres adjacent to Antelope Creek which could be irrigated if storage were developed. There are about 600 acres of irrigated lands along Hay and Wilson Creeks, all having an inadequate water supply and suffering from late season water shortages. Approximately 1,000 acres of dry land could be developed for irrigation on these creeks if an adequate water supply were available.

Power

The Lower Deschutes River potential for hydroelectric power development was recognized many years ago. Since the river flows in a canyon several hundred feet deep and water would have to be pumped at large expense to the higher lying plateaus for many other purposes, the development of hydroelectric power was considered the best use of this stretch of the river.

However, in considering all uses of water, the State Water Resources Board determined that it would be in the best interest of the State of Oregon to use the unappropriated waters of the Deschutes River below Pelton Reregulating Dam for recreation, fish, and wildlife and all other uses, except domestic and livestock, shall be excluded from future appropriation in this stretch of the river.

Computations were made to determine the potential power at sites which have been suggested by various groups and agencies in this stretch of the river. These computations were based upon using all the head not in conflict with other sites, monthly mean flows for the power years July 1928 to June 1948 less 100 cfs for fish facilities, an overall plant efficiency of 80.8 percent for run-of-river projects, and no consideration of storage and variations in demand.

Results (Figure 36) indicate that the power potential of the Lower Deschutes River is equal or greater than 267 thousand kilowatts 90 percent of the time and 471 thousand kilowatts 10 percent of the time. The median power that can be developed is 341 thousand kilowatts which represents an average annual energy production of 2.99 billion kilowatt hours.

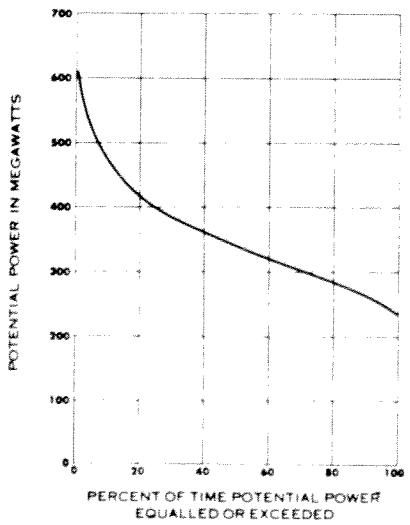


FIGURE 36. Undeveloped power potential of the Lower Deschutes River.

Average annual generation at the only major existing hydroelectric plant in this sub-basin, located on the White River near Tygh Valley, is 13 million kilowatt hours which is about one-half percent of the total undeveloped potential of this sub-basin.

Industrial

Existing industries in this sub-basin are chiefly lumber and building material operations. The demand for industrial water is small and probably will not increase in the future. No information is available on the potential for new developments.

Mining

There are several mineral deposits in the sub-basin (Plate 6) but only tuff is mined at the present. Present use of water for mining purposes is small and future developments of known mineral deposits are not expected to require large quantities of water.

Recreation

The principal recreation areas in this sub-basin are in the Hood River National Forest and the Deschutes River Canyon. The Parks Division of the State Highway Department lists two potential recreation areas within the sub-basin, one at the confluence of Bakeoven Creek with the Deschutes River, near Maupin, and the other at the mouth of the Deschutes River.

A detailed study of the area at the mouth of the Deschutes River was made by the Parks Division and, in 1955, the Oregon State Highway Commission approved purchase of the proposed park land but deferred construction until the Columbia Gorge Highway has been relocated and widened to four lanes. Main attractions at this park would be boating, fishing, and swimming on the Deschutes River and on Celilo Lake formed by The Dalles Dam on the Columbia River.

Wildlife

The amount of water used by wildlife is comparatively small and will not increase materially in the future.

Fish Life

This sub-basin has a great potential for increased fish populations it more advantageous conditions could be created. Low streamflows and, at times, completely dry creeks are the main problem in the Trout Creek watershed and other smaller drainages east of the Deschutes River. Future upstream water impoundments for flood control and irrigation could enhance fish life if such releases would consider fish water requirements. Bakeoven, Buck Hollow, and the Trout Creek systems contain remnant runs of summer steelhead which would benefit greatly from increased late summer flows.

A great potential for an increase in anadromous as well as resident game fish populations exists on White River and its tributaries. Good trout fishing for rainbow and, in some instances, eastern brook trout exist at the present but anadromous fish, mainly

chinook salmon and steelhead, are blocked from entering that drainage by a series of falls approximately one mile above the mouth of White River (Plate 2). Construction of fish ladders over these falls and the provisions for the maintenance of minimum flows in late summer and early fall would greatly enhance the fishery production in this area.

Pollution Abatement

No pollution problems in the streams and ground water are evident in the sub-basin and no problems are expected in the immediate future.

SUB-BASIN 4 UPPER CROOKED RIVER

GENERAL

Location and Size

The Upper Crooked River sub-basin includes all of the Crooked River watershed above river mile 66, near Hoffman Dam. This is the second largest of the sub-basins containing 2,479 square miles which is 24 percent of the total area of the Deschutes Basin.

Seventy-nine percent of the sub-basin area lies in Crook County, nine percent in Deschutes County, and three percent each in Wheeler, Grant, Harney, and Lake Counties.

The northern boundary of the sub-basin is formed by the Ochoco Mountains and the eastern boundary by the divide between Beaver Creek and the South Fork of the John Day River. The southern boundary is not well defined and runs along the dry plateaus between the Crooked River South Fork, and the Malheur Lake Basin in the southeast, and between Bear Creek and Dry River in the southwest. The western boundary crosses the Crooked River near Hoffman Dam and runs north into the Ochoco Mountains between the headwaters of the Crooked River North Fork and Ochoco Creek (Plate 1).

Stream System

Major tributaries of the Crooked River in this sub-basin are: the North Fork, with headwaters in the Ochoco Mountains; Beaver Creek, heading in the Ochoco Mountains and in the southwestern plateaus; the South Fork, with headwaters around Hampton Butte; and Camp and Bear Creeks which head in the Maury Mountains and southern plateaus (Plate 1).

There are approximately 1,980 miles of streams in this sub-basin of which only 330 miles are perennial in nature. These figures include 66 miles of the Crooked River main stem, 48 miles of the Crooked River North Fork, and 22 miles of Beaver Creek.

Profiles of these streams showing elevations versus stream miles are included in Plate 2. The North Fork of Crooked River drops an average of 67 feet per mile in its upper six miles and averages 26 feet per mile in its lower part. The main stem of Beaver Creek has an average gradient of 10 feet per mile. The main stem of the Crooked River has a fairly uniform gradient of approximately 8 feet per mile.

Climate

Average annual precipitation in the areas south of the Crooked River ranges between 11 and 14 inches. Annual precipitation extremes of 5 and 20 inches have been recorded in this area. Precipitation increases towards the north and varies between 11 and 27 inches

annually at the Ochoco Ranger Station in the Ochoco Mountains. Average annual precipitation in the areas north of the Crooked River ranges between 17 and 30 inches. Precipitation averages 3.60 inches at Bear Creek and 5.69 inches at Ochoco Ranger Station between May 1 and September 30.

Annual snowfall averages 72 inches at Ochoco Ranger Station. This weather station is located in the Lower Crooked River sub-basin, but is the closest active station which would indicate climatological conditions in the Ochoco Mountains within the Upper Crooked River sub-basin. Hydrological stations are located as shown in Plate 14.

Temperatures between minus 27 and plus 100 degrees Fahrenheit have been recorded in this sub-basin. Annual temperatures average between 40 and 44° F. at lower elevations.

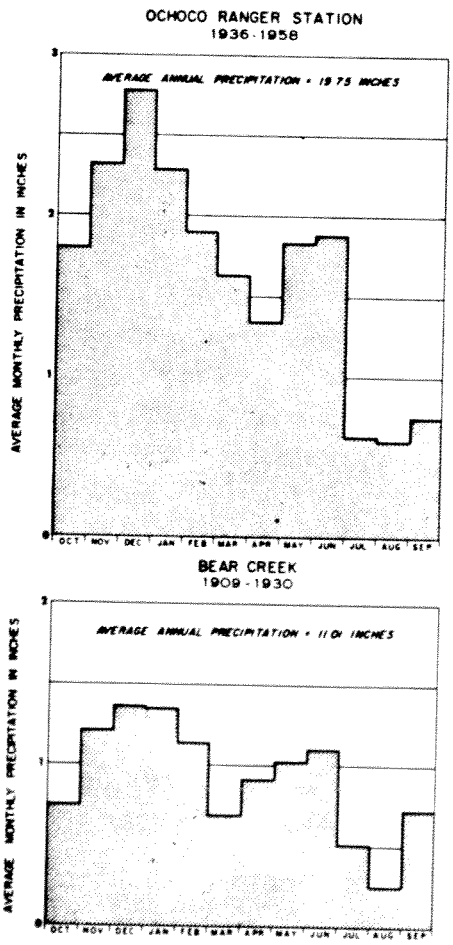


FIGURE 37. Average monthly precipitation at representative stations.

The average number of days without killing frosts is approximately 90 days in the southern portion of the sub-basin and increases to approximately 110 days along the northern boundary. Frosts can occur in any month of the year.

The pattern of precipitation by months in both the north and south parts of the sub-basin is indicated in Figure 37 which shows average monthly precipitations at the Bear Creek Station and the Ochoco Ranger Station. Seasonal characteristics are similar in that peak precipitation occurs in December and the minimum in August at both stations. However, the variation between the extremes is much greater at the higher elevation Ochoco Ranger Station than at the Bear Creek Station. Data available at these stations covered different years but both include dry and wet cycles so the direct comparison made above probably is valid. Figure 37 also indicates the higher precipitation in the northern part of the sub-basin by comparison of the annual averages which are about 20 inches at the Ochoco Ranger Station and 11 inches at Bear Creek.

Population

This is the most sparsely settled area in the Deschutes Basin with an estimated population of only 510 in 1960. There are no

incorporated cities in this sub-basin and all towns have populations below 100.

ECONOMY AND LAND USE

Land Ownership

Approximately 20 percent of the Upper Crooked River sub-basin is national forest land within the Ochoco National Forest, about 31 percent is public domain largely within the Crooked River grazing district, and an additional 1 percent is under other federal ownership status. About 2 percent of the sub-basin area is owned by the State of Oregon and the remaining 46 percent is largely under private ownership.

Timber

Most commercial forests in this sub-basin are located within the Ochoco National Forest in the Ochoco and Maury Mountains. Ponderosa pine is the predominant wood species and small acreages are covered by Douglas fir, white fir, western larch, and lodgepole pine. A large part of the commercial forests is in sawtimber stands. Extensive stands of juniper, classed as noncommercial forests, cover much of the remainder of the sub-basin. Only limited quantities of juniper are harvested and used for such purposes as fence posts, fuel wood, and small wooden novelties.

There are some logging operations but no large lumber mills in this sub-basin. Most of the timber cut is transported to mills outside the sub-basin, mainly to Prineville.

Agriculture

Agriculture is an important factor in the economy of this sub-basin. It is limited mainly to dry land farming, irrigation being practiced only on the main stem of the Crooked River and the lower sections of the major tributaries. There are approximately 80 farms in the sub-basin, raising mainly beef cattle and sheep. The most important feed crop is hay, which includes alfalfa. There are no food processing plants in the sub-basin.

Recreation

Since many streams go dry in the summer months and many others have insufficient flows to sustain fish life, fishing is limited as a contributing factor to recreation. A

major recreation attraction in this sub-basin is deer hunting in the Ochoco National Forest which attracts many hunters each season.

Mining

There are numerous mercury mines and prospects scattered throughout the Upper Crooked River sub-basin but at the present time mining activity is confined to a few small operations. A deposit of radioactive uranite has been found in the Bear Creek area and considerable exploration work has been performed. It is planned that once production is started shipments would be made to a reduction mill at Lakeview.

Transportation Media

No major U. S. or state highways cross the entire sub-basin. U. S. 20 from Bend to Burns cuts through the southern portion of the sub-basin at the town of Hampton. Oregon 27 travels through the western part along Crooked River and Bear Creek between Prineville and its intersection with U. S. 20.

A paved highway connects Prineville and Post and an improved highway leaves Oregon 27 at the confluence of Bear Creek, joins the Prineville-Post Highway, and continues from Post to Paulina and Suplee. Several shorter improved roads and forest roads make other areas of the sub-basin accessible.

Regular bus service is available only on U. S. 20. There are no regular freight truck routes but irregular service is available to most points in the sub-basin.

There are no railroads in this sub-basin.

The U. S. Forest Service maintains a summer landing strip on Big Summit prairie and an emergency air field, privately owned, is maintained near Hampton. There is no commercial airline service to this sub-basin.

SURFACE WATER SUPPLY

Yield

Very few gaging records are available on the streams in this sub-basin. The station with the longest observations is Crooked River above Hoffman Dam with records for the water years 1909 to 1914 and 1941 to 1958. These records were extended by correlation to include the critical water years in the 1930's. Annual yields for all years of

record together with correlated values are shown in Figure 38. There is considerable fluctuation from year to year but a general trend of low water years in the 1920's and

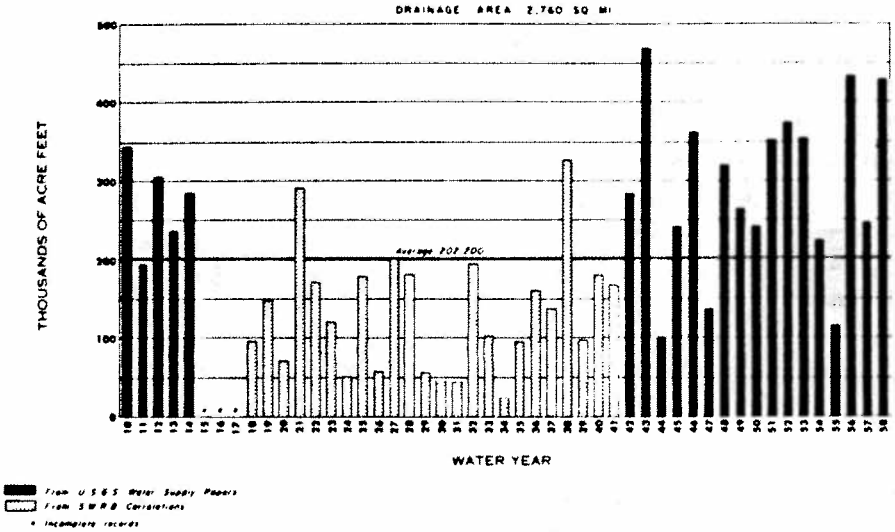


FIGURE 38. Annual yield of the Crooked River above Hoffman Dam, 1910-1958.

1930's and increasing yields in the 1940's and 1950's can be observed. The average annual yield of the Crooked River at this station is 202,200 acre-feet.

Correlations conducted by the U. S. Bureau of Reclamation for the same station for the period 1928 to 1941 show slightly smaller runoff values for water years with less than 100,000 acre-feet and slightly larger values for water years with runoff above 100,000 acre-feet. The lowest annual runoff was computed to be 23,200 acre-feet by the Bureau of Reclamation compared to 25,400 acre-feet computed by the State Water Resources Board. The average annual yield for the period 1928-1950 was computed to be 188,000 acre-feet by the Bureau of Reclamation compared to 184,400 acre-feet computed by the State Water Resources Board.

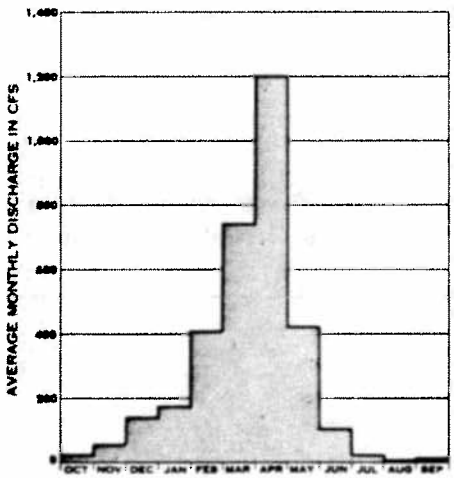


FIGURE 39. Average monthly discharge of the Crooked River above Hoffman Dam.

Distribution

Mean monthly discharges for the same location, Crooked River above Hoffman Dam, are shown in Figure 39. The runoff pattern at this location is characteristic for all streams in this

sub-basin. It shows very high flood peaks in March and April caused by rains and snow-melt in the mountains. In the summer months, streams go nearly dry as a result of very low precipitation and high irrigation diversions. The lowest monthly flows of the Crooked River above Hoffman Dam occur in August and average 8 cubic feet per second (cfs) compared to 1,200 cfs in April.

Extremes

No gaging stations were maintained on the Upper Crooked River and its tributaries during the low water years in the 1930's. The lowest recorded discharge of the Crooked River above Hoffman Dam was 0.5 cfs in August 1955. A daily discharge hydrograph for this water year is shown in Figure 40 which again illustrates the spring runoff peaks and the extreme low flows during the late summer months. Zero flows were observed at this location in 1940 but records for that year are incomplete.

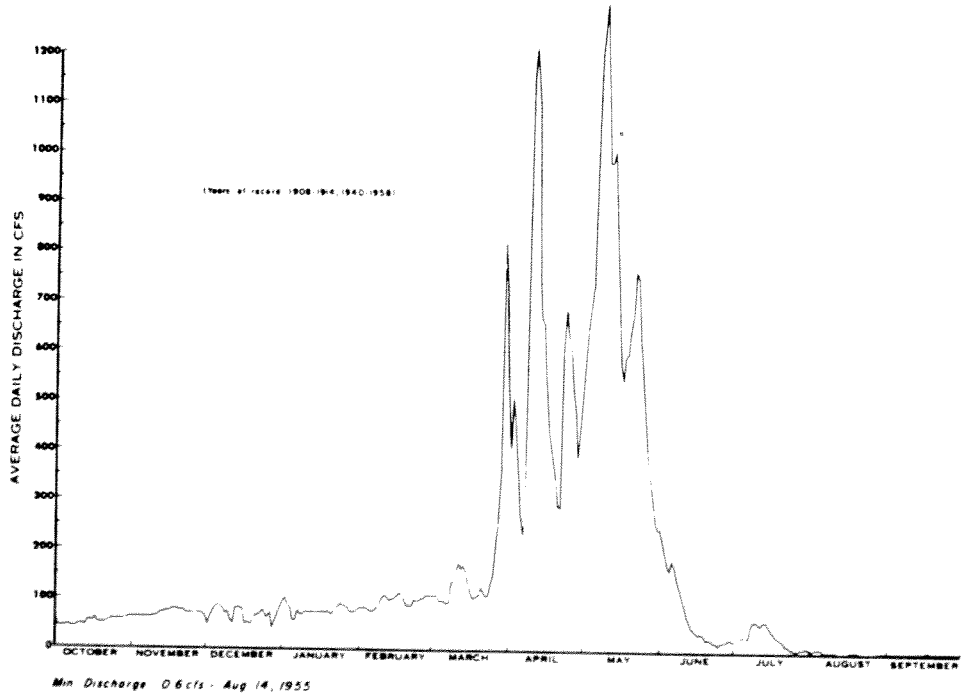


FIGURE 40. Discharge pattern of the Crooked River above Hoffman Dam for the complete water year having the minimum instantaneous flow of record, 1955.

Correlations established that the lowest annual yields at this location occurred in the 1930's. Table 8 summarized critical discharge and yield conditions which have been recorded at this and other stations in the Deschutes River Basin.

Depletions

Water rights in the Deschutes Basin at their points of diversion are shown in Plate 7. A detailed summary of these rights listing number, location, use, quantity, stream, and priority date is available at the office of the State Water Resources Board.

Water rights in the Upper Crooked sub-basin are pretty well scattered throughout the stream system. These rights are summarized by use and stream in Table 15.

The largest group of water rights is formed by irrigation rights which total 590 cfs for the irrigation of 45,502 acres. The only other consumptive water right is 1 cfs for domestic purposes and the only nonconsumptive water right is 0.05 cfs for mining. All rights total 591 cfs and are consumptive in nature with the exception of the small mining right.

TABLE 15

SURFACE WATER RIGHTS SUMMARY
SUB-BASIN 4 - UPPER CROOKED RIVER

USE	STREAM	CFS	TOTAL RIGHTS
Domestic	Beaver Creek	0.1	
	Camp Creek	0.1	
	Crooked River	0.1	
	Horse Heaven Creek	0.1	
	Johnson Creek	0.2	
	Little Bear Creek	0.1	
	South Fork Beaver Creek	0.2	
	South Fork Crooked River	0.1	
	Twelvemile Creek	0.1	
	TOTAL		1.1
Irrigation	Allen Creek	17.5	
	Bear Creek	15.1	
	Beaver Creek	51.0	
	Bulger Creek	1.1	
	Camp Creek	42.2	
	Crooked River	75.0	
	Grindstone Creek	18.8	
	Horse Heaven Creek	8.2	
	Johnson Creek	147.3	
	Little Bear Creek	4.2	
	Lost and Sheep Creeks	8.2	
	Lucky Creek	1.7	
	North Fork Beaver Creek	12.8	
	North Fork Crooked River	35.8	
	Paulina Creek	29.7	
	Peterson Creek	7.9	
	South Fork Beaver Creek	19.6	
	South Fork Crooked River	56.9	
	Swamp Creek	2.4	
	Twelvemile Creek	21.7	
	Wolf Creek	12.4	
	TOTAL		589.5
Mining	Johnson Creek	0.1	
	TOTAL		0.1
	GRAND TOTAL		590.7

If all consumptive water rights in the sub-basin would be used to the maximum legal extent, approximately 190,000 acre-feet could be diverted from the streams in this sub-basin each year. Although this is below the average annual yield of the stream system, shortages exist at many locations due to maldistribution of the water.

The pattern of legal rights to use water by stream miles for the entire Deschutes Basin was shown in Figure 9. Depletion rights in the Crooked River system comprise about 34 percent of the total for the basin while depletion rights in the Upper Crooked River sub-basin represent less than 1 percent of that same total and only 18 percent of all Crooked River depletion rights.

GROUND WATER SUPPLY Sub-basin 4

Yield and Distribution

There are only a few well records relative to the Upper Crooked River sub-basin on file in the State Engineer's office. One well, drilled to a depth of 191 feet on Rager Creek, found water between 150 and 175 feet and the water rose to land surface flowing freely at 29 gallons per minute (gpm).

One well on Antelope Creek, a tributary of Crooked River, was drilled to a depth of 210 feet and encountered water below 135 feet in sandstone with a static water level 18 feet below land surface. A bailer test yielded 10 gpm with a drawdown of 20 feet.

Higher yields have been obtained from wells recently drilled in the Hampton area. One well, 640 feet deep, encountered water at 145 feet in sand and clay. The water level stands at 142 feet and a pump test yielded 980 gpm with a drawdown of 46 feet. However, another well in the same area drilled to a depth of 515 feet also found water in sand but a bailer test yielded only 9 gpm with a drawdown of 11 feet. The static water level in this well is at 182 feet.

High yields have also been obtained from wells drilled in the Crooked River South Fork watershed. Here, a 220-foot well found water in unconsolidated volcanic fragments at a depth of 165 feet. This well yielded 1,100 gpm with a drawdown of 79 feet. Another well drilled to a depth of only 50 feet encountered water 34 feet below land surface in vesicular basalt. This well yielded 3,000 gpm with a drawdown of only 1.5 feet. However, a well drilled to 90 feet in the same area yielded only 50 gpm with a drawdown of 23 feet.

About the only conclusion that can be made is that additional investigation is necessary before the nature and extent of the ground water resources in this sub-basin can be defined.

To p. 145

Depletions

All ground water rights in this sub-basin are for irrigation and total 22 cfs for the irrigation of 1,854 acres. They consist of two ground water rights for a total of 4 cfs and 320 acres near Hampton and three ground water rights for a total of 18 cfs and 1,534 acres in an area approximately 10 miles northeast of Hampton.

SUB-BASIN INVENTORY - UPPER CROOKED

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

A 1914 withdrawal by the State Engineer withdrew and withheld 300,000 acre-feet for storage of irrigation water in the then proposed Crooked River Reservoir. Prineville Reservoir which is now under construction obtained its water right priority from this withdrawal.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Domestic water rights in this sub-basin total only one cfs and are all for surface waters. Households in this sub-basin obtain domestic water from springs, streams, wells, and irrigation ditches. The Crooked River Decree established that the rate of diversion for domestic and stock purposes, as part of irrigation rights, shall not exceed 1/40 cfs for each 1,000 head of stock and, further, that the quantities diverted for irrigation purposes shall include the amount necessary for domestic and stock use.

Municipal

Communities in this sub-basin are small and do not have municipal water systems so there are no water rights for municipal purposes.

Irrigation

Almost all of the water rights in this sub-basin are for irrigation. Rights for the use of surface waters total 590 cfs for 45,502 acres and rights for ground water total 22 cfs for the irrigation of 1,854 acres. The majority of the surface rights are located on Beaver, Camp, and Twelvemile Creeks, the North and South Forks of the Crooked River, and the main stem of the Crooked River. The remainder of the surface rights are scattered throughout the sub-basin along smaller tributaries. Ground water rights are all located in the vicinity of Hampton.

In 1956 the State Engineer appropriated 155,000 acre-feet for storage in Prineville Reservoir which will provide water for the irrigation of lands within the Crooked River Project in the area of Prineville. There are also 27 small reservoir rights in the sub-basin for storage of irrigation water totaling 7,960 acre-feet.

Irrigation is limited because of the pattern of streamflow and the lack of storage reservoirs. The Crooked River is considered torrential in nature due to high flows in the

spring time and nearly zero flows under present conditions in the dry part of the summer. Therefore, without storage it is necessary to use water for irrigation during the flood time since there is little water available later in the season. For this reason, the irrigation season was established by decree as lasting from February 1 until December 1 each year. An ample supply of water is usually available in the early spring months but severe water shortages exist at most locations later in the summer.

Power

There are no power projects and no power rights in this sub-basin.

Industrial

There are no large industrial establishments and no industrial water rights in this sub-basin.

Mining

The only mining right in this sub-basin is for 0.05 cfs for a mercury mine on Johnson Creek, a tributary of the Crooked River North Fork. This operation and all other mercury operations in the sub-basin use only small quantities of water and operate only intermittently. A uranium mine has been discovered in the Bear Creek area recently and production is expected to start soon. Only small quantities of water will be necessary for this operation.

Recreation

There are no water rights for recreation in this sub-basin. The only natural lake of large size is Marg Lake which has a surface area of 35 acres. There are about 37 reservoirs in the sub-basin of which 26 have a surface area larger than 5 acres. Prineville Reservoir after its completion will form the largest lake by covering 3,010 acres. The total surface area of all lakes and reservoirs after completion of Prineville Reservoir will be approximately 3,900 acres.

Recreational activities in this sub-basin are associated primarily with hunting, mule deer being the most important game animal. There is comparatively little fishing because of insufficient flows in the streams during the summer months.

There are no state parks, roadside rest areas, resorts, or public boat landings existing

in the sub-basin at present. Twelve forest camps are scattered throughout the Ochoco National Forest, three of them in the Maury Mountains, and the remainder in the Ochoco Mountains.

Wildlife

The Ochoco Mountains are one of the most popular mule deer hunting areas in the state. Various species of upland game birds, waterfowl, and furbearers are also found in this sub-basin. No major problems in regard to water needs for wildlife are reported in this area.

Fish Life

Crooked River formerly supported anadromous fish runs but the only game fish found today are rainbow and eastern brook trout. Much of the summer flow of the Crooked River and its tributaries above Prineville is diverted for irrigation and the streams are completely dry at times. Heavy silt loads carried by flash floods during periods of high runoff are also detrimental to fish life.

Trout production in the main stem Crooked River is limited in this sub-basin because of extreme low flows, high water temperatures, and an extensive population of rough fish, primarily suckers and squawfish. Trout production in the South Fork of Crooked River is also limited for the same reasons.

While the overall number of trout producing streams in this sub-basin is small, a few individual streams are considered of major importance. Some of the better trout fishing to be found in the Upper Crooked River Basin is provided by such tributaries as Deep Creek and Beaver Creek. Deep Creek receives supplemental stockings of approximately 3,000 legal rainbow trout each year.

The Oregon State Game Commission plans to stock Prineville Reservoir after its completion with rainbow trout but anticipates a rough fish problem after three or four years due to high water temperatures. If such develops, the fishery will be changed to warm water species such as bass or bluegill.

Pollution Abatement

No pollution abatement problems are reported in this sub-basin. The population is small and not concentrated, there are no community sewerage systems, and there are no industries that require special waste disposal facilities.

WATER CONTROL

Flood Control, Drainage, and Erosion

Major flood problems exist along the main stem of the Crooked River and on lower Bear Creek (Plate 13). Flash floods in the spring, caused by short periods of high temperature followed by light rainfall and rapid runoff of snowmelt, damage river banks and agricultural lands. Quite often ice is formed in the streams before such snowmelt with a resulting increase in both flood stages and damages. Figures for flood damages are not available. Flood problems of a lesser degree exist on a number of other small tributaries. Lower Bear Creek is flooded frequently also as a result of cloudburst storms.

No drainage problems are reported.

Severe water erosion occurs in the lower Bear Creek watershed (Plate 13) due primarily to topography and lack of adequate vegetative cover.

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic and Municipal

There are no community water supply systems in this sub-basin so all households have their own individual water supplies. Needs for domestic water will probably increase only slightly due to the small population of the area and the low potential for future growth.

Irrigation

Most irrigated lands in this sub-basin do not receive an adequate supply of water and many additional dry farmed lands are potentially irrigable. The Bureau of Reclamation recently completed an investigation to determine the feasibility of a reservoir at the Big Prairie site on the Crooked River North Fork which would store approximately 40,000 acre-feet and provide water to 6,290 acres of new land and a supplemental water supply to about 2,060 acres of presently irrigated lands. The lands to be irrigated under this project would consist of four units, two on the main stem of the Crooked River and two on tributaries.

The gross project area includes 14,550 irrigable acres, but water would be available only for 65 percent. It was concluded that this project was not economically feasible.

Approximately 5,100 acres have been developed for irrigation in the upper Beaver Creek watershed above the mouth of Wolf Creek and an additional 2,300 acres are considered suitable for irrigation. Additional water supplies through storage reservoirs will have to be developed before the irrigated acreage can be increased.

Ground water has been developed recently for irrigation in the vicinity of Hampton and on the G. I. Ranch on the Crooked River South Fork. Wells drilled recently tested 980, 1,100, and 3,000 gpm, respectively and ground water rights to irrigate 1,854 acres have been filed in this area. About 6,300 acres of new lands could be irrigated in this area if storage or additional wells of equally high yields were developed.

Power

No hydroelectric power developments have been proposed in this sub-basin and little, if any, potential exists due to stream characteristics.

Industrial

Industries in the sub-basin at present are small logging operations which do not have any water rights and no major increase in the use of water for this or other industrial purposes is expected in the near future.

Mining

Anticipated mining operations require only small quantities of water and no major increase in the water use for mining purposes is expected in the near future. Potential uranium production will be shipped to a mill in Lakeview for processing and large quantities of water would be needed only if the uranium market would justify construction of a processing plant at the proposed mine.

Recreation

Recreation presently plays a minor part in the economy of this sub-basin but it is anticipated that more tourists will be attracted after completion of Prineville Reservoir. The Parks Division of the State Highway Department lists a potential park area at the confluence of Bear Creek with the Crooked River which could be developed for day use, camping, and boating along the reservoir.

The Bureau of Reclamation believes, though, that only local residents will be attracted by the reservoir and recommends a camping area for a maximum of 75 persons. The drawing power of Prineville Reservoir for tourists from outside the area is considered by the Bureau to be small because of the superior scenery and camping facilities available in the nearby mountains.

Fish and Wildlife

The Congressional Act authorizing the Crooked River Project provides for a conservation release of 10 cfs from Prineville Reservoir during the nonirrigation season to provide downstream fishery benefits. However, this flow can be reduced or stopped by the Secretary of the Interior if the primary purpose of the project demands it.

No major changes are foreseen for the future that would create new problems in regard to the water needs of wildlife.

If upstream storage reservoirs were constructed in this sub-basin and if cool water could be supplied in the summer months with proper minimum flows, a good trout fishery could be produced through rehabilitation. In such a case it would also be necessary to inaugurate an extensive irrigation diversion screening program.

Pollution Abatement

Population increase in this sub-basin is expected to be very slow and, therefore, no major pollution problems should arise in the near future.

SUB-BASIN 5 LOWER CROOKED RIVER

GENERAL

Location and Size

The Lower Crooked River sub-basin includes all of the Crooked River watershed from mile 66, Hoffman Dam, to its confluence with the Deschutes River (Plate 1). This is the smallest of the sub-basins and contains 1,657 square miles which is about 16 percent of the total area of the Deschutes Basin.

About 50 percent of the sub-basin area lies in Crook County, 43 percent in Deschutes County, 5 percent in Jefferson County, 1 percent in Wheeler County, and less than 1 percent in Lake County.

The northern boundary of the sub-basin goes from the Ochoco Mountains west between Willow Creek and the Crooked River. The western boundary, which is not well defined, runs along the plateaus between the Deschutes main stem and the Dry River and continues south to the Paulina Mountains. The southern boundary runs along the plateaus between the Dry River and the Goose and Summer Lakes Basin while the eastern boundary is formed by the divide between the Dry River and Bear Creek and north between the watersheds of Ochoco Creek and the Crooked River North Fork.

Stream System

The Crooked River enters a wide valley near Prineville, then cuts into a deep canyon in its lower region until it reaches a depth of almost 1,000 feet at its confluence with the Deschutes River. The main tributary of Crooked River in this sub-basin is Ochoco Creek with its headwaters in the Ochoco Mountains.

There are approximately 960 miles of streams in this sub-basin of which only 250 are perennial in nature. These figures include 66 miles of the Crooked River main stem.

Profiles of the major streams in the Deschutes Basin showing elevations versus stream miles are shown in Plate 2. The Crooked River has an average gradient of 8 feet per mile upstream of river mile 28, drops about 28 feet per mile from there to mile 20, and steepens to a drop of 46 feet per mile below mile 20.

Climate

Annual precipitation varies between 5 and 18 inches in the Prineville area and between 11 and 27 inches at Ochoco Ranger Station. Average annual precipitation is above 20 inches in the Ochoco Mountains and ranges from 9 to 11 inches in the Prineville area

and in the southern portion of the sub-basin. Precipitation averages 3.30 inches at Prineville and 5.69 inches at Ochoco Ranger Station between May 1 and September 30.

Average monthly precipitation at the Ochoco Ranger Station was shown in Figure 37 and similar data for the Prineville Station is plotted in Figure 41. The pattern at Prineville follows the general case exhibiting winter and spring peaks and a late summer low with the exception that average May and June precipitation at Prineville is as high as average November and December precipitation, about 1 inch each month. July and August are the driest months at Prineville, averaging about 0.3 inches each month.

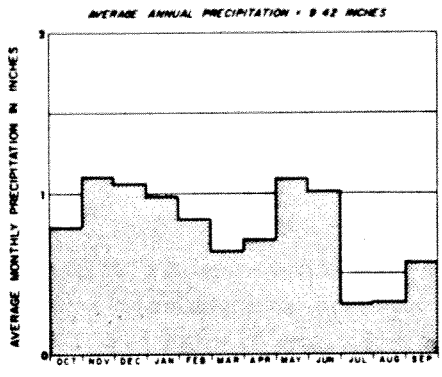


FIGURE 41. Average monthly precipitation at the Prineville station, 1897-1958.

Annual snowfall averages 14 inches at Prineville and 72 inches at Ochoco Ranger Station.

Long-time temperature measurements are available in this sub-basin for Ochoco Ranger Station located 26 miles northeast of Prineville on Ochoco Creek and Prineville. The climatological station at Prineville was opened in 1897 and has the longest continuous records of all stations in the Deschutes Basin. Temperatures between minus 35 and plus 119 degrees Fahrenheit have been recorded at Prineville and between minus 27 and plus 100° F. at Ochoco Ranger Station. The average annual temperature is 47° F. at Prineville and 43° F. at Ochoco Ranger Station.

Frosts can occur in any month of the year in this sub-basin. The average number of days without killing frosts is 110 days at Prineville and decreases to approximately 80 days at the southern boundary of the sub-basin.

Population

The Lower Crooked River sub-basin has an estimated population of 9,540 in 1960 which is the second largest population of all the Deschutes sub-basins. The largest city is Prineville with a 1960 population of 3,260. The only other incorporated city in the sub-basin is Culver with a 1960 population of 300. Population trends of incorporated cities in the Deschutes Basin were shown in Figure 1 which illustrated the leveling off in growth during the past 10 years of both Prineville and Culver.

There are eight unincorporated communities in the sub-basin of which only two, Powell Butte and Opal City, have populations above 100.

ECONOMY AND LAND USE

Land Ownership

The administration or ownership of land in the Deschutes Basin was shown by sub-basins in Table 4. Approximately 29 percent of the total area of 1,660 square miles of the Lower Crooked River sub-basin is national forest land within the Ochoco and Deschutes National Forests. About 25 percent of the sub-basin area is public domain lying predominantly within the Crooked River grazing district. Approximately 2 percent is owned by the State of Oregon and the remaining 44 percent is mainly under private ownership.

Timber

Timber is of major importance to this sub-basin and Prineville is second only to Bend in the concentration of sawmill activity in the Deschutes Basin. Ten logging contractors and seven lumber mills were reported in 1959, four of them having more than 100 employes each.

The main source of logs for the timber industry of Prineville is the Ochoco National Forest which occupies 75 percent of the commercial timber land of Crook County. Log production in Crook County has been fairly steady in the past 10 years and was over 80 million board feet in 1958 (Figure 2). Uncut sawtimber in Crook County was estimated to be 5.6 billion board feet in 1953.

Agriculture

Agriculture is also of major importance to the economy of the sub-basin. Five hundred farms were estimated in the area in 1954 raising mainly beef cattle, sheep, and chickens and growing wheat and hay as principal feed crops.

There are five irrigation districts in the sub-basin of which two, the Ochoco Irrigation District and Crook County Improvement District No. 1, lie entirely within the sub-basin. The eastern half of the Central Oregon Irrigation District and a small portion of the Arnold and North Unit Irrigation District are also located within the sub-basin.

Recreation

Major centers of recreation in this sub-basin are the Crooked River Canyon, Ochoco Reservoir, and the Ochoco Mountains. Ochoco Lake furnishes excellent fishing,

camping, swimming, and boating. The Ochoco Mountains are among the more popular hunting areas for mule deer within the state.

Mining

Mining in this sub-basin is confined mainly to sand and stone operations. There is one establishment near Prineville processing bentonite and radioactive mercury has been discovered in the Powell Butte area southeast of Redmond but development has not advanced much beyond the prospecting stage.

Transportation Media

Several U. S. highways cross this sub-basin and make most parts easily accessible. U. S. 26 from Portland goes through Prineville east to the John Day Basin. U. S. 126 from Eugene joins U. S. 26 at Prineville while U. S. 97 and U. S. 20 traverse portions of the sub-basin in the west and south.

Oregon 27 travels south from Prineville up the Crooked River and Bear Creek until it joins U. S. 20 between Millican and Brothers.

A paved road traverses the sub-basin from U. S. 97 near Terrebonne to Prineville and continues to Post on the Crooked River. Two other paved highways connect Powell Butte and Alfalfa with Bend.

Several improved and unimproved roads make other parts of the basin accessible.

Regular bus service is maintained on U. S. 20 and 26. There are no regular freight truck routes in the sub-basin but irregular service is available to most points in the sub-basin.

The only railroad in the sub-basin is the City of Prineville spur line operating between Prineville and the Oregon Trunk Line near Redmond. Freight service only is available on this line.

Prineville operates a municipal airport near the city limits. Landing strips are also maintained near Millican and Brothers, both privately owned. No commercial airline service is available in this sub-basin.

SURFACE WATER SUPPLY

Yield

Water entering this sub-basin each year was shown by Figure 38 in the form of the yield of the Crooked River above Hoffman Dam, which averaged 202,200 acre-feet for the years 1910-1958. Water leaving the sub-basin each year, the yield of the Crooked River near Culver, is shown in Figure 42. At this location the average annual yield, 1918-1958, is about 1,123,000 acre-feet. Much of the increase between the two locations can be attributed to the uniform discharge from springs in the Lower Crooked River Canyon which are estimated to contribute about 700,000 acre-feet annually to the yield at Culver. This influence on annual yields is also evidenced by the lesser fluctuation from year to year at Culver and the smaller differences between dry and wet years than those experienced at other gaging stations.

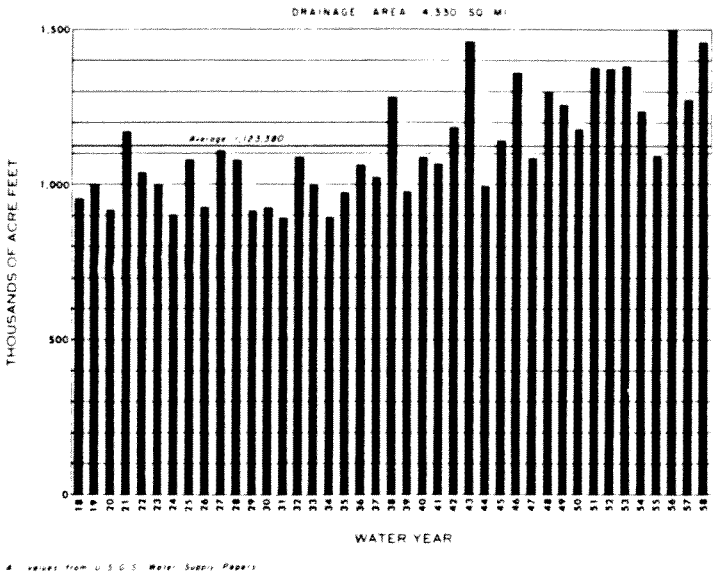


FIGURE 42. Annual yield of the Crooked River near Culver, 1918-1958.

Yields of the major tributary in this sub-basin, Ochoco Creek, are shown in Figure 43. Although differences between high and low years and fluctuations from year to year are greatly pronounced, wet and dry cycles can be identified. The average annual yield at this location is about 41,800 acre-feet based upon Ochoco Reservoir releases for the period 1920-1958.

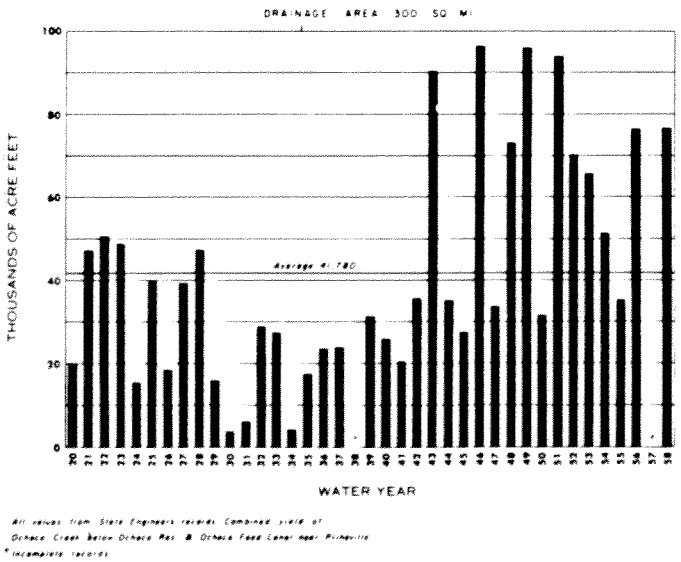


FIGURE 43. Annual yield of Ochoco Creek as measured by Ochoco Reservoir release, 1920-1958.

Distribution

Average monthly discharges of the Crooked River near Culver and Ochoco Creek below Ochoco Reservoir are shown in Figure 44 which again illustrates the effect of stream regulation.

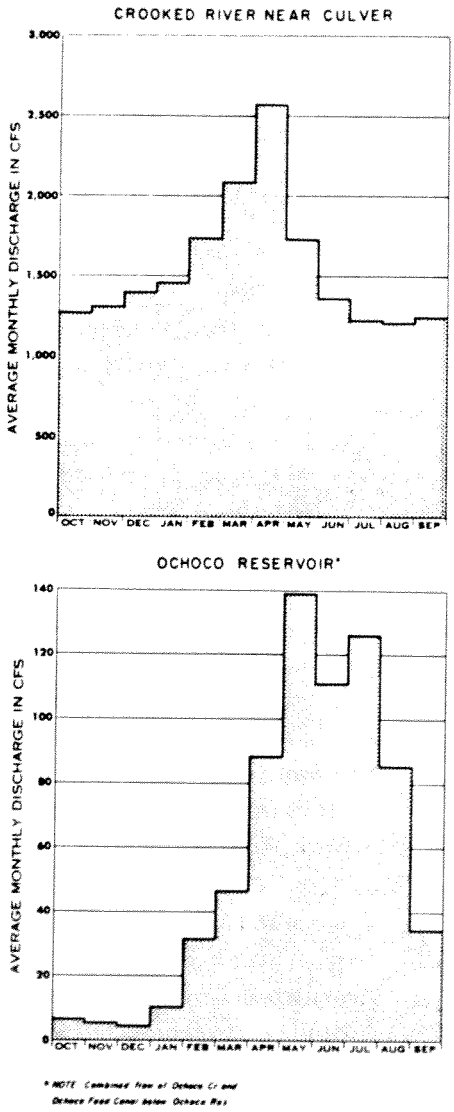


FIGURE 44. Average monthly discharges at representative stations in the Lower Crooked sub-basin, 1920-1958.

The pronounced April peak in Crooked River flows is the result of spring rains combined with snowmelt, mostly in the Ochoco Mountains. For eight months out of the year, June-January, flows at Culver are very uniform due primarily to the influence of the aforementioned springs in the lower canyon.

Ochoco Creek flows are completely regulated resulting in unnaturally high flows during the summer, which are mostly irrigation releases, and very low winter flows during the reservoir filling period. Irrigation releases usually start in the latter part of April but a portion of the May peak sometimes consists of flood releases since Ochoco Reservoir is also operated for flood control. The reservoir is usually empty by October and releases from then through December are quite small because of very little inflow.

This operational pattern of Ochoco Reservoir will be altered upon completion of Prineville Reservoir since the two will be operated as a unit with Ochoco Reservoir playing a larger part in flood control. This will result in higher releases in early spring and smaller releases in late spring, the time of heaviest natural runoff.

Extremes

The daily pattern of runoff during an extreme low flow year is shown for the Crooked River in Figure 45. This is a plot of the average daily discharges for the water year having the minimum flow of record at the Culver gaging station. Again the influence of the lower canyon springs is evidenced by uniformity of flow throughout the year except for a short peak

early in January and during the spring runoff period. The minimum discharge at this station was 920 cfs on October 14, 1945 while the minimum annual yield, 894,000

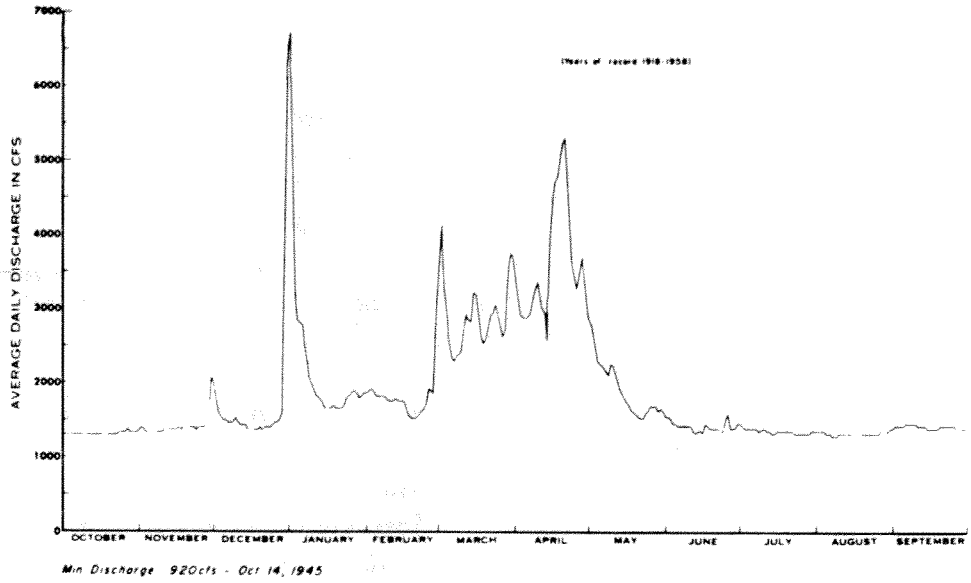


FIGURE 45. Discharge pattern of the Crooked River near Culver for the water year having the minimum instantaneous flow of record, 1946.

acre-feet, occurred in 1931. Critical flows and yields at this and other stations throughout the Deschutes Basin are summarized in Table 8.

Depletions

Water rights in the Deschutes Basin at their points of diversion are shown in Plate 7. A detailed summary of these rights listing number, location, use, quantity, stream, and priority date is available at the office of the State Water Resources Board.

Most water rights in the Lower Crooked sub-basin are concentrated in the vicinity of Prineville. These rights are summarized by use and stream in Table 16.

Of the total 2,657 cubic feet per second (cfs), 1,947 cfs are nonconsumptive and 710 cfs consumptive in nature. All nonconsumptive rights are for power while consumptive rights include 703 cfs for irrigation of 47,040 acres, and 5 cfs for municipal and 2 cfs for domestic purposes.

The pattern of legal rights to use water by stream miles for the entire Crooked River

SUB-BASIN INVENTORY - LOWER CROOKED

Basin is shown in Figure 46. The Lower Crooked portion of this extends from mile 66

TABLE 16

SURFACE WATER RIGHTS SUMMARY
SUB-BASIN 5 - LOWER CROOKED RIVER

USE	STREAM	CFS	TOTAL RIGHTS
Domestic	Crooked River	1.4	
	Dry Creek	0.2	
	Dry River	0.1	
	Ochoco Creek	0.2	
	TOTAL		1.9
Irrigation	Crooked River	276.2	
	Dry Creek	11.6	
	Dry River	23.9	
	Johnson Creek	5.7	
	Lytle Creek	6.3	
	Marks Creek	4.9	
	McKay Creek	48.9	
	Mill Creek	16.0	
	Ochoco Creek	309.1	
	TOTAL		702.6
Municipal	Crooked River	5.0	
	TOTAL		5.0
Power	Crooked River	1,947.0	
	TOTAL		1,947.0
	GRAND TOTAL		2,656.5

downstream and comprises 82 percent of the total depletion. A large jump in consumptive depletion rights is evident at mile 47 which is the Prineville area. Total rights more than double in the lower few miles as a result of nonconsumptive power rights existing in that stretch of the river.

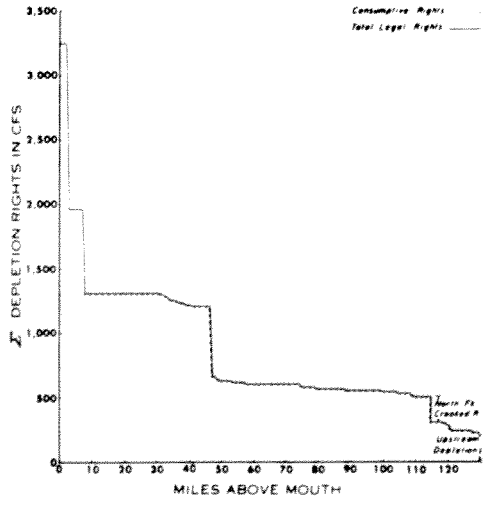


FIGURE 46. Legal depletion rights by stream mile of the Crooked River as of January 1960.

Ordinate values on the depletion diagram do not include supplemental irrigation rights and these are not part of Table 16. Supplemental rights permit alternate sources of supply but do not add to the original rights.

If all consumptive water rights in this sub-basin were used to the maximum legal limit, approximately 200,000 acre-feet would be diverted from the streams each year. This is less than the average annual yield of all streams in the sub-basin but shortages do exist in many locations because of low flows at the times of heaviest use. Surplus water exists mainly in the Lower Crooked River Canyon but use

of this water for most purposes would require a pumping lift of several hundred feet.

GROUND WATER SUPPLY Sub-basin 5

Yield and Distribution

The most extensive ground water development in the Deschutes Basin has taken place in the Prineville Valley, an area approximately nine miles long and four miles wide at its widest point.

Unconfined water is found in recent alluvial gravel. This gravel is completely saturated with water in places and many private residences obtain water from it but no large capacity wells have yet been drilled. The shallow gravel is recharged to a large extent from river seepage and from waste irrigation water.

Shallow, unconfined water is also found in the older alluvium on the higher benchlands where it is not covered by thick beds of young alluvium. This aquifer consists mostly of silty sand and water is obtained from it only for domestic use. From 200 to 300 gallons per minute (gpm) were pumped from a group of 15 wells with depths ranging from 40 to 60 feet for the municipal water supply of Prineville.

The most important known source of ground water in the Prineville area is confined water in the older alluvium. It is chemically softer than water in the younger alluvium and in places is under sufficient pressure to be used without pumping for domestic purposes. Measurements indicate that the confined water moves in a southwest direction from the upper benchlands to the lower valley (see Plate 8). This aquifer is recharged from the upper benchlands, where confining and impermeable layers of sand and silt are lacking or are shallow, and from bedrock under the upper benchlands. Measurements also indicate that the average hydraulic gradient is about 40 feet per mile and it was estimated that for each mile-long segment of the aquifer about 268,000 gallons of water a day (0.4 cfs) may move down this slope.

Fluctuations in the water levels and pressures in wells in this area conform to long-term precipitation cycles on their recharge area and are also influenced by withdrawal of water from wells and interference between wells. This interference is quite significant and often overshadows the seasonal changes. This is caused because most of the wells are within two to three miles of potential recharge areas and the increased gradient as a result of drawdown is reflected to the recharge area after relatively small quantities of water are drawn from storage. Therefore, the aquifer responds quickly to changes in rate of withdrawal.

Ground water has also been found in the consolidated bedrock but only a few such

wells have been drilled in the Prineville area. Some wells did not yield water and the successful wells yielded only enough for single households. The deepest of these wells was drilled 1,002 feet without encountering water. It is generally believed that the bedrock does not contain ground water in commercial quantities.

The only pumpage records exist in a well operated by Pacific Power and Light Company for the municipal supply of Prineville. This well pumps water from the confined aquifer of older alluvium. The highest monthly recorded pumpage for the years 1944 to 1946 was 11,233,000 gallons (0.58 cfs) and the highest annual pumpage in those years was 66,451,000 gallons (0.28 cfs) in 1946. It is estimated that an unmetered well of a lumber company pumps at a rate of about 500 gallons per minute (1.10 cfs) intermittently for a total of approximately 100,000 gallons a day (0.15 cfs).

It is estimated that the total summer withdrawal in and around the City of Prineville is approximately 500,000 gallons a day (0.77 cfs) and the winter use about half as great. This gives an average annual withdrawal of about 330,000 gallons a day or about 2,600 acre-feet per year from the older alluvium of the Prineville area for the years 1940 to 1945.

The chemical quality of the ground water in the Prineville area is generally satisfactory for domestic, industrial, and irrigation purposes although most of it is a hard, bicarbonate type of water which results in the deposition of scale in hot water pipes and heaters.

Few well logs are available for areas outside the immediate vicinity of Prineville. Wells near Powell Butte were drilled to depths ranging from 110 to 470 feet and encountered water at various depths and in different materials, including basalt, sandstone, and lava. Yields of these wells were small with bailer tests yielding from 5 to 20 gpm at various drawdowns.

Records for wells along Allen Creek, about nine miles north of Prineville, show one drilled to a depth of 36 feet with a static level five feet below land surface. The bailer test of this well yielded 55 gpm with a drawdown of eight feet. The aquifer is sand and gravel. A second well was drilled in the same area to a depth of 282 feet which did not encounter water.

Depletions

Ground water rights in this sub-basin total 20 cfs. The largest group totals 12 cfs for the irrigation of 1,404 acres and the remainder consists of 6 cfs for municipal and 2 cfs for industrial purposes.

SUB-BASIN INVENTORY - LOWER CROOKED

LEGAL RESTRICTIONS AND LIMITATIONS ON WATER USE

In 1914 the State Engineer withdrew 300,000 acre-feet for storage of irrigation water in the proposed Crooked River Reservoir on Crooked River. Prineville Reservoir which is now under construction obtained its water right priority from this withdrawal. In the same year he also withdrew 50,000 acre-feet for storage of irrigation water in the then proposed Ochoco Creek Reservoir on Ochoco Creek.

In 1959 the State Water Resources Board reserved the unappropriated waters of the main stem of the Crooked River between its confluence with the Deschutes River and river mile 6.5 for domestic, livestock, hydroelectric power, recreation, fish, and wildlife purposes.

PRESENT WATER USE AND ASSOCIATED PROBLEMS

Domestic

Rights for the use of water for domestic purposes total less than two cfs and all are for surface waters. Many households in the area of Prineville obtain domestic water from wells but the quantities pumped are so small that no water rights are required. Many rural households, particularly within the irrigation districts obtain water from the irrigation canals. The Crooked River Decree limits the diversion of water for domestic and stock purposes to 1/40 cfs per 1,000 head of stock and these quantities are included in the irrigation diversions.

Municipal

Water rights for municipal purposes in this sub-basin consist of five cfs for surface water and six cfs for ground water. The surface water right is held by the Deschutes Valley Water District which pumps water from Opal Springs in the Crooked River Canyon and supplies rural households within the North Unit Irrigation Districts as well as the Cities of Madras, Culver, and Metolius. These were discussed in Sub-basin 2 - Middle Deschutes River.

Pacific Power and Light Company holds the ground water rights which are used for the municipal water supply of the City of Prineville. This water is obtained from several wells having a total yield of 1,800 gallons per minute (4.0 cfs) which is about 150 percent of the maximum daily consumption of record. The wells provide a good dependable supply and no critical periods have been experienced in the past. For emergency purposes, water is stored in three elevated tanks having a total storage volume of 800,000 gallons.

The quality of this water is generally good although it is moderately hard and contains some iron. Chlorination is the only treatment necessary.

Irrigation

Irrigation rights total 703 cfs for the irrigation of 47,040 acres from surface waters and 12 cfs for the irrigation of 1,404 acres from ground water. The largest groups of irrigation rights within this sub-basin are within the Ochoco Irrigation District, the eastern branch of the Central Oregon Irrigation District, and the Lone Pine District. Only the Ochoco Irrigation District obtains water from the Crooked River watershed, the other two districts using Deschutes water. Most smaller irrigation rights are located along Ochoco Creek, McKay Creek, and the main stem of the Crooked River.

Ochoco Irrigation District presently irrigates approximately 8,200 acres. Prineville Reservoir, now under construction by the U. S. Bureau of Reclamation, will provide a stable water supply for 9,990 acres of presently dry farmed land and supplemental water to 10,220 acres of presently irrigated land including many of those of the Ochoco Irrigation District. The Crooked River Extension, which is still in the project stage, would provide water for 2,720 additional acres.

Existing reservoir permits in this sub-basin also include a total of 3,030 acre-feet for 13 smaller reservoirs.

Power

Nearly all of the power rights of 1,947 cfs are for the Crooked River main stem. One thousand two hundred and seventy-five cfs are for the Cove powerplant on the Lower Crooked River of which 750 cfs are issued to the Bureau of Reclamation and 525 cfs to Pacific Power and Light Company, the operator of the plant. Six hundred and fifty cfs are issued to the Deschutes Valley Water District for the purpose of pumping municipal water. The remainder of the rights are mainly for pumping irrigation water rather than for the production of electric power.

The present installed capacity of the Cove powerplant is 2,750 KW and the average annual energy production 22 million kilowatt hours.

Industrial

Existing industrial water rights in this sub-basin are for ground water only and total two cfs. They are all for lumber mills in Prineville. The supplies seem to be adequate

to satisfy present needs and the water is of generally good quality except that it is moderately hard and forms scale in boilers and hot water pipes.

Mining

The only mining establishment, in addition to sandstone and gravel operations, is a bentonite processing plant near Prineville. Their water use is small and no water rights for mining have been issued. Radioactive mercury has been found in the Powell Butte area but little more than prospecting has been done so far. Water needs for this type of development would be minor.

Recreation

There are no water rights for recreation in this sub-basin, but water plays an important part in the overall recreation picture. The two state parks in the sub-basin, Ochoco State Park on Ochoco Reservoir and Cove Palisades State Park at the confluence of the Crooked and Deschutes Rivers, are among the most popular tourist spots in the sub-basin. The Parks Division of the Oregon State Highway Department counted 116,000 visitor days and 4,600 camper nights in Ochoco State Park in 1958 and trends in the use of both parks were shown in Figure 5.

The largest lake in the sub-basin, Huston Lake, has a surface area of 40 acres. There are 15 reservoirs, 13 larger than 5 acres in surface area, the largest being Ochoco Reservoir with a surface area of 1,080 acres. The total surface area of all lakes and reservoirs in the sub-basin is approximately 1,640 acres. Public boat landings are located on Huston Lake and Ochoco Reservoir.

Eight forest camps are maintained in the Ochoco National Forest. Approximately 10,000 visitors were estimated in that forest in 1954.

These recreation areas are all located on Plate 5 and a summary of the facilities at each is available at the State Water Resources Board's office.

Wildlife

Mule deer is the predominant big game species in this sub-basin, each season attracting many hunters to the Ochoco Mountains. Other game animals include waterfowl, upland game birds, and furbearers. No particular problems have been reported in regard to the water needs of wildlife in this sub-basin.

An increase in the population of upland game birds, the principal species being valley quail, ring-necked pheasants, morning doves, and Hungarian partridges, is expected after completion of the Crooked River Project. Additional irrigated lands in the project area may also result in increased populations of spotted skunks, weasels, muskrats, and mink.

Fish Life

Historically the Crooked River and its tributaries supported runs of spring chinook salmon and steelhead trout, but these have been reduced for at least 35 years. Some steelhead are still believed to enter the system and spawn on McKay and Ochoco Creeks but to what extent is not known. Rainbow trout are the only resident game fish spawning in this sub-basin.

Conditions similar to those in the Upper Crooked River watershed exist here. Heavy flash floods during the spring runoff season carrying heavy silt loads, low flows combined with high temperatures in the summer, and completely dry streams during the irrigation season are detrimental to fish life. Many tributaries of the Crooked River provide from fair to good early season angling but water flows are normally such that anglers discontinue the utilization of the tributary streams by mid-June.

Good fish producing areas are found in the lower 10 miles of the Crooked River where flows are greatly augmented by springs in the canyon walls. Natural reproduction is supplemented by stocking approximately 7,000 legal rainbow trout each year in the vicinity of Cove Palisades State Park. Rainbow trout are also stocked in Ochoco, Mill, and Marks Creeks.

From a fish production standpoint, none of the streams in this sub-basin presently compare with the Little Deschutes River and other tributaries of the Upper Deschutes but, nevertheless, they are important because they comprise the only available stream fishing within the Lower Crooked sub-basin.

Ochoco Reservoir is popular with anglers and rainbow trout have to be stocked annually by the Game Commission because reservoir drawdown reduces the spawning potential. The Game Commission recommends a coordinated operation schedule for Prineville and Ochoco Reservoir which would hold the minimum water level of Ochoco Reservoir as high as possible.

The Congressional Act authorizing the Crooked River Project provides a minimum conservation release of 10 cfs below Prineville Reservoir during the nonirrigation season to maintain fish life in the Crooked River below the dam. This flow can be reduced or stopped by the Secretary of the Interior if and when the primary purpose of the reservoir

operation warrants it. The Oregon State Game Commission recommends a minimum flow in the Crooked River below Prineville Dam of 50 cfs for the months May through February and 100 cfs in the months March and April (Table 11). These flows are considered essential to maintain fish production at its present level.

It is also recommended that a minimum flow of 10 cfs be maintained in Ochoco Creek below Ochoco Reservoir. At present, flows below the reservoir drop to zero at times during the storage season.

Pollution Abatement

The only public sewerage system in the sub-basin is at Prineville and serves a population of 3,500. This system was designed for a population of 5,000 and is considered adequate for present and immediate future conditions. A conventional trickling filter was replaced in 1960 by a sewage stabilization pond (raw sewage lagoon) having an overflow to the Crooked River.

Rural households in the sub-basin commonly dispose of wastes into septic tanks or cesspools. Disposal of sewage into septic tanks is also used by about 500 homes in subdivisions adjacent to Prineville. No contamination of the ground water which furnishes the main water supply in the area has been observed to date. The aquifers are overlain by impermeable silt and hardpan which prevents infiltration of sewage into the ground water.

WATER CONTROL

Flood Control

Floods in this sub-basin occur primarily in the area around Prineville along the Crooked River, Ochoco Creek, and McKay Creek. They are caused mostly by short periods of high temperatures followed by relatively light rainfall which often cause rapid runoff of snowmelt in the late winter and spring. Quite often ice forms in the streams before the snowmelt resulting in increased flood stages and damage.

The greatest historical flood, which occurred in 1890, changed the course of the river above and through Prineville. Lands affected by major floods are agricultural areas at lower elevations and part of the urban and suburban area of Prineville (Plate 13).

Average annual damages based on past floods amount to $63,600 in the entire Crooked River Basin. Of this, $18,200 is attributed to Ochoco Creek, mainly within Prineville, and McKay Creek causes an annual damage of approximately $4,400 to agricultural

lands, highways, and railroads. The remaining $41,000 annual damages occur within the City of Prineville and throughout the remainder of the valley due to main stem floods.

Ochoco Reservoir was designed to store water for both irrigation and flood control. In the past, the capacity of 50,000 acre-feet has not always been adequate to prevent floods on Ochoco Creek below the dam. Completion of Prineville Reservoir, capacity 155,000 acre-feet, will appreciably reduce floods and flood damages on Ochoco Creek and the Crooked River under the proposed coordinated plan of operation of the two reservoirs. This plan will permit Ochoco Reservoir to be used more for flood control than in previous years thus reducing Ochoco Creek flood damages.

Under this plan, out of the total usable capacity of 46,500 acre-feet of Ochoco Reservoir, 16,500 acre-feet will be used exclusively for flood control and an estimated additional 12,000 acre-feet jointly for irrigation and flood control. Prineville Reservoir, with a usable capacity of 153,000 acre-feet, will have no exclusive reservation of flood control space but 60,000 acre-feet will be used jointly for irrigation and flood control and thus reduce flood damages on the main stem of the Crooked River. The annual monetary benefits for flood control, including Ochoco and Prineville Reservoirs, are estimated at $34,500.

Drainage

The most severe drainage problems exist near and below Prineville in the Crooked River Valley. These problems are a direct result of flood and should also be reduced appreciably upon completion of the Prineville Reservoir.

Erosion

The only notable erosion is along the Crooked River below Prineville. Again the direct result of high water stages, this problem too will be reduced upon completion of the Prineville Reservoir.

Slight bank and channel erosion occurs in most smaller tributaries caused by flash floods in the spring.

POTENTIAL WATER USE AND ASSOCIATED PROBLEMS

Domestic

Domestic water supplies in this sub-basin presently are satisfied from wells, irrigation

ditches, streams, and springs. The main source of domestic water in the Prineville Valley is from ground water in the valley alluvium. Interference has been noted between wells because of their close proximity to each other and to the recharge area. However, supplies have been adequate in the past and no shortages are anticipated in the near future.

Municipal

Prineville, the principal city in the sub-basin, receives its water from wells drilled mainly into the old alluvium. Prineville has an ample water supply at present and the capacity and recharge rates of the wells are considered adequate to satisfy immediate future demands. Shortages might be expected if major water-using industries requiring municipal water should locate in the area.

Irrigation

Prineville Reservoir will provide irrigation water for 9,990 acres of new land and a supplemental water supply for 10,220 acres of land now inadequately irrigated. The Crooked River Extension, not yet authorized, would provide water for 2,720 additional acres.

Forty-six thousand two hundred acre-feet of the yield of Prineville Reservoir are still unassigned and could be used on other lands. Lands being considered are located in and adjacent to the North Unit Irrigation District, within the proposed South Unit of the Deschutes Project, and within the Central Oregon Irrigation District.

The average annual shortage of the North Unit Irrigation District is 39,800 acre-feet for a 26-year period similar to 1925-1950. The use of the unassigned space for the proposed Prineville Reservoir would have reduced these shortages to 8,200 acre-feet per year at the Deschutes River storage reservoirs. It would, for all intents and purposes, have eliminated all significant shortages in the North Unit, except in 1931 when a shortage of 91,000 acre-feet would have occurred. (Source: 1953 Crooked River Report. Figures above would have to be revised to consider Crooked River Extension.) An alternative plan would be to irrigate about 10,500 acres of new land in and adjacent to the North Unit (Plate 4) which could be supplied with no shortages. This acreage could be expanded to 12,000 if a shortage of 31 percent in one year were accepted.

The South Unit of the Deschutes Project includes about 25,000 acres (Plate 4) and approximately 7,000 to 9,000 acres of this land could be irrigated by waters from the Crooked River Project. This acreage alone would not justify the construction of

necessary canal or water supply works. Therefore, the irrigation of South Unit lands hinges on the development of additional storage on the main stem of the Deschutes or its upper tributaries so that a larger area can be served.

There are also about 2,000 acres of dry land under the Central Oregon Irrigation District Canal that could be served from the same supply.

Power

Major potential power sites in this sub-basin that have been considered in the past are the Upper and Lower Box Canyon sites in the Lower Crooked River Canyon. These sites are in conflict with each other and were not included in determining the undeveloped power potential of the Deschutes River Basin because of conflicts with existing uses of water. For example, either of these projects would inundate Opal Springs which now furnish most of the water supply for the Cities of Madras, Culver, Metolius, and rural households of the North Unit Irrigation District. Also, upstream withdrawals for irrigation have greatly reduced the water available for power production at these sites since they were first studied.

Industrial

Industrial expansion would occur mainly in the vicinity of Prineville. A potential exists for food processing plants including potatoes and meat, expansion in lumber operations, and timber by-products operations. Anticipating that water shortages would be associated with the development of such major water-using industries, the City of Prineville has requested that 15,000 acre-feet of the unassigned yield of Prineville Reservoir be set aside for industrial use in the Prineville area.

Recreation

The most popular recreation area in this sub-basin containing one of the most popular state parks in the Deschutes Basin is Ochoco Lake which attracts many boating and fishing enthusiasts each year. Facilities in this state park currently have difficulty in satisfying the demand and expansion space is limited so that the projected future use will not increase appreciably over the present level.

Potential recreation areas listed by the State Parks Division in this sub-basin are Arnold Ice Caves, 20 miles southeast from Bend, and Smith Rock above the Lower Crooked River Canyon near U. S. 97. The State Parks Division completed a detailed study of the Smith Rock area and in 1959 the State Highway Department approved the acquisition

of some 600 acres of land for a new state park. Interest in this area will be confined mostly to sightseeing and geological attractions since water interests such as swimming and fishing are limited due to the low summer flows of the Crooked River in this section.

Wildlife

No major problems in regard to water needs of wildlife are anticipated in the near future unless the habitat is changed materially by new developments.

Fish Life

Low flows and high diversions comprise the major problem for fish life in the entire Crooked River watershed. However, an appreciable potential for enhancement of fish life exists but is entirely dependent upon securing adequate streamflow as recommended in Table 11. The greatest potential is for establishing a sizeable steelhead run in the stream system below Prineville Reservoir (Plate 11). However, in view of stream characteristics and the present level of development, little fishery enhancement will take place unless storage and releases are provided specifically for fish life.

Pollution Abatement

Problems are anticipated in the future if suburban development in the Prineville area should expand to a degree where existing septic tank type of waste disposal would interfere with domestic water supplies pumped from individual shallow wells.

Major water-using industries might also be faced with a problem of waste disposal in order to prevent stream pollution.

APPENDIX

AUTHORITY

The authority for the preparation and presentation of this report is set forth in ORS 536.300. The Legislative Assembly recognizes and declares in ORS 536.220(1) that:

"(a) The maintenance of the present level of the economic and general welfare of the people of this state and the future growth and development of this state for the increased economic and general welfare of the people thereof are in large part dependent upon a proper utilization and control of the water resources of this state, and such use and control is therefore a matter of greatest concern and highest priority.

"(b) A proper utilization and control of the water resources of this state can be achieved only through a coordinated, integrated state water resources policy, through plans and programs for the development of such water resources and through other activities designed to encourage, promote and secure the maximum beneficial use and control of such water resources, all carried out by a single state agency.

"(c) The economic and general welfare of the people of this state have been seriously impaired and are in danger of further impairment by the exercise of some single-purpose power or influence over the water resources of this state or portions thereof by each of a large number of public authorities, and by an equally large number of legislative declarations by statute of single-purpose policies with regard to such water resources, resulting in friction and duplication of activity among such public authorities, in confusion as to what is primary and what is secondary beneficial use or control of such water resources and in a consequent failure to utilize and control such water resources for multiple purposes for the maximum beneficial use and control possible and necessary."

The authority for the report, the study on which it is based, and the actions effected are specifically delegated to the State Water Resources Board in ORS 536.300(1) and (2) which state:

"(1) The board shall proceed as rapidly as possible to study: existing water resources of this state; means and methods of conserving and augmenting such water resources; existing and contemplated needs and uses of water for domestic, municipal, irrigation, power development, industrial, mining, recreation, wildlife, and fish life uses and for pollution abatement, all of which are declared to be beneficial uses, and all other related subjects, including drainage and reclamation.

"(2) Based upon said studies and after an opportunity to be heard has been

given to all other state agencies which may be concerned, the board shall progressively formulate an integrated, coordinated program for the use and control of all the water resources of this state and issue statements thereof."

Within the limits of existing data and knowledge, the study has taken into full consideration the following declarations of policy under ORS 536.310:

"(1) Existing rights, established duties of water, and relative priorities concerning the use of the waters of this state and the laws governing the same are to be protected and preserved subject to the principle that all of the waters within this state belong to the public for use by the people for beneficial purposes without waste;

"(2) It is in the public interest that integration and coordination of uses of water and augmentation of existing supplies for all beneficial purposes be achieved for the maximum economic development thereof for the benefit of the state as a whole;

"(3) That adequate and safe supplies be preserved and protected for human consumption, while conserving maximum supplies for other beneficial uses;

"(4) Multiple-purpose impoundment structures are to be preferred over single-purpose structures; upstream impoundments are to be preferred over downstream impoundments. The fishery resource of this state is an important economic and recreational asset. In the planning and construction of impoundment structures and milldams and other artificial obstructions, due regard shall be given to means and methods for its protection;

"(5) Competitive exploitation of water resources of this state for single-purpose uses is to be discouraged when other feasible uses are in the general public interest;

"(6) In considering the benefits to be derived from drainage, consideration shall also be given to possible harmful effects upon ground water supplies and protection of wildlife;

"(7) The maintenance of minimum perennial streamflows sufficient to support aquatic life and to minimize pollution shall be fostered and encouraged if existing rights and priorities under existing laws will permit;

"(8) Watershed development policies shall be favored, whenever possible, for

the preservation of balanced multiple uses, and project construction and planning with those ends in view shall be encouraged;

"*(9) Due regard shall be given in the planning and development of water recreation facilities to safeguard against pollution;*

"*(10) It is of paramount importance in all cooperative programs that the principle of the sovereignty of this state over all the waters within the state be protected and preserved, and such cooperation by the board shall be designed so as to reinforce and strengthen state control;*

"*(11) Local development of watershed conservation, when consistent with sound engineering and economic principles, is to be promoted and encouraged; and*

"*(12) When proposed uses of water are in mutually exclusive conflict or when available supplies of water are insufficient for all who desire to use them, preference shall be given to human consumption purposes over all other uses and for livestock consumption, over any other use, and thereafter other beneficial purposes in such order as may be in the public interest consistent with the principles of this Act under the existing circumstances.*"

ORS 449.545

"Contamination of Deschutes River prohibited. No person shall put or deposit in the Deschutes River, its tributaries, or artificial canal or ditch in which the waters of the Deschutes River run, any sewage, refuse, waste or polluting water, or any dead animal carcass or part thereof, or any matter which either by itself, or in connection with any other substance, will corrupt or impair the quality of the water of the river for domestic or municipal purposes, or place any such substance in such position that it escapes or is carried into such waters by the action of the elements or otherwise."

ORS 538.110

"Tumalo Creek, Deschutes County; diversion prohibited; excepted uses; existing rights. For the purpose of maintaining and perpetuating the recreational and scenic resources of Oregon, the waters of that portion of Tumalo Creek, in Deschutes County, situated above a point one-half mile above the intake of the Columbia Southern Canal in section 2, township 18 south, range 10 east, Willamette Meridian, in Deschutes County, shall not be diverted for any purposes whatsoever, except for municipal, domestic and stock uses. Nothing in this section shall be construed to impair any vested rights existing as of June 4, 1929, in the creek or its tributaries. This section shall not apply to the waters of the south fork of Tumalo Creek."

ORS 538.440

"Bend; right to waters of Tumalo Creek. Whenever the city of Bend, Deschutes County, shall have acquired the right to appropriate or use from the Deschutes River at least 11 cubic feet per second of water for delivery into the feed canal belonging to Deschutes County Municipal Improvement District, which feed canal is now supplied from the Deschutes River at a diversion located in or near Bend, then the city may take from the direct flow of Tumalo Creek, in Deschutes County, not to exceed 11 cubic feet per second of water for providing a supply of water for domestic and municipal purposes; provided, however, that should the waters of the Deschutes River so acquired for the purpose of the exchange be appurtenant to lands calling for a different point of diversion, the place of use and point of diversion of the water may be changed to meet the requirements of this section."

WITHDRAWALS BY STATE ENGINEER

DESCHUTES RIVER AND THE WATER STORED IN THE BENHAM FALLS RESERVOIR

"I, John H. Lewis, State Engineer of the State of Oregon, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon the regular flow of the Deschutes River and the water stored in the Benham Falls Reservoir to the extent of 900,000 acre feet for irrigation, power and domestic purposes, in accordance with the authority vested in me by virtue of a certain Act of Legislature providing for withdrawing and withholding from general appropriation the necessary water or water rights for the use and benefit of irrigation and power projects under investigation by the State in cooperation with the United States, filed in the office of the Secretary of State on February 21, 1913.

"Dated this 28th day of February, 1913.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this filing to withdraw and withhold from general appropriation under the laws of the State of Oregon, the necessary water or water rights for the use and benefit of the irrigation and power projects under investigation by the State in cooperation with the United States as provided in the act of the legislature relating thereto, filed in the office of the Secretary of State, February 21, 1913."

APPLICATION NO. 2802, dated February 28, 1913, is in the name of John H. Lewis, State Engineer, for a permit to appropriate the waters listed in the above withdrawal.

DESCHUTES RIVER AND ITS TRIBUTARIES ABOVE BENHAM FALLS

"I, John H. Lewis, State Engineer of the State of Oregon, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon, 900,000 acre feet of the waters of the Deschutes River and its tributaries above Benham Falls to be stored in Benham Falls Reservoir, for irrigation, power and domestic purposes, in accordance with the authority vested in me by virtue of a certain Act of the Legislature providing for withdrawing and.

withholding from general apporpriation the necessary water or water rights for the use and benefit of irrigation and power projects under investigation by the State in cooperation with the United States, filed in the office of the Secretary of State on February 21, 1913.

"Dated this 28th day of February, 1913.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this filing to withdraw and withhold from general appropriation under the laws of the State of Oregon, the necessary water or water rights for the use and benefit of the irrigation and power projects under investigation by the State in cooperation with the United States as provided in the Act of the Legislature relating thereto, filed in the office of the Secretary of State, February 21, 1913."

APPLICATION NO. 2803, dated February 28, 1913, is in the name of John H. Lewis, State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

BIG CULTUS RIVER, LITTLE CULTUS RIVER, QUINN RIVER, THOMAS CREEK, SNOW CREEK, WEST FORK DESCHUTES RIVER, OUTLET DEER LAKE, UNNAMED SPRINGS, AND ALL STREAMS TRIBUTARY TO THE WEST FORK OF THE DESCHUTES RIVER AT OR ABOVE CRANE PRAIRIE

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon, 187,000 acre feet of the waters of Big Cultus River, Little Cultus River, Quinn River, Thomas Creek, Snow Creek, West Fork Deschutes River, outlet Deer Lake, unnamed springs, and all streams tributary to the West Fork of the Deschutes River at or above Crane Prairie, to be stored in Crane Prairie Reservoir for irrigation purposes, which may be required for the project under investigation or to be investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon, by

WITHDRAWALS BY STATE ENGINEER

John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 28th day of October, 1913.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation, any unappropriated waters of the above named streams and springs, for the use and benefit of the irrigation project which is to be jointly investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder.

APPLICATION NO. 3261, dated October 28, 1913, is in the name of John H. Lewis, State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

OCHOCO CREEK TO BE STORED IN OCHOCO CREEK RESERVOIR

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon, 50,000 acre feet of the waters of Ochoco Creek to be stored in Ochoco Creek Reservoir, for irrigation purposes, which may be required for the project under investigation or to be investigated under the provision of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon, by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 8th day of April, 1914.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named stream, for the use and benefit of the irrigation project known as the Ochoco Creek Project, which is to be jointly investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder."

APPLICATION NO. 3587, dated April 8, 1914, is in the name of John H. Lewis, State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

CROOKED RIVER TO BE STORED IN CROOKED RIVER RESERVOIR

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon, 300,000 acre feet of the waters of Crooked River to be stored in Crooked River Reservoir, for irrigation purposes, which may be required for the project under investigation or to be investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon, by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 8th day of April, 1914.

/s/ JOHN H. LEWIS

John H. Lewis

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named stream, for the use and benefit of the irrigation project known as the Crooked River Project, which is to be jointly investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder."

APPLICATION NO. 3589, dated April 8, 1914, is in the name of John H. Lewis,

State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

BADGER, THREE MILE AND GATE CREEKS, TRIBUTARY OF WHITE AND DESCHUTES RIVER

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon all unappropriated water of Badger, Three Mile and Gate Creeks, tributary of White and Deschutes River, for irrigation purposes, which may be required for the project under investigation or to be investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon, by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 22d day of January, 1915.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

NOTE: Badger Creek released from withdrawal, see letter from John T. Whistler, November 10, 1915.

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named streams, for the use and benefit of the irrigation project, known as the Tygh Valley-Wamic Irrigation Project, which is to be jointly investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder."

APPLICATION NO. 4073, dated January 22, 1915, is in the name of John H. Lewis, State Engineer, for a permit to appropriate the waters listed in the above withdrawal.

WITHDRAWALS BY STATE ENGINEER

WHITE RIVER AND ITS TRIBUTARIES

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon all unappropriated water of White River and its tributaries, for irrigation, power and domestic purposes which may be required for the project under investigation or to be investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon, by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 11th day of November, 1915.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named streams for the use and benefit of the irrigation project known as the Tygh Valley-Wamic Irrigation Project, which is to be investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder."

APPLICATION NO. 4624, dated November 11, 1915, is in the name of John H. Lewis, State Engineer, for a permit to appropriate the waters listed in the above withdrawal.

WHITE RIVER AND ITS TRIBUTARIES, TRIBUTARY OF THE DESCHUTES RIVER, TO BE STORED IN CLEAR LAKE RESERVOIR

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon all unappropriated waters of White River and its tributaries, tributary of the Deschutes River, to be stored in Clear Lake Reservoir

for irrigation, power and domestic purposes, which may be required for the project under investigation or to be investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior, and the State of Oregon by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder.

"Dated this 11th day of November, 1915.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named streams for the use and benefit of the irrigation project known as the Tygh Valley-Wamic Irrigation Project, which is to be jointly investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder."

APPLICATION NO. 4625, dated November 11, 1915, is in the name of John H. Lewis, State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

HOOD RIVER, EAST FORK OF HOOD RIVER AND THEIR TRIBUTARIES IN THE VICINITY OF MT. HOOD, ZIG ZAG RIVER, LITTLE ZIG ZAG RIVER, SAND CANYON, SALMON RIVER, STILL CREEK AND OTHER TRIBUTARIES OF SALMON RIVER AND ZIG ZAG RIVER IN THE VICINITY OF MT. HOOD, WARM SPRINGS RIVER, BADGER CREEK, BEAVER CREEK AND OTHER TRIBUTARIES OF WARM SPRINGS RIVER

"I, John H. Lewis, State Engineer of the State of Oregon, in accordance with the authority in me by virtue of Chapter 87, Laws of Oregon for 1913, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon, all unappropriated water of Hood River, East Fork of Hood River and their tributaries in the vicinity of Mt. Hood, Zig Zag River, Little Zig Zag River, Sand Canyon, Salmon River, Still Creek and other tributaries of Salmon River and Zig Zag River in the vicinity of Mt. Hood, Warm Springs

River, Badger Creek, Beaver Creek and other tributaries of Warm Springs River, either by direct flow or by storage, for irrigation, power and domestic purposes, for the reclamation of the lands in the White River Project which was investigated under the provisions of said Act and that certain contract between the United States of America, by Franklin K. Lane, Secretary of the Interior and the State of Oregon, by John H. Lewis, State Engineer, approved by Oswald West, Governor, on the 5th day of May, 1913, executed thereunder, or for the reclamation of lands on the Fifteen Mile Creek Project in Wasco County, to be investigated hereafter as further information may demonstrate to be feasible and practical.

"Dated this 5th day of September, 1917.

/s/ JOHN H. LEWIS

John H. Lewis,

State Engineer of the State of Oregon."

"It is the purpose of this instrument to withdraw and withhold from general appropriation any unappropriated waters of the above named streams for use and benefit of the irrigation project known as the Tygh Valley-Wamic Irrigation Project, which is designated in the Cooperative Report as the White River Project, which was investigated under the provisions of said Chapter 87, Laws of 1913, and the contract between the State and the United States, executed thereunder, or for the reclamation of lands on the Fifteen Mile Creek Project in Wasco County, to be investigated hereafter as further information may demonstrate to be feasible and practical."

APPLICATION NO. 5728, dated September 5, 1917, is in the name of John H. Lewis, State Engineer, for a permit to appropriate the waters listed in the above withdrawal.

DESCHUTES RIVER AND ITS TRIBUTARIES

"WHEREAS, the State Engineer has heretofore withdrawn from appropriation under the provisions of Chapter 87, Laws of Oregon for 1913, certain unappropriated waters of the Deschutes River; and

"WHEREAS, subsequently certain allotments were made of said withdrawn

waters for storage in Benham Falls, Crane Prairie, and Odell Lake Reservoirs; and

"WHEREAS, it appears that certain other reservoir sites may be found feasible and practical for the storage of said water; and

"WHEREAS, it may be desirable to store the waters of the Deschutes River in certain reservoirs now being investigated,

"NOW, THEREFORE, reserving to the State all rights which they may now have for the storage of the waters of the Deschutes River under prior withdrawals in reservoirs to which said water was allotted or in other sites,

"I, CHAS. E. STRICKLIN, State Engineer of Oregon, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon the regular flow of the Deschutes River and the water to be stored in the reservoirs now being investigated by the U. S. Reclamation Service on the Deschutes River above Bend to the extent of 900,000 acre-feet for irrigation, power and domestic purposes, in accordance with authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913.

"Dated this 22nd day of November, 1934.

/s/ CHAS. E. STRICKLIN

CHAS. E. STRICKLIN,

State Engineer."

APPLICATION NO. 15631, dated November 22, 1934, is in the name of Chas. E. Stricklin, State Engineer, for a permit to construct a reservoir and to store the waters listed in the above withdrawal.

DESCHUTES RIVER AND ITS TRIBUTARIES

"WHEREAS, the State Engineer has heretofore withdrawn from appropriation under the provisions of Chapter 87, Laws of Oregon for 1913, certain unappropriated waters of the Deschutes River; and

"WHEREAS, subsequently certain allotments were made of said withdrawn

waters for storage in Benham Falls, Crane Prairie, and Odell Lake Reservoirs; and

"WHEREAS, it appears that certain other reservoir sites may be found feasible and practical for the storage of said water; and

"WHEREAS, it may be desirable to store the waters of the Deschutes River in certain reservoirs now being investigated,

"NOW, THEREFORE, reserving to the State all rights which they may now have for the storage of the waters of the Deschutes River under prior withdrawals in reservoirs to which said water was allotted or in other sites,

"I, CHAS. E. STRICKLIN, State Engineer of Oregon, do hereby withdraw and withhold from appropriation on behalf of the State of Oregon the regular flow of the Deschutes River and the water to be stored in the reservoirs now being investigated by the U. S. Reclamation Service on the Deschutes River above Bend to the extent of 900,000 acre-feet for irrigation, power and domestic purposes, in accordance with authority vested in me by virtue of Chapter 87, Laws of Oregon for 1913.

"Dated this 22nd day of November, 1934.

/s/ CHAS. E. STRICKLIN

CHAS. E. STRICKLIN,

State Engineer."

APPLICATION NO. 15632, dated November 22, 1934, is in the name of Chas. E. Stricklin, State Engineer, for a permit to appropriate the waters listed in the above withdrawal.

PROGRAM BY STATE WATER RESOURCES BOARD

"In the matter of formulating an integrated, coordinated program for the use and control of the water resources of the Lower Main Stem Deschutes River, Lower Metolius, and Lower Crooked Rivers.	)))))	Lower Deschutes Basin November 25, 1959

"WHEREAS the State Water Resources Board under the authority of ORS 536.300 has undertaken a study of that portion of the Deschutes River including the main stem of the Deschutes River from its confluence with the Columbia River to river mile 120.0 as shown in U.S.G.S. Water Supply Paper 344; the main stem of the Crooked River from its confluence with the Deschutes River to river mile 6.5 as shown on U.S.G.S. Plans and Profiles, 1926; and the main stem of the Metolius River from its confluence with the Deschutes River to river mile 13.0 as shown in U.S.G.S. Water Supply Paper 344;

"WHEREAS in this study consideration was given to means and methods of augmenting such water resources, existing and contemplated needs and uses of water for domestic, municipal, irrigation, power development, industrial, mining, recreation, wildlife and fish life uses, and for pollution abatement as well as other related subjects including drainage, reclamation, and flood control; and

"WHEREAS as a result of said study the following findings have been reached by this Board:

"1. Recreation uses represent and will continue to bring substantial benefits to the state.

"2. Fish and wildlife uses represent and will continue to bring substantial benefits to the state.

"3. Hydroelectric power production utilizing the waters of the Deschutes River and its tributaries between river mile 100.0 and river mile 120.0 will bring substantial benefits to the state.

"4. Domestic use does not represent a significant quantity either for existing or presently contemplated needs.

"5. Mining use does not represent a significant quantity either for existing or presently contemplated needs.

"6. Municipal use is not a significant factor for either existing or presently contemplated needs.

"7. *Pollution abatement is not a significant factor for either existing or presently contemplated needs.*

"8. *Industrial use is not a significant factor for either existing or presently contemplated needs.*

"9. *Irrigation use is not a significant factor for either existing or presently contemplated needs.*

"10. *Drainage and reclamation of drained lands are not existing or presently contemplated factors in water use.*

"CONCLUSION

"1. *The maximum beneficial use of that portion of the main stem of the Deschutes River from its confluence with the Columbia River to and including river mile 100.0, is for recreation, fish and wildlife purposes and no appropriations of water in this area shall be permitted except for domestic, livestock, recreation, fish and wildlife uses.*

"2. *The hydroelectric potential from river mile 100.0, main stem Deschutes River, to river mile 120.0, main stem Deschutes River, should be utilized. Such utilization is hereby encouraged for any properly state and federal licensed hydroelectric projects commensurate with multiple-purpose use for recreation, fish and wildlife, and constructed and operated in accordance with plans approved by the State Water Resources Board. Projects constructed for hydroelectric power purposes must include regulation facilities as needed to minimize river flow fluctuations resulting from such project operation in order to protect downstream recreation, fish and wildlife values and must be so operated as to provide minimum pool fluctuations during the recreation season while maintaining minimum perennial flows downstream.*

"3. *The waters of the Crooked River from its confluence with the Deschutes River to river mile 6.5 may be utilized for hydroelectric purposes commensurate with multiple-purpose use for recreation, fish and wildlife.*

"4. *The waters of the Metolius River from its confluence with the Deschutes River to river mile 13.0 may be utilized for hydroelectric purposes commensurate with multiple-purpose use for recreation, fish and wildlife.*

"5. *Projects to utilize the aforementioned waters must be approved by the State Water Resources Board.*

"6. *Water rights acquired for hydroelectric projects constructed for the purpose of utilizing the waters of the Deschutes, Metolius, and Crooked Rivers must be subordinate in priority to all existing and future upstream beneficial uses of water except for hydroelectric power.*

"NOW THEREFORE BE IT RESOLVED that this Board hereby adopts the following program in accordance with the provisions of ORS 536.300 (2) relating to the waters of the lower main stem Deschutes River, lower Metolius, and lower Crooked Rivers:

"A. *The maximum beneficial use of that portion of the main stem of the Deschutes River from its confluence with the Columbia River to and including river mile 100.0 is for recreation, fish and wildlife purposes and no appropriations of water in this area shall be permitted except for domestic, livestock, recreation, fish and wildlife uses.*

"B. *The maximum economic development of the state and the attainment of the highest and best use of the waters of the lower main stem Deschutes River from river mile 100.0 to river mile 120.0 and the attainment of an integrated and balanced program for the benefit of the state as a whole will be achieved through utilization of the aforementioned waters for domestic, livestock, hydroelectric power, fish, wildlife, and recreation purposes and the aforementioned waters of the main stem Deschutes River are hereby so classified.*

"C. *The maximum economic development of this state and the attainment of the highest and best use of the waters of the lower main stem Crooked River from its confluence with the Deschutes River to river mile 6.5 and the waters of the main stem of the lower Metolius River from its confluence with the Deschutes River to river mile 13.0 will be attained through utilization of such waters for domestic, livestock, hydroelectric power, fish, wildlife, and recreation purposes and the aforementioned waters of the lower main stem, Crooked River, and lower main stem, Metolius River, are hereby so classified.*

"D. *Applications for the use of such water shall not be accepted by any state agency for any other purpose and applications for such other purposes are declared to be prejudicial to the public interest and the granting of applications for such other uses would be contrary to the integrated, coordinated program for the use and control of the water resources of the state.*

"E. *Water rights acquired for structures or works for the utilization of the waters for hydroelectric purposes shall be subordinate to all present and future upstream beneficial uses of water except for hydroelectric power. Structures or works for the utilization of the waters in accordance with the aforementioned classifications are also declared to be prejudicial to the public interest unless planned, constructed, and operated in conformity with the applicable provisions of ORS 536.310 and any such structures or works are further declared to be prejudicial to the public interest which do not give proper cognizance to the multiple-purpose concept.*

"Done and dated this 25th day of November, 1959.

STATE WATER RESOURCES BOARD

/s/ DONEL J. LANE

By _____
Donel J. Lane, Secretary"

POTENTIAL WATER DEVELOPMENT PROJECTS
DAM AND RESERVOIR SITES - DESCHUTES RIVER BASIN

SITE NAME	STREAM	DR. AREA Sq. Mi.	AVERAGE ANNUAL YIELD Ac.-Ft.	PURPOSE	DAM			RESERVOIR					POWER				LOCATION				SOURCE NUMBER
					Height Feet	Crest Length Feet	Type	Min. Pool Elev. Ft.-MSL	Max. Pool Elev. Ft.-MSL	Min. Pool Area Acres	Max. Pool Area Acres	Usable Storage Ac.-Ft.	Total Storage Ac.-Ft.	Installed Capacity KW	Average Annual Generation 1,000 KWH	Gross Head Feet	Channel or Conduit Feet	Twp.	Rng.	Sec.	Str. Mile	
ALLEN CREEK, LOWER	Allen Creek						S						150				13S	16E	17		8
ALLEN CREEK, UPPER	Allen Creek	27		I			S						100				13S	16E	9		1
ALLEN CREEK				I			S														3
ANTELOPE CREEK, LOWER	Antelope Creek	35		I	48		S				113		1,550				8S	16E	12		1
ANTELOPE CREEK, UPPER	Antelope Creek	11		I	48		S				17		270				7S	17E	28		1
ASHLEY	Antelope Creek	77		I	59		S						1,200				8S	16E	15		8
AUBREY FALLS	Deschutes River			I	65		S										16S	12E	17	15N	6
" "	" "			I	40		S										16S	12E	20	155	6
BEAR CREEK	Bear Creek			I-FC			S						5,000				19S	17E	2		1, 8
BEAVER CREEK	Beaver Creek			I			S						10,000				16S	24E	20	14	8
BEAVER CREEK	N. Fork Beaver Creek	70		I-FC	55	1,300	S		3,890				15,000				16S	25E	21		1, 7, 8
BEAVER CR., N. FK.	N. Fork Beaver Creek						S						300				16S	25E	10		8
BENHAM FALLS	Deschutes River	1,760		P			D														
" "	" "	1,760		I			S		4,200		19,500	395,000	442,500			100	4,000	19S	11E	9	18S	6
" "	" "	1,760		I	41	1,278	S		4,170		6,000		55,000					19S	11E	17	18S	5, 6
" "	" "	1,760		I	65	3,035	S		4,193		15,500		300,000					19S	11E	20	18S	
" "	" "			I	30	6,000	S		4,172		6,000		55,000					19S	11E	29	18S	
" "	" "			I	64	4,100	S	4,151	4,179	300	8,800	78,000	108,000					19S	11E	30	18S	
" "	" "			I	55	4,300	S		4,195		14,600		300,000					19S	11E	30	18S	
BENHAM FALLS, EAST SIDE ST-PASS	Deschutes River	1,760		I	12	150	D		4,155									19S	11E	16	18Z	3
BENHAM FALLS, WEST SIDE ST-PASS	Deschutes River	1,760		I-P	14	170	D								119,900	257		19S	11E	17	18Z	3
BEUTLER	Cottonwood Canyon						S						136				3S	16E	28		8
BIRDY	Unnamed						S						117				4S	16E	22		8
BIG COLTUS LAKE	Coltus Creek			I			S						80,000				20S	7E	24		7
BIG MARSH	Big Marsh Creek	32		I			S				2,200		20,000				25S	7E	6		3
" "	" "	32		I	30		S		4,748				32,000				25S	7E	6		3
" "	" "			D-2	60		S				2,720		90,000				25S	7E	7		3
BIG PRAIRIE	N. Fork Crooked R.			I									34,000				14S	22E	27	25	1, 8
" "	" " " "	158		I-FC	35	400	S		4,700				20,000				14S	22E	30	30	2, 7
" "	" " " "	158	47,500	I-FC	66	600	S		4,494		3,800	39,000	40,000				14S	22E	30	30	3
BIG SUMMIT	" " " "			I-FC			S						20,000				14S	22E	30	30	2
BLACK ROCK	Crescent Creek	165		I	52	1,450	S		4,487		2,010		32,000				24S	8E	9	13	3
BOX CANYON, LOWER	Crooked River			P	155		S		2,075								12S	12E	27	6	5
BOX CANYON, UPPER	" "			P	100		S										12S	12E	28	7	5
BRENNAN	Grindstone Creek			I			S						100				17S	24E	23		1, 8
BUCK CREEK	Buck Creek						S						300				21S	23E	26		8
CAMAS PRAIRIE	Unnamed			I			S										5S	10E			3
CAMP CR., SOUTH FK.	South Fork Camp Creek						S						500				19S	21E	17		8
CEMETERY CREEK	Cemetery Creek						S						100				17S	21E	11		8
COLEMAN	Deschutes River			P	78		S		1,355							58	9S	13E	12	90	5
COTTONWOOD CANYON	Cottonwood Canyon						S						40				3S	16E	33		8
CRESCENT CREEK	Crescent Creek	185		I	75	2,800	S		4,407		1,070		32,000				24S	9E	6	4	3
CROOKED R., N. FK.	N. Fork Crooked River		47,500	I			D										14S	22E	29	29	3
CROOKED R., S. FK.	S. Fork Crooked River						S						18,000				18S	22E	13		8
DAVIS CREEK	Davis Creek						S						150				18S	21E	23		8
DAVIS LAKE	Davis Lake			I	32	8,800	S	4,376	4,392	170	3,800	39,000					22S	7E	25		3
DEEP CREEK	Deep Creek	84	35,500	I			D										14S	22E	26		3
DILLON FALLS	Deschutes River			P			S									65	19S	11E	4	17Z	6
DRAKE CREEK	Drake Creek						S						100				17S	20E	10		8
DRY CREEK	Ray Creek			I-FC			S						100				10S	15E	29		1
EAST MORMON	Newbill Creek			I	43		S						692				12S	15E	33		1
EVANS CREEK	Evans Creek						S						250				13S	17E	34		8
FINNIGAN CANYON, LOWER	Finnigan Canyon						S						60				3S	16E	35		8
FINNIGAN CANYON, UPPER	Finnigan Canyon						S						100				3S	17E	31		8
FIR TREE	N. Fork Crooked River			I	166		S										15S	22E	16	20	3
" "	" " " "			I	215		S	4,325									14S	22E	16	20	3
FRIEDA	Deschutes River			P	178		S		1,110					58,000	342,000	145	30	6S	13E	13	6Z	2, 4, 5
GARNET	La Follet Creek						S						100				20S	21E	9		8

POTENTIAL WATER DEVELOPMENT PROJECTS
DAM AND RESERVOIR SITES - DESCHUTES RIVER BASIN

SITE NAME	STREAM	DR. AREA Sq Mi.	AVERAGE ANNUAL YIELD Ac-Ft.	PURPOSE	DAM HEIGHT Feet	DAM CREST LENGTH Feet	DAM TYPE	RESERVOIR MIN. POOL ELEV. Ft.-MSL	RESERVOIR MAX. POOL ELEV. Ft.-MSL	RESERVOIR MIN. POOL AREA Acres	RESERVOIR MAX. POOL AREA Acres	USABLE STORAGE Ac-Ft.	TOTAL STORAGE Ac-Ft.	POWER INSTALLED CAPACITY Kw	POWER AVERAGE ANNUAL GENERATION 1,000 KWH	POWER GROSS HEAD Feet	POWER CHANNEL OR CONDUIT Feet	LOCATION TWP.	LOCATION RNG.	LOCATION SEC.	LOCATION STR. MILE	SOURCE NUMBER
GATE CREEK	Gate Creek						S						600					4S	[illegible]	36		8
GREEN LAKES	Green Lakes			I			S											17S	8E	23		[illegible]
GRINDSTONE, LOWER	Grindstone Creek			I			S						150					17S	24E	10		1, 8
GRINDSTONE, UPPER	Grindstone Creek			I			S						300					17S	24E	34		1
GUTZIER	Unnamed						S						[illegible]					4S	13E	31		8
HENDERSON	Off-channel			I			S						4,000					14S	[illegible]	28		[illegible]
HOFFMAN	Crooked River			I I			S S				3,300 [illegible]	200,000 [illegible]	222,000 1,065,000					16S 16S	16E 16E			3, [illegible]
HOWARD CREEK	Howard Creek			I			S						15,000					14S	20E	12		8
HUDSPETH LAKE	N. Fork Crooked River			I-R	90	[illegible]	S				440	12,000	14,000					14S	21E	29	40	[illegible], 8
INDIAN CREEK	Indian Creek						S						300					18S	20E	9		8
INDIAN FORD, LOWER INDIAN FORD, UPPER	Indian Ford Creek			I I	60 [illegible]	[illegible]	S S	[illegible]	[illegible]	[illegible]	133 85		1,444 [illegible]					14S 14S	9E 9E	14 [illegible]		1 1
INEZ MARIA	Paulina Creek			I	[illegible]	[illegible]	S				96		856					21S	11E	29		1
INTERCEPTION	Deschutes River			D-I-P D-I-P	[illegible]	385 [illegible]	S S		[illegible]					21,700 [illegible]	58,900 84,400			11S 11S	12E 12E	35 [illegible]	113 113	1 1
JACKS CREEK	Metolius River			P	[illegible]		S		[illegible]					11,300	88,500	300	31,[illegible]	12S	9E	[illegible]	35	[illegible], 8
JASPER	Camp Creek						S						300					18S	21E	13		8
JEFFERSON CREEK	Metolius River			P	20		D		[illegible]					26,500	130,000	400	47,500	11S	9E	35	[illegible]	[illegible]
JONES CANYON	Jones Canyon						S						60					3S	16E	30		8
KAUFFMAN, LOWER KAUFFMAN, UPPER	Willow Creek			I I	36 8		S S						8 1,040					12S 11S	15E 16E	26 19		1 1
KENNEDY	Hazel Hollow						S						200					5S	11E	3		8
LAIDLAW	Deschutes River			I			D											16S	12E	31	158	[illegible]
LAPSEIL	Salt Creek						S						100					5S	15E	10		8
LAVA ISLAND FALLS	Deschutes River			I P	25	100	D D		3,936							100		18S 18S	11E 11E	27	175	[illegible]
LAWSON CREEK	Lawson Creek						S						300					15S	17E	13		8
LITTLE BEAR CREEK, LOWER	Little Bear Creek						S						50					18S	18E	18		8
LITTLE BEAR CREEK, UPPER	Little Bear Creek						S						150					18S	18E	4		8
LITTLE SUMMIT	Little Summit Creek	[illegible]		I			S															3
LLEWELLYN CREEK	Llewellyn Creek						S						400					16S	22E	34		8
LOCKIT	Deschutes River			P	96		S		39[illegible]					34,000	202,000	70		1S	16E	8	14	2, 4, 5
LONE PINE CREEK	Lone Pine Creek			I			S						3,000					14S	19E	4		8
LOCKETT CREEK				I			S															3
LOST CREEK	Lost Creek						S						150					16S	20E	16		8
LOWER	Deschutes River			P			D									110	5,000					6
LYLE	Wilson Creek			I-FC			S						103					10S	15E	9		1
MARKS CREEK	Marks Creek						S						200					13S	19E	31		3
MAUPIN	Deschutes River			P	148		S		960					48,000	280,000	120	[illegible]	5S	14E	[illegible]	52	2, 5
McKAY	Hollow Marker Canyon						S						85					5S	17E	27		8
McKAY	McKay Creek						S						150					13S	16E	12		8
McKAY CREEK	McKay Creek	[illegible]		I			S						[illegible]					13S	17E	[illegible]		1
MECCA	Deschutes River			P	[illegible]		S		[illegible]		8[illegible]					[illegible]		9S	13E	30	9[illegible]	5, 6
METOLIUS, see Round Butte																						
MILLS	Beaver Creek			I			S											16S	23E	34	8	1
MILLS	Unnamed						S						[illegible]					1[illegible]S	[illegible]E	19		8
MOODY	Deschutes River			P	[illegible]		S		[illegible]		[illegible]			66,000	[illegible],000	[illegible]		N	[illegible]E	16	3	2, 4, 5, 6
NEWSOME CR., LOWER	Newsome Creek						S						[illegible]					1[illegible]S	13E	18		8
NEWSOME CR., UPPER	Newsome Creek						[illegible]						[illegible]					1[illegible]S	19E	4		4
OAK BROOK	Deschutes River			P	98		S		645					[illegible]	[illegible]	66		3S	15E	18	3	[illegible]
OAK SPRINGS	Deschutes River			[illegible]	[illegible]		S		[illegible]					[illegible]	3,[illegible]	35		4S	14E	[illegible]	4[illegible]	[illegible]
ODELL LAKE	Odell Creek	[illegible]		I D-I			[illegible]	[illegible]	[illegible]	3,5[illegible]		[illegible]						23S 23S	6E 6E	[illegible]		[illegible]

POTENTIAL WATER DEVELOPMENT PROJECTS
DAM AND RESERVOIR SITES - DESCHUTES RIVER BASIN

SITE NAME	STREAM	DR. AREA SQ. MI.	AVERAGE ANNUAL YIELD Ac.-Ft.	PURPOSE	DAM HEIGHT Feet	DAM CREST LENGTH Feet	DAM TYPE	RESERVOIR MIN. P.I. ELEV. Feet MSL	RESERVOIR MAX. P.I. ELEV. Feet MSL	RESERVOIR MIN. P.I. AREA Acres	RESERVOIR MAX. P.I. AREA Acres	RESERVOIR USABLE STORAGE Ac.-Ft.	RESERVOIR TOTAL STORAGE Ac.-Ft.	POWER INSTALLED CAPACITY KW	POWER AVERAGE ANNUAL GENERATION (+) KWH	POWER GR. SS HEAD Feet	POWER CHANNEL N. LENGTH Feet	LOCATION TWP.	LOCATION RNG.	LOCATION SEC.	LOCATION STR. MILE	SOURCE REMARKS
"LD DRY CREEK	Old Dry Creek												200					14S	15E	17		8
PAULINA	Beaver Creek			I-PC									45,000					16S	21E	30		2
PAULINA VALLEY	Paulina Creek			I	14		D											16S	21E	31		3
POST	Crooked River	2,160		I-PC	110	700	S		3,458		3,690	121,000	123,000					17S	21E	6	1/3	3, 4, 7
	" "	2,160		I	43		S		3,458			121,000						17S	21E	6	1/3	4
POTHOLE	Off-channel			I			S						3,000									1, 8
POWELL	North Fork Beaver Cr.	60		I	41		S						15,000					16S	6E			2
PRICE	Crooked Creek						S						200					20S	7E	18		8
Q RANCH	Camp Creek						S						400					19S	7E	35		8
RABBIT VALLEY	Tributary			I	20		S						400					14S	2E	24		8
																		14S	2E	24		1
RABBIT VALLEY	Watson Creek			I			S						566					14S	12E	26		
RECLAMATION	Deschutes River			P	118		S		4,490		4,610			46,000	272,000	95	800	18	14E	5	20	2, 4, 5, 6
RIGGS	Metolius River			P	90		S		1,200							135	9,000	11S	11E	28	8	4
RIMROCK	Deschutes River			P			S											2N	14E	26	0	1
ROBA CREEK	Roba Creek						S											20S	23E	29		8
ROUND BUTTE	Deschutes River			P	440		S						100					14S	12E	22	1/3	1
METOLIUS	" "			P	245	1,320	S	1,860	1,945	1,300	3,600	250,000	500,000	195,000	832,000	300		11S	12E	22	1/3	3
	" "			P			S		1,945					330,000	975,000	372	1,340	11S	12E	22	1/3	3
	" "			I			S									210		11S	12E	15	1/3	5, 4
	" "																	11S	12E	15	1/3	1
SAGE FLAT	Off-channel			I	32	3,430	S				955		25,500									3
SAND HOLLOW	Sand Hollow Creek						S						300					14S	10E	21		3
SARGIS CREEK	Sarsly Creek						S						100					19S	22E	17		8
SCHOOLIE	Warm Springs River	95	110,000	I	100		S						100,000					17S	21E	9		8
SCHONEBEP	Tributary						S						100					7S	10E	17	37	2
SHEEP ROCK	Lost Sheep Rock Cr.						S						100					4S	13E	21		8
SHERAR FALLS	Deschutes River			P	88		S		980		1,170			36,000	210,000	15	4,600	16S	21E	18		8
SIMAM X	Deschutes River			P	106		S		595					43,000	254,000	90		4S	14E	3	44	2, 4, 5, 6
STEWART CREEK	Stewart Creek						S											2S	15E	34	29	2, 4, 5
STYTLE LAKE	Lake Creek	22		I			S					6,000	200					17S	21E	8		8
" "	" "	22	35,200	I	50	1,320	S	3,433	3,472	240	430	6,000						13S	8E	24	6	1
" "	" "	22		I	55		S		3,475			18,000						13S	8E	24	6	3
" "	" "	22		I	68	1,100	S	3,430				18,000						13S	8E	24	6	3
												17,600						13S	8E	24	6	2
TENEEMILE, LOWER	Threemile Creek						S						300					4S	12E	19		8
TENEEMILE, UPPER	Threemile Creek						S						400					4S	11E	31		8
TWELVEMILE	Twelvemile Creek						S						200					19S	21E	13		8
YEAZIE CREEK	Yeazie Creek						A						300					11S	10E	5		8
VICTOR SCHOOL	Tributary			I	40		S											4S	13E			7
WAMIC	Threemile Creek			I	100		S						24,000					4S	13E	9		2
WAPINITIA	Wapinitia Creek			I			S						20,200					5S	12E	24		1
WATSON	Watson Creek						S						60					16S	11E	29		8
				I	22	470	S				194		336					16S	11E	29		8
WHITEHORSE RAPIDS	Deschutes River			P	120		S		1,260					38,500	186,000	138	4,600	7S	14E	19	11	4, 6
WHITE RIVER	White River			I	60		S											9S	10E	11	29	3
WHITEWATER CREEK	Warm Springs River			P	8		A		1,070					20,600	143,000	160	21,000	10S	11E	8	19	4, 6
WILLOW CREEK	Willow Creek			P	31		S						800					11S	14E	18		1
WILSON CREEK	Wilson Creek			I-PC	34		S						450					10S	14E	3		1
WOLF MOUNTAIN	Powell Creek	4		I	94	1,830	S				287		5,030					19S	9E	6		1, 2, 8
UNNAMED	Tributary						S						15					7S	11E	1		8
UNNAMED	Tributary						S						140					4S	14E	34		8
UNNAMED	Tributary						S						80					4S	15E	10		8
UNNAMED	Tributary						S						70					4S	15E	3		8
UNNAMED	Tributary						S						80					4S	14E	11		8
UNNAMED	Tributary						S						100					4S	14E	15		8
UNNAMED	Tributary						S						70					4S	11E	4		8
UNNAMED	Tributary						S						50					11S	11E	8		8
UNNAMED	Tributary						S						30					5S	11E	3		8

POTENTIAL WATER DEVELOPMENT PROJECTS
DAM AND RESERVOIR SITES -- DESCHUTES RIVER BASIN

EXPLANATORY NOTES

PURPOSE:

- D - Domestic
- I - Irrigation
- P - Power
- R - Recreation
- FC - Flood Control

TYPE:

- D - Diversion
- S - Storage

SOURCE:

1. Department of Agriculture, Soil Conservation Service, and Forest Service
2. Department of the Army, Corps of Engineers
3. Department of the Interior, Bureau of Reclamation
4. Department of the Interior, Federal Power Commission
5. Department of the Interior, Geological Survey
6. Oregon Cooperative Work, Department of the Interior with State of Oregon
7. Oregon State Engineer
8. County Water Resources Committees
9. Consulting Engineers' Reports

NOTE: This table includes projects with conflicting reservoir areas.

SELECTED BIBLIOGRAPHY

FEDERAL AGENCIES

Department of Agriculture

Agricultural Research Service

Agricultural Economy, Deschutes River Basin, Oregon, May 1, 1960.

Forest Service - Pacific Northwest Region

Forest Statistics for Klamath County, Oregon, Forest Survey Report No. 99, June 1947.
Production of Lumber in Oregon and Washington, 1869-1948, Forest Survey Report No. 100, December 1949.
Production of Logs in Oregon and Washington, 1925-1948, Forest Survey Report No. 101, April 1950.
Forest Statistics for Lake County, Oregon, Forest Survey Report No. 102, May 1950.
Forest Statistics for Crook County, Oregon, Forest Survey Report No. 114, May 1954.
Forest Statistics for Jefferson County, Oregon, Forest Survey Report No. 115, June 1954.
Forest Statistics for Deschutes County, Oregon, Forest Survey Report No. 116, July 1954.
Forest Statistics for Wasco County, Oregon, Forest Survey Report No. 127, July 1958.
Forest Camping in Oregon, Directory of National Forest Camps, 1958-1959.
Timber Harvest by Ownership in State of Oregon, 1949-1958.
National Forests, Deschutes River Basin, May 1960.

Soil Conservation Service and Forest Service

Review and Evaluation of Small Watershed Project Needs Within the Deschutes River Basin, January 1961.

Weather Bureau

Climatic Summary of the United States, Climatic Data Herein From the Establishment of Stations to 1930, Inclusive, Section 3 - Western Oregon, Section 4 - Eastern Oregon, 1936.

SELECTED BIBLIOGRAPHY

Army, Corps of Engineers

Review Report on Columbia River and Tributaries, Appendix K, Minor Streams below Yakima River, October 1948.

Department of Commerce

Bureau of Census

Census of Agriculture
Census of Population
Census of Mineral Industries

Weather Bureau

Climatic Summary of the United States - Supplement for 1931 through 1952, Oregon, Climatography of the United States No. 11-31, 1956.
Sub-station History, Oregon, Key to Meteorological Records Documentation No. 1.1, 1956.
Index of Oregon Weather Stations by Counties, State Climatologist, October 1958.
Climatological Data - Annual Summaries and Monthly Reports.

Department of the Interior

Bureau of Reclamation

Deschutes Investigations, Oregon, 1934-1935, Part I, Storage Investigations, Volume I and II, by C. C. Fisher, July 1936.
Deschutes Investigations, Oregon, 1935-1936, Part II, Crooked River Project, by C. C. Fisher, May 1936.
Deschutes Investigations, Oregon, 1935-1936, Part III, North Unit Project, by C. C. Fisher, July 1936.
Deschutes Investigations, Oregon, Plainview Project from Suttle Lake, by C. C. Fisher, February 1937.
Deschutes Investigations, Oregon, South Unit Project, by C. C. Fisher, September 1937.
Deschutes Project, Oregon, By-Pass Channel Reconnaissance Report, January 1951.
Deschutes Project, Oregon, Domestic Water System, Project Planning Report, No. 1-5.153-1, May 1951.
Crooked River Project, Oregon, February 1953.

North Unit, Deschutes Project, Oregon, Haystack Equalizing Reservoir, August 1953.
Crescent Lake Dam Project, Oregon, February 1954.
Wapinitia Project, Oregon, Juniper Division, March 1954.
Deschutes Project, Oregon, Supplemental Storage, Benham Falls Dam, September 1955.
Crooked River Project Extension, Oregon, March 1960.
Post Project, Oregon, Wrap-up Report, June 1960.

Geological Survey

Preliminary Report on the Geology and Water Resources of Central Oregon, by Israel C. Russell, Bulletin No. 252, 1905.
Deschutes River, Oregon, and its Utilization, by F. F. Henshaw, John H. Lewis and E. J. McCaustland, Water Supply Paper 344, 1914.
Quality of Surface Water in Oregon, by Walton Van Winkle, Water Supply Paper 363, 1914.
Large Springs in the United States, by O. E. Meinzer, Water Supply Paper 557, 1927.
Geology and Water Resources of the Middle Deschutes River Basin, Oregon, by Harold T. Stearns, Water Supply Paper 637-D, 1931.
Surface Water Supply of the United States, Part 12, North Pacific Slope Basins, C. Pacific Slope Basins in Oregon and Lower Columbia River Basin, 1924-1934.
Surface Water Supply of the United States, Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin, 1935-1958.
Quality of Surface Waters of the United States, Parts 9-14, Colorado River Basin to Pacific Slope Basins in Oregon and Lower Columbia River Basin, 1950-1954.

Federal Power Commission

Uses of Deschutes River, Oregon, by D. C. Henny, J. B. Cavanaugh, and F. F. Henshaw, 1922.

OREGON STATE AGENCIES

Board of Health

Biennial Reports, Sanitary Authority.

Department of Employment

Employment and Payrolls in Covered Industries, Quarterly and Annual Reports, 1948-1958.

Department of Geology and Mineral Industries

Oregon Mineral Deposits, Miscellaneous Paper No. 2, 1957.

Fish Commission

Biennial Reports

Game Commission

Annual Reports, Fish Division
Annual Reports, Game Division
Biennial Reports, Game Division
The Deschutes Basin, A Report on the Fish and Wildlife Resource, December 1950.
Deschutes Basin, Desirable Minimum Flow Survey, 1959 to 1960.

Highway Department

Annual Reports, Parks and Recreation Division.

Oregon State College

Geology of the Madras Quadrangle, by Edwin T. Hodge, Oregon State Monographs, Studies in Geology, No. 1, June 1940.
The Geology of North Central Oregon, by Edwin T. Hodge and W. D. Wilkenson, Oregon State Monographs, Studies in Geology, No. 3, November 1941.

State Engineer

Biennial Reports
Water Resources of the State of Oregon, Bulletins 4 and 7 to 10, 1878-1941.
The Deschutes Basin, A Report on the Water Resources, by Charles E. Stricklin, January 1951.
A Brief Description of the Ground Water Resources of the Deschutes River Basin, Oregon, by Jack E. Sceva, June 1960.

SELECTED BIBLIOGRAPHY

Water Resources Board

Water Quality Data Inventory, Bulletin No. 1, June 1956.
Water Quality Data Inventory Supplement, Bulletin No. 2, June 1957.

Water Resources Committee

A Report on Water Supply Sources and Water Use in 187 Oregon Cities, 1954.

COOPERATIVE PROGRAMS

U. S. Department of Agriculture, Soil Conservation Service, and Oregon Agricultural Experiment Station

Soil Survey, Deschutes Area, Oregon, December 1958.

U. S. Department of the Interior, Reclamation Service, and State of Oregon
Deschutes Project, December 1914.
Ochoco Project and Crooked River Investigations, June 1915.
Warner Lake Valley and White River Projects, February 1916.

U. S. Department of the Interior, Fish and Wildlife Service, and Oregon State Game Commission

Recommended Minimum Flows below Wickiup Reservoir, December 1947.

U. S. Department of the Interior, Geological Survey, and Oregon State Engineer

Ground Water in the Prineville Area, Oregon, by John W. Robinson, unpublished report, April 1947.
Gaging Station List, State of Oregon, October 1955.

HEARINGS

State Water Resources Board

Transcript of Testimony in the Matter of the Referral of the Application of Portland General Electric Company for a Permit to Construct the Round Butte Project, Deschutes River, Portland, Oregon, October 12 to 16, 1959.

SELECTED BIBLIOGRAPHY

Transcript of Testimony, Reconvened Hearing in the Matter of the Referral of the Application of Portland General Electric Company for a Permit to Construct the Round Butte Project, Deschutes River; Salem, Oregon, November 19, 1959.

Hearing Record in the Matter of a Water Resource Program for the Deschutes River Basin; Redmond, Oregon, March 1, 1960.

MISCELLANEOUS REPORTS

Interim Report - Recreation Areas and Facilities, Columbia Basin Inter-Agency Committee, Pacific Northwest Region, Recreation Subcommittee, September 1956.

Geology of the Bend Quadrangle, Oregon, and Volcanism in the Central Part of the High Cascade Range of Oregon and the Plateau to the East, by Howel Williams, Department of Geological Sciences, University of California, 1957.

Pacific Northwest Hydrologic Data Collection Program, Columbia Basin Inter-Agency Committee, Subcommittee on Hydrology, January 1959.

Round Butte Project, Feasibility Report, Bechtel Corporation, Engineers, October 1958.

ABBREVIATIONS AND SYMBOLS

ac	acre
Ave.	average
BLM	Bureau of Land Management
BM	Board Measure
Br.	branch, bridge
Can.	canal, canyon
cfs, CFS	cubic feet per second
Co.	county
Const.	Construction
Cr.	creek
DA	drainage area
DCMID	Deschutes County Municipal Improvement District
Dept.	Department
Des.	Deschutes
Dist.	District
Dom.	domestic
E.	east
F.	Fahrenheit
Fig.	figure
Fk.	fork
ft.	feet, foot
G.	gulch
gpd	gallons per day
gpm	gallons per minute
H	head
Hol.	Hollow
Impr.	Improvement
Inc.	Incorporated
Ind.	industrial, industries
Irrig.	irrigation
Jct.	junction
KW	kilowatts
KWH	kilowatt hours
L.	little, lake
Max.	maximum
Mdw.	Meadow
mgd	million gallons per day
mi	mile
Min.	mining, minimum
Mt.	mount
Mtn.	mountain
Mun.	municipal
M.P.	municipal park
msl, MSL	mean sea level
N.	north
No.	number
nr.	near
Ore.	Oregon
OSHD	Oregon State Highway Department
Pt.	point
P.O.	post office
Pow.	power
ppm	parts per million
Q	rate of flow
quad	quadrangle
R.	range, river
Rec.	Reclamation, recreation
Res.	reservoir
Res'rs.	reservoirs
Riv.	river
R.S.	ranger station
S.	south
Sec.	section
Ser.	Series
Σ	sigma (a summation)
Spr.	spring
Sq.Mi.	square mile
SWRB	State Water Resources Board
T.	township
USFS	United States Forest Service
USGS	United States Geological Survey
W.	west
WSP	water supply papers

APPROXIMATE HYDRAULIC EQUIVALENTS

1 acre foot
- = *a volume 1 acre in area and 1 foot in depth*
- = *326,000 gallons*
- = *43,560 cubic feet*
- = *0.5 cubic feet per second for 1 day*

1 cubic foot per second
- *falling 8.8 feet will produce 1 horsepower**
- *falling 11.8 feet will produce 1 kilowatt**
- = *7.5 gallons per second*
- = *450 gallons per minute*
- = *2.0 acre-feet per day*
- = *650,000 gallons per day*

1 inch per day
- = *0.04 cubic feet per second per acre*
- = *27 cubic feet per second per square mile*
- = *19 gallons per minute per acre*

1 inch per hour
- = *1.0 cubic feet per second per acre*
- = *640 cubic feet per second per square mile*
- = *450 gallons per minute per acre*

1 million gallons per day
- = *690 gallons per minute*
- = *1.5 cubic feet per second*
- = *3.0 acre-feet per day*

* *theoretical for water at standard conditions*