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THE WATER RESOURCES OF THE METHOW BASIN

by

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(For Use by the Water Resources Management Division)

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INTRODUCTION

The purpose of this report is to present an analysis of the water resources of the Methow Basin, with emphasis upon water use and irrigated lands. Much general background information, as well as some detailed hydrologic analysis, has already been published. These sources are very useful and are given in the bibliography. Especially useful is the recent (1974) report by Walters and Nassar.

Land Use

Figure 1 shows the basin and its subdivisions. These subdivisions are determined by the SCS for covenient inventory purposes. A good breakdown of land use, by sub-basin, is given in Table 1.

Water Use

Based on available information, the estimated water use in the Methow Basin is:

Use	Surface (acre-feet)	Ground (acre-feet)	Total (acre-feet)
Irrigation	75,000	3,000	78,000
Industrial	8,600	2,400	9,000
Public Supply	0	600	600
Other	0	150	150
TOTAL	83,600	6,150	87,750

Water Rights

There are (1976) a total of 438 prime water rights and 62 water right applications. The total prime water rights are for 629 cfs consumptive use and 82 cfs partially consumptive and nonconsumptive. These are broken down in Table 2 by source. In addition, there are 23 supplemental water rights (20 surface, 3 ground) for a total of 21 cfs.

The annual water use which would result from use of all the consumptive rights is estimated to be:

Use	Surface (acre-feet)	Ground (acre-feet)	Total (acre-feet)
Irrigation	107,300	11,700	119,000
[illegible]	[illegible]	[illegible]	[illegible]
Domestic	200	600	800
Other	100	200	300
Total	107,800	12,600	120,400

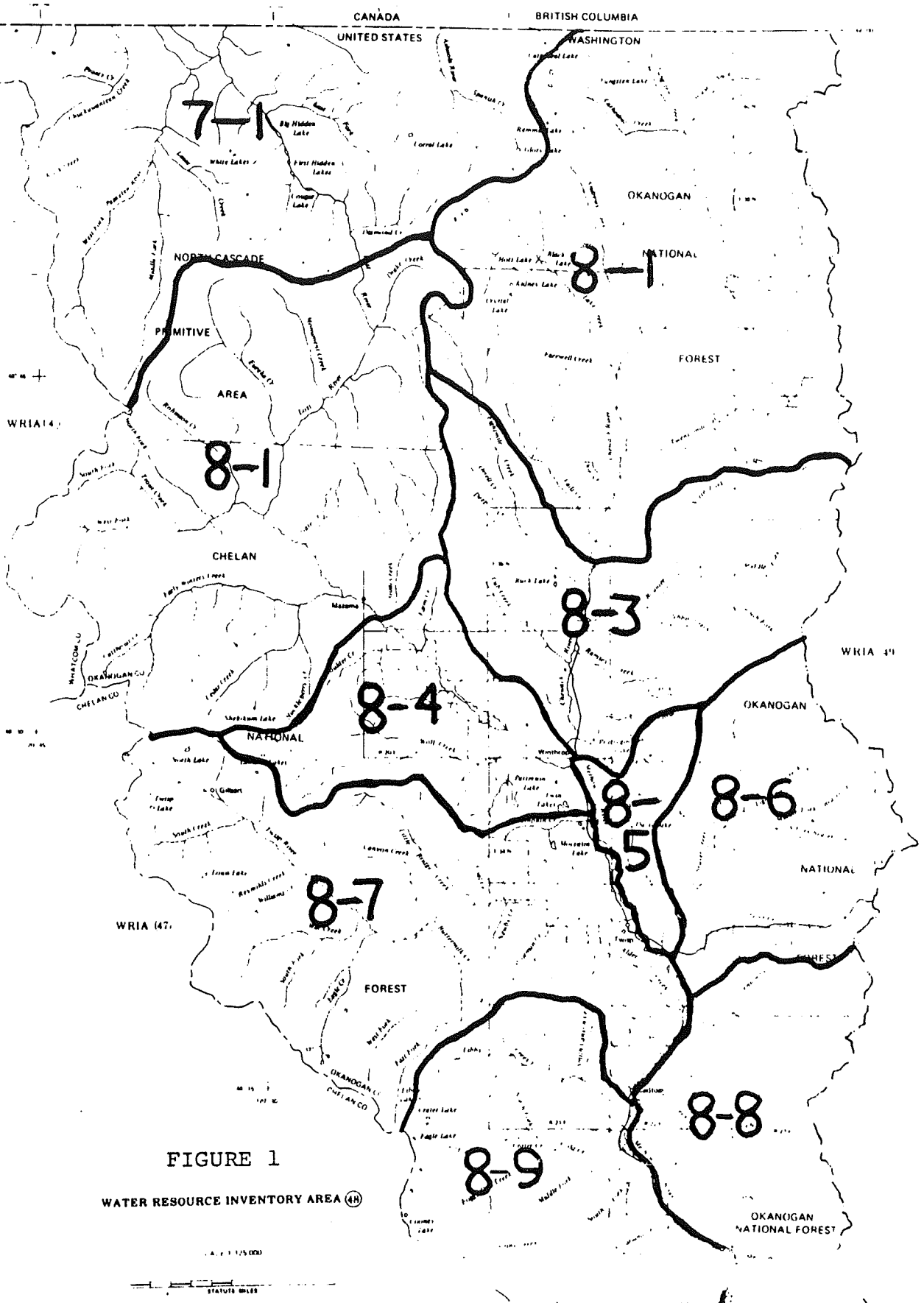


FIGURE 1

WATER RESOURCE INVENTORY AREA (48)

Methow Basin and Subbasins

Table 1: Land Use in the Methow Basin

Subbasin Na	Map No.	Forest Land Grazed	Forest Land Not Grazed	Crop Land	Range Land	Other	Total	Irrigated Land (Acres)	Potential Irrigated Land (Acres)
Upper Chewack C	8-1	188,968	0	0	22,000	5,435	216,403	0	0
Upper Methow R.	8-2	190,278	0	340	22,000	7,735	220,353	200	0
Lower Chewack C	8-3	107,140	0	2,600	12,000	2,579	124,319	900	1,000
Middle Methow R	8-4	84,153	0	2,600	8,000	3,566	98,319	1,500	500
Davis Lake Area	8-5	11,969	0	1,500	10,000	2,451	25,920	1,000	1,000
Beaver Cr.	8-6	40,669	0	4,800	24,000	1,005	70,474	700	0
Twisp R.	8-7	150,913	0	2,200	18,000	6,011	177,124	1,000	1,200
East Lower Methow	8-8	33,507	0	3,800	45,000	1,477	83,784	800	1,500
West Lower Methow	8-9	107,413	0	1,400	24,000	3,272	136,085	700	500
Upper Similkameen	7-1	--	-	--	--	--	--	--	--
TOTAL		915,010	0	19,240	185,000	33,531	1,152,781	6,800	5,700
% of Basin Area		79.3	0	1.7	16.0	2.9	100		

Sources: SCS Inventory of Soil and Water Conservation Needs (unpublished data) in acres.

Table 2: Water Rights in the Methow Basin

Source	Issued Rights			Applications		
	Consumptive	Partly Consumptive	Non Consumptive	Consumptive	Partly Consumptive	Non Consumptive
Surface Wate						
Number	275	3	7	48	0	2
Instant. eous Rate of Diversi (cfs)	543.6	18.4	63.9	31.7	0	10.0
Ground Water						
Number	163	-	-	14	-	-
Instant eous Rate of Diversi (cfs)	85.6	-	-	5.9	-	-
Reservoir						
Number	3	0	0	0	0	0
Storage apacity (acre-f t)	6,415	0	0	0	0	0
Total						
Number	438	3	7	62	0	2
Instant eous Rate of Diversi (cfs)	629.2	18.4	63.9	37.6	0	10.0

Date of Data earch: June 1976

Water Supply

The water supply of the Methow River is highly variable through the year. The median monthly flow of the Methow River near its mouth is shown in Figure 2. About 60 percent of the annual runoff occurs in May and June. The runoff pattern of the Methow is controlled by seasonal storage of precipitation as shown in the winter and rapid runoff in the late spring when the snow melts.

The variation between years is also important, as is shown in Figure 3. The 1972 water year had the largest runoff (2,143 kilo acre-feet) and the 1973 water year next to the smallest runoff (684 kilo acre-feet).

The water supply variation in space is shown in Figure 4. As the diagram shows, 70 percent of the runoff occurs above Winthrop, 19 percent from the Twisp River, and the remaining 11 percent from the remainder of the basin.

LAND USE

The Methow Basin is a land of ridges and canyons, except for the valley floor between Mazama and Carlton. In this stretch of 32 miles, the valley bottom is more than a mile wide. The broad glaciofluvial terraces were found to be suitable for irrigation; as a result, homesteaders settled the valley in the late 1800's initially in the vicinity of Twisp and near Pateros. Most of the irrigation development occurred between 1905 and 1910. Much of the nonirrigated land in the Methow Basin is grazed.

In 1967, the SCS reported 19,240 acres of land cropped of which 6,800 acres were irrigated.

Apples and pears were once the principal crops of the Methow River Valley south of Twisp, but the extremely low temperatures that prevail during the winter months repeatedly have caused extensive damage to the orchards. The most recent wide-scale damage occurred during the winter of 1968 when low temperatures in places ruined hundreds of acres of orchards. As a result of this, many farmers have gone out of business or have changed to different crops.

There are three major zones of agricultural land use in the valley. From the mouth of the Methow River, upstream to Carlton, practically all of the irrigated land is in apple production. From Carlton to Twisp, the land use is about equally divided between orchards and general field crops. The orchards in this area are the most subject to severe winter kill and frost damage. The principal field crop grown is potatoes. From Twisp to the upper end of the valley, most of the irrigated lands are in forage crops, such as alfalfa, with a small percentage in small grains to fit crop rotations.

[illegible] similar areas along the Columbia River. Yields progressively decrease farther upstream because of the shorter growing season. Forage crop yields are low, but the crops are important because they are used to supplement federal rangelands for livestock. Average alfalfa yields are between 2.5 and 3 tons per acre.

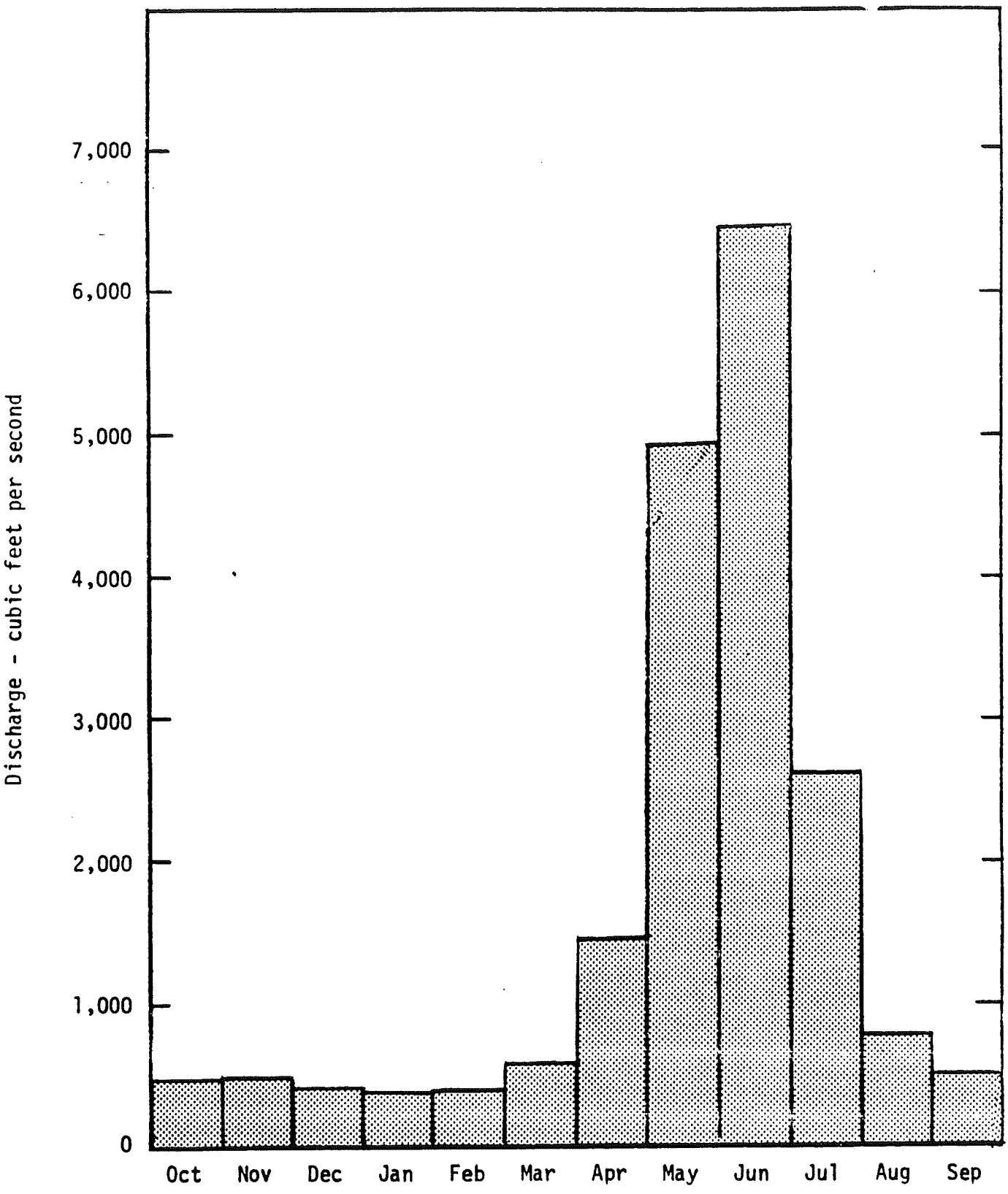


FIGURE 2. Median Monthly Discharge of the Methow River near Pateros.

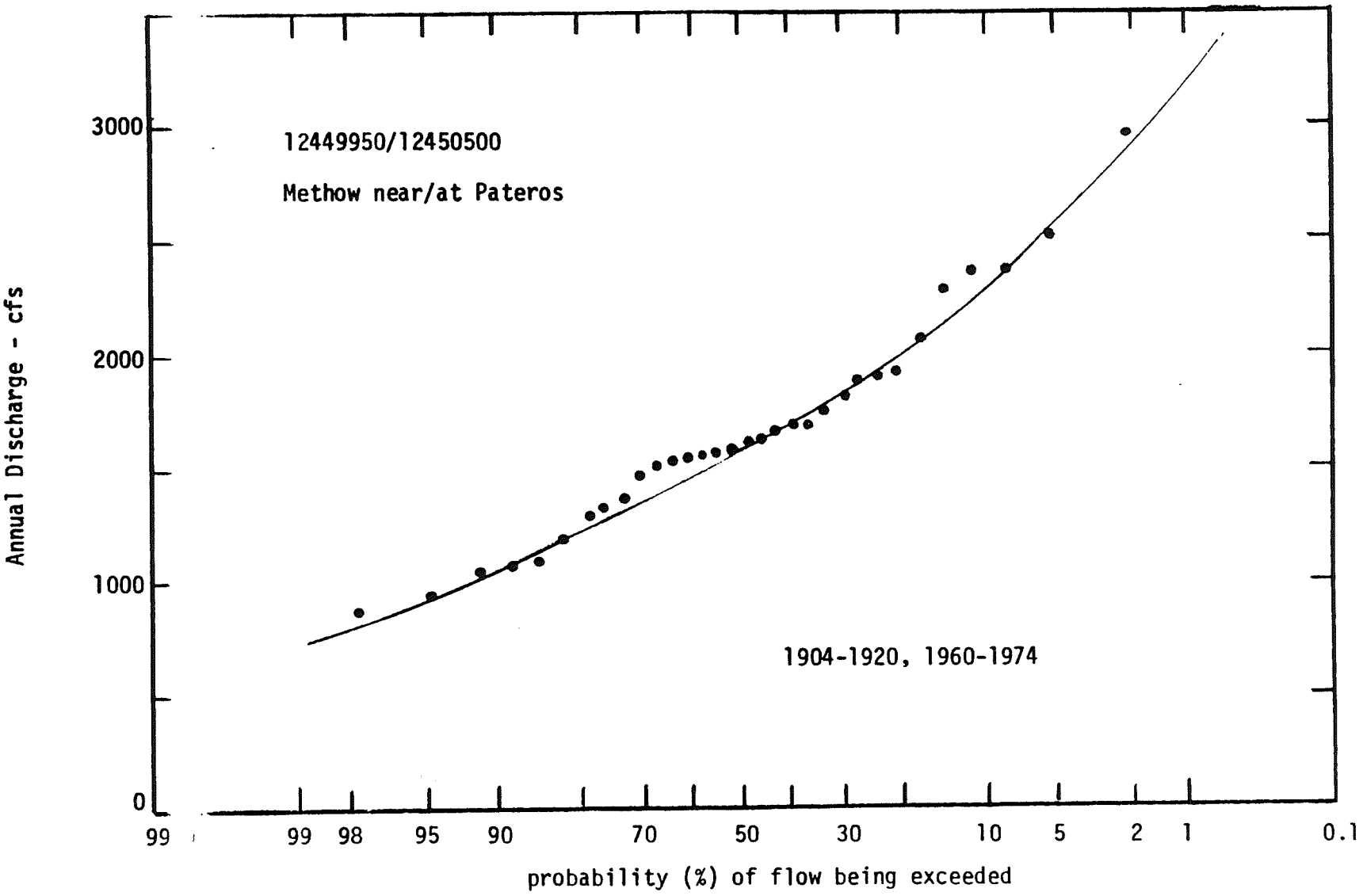


FIGURE 3. Frequency of Annual Discharge from Methow Basin.

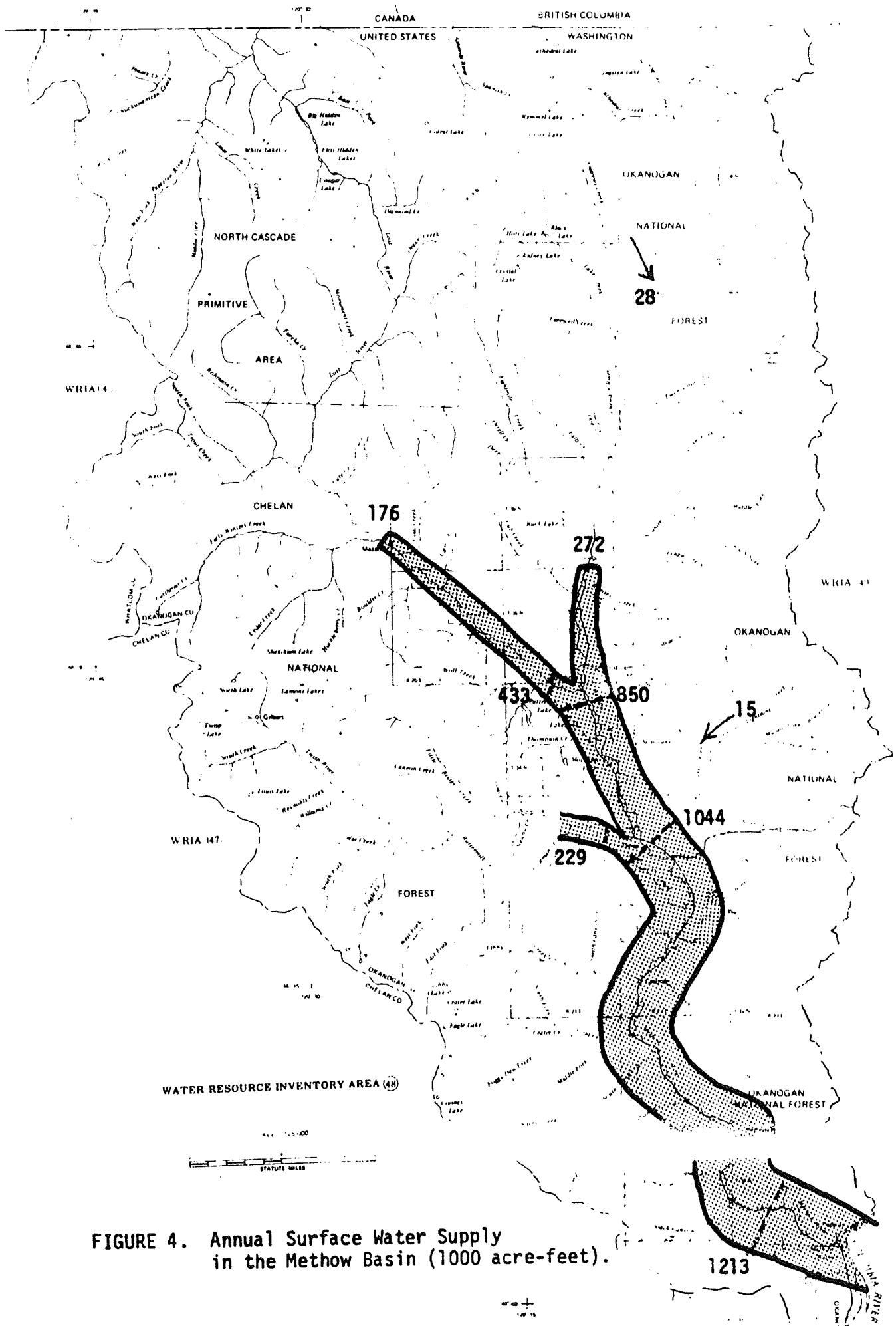


FIGURE 4. Annual Surface Water Supply in the Methow Basin (1000 acre-feet).

The Methow River Basin is also a major livestock-producing area of Okanogan County. During the summer months the animals graze on rangeland, pasture, or on Okanogan National Forest land and Washinton Department of Natural Resources land. During the winter, the cattle are returned to their home pastures at lower elevations or shipped elsewhere to avoid severe winters and high feed costs. Over the past ten years, there has been a significant drop in the number of ranches. Many of these ranches are being sold, subdivided, and/or platted. The new highway through the Cascades will probably have a very significant impact on land use in the basin.

The wide range in elevation and precipitation has resulted in a variety of tree species. Forests are coniferous with the exception of narrow stands of hardwood along streams. Various true firs, spruce, and lodge-pole pine are found at the higher elevations. Spruce stands are found in a narrow strip along the west boundary and covering the study area's northwest corner. The area's principal species are Douglas fir and ponderosa pine. Extensive ponderosa stands cover the drier, low elevation sites. Douglas fir occupies moderate elevations along the west-eastern mountain slopes and high drainages. The lower slopes of the Methow Basin below Winthrop are largely nonforested or covered with a sparse ponderosa pine. The climate is semi-arid and most of the precipitation occurs as snow.

The 1961 irrigated crops in the valley, as reported by the U.S. Bureau of Reclamation, were:

Alfalfa	4,700 acres	(45 percent)
Orchard	2,500 acres	(23 percent)
Pasture	2,000 acres	(19 percent)
Grain	800 acres	(8 percent)
Row Crops	500 acres	(5 percent)
Total	10,500 acres	(100 percent)

Many sources list the number of irrigated acres in the basin. For reference purposes, the [in basin] estimates include:

Irrigated Acres In Basin	Source	Date
13,400	Walters, State Water Supply Bulletin	1974
12,830	Simons, U.S.G.S. WSP-1220 (irrigation district records, water rights, and census reports).	1946
[illegible]	Bureau of Reclamation	1961
6,800	Soil Conservation Service	1967, 1975
3,200	Irrigation Districts	1975

Figure 5 shows the approximate location of irrigated lands in the Valley. For a more precise map, the reader is referred to the map of irrigated land given in the 1961 U.S. Bureau of Reclamation report on the Methow.

The water rights in a basin are often substantially different from the water use. This occurs because of incomplete development water use, non-use, and water rights existing prior to enactment of the surface water code (1917) and the ground water code (1945). A comparison of the water rights in Okanogan County is given in Table 3. These are compared graphically on Figure 6.

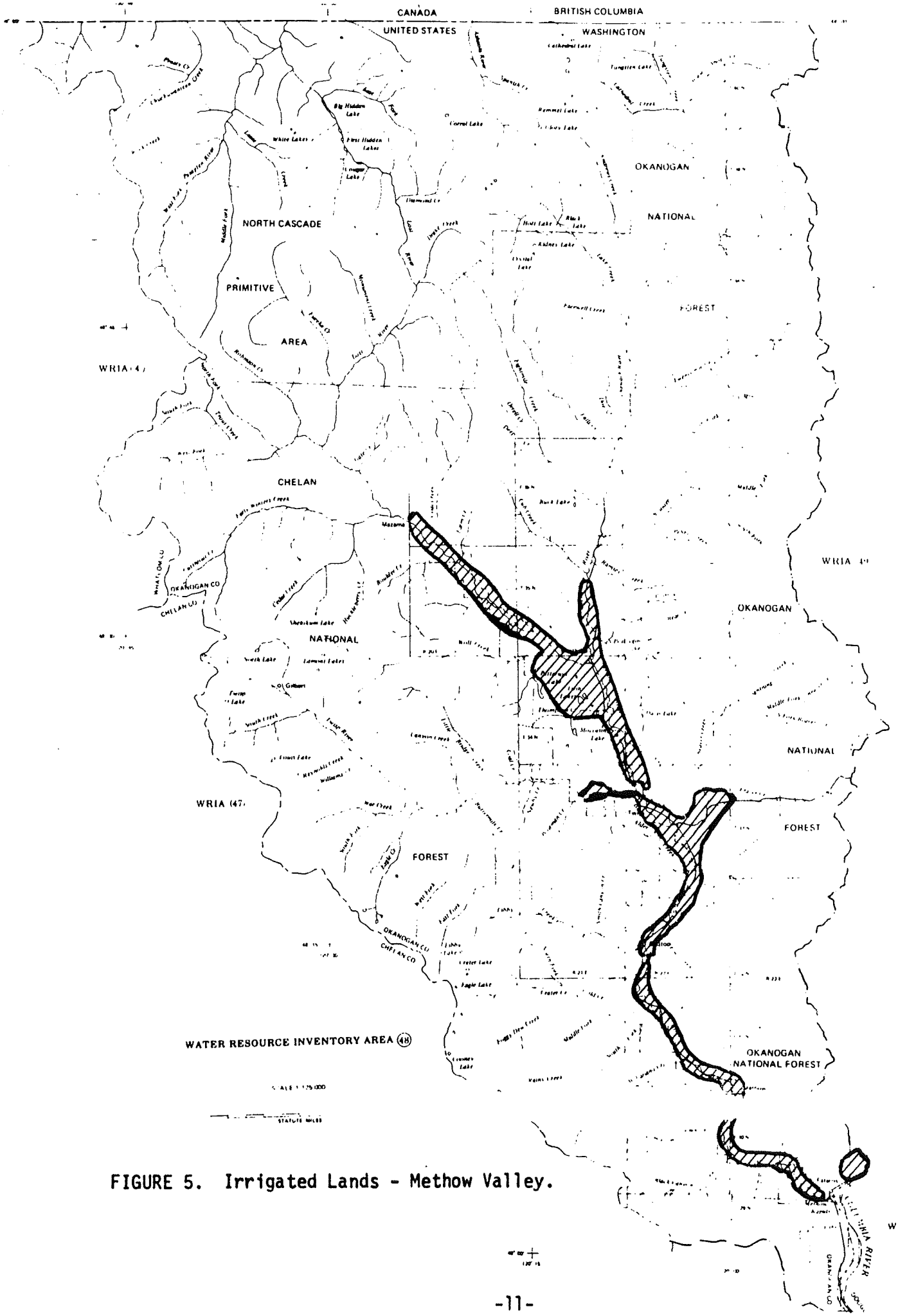


FIGURE 5. Irrigated Lands - Methow Valley.

Table 3: Irrigated Acres and Water Rights -- Okanogan County

Area	1930	1940	1950	1960	1967	Actual (SCS) 1967
Water Right (Surface)						
Okanogan County	59,936	59,949	63,988	79,620	88,580	--
Methow-Okanogan Basins	57,206	58,061	61,400	74,257	80,021	33,100
Okanogan Basin	42,136	42,625	45,780	58,206	63,281	26,300
Methow Basin	15,070	15,462	15,620	16,501	16,740	6,800
Water Right (Ground)						
Okanogan County	1,357	1,572	2,326	26,851	36,940	--
Methow-Okanogan Basins	994	1,172	1,861	25,265	34,288	3,310
Okanogan Basin	994	1,172	1,813	24,862	32,622	3,310
Methow Basin	0	0	48	403	1,666	0
Total Water Rights						
	61,293	61,521	66,314	106,471	125,520	--
Actual Irrigated Acres -- (Census of Agriculture)	28,190	29,149	29,920	42,715	40,194*	45,623**
Ratio (Rights to use)	2.17	2.11	2.22	2.49	3.12	

* 1969 cen
** SCS - Washington Soil and Water Conservation Needs Inventory (1967)

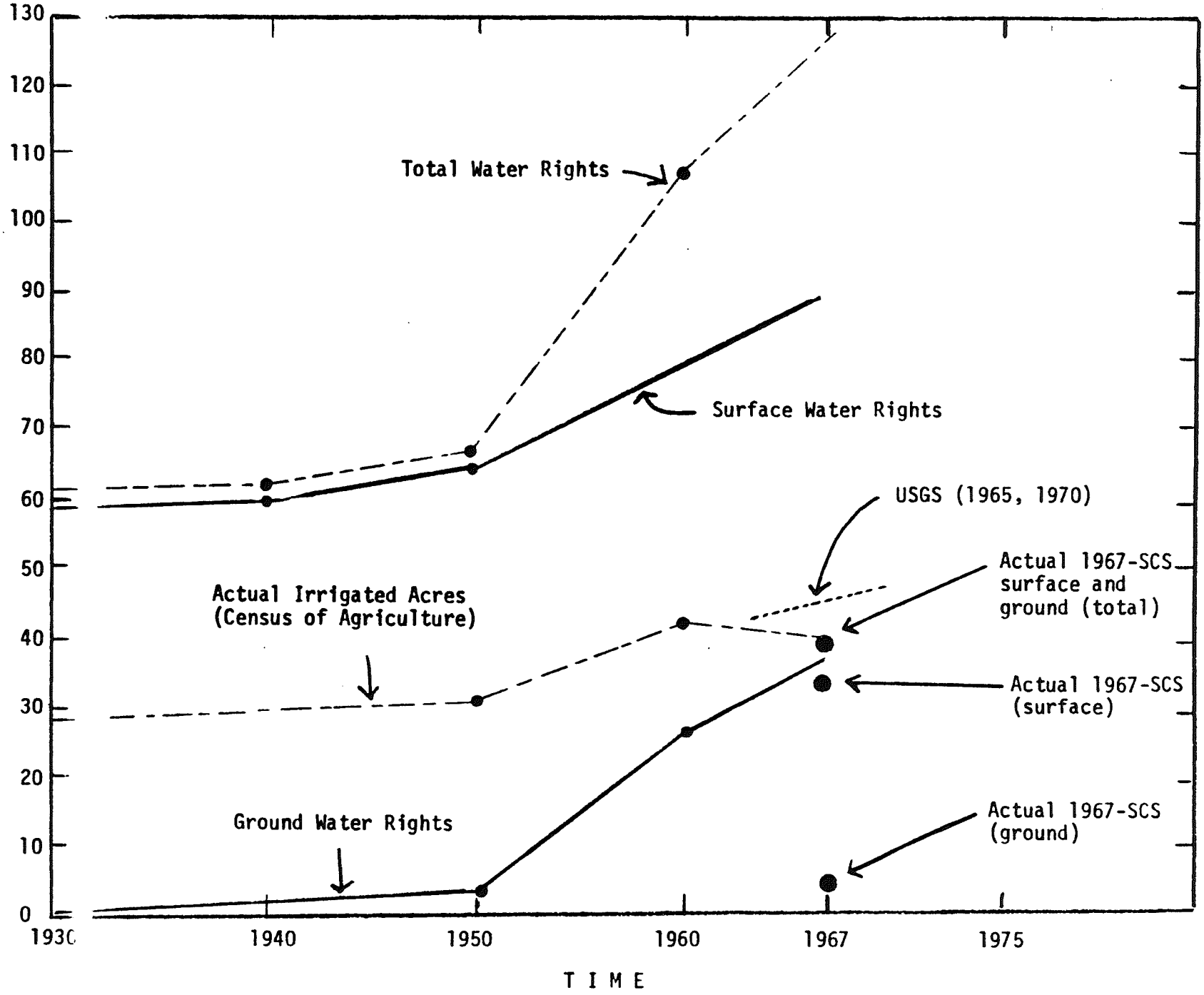


FIGURE 6. Irrigated Acres in Okanogan County.

WATER USE

The earliest known diversion in the Methow Valley was the China Ditch, near Pateros. The water was used for placer mining. In 1898 water was diverted from the Twisp River for irrigation. Some irrigation probably occurred prior to 1898 but most of the development occurred after 1900.

A diagram presenting the available information on irrigated lands is given in Figure 7. The actual area of the irrigated land in the basin is not known with any degree of certainty; the most likely estimate is 10,500 acres. A value of 10,500 acres has been used in this report.

The location of the surface water diversions for the irrigated land are given below by acres of land irrigated.

	Walters and Nassar	U.S. Bureau of Reclamation
Above Winthrop	5,000	4,784
Winthrop - Twisp	4,400	3,357
Beaver Creek	1,600	850
Below Twisp	3,000	1,509
Total	14,000	10,500

The location of the diversions above Carlton are shown on Figure 8 and tabulated in Table 4.

Most of the diversion of water below Twisp is directly from the Methow River. The only creeks presently used for irrigation in any great extent are:

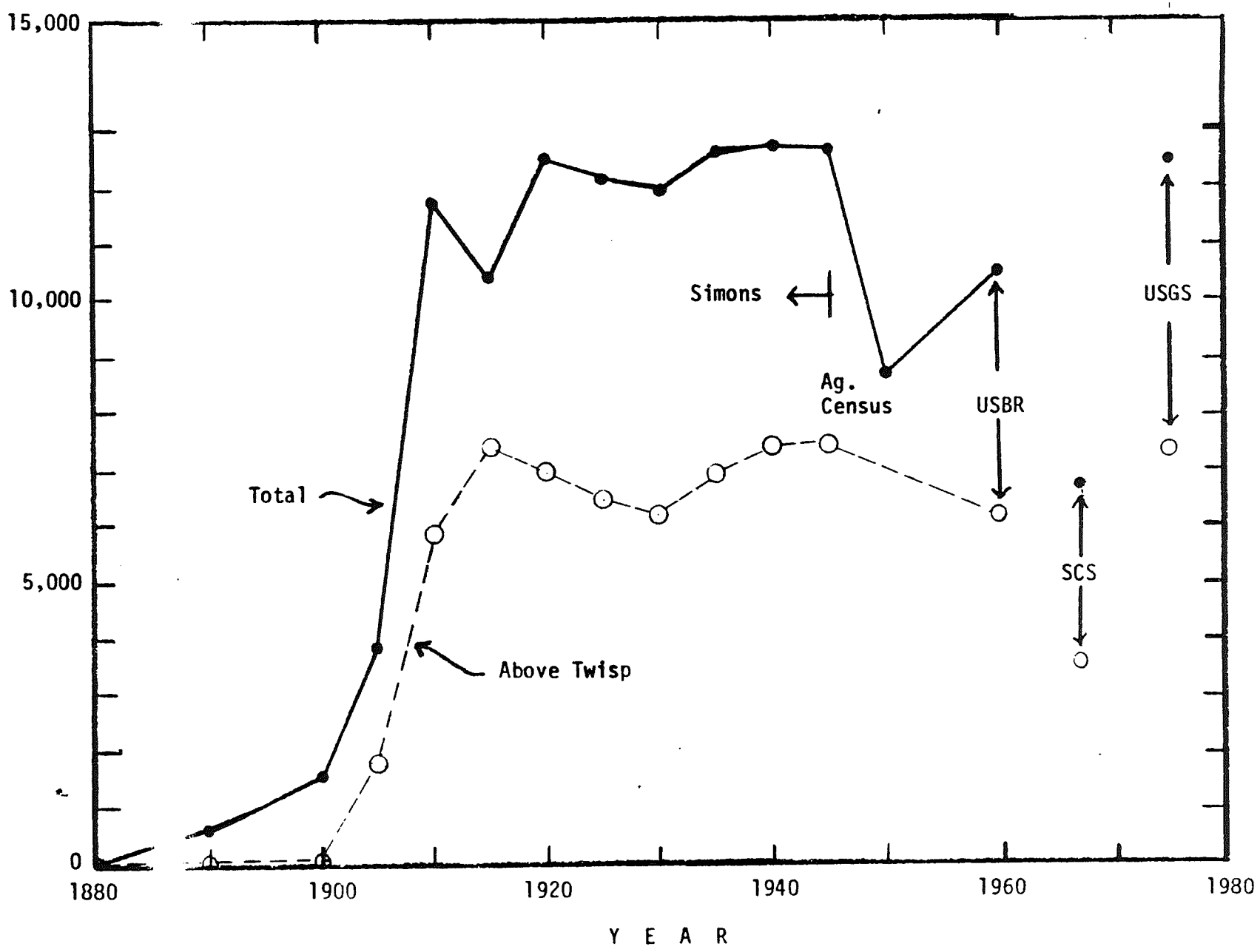
Gold Creek -	150 acres
Black Canyon Creek -	60 acres

Hence, the direct diversion for the mainstream is for 1,300 acres.

To arrive at an estimation of crop requirements, the Blaney - Criddle method was used to determine evapotranspiration (see Table 5). Table 6 gives the crop requirements in inches. Irrigated acres are broken down into four main crops based on the U.S. Bureau of Reclamation estimates of crops grown. The amount of potential crop use, in acre-feet, is given below:

Orchards	4,742 acre-feet
Alfalfa	8,411 acre-feet
Pasture	2,870 acre-feet
Grains	1,531 acre-feet
Total	17,554 acre-feet (2.58 acre-feet/acre)

There is a very large amount of water loss involved in present irrigation methods. Poor equipment and leaky, unlined canals cause up to a 45 percent water loss. This means that about twice as much water is diverted from the river than is really needed for irrigation.



FIGUR 7. Historic Pattern of Irrigation Land in the Methow Basin.

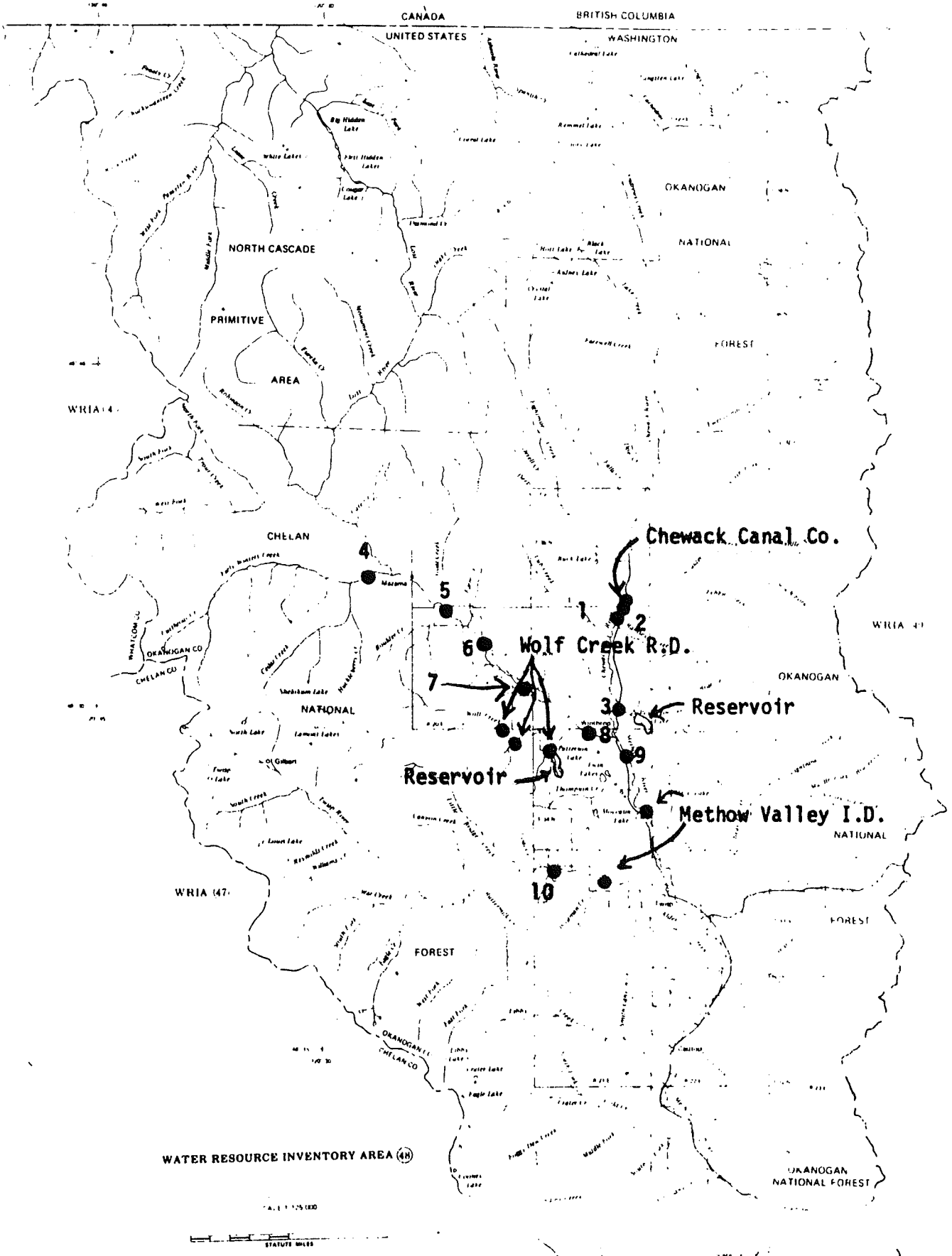


FIGURE 8. Major Irrigation District Diversions (see Table 4 for number key).

Table 4: Diversions from Methow River above Twisp

Map No.	Name	Irrigated Land (acres)	Canal Capacity (cfs)	Estimate August Diversion (cfs)	Reservoir Capacity (ac-ft)	Date Canal Built
-	ewack Canal Co.	1,200	50	37	1,800	1910,1911
1	yline-Piercy LaRue Ditch Co.	260	-	19	0	1906
2	lton Ditch Co.	400	-	18	0	1904
3	nes Ditch	100	-	16	0	--
4	ly Winters Canal Co.	650	-	23	0	--
5	inney Mountain Ditch Co.	350	-	23	0	1910
6	kview Ditch Co.	435	-	25	0	--
7	sell Canal	330	-	--	0	--
-	f Creek Irrigation District	659	-	--	2,800	1922
8	horn Ditch Co.	400	-	21	0	--
9	kley Irrigation Co.	1,000	50	--	0	1903
10	sp Valley Power & Irrigation Co.	400	24	23	0	1898,1909
-	how Valley Irrigation District					
	Methow	1,242	120	96	0	)
	Twisp	715	60	35	0	)1914
	tal	8,141				

Source: U . Bureau of Reclamation Report

Table 5: Factors for Computing Crop Requirements
Methow Basin

Factor		Month O	N	D	J	F	M	A	M	J	J	A	S	Annual
Precipitation (inches)														
Winthrop		1.02	1.94	2.50	2.04	1.59	0.89	0.67	1.01	1.23	0.52	0.48	0.66	14.55
Methow		0.81	1.96	1.50	1.55	1.47	1.12	1.22	0.87	0.65	0.36	0.46	0.41	12.38
Temperature (°F)														
Winthrop		47.2	32.6	22.9	18.4	24.4	35.3	47.2	55.2	61.3	68.2	66.3	58.6	44.8
Methow		48.7	33.7	25.0	22.8	31.1	38.4	48.6	56.5	65.1	72.3	69.8	60.7	47.7
P (% daylight hrs.)		7.47	6.19	5.80	6.12	6.38	8.25	9.18	10.56	10.77	10.87	9.92	8.45	
K_t (dimatic coeff.) (average)		0.52	.30	.30	.30	.30	.31	0.51	0.65	0.78	0.90	0.86	0.71	
K_c (crop coeff.)	(acres)													
Orchards	1,635	0.9	0.8	0.7	0.6	0.7	0.9	1.0	1.4	1.5	1.4	1.4	1.4	
Alfalfa	3,040	1.2	0.8	0.6	0.6	0.7	1.5	2.0	1.9	1.1	1.1	1.2	1.2	
Pasture	1,290	1.1	0.8	0.6	0.5	0.6	1.0	1.2	1.2	1.0	1.0	1.1	1.1	
Grain	835	0	0	0	0.2	0.3	0.3	0.6	0.7	1.0	1.0	1.0	1.2	
Total	6,800													

Developed using the Blaney-Criddle method and the average temperature of Winthrop and Methow.

Table 6: Crop Requirements for Methow Basin

Crop	O	N	D	J	F	M	A	M	J	J	A	S	Annual
Orchards													
ET (pot tial)	1.68	0.49	.29	.23	.37	.85	2.24	5.37	7.96	9.62	8.13	5.01	42.2
ET-P (W throp)	.66	0	0	0	0	0	1.57	4.36	6.73	9.10	7.65	4.35	34.4
ET-P (M how)	.87	0	0	0	0	0	1.02	4.50	7.31	9.26	7.67	4.60	35.2
													34.8
Alfalfa													
ET_p	1.55	0.49	.25	.23	.37	1.41	4.48	7.28	5.84	7.56	6.97	4.29	40.7
ET-P (W throp)	.53	0	0	0	0	.52	3.81	6.27	4.61	7.04	6.49	3.63	32.9
ET-P (M how)	.74	0	0	0	0	.29	3.26	6.41	5.19	7.20	6.51	3.88	33.5
													33.2
Pasture													
ET_p	2.05	0.49	.25	.19	.32	.94	2.69	4.60	5.31	6.87	6.39	3.94	34.0
ET-P (W throp)	1.03	0	0	0	0	.05	2.02	3.59	4.08	6.35	5.91	3.28	26.3
ET-P (M how)	1.24	0	0	0	0	0	1.47	3.73	4.66	6.51	5.93	3.53	27.1
													26.7
Grains													
ET_p	0	0	0	.08	.16	.28	1.35	2.68	5.31	6.87	5.81	4.29	26.8
ET-P (W throp)	0	0	0	0	0	0	.68	1.67	4.08	6.35	5.33	3.63	21.7
ET-P (M how)	0	0	0	0	0	0	.13	1.81	4.66	6.51	5.35	3.88	22.3
													22.0

	Ac-Ft:	
Orchards	4,742	
Alfalfa	8,411	
Pasture	2,870	
Grains	1,531	
Total	17,554	(2.58 ac-ft/acre)

The depletion factors developed for the Methow Basin, in cubic feet per second per acre irrigable are:

October	0.0028	April	0.0022
November	0.0014	May	0.0088
December	0.0004	June	0.0102
January	0	July	0.0092
February	0	August	0.0080
March	0	September	0.0050

The net depletion is 2.35 acre-feet per acre. Farm efficiency is about 60 percent and delivery efficiency 55 percent. The total diversion is estimated to be about 75,000 acre-feet per year for irrigation.

Industrial use of water is about 8,625 acre-feet per year with about 6,000 acre-feet per year being used by a lumber company near Twisp (6,000 acre-feet).

According to Walters and Nassar, groundwater is used to irrigate 1,000 acres. Also, public water supplies are all from groundwater sources. The total groundwater uses given are:

Irrigation	3,000 acre-feet
Industrial	2,900 acre-feet
Public Supply	600 acre-feet
Other	150 acre-feet
Total	6,150 acre-feet

The total water use in the Basin is about 88,000 acre-feet.

WATER RIGHTS

Summaries of surface and ground-water rights for the Basin are given in Tables 7 and 8. These summaries are based on the water rights data base as existing on 24 June 1976. In May 1975, the water rights were developed for subbasins based on the Soil Conservation Service subbasins shown on Figure 1. These are given in Tables 9 and 10.

The following considerations must be kept in mind when using the subbasin information:

1. The subbasin breakdown boundaries that were selected for the computerized summary follow natural watershed boundaries. This was done to insure a high amount of accuracy when determining a water budget, and explains why some SCS irrigated-acre figures do not parallel water right acres as expected.

2. Most water rights have more than one use listed, even though the amount of water allocated remains the same. This is especially true of irrigated water rights. In the tables, for convenient data handling purposes, all common-use rights that included irrigation as a use were listed as irrigation rights.

3. Water right quantities are as accurate as can be expected. The only sure way to account for any duplication would be to go through the rights one by one.

Water right claims for the basins are given in Table 11. This table does not report many of the claims actually received but it does indicate that the claims to water in the Methow Basin are important in the development of any water resource management policy for the basin.

Table 11. Water Right Claims in the Methow Basin, 1974

Source	Number of Water Right Claims					Irrigated Acres
	Domestic	Stock	Irrigation	Other	Total	
Surface	96	178	83	95	452	6,103
Ground	314	72	59	7	452	478
Total	410	250	98	102	904	6,581

Note: A high degree of reliability should not be placed on these figures; there is no accurate way to assess the human error involved when filing a claim.

Table 7: Summary of Water Rights in the Methow Basin

	Water Rights			Applications		
	Surface	Ground	Total	Surface	Ground	Total
	(cubic feet per second)			(cubic feet per second)		
Irrigation	536.7	58.5	595.2	25.0	4.8	29.8
Commercial/Industrial*	1.9	0.6	2.5	0	0	0
Domestic*	1.6	11.7	13.3	2.7	1.1	2.8
Stock Water	0.3	0.1	0.4	0	0	0
Other	3.1	14.7	17.8	4.0	0	4.0
Total	543.6	85.6	629.2	31.7	5.9	37.6

Date of data research: June 1976

* Single use only.

WATER BUDGET

Water resource studies for basins such as that of the Methow River generally involve a water budget, or water balance, wherein all the elements of the hydrologic cycle are accounted for. The elements, as expressed in the classic equation $R=PL\pm\Delta S$, are defined as:

R - mean annual runoff from the basin,
P - mean annual precipitation in the basin,
L - total water loss (evapotranspiration, consumptive use, and subsurface flow from the basin), and
WS - annual net change in storage in lakes, reservoirs, ground water, and ice or snow.

Rarely, if ever, are all of these elements actually measured adequately; water in the atmosphere and in the ground can only be sampled, rather than measured in its entirety. To balance the equation, the hydrologist considers the available water measurements, and estimates reasonable values for the unmeasured quantities. This has been done for the Methow Basin, as described in several published studies. What follows is a brief review of those studies, and a slightly revised summary of the Basin's water resources.

Precipitation

In Water-Supply Bulletin 38, Walters and Nassar presented the following yearly water budget:

Inflow	(Acre-feet)
Precipitation	3,100,000
Ground Water	Insignificant
Outflows	
Evapotranspiration	
(1) irrigated land	25,000
(2) nonirrigated land	1,135,000
Surface Water	1,200,000
Ground Water	740,000

The only measured quantity is the surface water outflow, which is the long-term mean annual runoff at the gaging station near Pateros. Mean annual precipitation and evapotranspiration were estimated on the basis of weather records, leaving ground water "outflow" as a residual item in the water budget. The trouble is, the estimated ground water "outflow" was so unreasonably high that the authors were compelled to note that "either the mean annual precipitation on the basin may actually be less

greater than was estimated." Both of these possibilities are probably correct.

Table 10: Ground Water Rights by Subbasin - Methow Basin

Subbasin	No.	Water Right Amount - CFS Irrigation	Other	Total	Number of Rights	Irrigated Acres	Actual Irrigated Acres-SCS
Upper Chewa	8-1	0	0	0	0	0	0
Upper Metho	8-2, 8-4	3.40	1.22	4.62	9	208	0
Lower Chewa	8-3	.74	.2	.94	7	43	0
Methow - Tw	8-5	8.31	18.60	26.9	24	314	0
Beaver Creel	8-6	.21	0	.21	2	8	0
Twisp River	8-7	.78	0	.78	3	0	0
Middle & Lo Methow	8-8, 8-9	32.04	3.8	35.84	67	9,549	0
Total		45.48	23.82	69.30	112	10,122	0

Data Base: 1975; includes all active water rights.

Table 8: Irrigated Land with Water Rights in the Methow Basin

Source	Water Rights			Applications		
	Irrigated Area (acres)	No. With Area Specified	No. Without Area Specified	Irrigated Area (acres)	No. With Area Specified	No. Without Area Specified
Surface Wate	16,636	226	9	1,355	32	9
Ground Water	2,966	91	17	170	7	3
Reservoir	0	0	3	0	0	0
Total	19,602	317	29	1,525	39	12

Date of data search: June 1976

Table 9: Surface Water Rights by Subbasin - Methow Basin

Subbasin	No.	Water Right Amount - CFS Irrigation	Other	Total	Number of Rights	Irrigated Acres	Actual Irrigated Acres-SCS
Upper Chewac	8-1	0	0	0	0	0	0
Upper Methow	8-2 8-4	91.35	.05	91.4	24	1,557	1,700
Lower Chewac	8-3	7.08	.36	7.44	13	357	900
Methow - Twi p	8-5	159.8	.67	160.47	25	2,049	1,000
Beaver Creel	8-6	220.3	0	220.3	43	9,974	700
Twisp River	8-7	6.76	.21	6.97	19	270	1,000
Middle & Lo : Methow	8-8 8-9	59.07	.60	59.67	129	2,935	1,500
Total		544.36	1.89	546.25	253	17,142	6,800

Data Base: y 1975; includes all active water rights.

Mean basin precipitation was estimated by Walters and Nassar from the Washington State map published by the SCS and Weather Bureau in March, 1965. The same map was used by Orsborn and Sood (1973), to estimate average annual precipitation as 31.4 inches, but even this value appears to be too high. A more likely value for the long-term basin mean is about 30 inches, equivalent to a total input volume of 2,875,000 acre-feet per year.

Water Loss

Total water loss in the Methow Basin is assumed to be by evapotranspiration and consumptive use, as there is not likely to be a significant amount of subsurface flow out of the area.

Using the USBR figure of 10,500 acres for the Methow Basin, it is estimated that the average annual volume of water lost by evapotranspiration is 27,100 acre-feet. This estimate is based on irrigation water requirements (consumptive use minus rainfall) for major crops in the basin, which are alfalfa, orchards, pasture, and grains. The estimated net use of 2.58 acre-feet per acre (31 inches) is higher than the value 1.75 assumed by Simons (1953), or the 1.67 assumed by Walters and Nassar (1974). It agrees reasonably with the 2.5 acre-feet per acre depletion reported for the Chelan-Okanogan area in the Columbia-North Pacific study of 1971 (Table 46, Appendix IX).

For nonirrigated areas, an average annual evaportranspiration rate of 12 inches per year was assumed by Walters and Nassar. Over most of the basin, where annual precipitation exceeds that amount, the rate is estimated to be in the range of 15 to 20 inches. An average of 17 inches may be a reasonable value for the Methow Basin as a whole. On the 1,146,000 acres of nonirrigated land, the average annual water loss would then be 1,623,500 acre-feet. Adding the loss from irrigated land brings the total evapotranspiration to 1,650,600 acre-feet.

The average annual discharge for various lengths of time are:

1960 - 1974	1,203,200 acre-feet
1904 - 1919, 1961 - 1975	1,212,800 acre-feet
1904 - 1975	1,162,700 acre-feet

The maximum differences is 50,100 acre-feet. The missing data in the 1904 - 1975 period was estimated using a regression relationship developed between the Methow River gage near Twisp and the gages near Pateros.

Revised Water Budget

Based on the revised estimates of inflow and outflow, the revised water budget is:

Inflow	
Precipitation	2,875,000 acre-feet
Ground Water	insignificant

Outflow	
Evapotranspiration	
(1) irrigated lands	27,100 acre-feet
(2) nonirrigated land	1,623,500 acre-feet
Surface Water	1,162,700 acre-feet
Ground Water	61,700 acre-feet

This water balance is an improvement over the balance reported by Walters and Nassar but is still a low-order of resolution estimate.

WATER SUPPLY

The water supply at the Methow River Basin is dominated by storage of precipitation as snow followed by a spring runoff at a time when the precipitation input is relatively low. Most of the water use in the basin is from surface water sources; nevertheless ground water is an important component of the Basin's water supply.

Ground Water

A good summary of the ground water resources in the Methow Basin is given in Walters and Nassar - Water in the Methow Basin, Washington.

In general, ground water in sufficient quantity for development is found only in the unconsolidated glacial and alluvial deposits in the valley floors and adjacent river terraces.

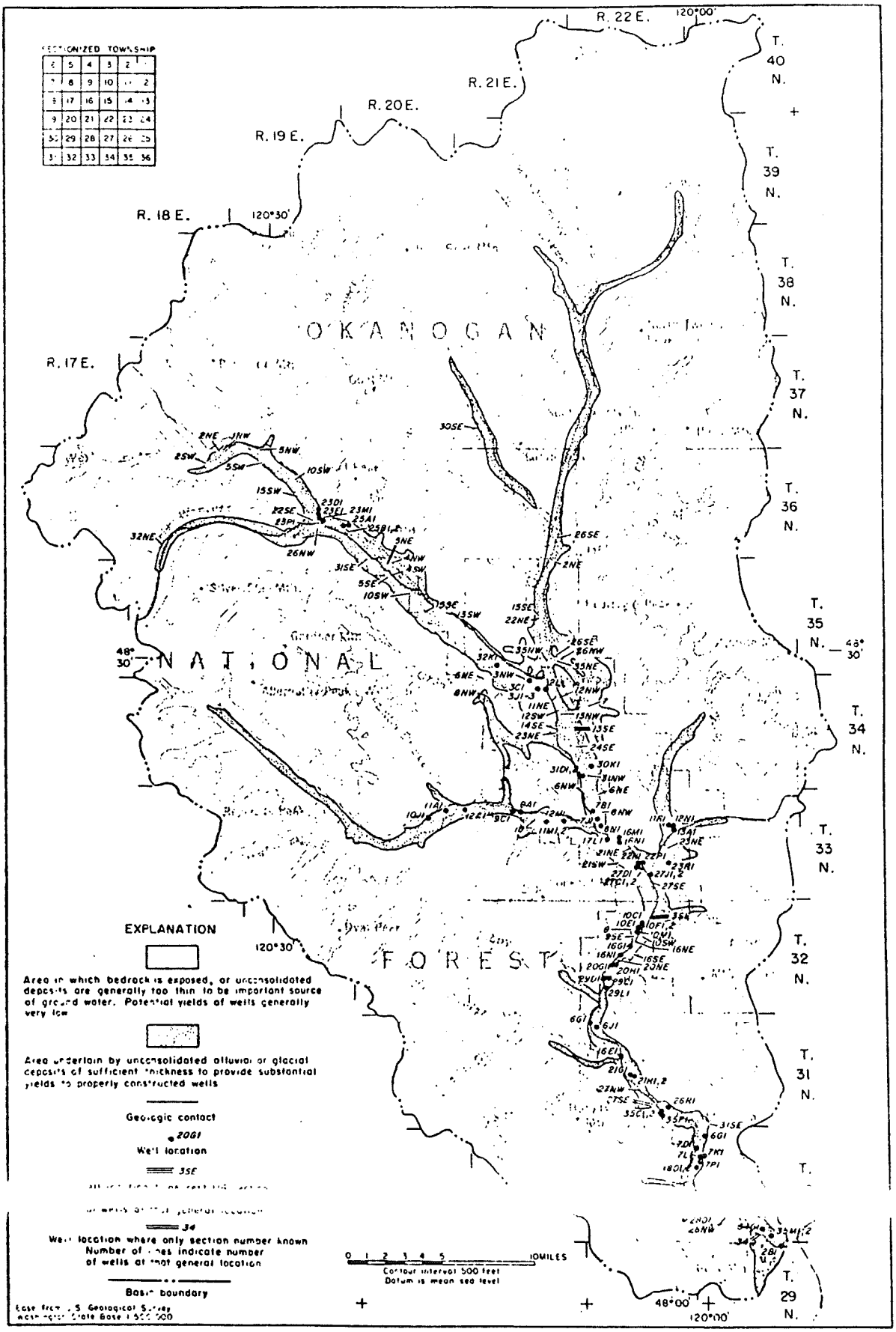
The bedrock underlying the Methow Basin consists principally of consolidated Cretaceous sedimentary rocks in the Upper Methow above the Chewack and Mesozoic granitic rocks in the Chewack, Upper Beaver, and the area along the eastern drainage divide. The rocks in the Lower Valley are consolidated and of Jurassic and pre-Jurassic age. On the west side of the lower valley, granific rocks predominate.

All of the bedrock formations found in the basin contain water in random joints, and the occurrence of water-bearing joints is extremely difficult to locate. Most of the joints system will yield only small quantities of water, although some may yield moderate quantities.

A map showing the location of the water-bearing unconsolidated materials is given as Figure 9.

The unconsolidated material in the Methow Valley below Carlton is discontinuous; bedrock is exposed in many places, both on the valley floor and in the valley walls. Properly constructed wells in the unconsolidated material generally yield 200 to 500 gpm (0.45 to 1.12 cfs).

The unconsolidated materials in the central valley between Winthrop and Carlton are continuous and have ranges in yield between 100 to 1,300 gpm [illegible] and average 550 gpm (1.22 cfs). An area of several square miles in the Methow River valley, just below the mouth of Beaver Creek, is underlain by clay and fine sand locally more than 100 feet thick. This zone probably significantly restricts the down valley movement of ground water in the unconsolidated materials.



From Walters and Nasser

FIGURE 9. Location of wells and distribution of unconsolidated deposits in the Methow River basin

Highly permeable material of considerable depth exists along the floor of the Methow Valley above Winthrop. The wells are used for domestic purposes and are adequate. Yields of at least 100 gpm (0.22 cfs) are probable. The valley of the Chewack contains unconsolidated materials but the yields are probably less than the Methow Valley although they are typically adequate for domestic purposes.

Surface Water

The surface water supply of the Methow Basin is fairly large but somewhat out of phase with the demands placed on the resources by industrial man.

The variation of the average monthly flow of the Methow near its mouth is given in Table 12. The periods 1904 - 1919, and 1961 - 1975 have been used for most of the analyses described in this report.

The locations of gaging stations and points for which information on the frequency of monthly flows was desired are shown on Figure 10. The records for the two stations (12449950 and 12450500) located near the mouth of the river have been combined to form one record. The average annual runoff for the "Methow near Pateros" (12449950) was 1,664 cfs. The runoff between this station and the location of the "Methow at Pateros" (1250500) was not more than 10 cfs.

Information for the stations is described below:

Methow at/near Pateros (12449550): The results of an analysis of the mean monthly flows is given in Table 13. The missing data for the period 1921 through 1960 was estimated using a regression relationship with the "Methow at Twisp." The quality of the relationship was good. The results of the analysis are given in Table 14. The data was corrected for depletions; the results are given in Table 15.

Methow at Twisp (12449500): The results of an analysis of measured data are given in Table 16. The measured data were corrected for depletion and then analyzed; the results are given in Table 17.

Beaver Creek, below South Fork, near Twisp (12449600): The data was analyzed; the results are presented in Table 18.

Andrews Creek near Mazama, (12447300): The results of an analysis of the measured data are given in Table 19.

Twisp River near Twisp (12448998): Data for May 16 - September 30, 1975 were regressed with the "Methow near Pateros." The regression was then used to estimate mean monthly flows for the "Twisp near Twisp." The quality of the relationship is fair to good. The results are given in Table 20.

Methow River at Winthrop (12448500): Data for January - October 1971, and August 1971 - June 1972, was regressed with "Methow River at/near Pateros" and the results were used to generate flows for the "Methow River at Winthrop." The quality of the regressions is good except for

Table 12: Average Monthly Discharge of the Methow River at/near Pateros.

Month	Period				
	1904 - 1975*	1904 - 1920	1960 - 1975	1904 - 1920, 1960 - 1975	1904 - 1919, 1961 - 1975
October	525	525	532	529	502
November	562	539	526	532	512
December	485	456	458	457	440
January	413	396	418	407	400
February	418	382	440	410	410
March	548	544	580	562	560
April	1,747	1,902	1,375	1,647	1,668
May	5,356	4,938	5,080	5,006	5,142
June	5,968	6,237	7.080	6,648	6,765
July	2,151	2.674	2,260	2,473	2,495
August	652	763	704	734	745
September	436	494	425	461	464
Annual (1,000 ac-f	1,163	1,198	1,199	1,199	1,213

* 1920 - 1 .0 data developed by regression with Methow at Twisp (12449500)

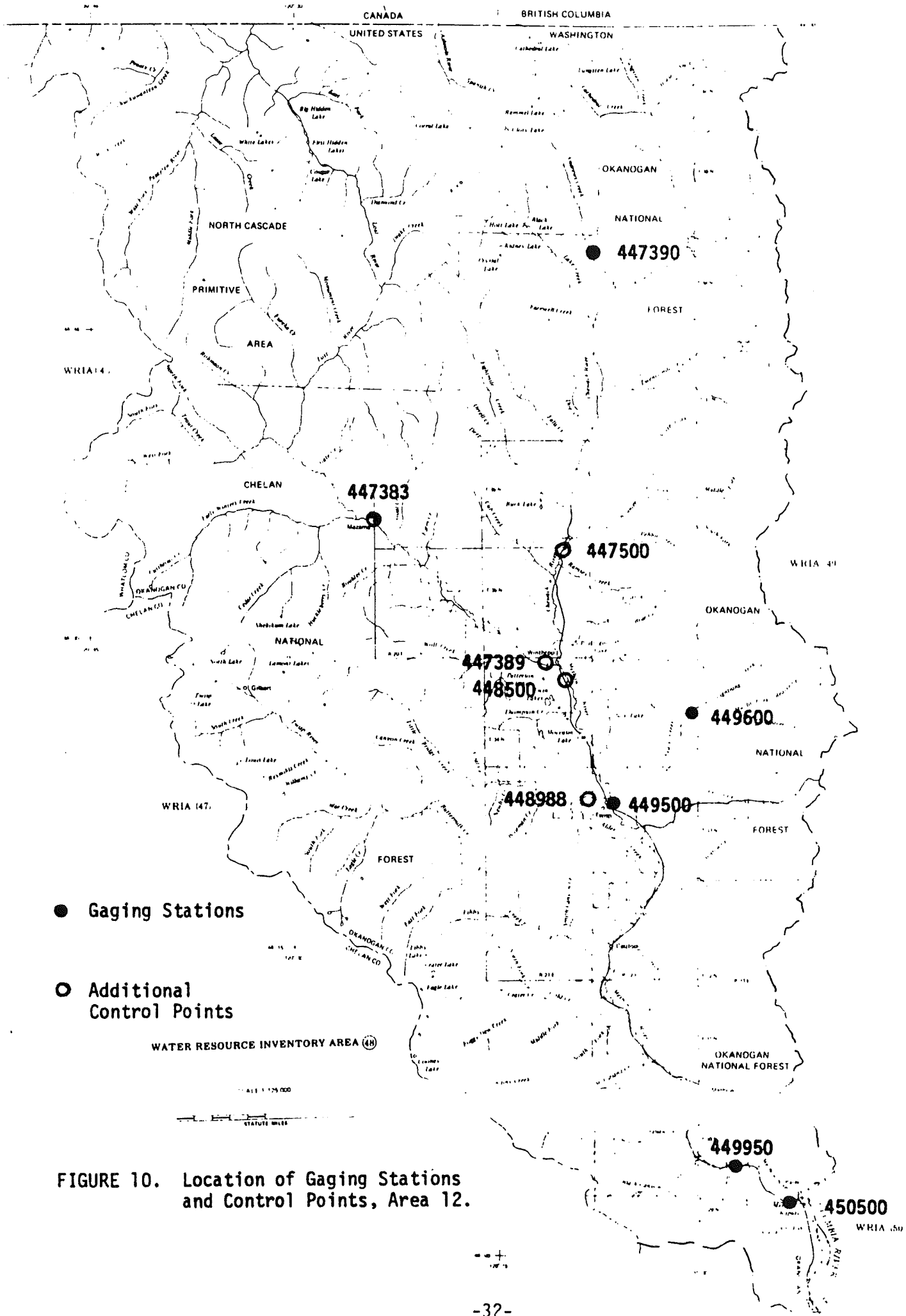


FIGURE 10. Location of Gaging Stations and Control Points, Area 12.

TABLE 13

FREQUENCY AND WATER USE DATA

FOR Methow near Petaros . U.S.G.S. GAGE 12-4499.5

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Disch ge	502	512	440	400	410	560	1,668	5,142	6,765	2,495	745	464
Discharge t exceeded t : in three y rs	540	555	474	428	440	606	1,828	5,623	7,443	2,757	817	501
Discharge t exceeded o : in two yea (Q_2)	486	492	427	391	397	509	1,441	4,849	6,340	2,254	700	450
Discharge t exceeded once in ten years (Q_{10})	355	343	311	298	292	301	709	3,118	3,929	1,237	442	327
$Q_2 - Q_{10}$	131	149	115	93	105	208	732	1,731	2,411	1,017	258	123
Water Use (Depletio	-	-	-	-	-	-	-	-	-	-	-	-

50% exceedance

590-860

1000-1800

Period of cord 1904-1919; 1961-1975 Remarks: Measured data, log normal distribution

ECY 070-3

TABLE 14

FREQUENCY AND WATER USE DATA

FOR Methow at/near Pateros . U.S.G.S. GAGE 12-4499.5

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discharge	525	562	485	413	418	548	1,747	5,356	5,968	2,151	652	436
Discharge not exceeded two in three years	569	611	528	445	451	592	1,896	5,898	6,618	2,368	715	474
Discharge not exceeded one in two years (Q_2)	491	526	458	400	401	497	1,448	4,954	5,443	1,862	598	414
Discharge not exceeded one in ten years (Q_{10})	316	336	301	292	282	296	648	2,944	3,038	910	352	278
$Q_2 - Q_{10}$	175	190	157	108	119	201	800	2,009	2,405	952	247	137
Water Use (Depletion)	-	-	-	-	-	-	-	-	-	-	-	-

Period of record 1904-1975 Remarks: Measured and generated data, log normal distribution

TABLE 15

FREQUENCY AND WATER USE DATA

FOR Methow at/near Pateros . U.S.G.S. GAGE 12-4499.5

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Disch ge	473	497	436	400	410	560	1,961	5,234	6,872	2,592	829	516
Discharge t exceeded t . in three y irs	510	539	470	428	440	606	1,854	5,719	7,555	2,861	905	554
Discharge c exceeded o . in two yea (Q_2)	457	476	422	391	397	509	1,468	4,946	6,455	2,362	789	504
Discharge t exceeded o in ten yea (Q_{10})	328	324	307	298	292	301	732	3,206	4,037	1,333	524	379
$Q_2 - Q_{10}$	129	147	115	93	105	208	736	1,739	2,418	1,029	265	125
Water Use (Depletior	-29	-15	-4	0	0	0	23	92	107	97	84	52

Period of cord 1904-1919; 1961-1975 Remarks: Corrected for depletions; Log normal distribution

TABLE 16

FREQUENCY AND WATER USE DATA

FOR Methow at Twisp . U.S.G.S. GAGE 12-449500

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discharge	382	391	326	290	299	434	1,431	4,558	6,019	2,176	601	347
Discharge not exceeded two in three years	413	426	354	313	323	467	1,566	4,986	6,626	2,405	661	380
Discharge not exceeded one in two years (Q_2)	366	370	312	280	285	382	1,215	4,290	5,631	1,950	555	333
Discharge not exceeded one in ten years (Q_{10})	253	243	213	200	196	210	570	2,739	3,466	1,044	328	224
$Q_2 - Q_{10}$	112	127	98	80	89	172	645	1,551	2,165	906	226	108
Water Use (Depletion)	-	-	-	-	-	-	-	-	-	-	-	-

Period of record 1904-1919; 1961-1975 Remarks: Generated data, log normal distribution

TABLE 17

FREQUENCY AND WATER USE DATA

FOR Methow at Twisp . U.S.G.S. GAGE 12-449.5

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Disch ge	401	457	392	311	317	416	1,566	4,920	4,891	1,695	526	348
Discharge t exceeded t in three y rs	434	499	428	338	343	447	1,688	5,440	5,434	1,857	575	374
Discharge t exceeded o in two yea (Q_2)	355	413	357	296	297	369	1,257	4,497	4,436	1,455	483	321
Discharge t exceeded c in ten yea (Q_{10})	194	236	209	200	194	209	522	2,549	2,423	703	287	208
$Q_2 - Q_{10}$	161	178	148	96	103	160	735	1,948	2,013	752	196	113
Water Use (Depletio	-15	-8	-2	0	0	0	17	70	83	78	71	46

Period of cord 1920-1962 Remarks: Corrected for depletions, log normal distribution.

Table ___ FREQUENCY AND WATER USE DATA

FOR Beaver Creek, below South Fork, near Twisp. U.S.G.S. Gage 12-449.6.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discharge	8	8	7	7	7	8	17	82	70	21	9	7
One in Two Year Discharge (Q_2)	8	7	6	6	7	7	14	64	50	17	8	7
One in Ten Year Discharge (Q_{10})	5	5	5	5	6	5	7	25	17	8	5	5
$Q_2 - Q_{10}$	3	2	1	1	1	2	7	39	33	9	3	2
Water Use	-	-	-	-	-	-	-	-	-	-	-	-

Period of Record 1961-1974. Remarks: Measured discharge, log normal distribution

Table 19 FREQUENCY AND WATER USE DATA

FOR Andrews Creek near Mazama. U.S.G.S. Gage 12-4473.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discharge	6	5	3	3	3	3	7	125	228	57	11	6
One in Two Year Discharge (Q_2)	6	5	3	3	3	3	6	119	190	42	10	5
One in Ten Year Discharge (Q_{10})	4	3	2	2	2	2	4	76	80	13	4	3
$Q_2 - Q_{10}$	2	1	1	1	1	1	3	43	110	29	5	2
Water Use	-	-	-	-	-	-	-	-	-	-	-	-

Period of Record 1969-1974. Remarks: Measured flows, log normal distribution assumed

TABLE 20 FREQUENCY AND WATER USE DATA

FOR Twisp near Twisp . U.S.G.S. GAGE 12-4489.98

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discha e	63	65	52	45	47	76	308	1,071	1,428	489	109	56
Discharge n exceeded tw in three ye s	68	70	57	49	51	79	334	1,174	1,575	541	120	61
Discharge n exceeded on in two year (Q_2)	59	60	49	43	44	62	248	1,003	1,330	428	97	53
Discharge n exceeded on in ten year (Q_{10})	38	36	32	30	29	30	102	628	804	212	52	34
$Q_2 - Q_{10}$	21	23	17	14	15	32	146	375	526	215	45	19
Water Use (Depletions	-	-	-	-	-	-	-	-	-	-	-	-

Period of R ord 1904-1919; 1961-1975 Remarks: Generated data log-normal distribution

flows "at Pateros" of less than 600 cfs where the quality of the relationship is fair. The results are given in Table 21.

Chewack River near Winthrop (12447500): Data for the period 1920 - 1921 was regressed with the "Methow at Twisp" and the regression relationship between "at Twisp" and "near Pateros" was used to give a relationship between "Chewack River near Winthrop" and the "Methow near Pateros." The quality of the relationship is fair. The results of the analysis are given in Table 22.

Methow River, above the Chewack River, near Winthrop (12447389): Miscellaneous measurements were regressed with the "Methow near Pateros." The quality of the relationship is poor. The results are given in Table 23.

Methow River, below Early Winters Creek, near Mazama (12447383): Miscellaneous measurements were regressed with the "Methow near Pateros" and the results were used to estimate the mean monthly flows below Early Winters Creek. The quality of the relationship is poor. The results are given in Table 24.

Comparison of Estimates of Discharge:

Estimates of the average monthly flow given in Office Report 46 have been compared to estimates presented here (Table 25). The estimates in this report superceed those in Office Report 46.

Estimates of average annual flows from various tributaries of the Methow are given in the 1961 U.S. Bureau of Reclamation report. These have been compared to the estimates given in Office Report 46, and in this report (Table 26). The estimates in Office Report 46 and this report are the best available estimates.

Low flows: The estimates of seven-day low flows in the Methow Basin are given in Table 27.

The regression curves developed for the monthly flow analysis were used to estimate the seven-day flows; hence, the estimates are only as good as the regression relationship discussed previously.

Flows in Canals Past Gage on "Methow River at Twisp":

Three canals bypass the location of the U.S.G.S. gage on the "Methow River at Twisp." Data on the flows in the canals at various times is given in Walters and Nassar. A "Monte Carlo" estimating procedure was used to estimate the average monthly flows. These estimates are given in Table 28.

The 1961 report on the Methow by the Bureau of Reclamation did not indicate the existence of Risky Ditch.

Correlation between successive months:

A method of obtaining some idea of the persistence of flows is to look at the correlation between flows in successive months. A correlation

TABLE 21

FREQUENCY AND WATER USE DATA

FOR Methow at Winthrop . U.S.G.S. GAGE 12-4485

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discha e	333	340	291	264	270	374	1,151	3,662	4,857	1,740	501	307
Discharge n exceeded tw in three ye s	359	369	314	283	291	404	1,260	4,007	5,349	1,923	549	332
Discharge n exceeded on in two year (Q_2)	322	326	281	257	261	337	986	3,440	4,534	1,563	469	298
Discharge n exceeded on in ten year (Q_{10})	233	225	203	194	190	196	475	2,183	2,770	843	292	214
$Q_2 - Q_{10}$	89	101	78	63	71	141	511	1,257	1,764	720	177	84
Water Use (Depletions	-	-	-	-	-	-	-	-	-	-	-	-

Period of k ord 1904-1919; 1961-1975 Remarks: Generated by regression with Methow at/near Pateros (12-4498.5) L normal distribution

ECY 0 99

TABLE 22

FREQUENCY AND WATER USE DATA

FOR Chewack Near Winthrop . U.S.G.S. GAGE 12-4475

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discha	80	82	69	61	63	91	309	1,240	1,841	479	127	73
Discharge n exceeded tw in three ye	87	90	74	66	68	98	335	1,357	2,031	524	139	80
Discharge n exceeded on in two year (Q_2)	77	78	66	59	60	80	258	1,099	1,612	418	117	70
Discharge n exceeded on in ten year (Q_{10})	53	51	45	42	41	44	118	587	809	213	69	47
$Q_2 - Q_{10}$	24	27	21	17	19	36	140	512	803	205	48	23
Water Use (Depletions	-	-	-	-	-	-	-	-	-	-	-	-

Period of R rd 1904-1919; 1961-1975 Remarks: Generated by regression with Methow at/near Pateros (12-4499.5), normal distribution

ECY 070-9

TABLE 23

FREQUENCY AND WATER USE DATA

FOR Methow above Chewack near Winthrop. U.S.G.S. GAGE 12-4473.89

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Discha	213	217	190	174	178	234	623	1,732	2,217	900	304	199
Discharge n exceeded tw in three ye	229	234	203	185	190	254	686	1,887	2,430	993	332	214
Discharge n exceeded on in two yea (Q_2)	208	210	185	171	173	217	554	1,651	2,103	828	289	194
Discharge n exceeded on in ten yea (Q_{10})	157	152	139	134	131	135	292	1,109	1,366	482	191	145
$Q_2 - Q_{10}$	51	58	46	37	42	82	261	542	736	346	98	49
Water Use (Depletion	-	-	-	-	-	-	-	-	-	-	-	-

Period of r rd 1904-19; 1961-75 Remarks: mean: 599

REV 6. 9

TABLE 24

FREQUENCY AND WATER USE DATA

FOR Methow River below Early Winters Creek. U.S.G.S. GAGE 12-4473.83

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean Disch ge	63	65	54	48	49	73	248	771	1,015	374	102	57
Discharge t exceeded t in three y rs	69	71	58	51	53	78	273	843	1,117	413	113	62
Discharge t exceeded o in two yea (Q_2)	60	61	51	46	47	63	211	727	951	337	94	55
Discharge t exceeded o in ten yea (Q_{10})	41	39	35	33	32	33	99	468	589	184	54	37
$Q_2 - Q_{10}$	19	22	17	13	15	30	113	260	362	153	40	18
Water Use (Depletion	-	-	-	-	-	-	-	-	-	-	-	-

Period of ecord 1904-1919; 1961-1975 Remarks: Generated data, log--normal distribution

Table 25: Comparison of Various Estimates of Average Monthly Flows

Month	12-447500 Chewack near Winthrop		12-448500 Methow at Winthrop		12-447389 Methow above Chewack	
	This Report	Richardson, Office Report 46	This Report	Richardson, Office Report 46	This Report	Richardson, Office Report 46
October	80	118	333	361	204	238
November	82	123	340	424	210	295
December	69	106	291	365	173	254
January	61	60	264	272	152	209
February	63	50	270	251	158	199
March	91	69	374	328	225	256
April	309	247	1,151	1,397	633	1,139
May	1,240	1,620	3,662	4,570	1,524	2,880
June	1,841	1,530	4,857	4,537	1,877	2,757
July	479	338	1,740	1,344	874	990
August	127	102	501	483	325	376
September	73	64	307	308	185	241
Annual	376	370	1,176	1,208	545	821

Table 26: Comparison of Estimates of Annual Runoff in the Methow Basin

Location	USGS Number	Drainage Area (sq. mi.)	Estimated Annual Runoff (acre-feet)	
			USBR	Office Report 46 and this report
Chewack Cre at Winthrop	12 - 448000	544	240,000	293,000
Methow Rive above Winthrop	12 - 447389	470	592,000	433,200
Bear Creek	-	21	5,010	2,900
Thompson Cr k	-	14.5	3,410	3,800
Twisp at Tw p	12 - 448998	245	145,000	229,200
Beaver Cre	-	111	37,940	23,000
Libby Creel	-	44	14,120	10,700
Gold Creek	-	88.6	27,490	23,600
McFarlan Cr k	-	13.1	4,300	700
Black Cany Creek	-	24.6	7,680	1,300
Methow Riv at Twisp	12 - 449500	1,301	991,600	1,041,400
Methow Riv near Pateros	12 - 449950	1,810	1,145,000	1,212,800

Table 27: Seven-Day Low Flows in the Methow Basin

Station Number	Name	Reoccurrence Interval in Years 1.05	2	5	10	20
From Walters and Nassar						
12 44950	Methow River at Twisp	310	205	175	160	150
12 44960	Beaver Creek below South Fork, near Twisp	6.8	4.3	3.5	3.1	2.9
12 44995	Methow near Pateros	410	300	260	245	240
12 45050	Methow at Pateros	420	310	260	240	220
Analysis for this Report						
12 44730	Andrews Creek near Mazama	4.6	2.2	1.7	1.5	1.3
12 44995) 12 45050)	Methow at/near Pateros	375	297	258	238	220
Regression with Methow at/near Pateros:						
12 44738	Methow below Early Winters Creek near Mazama	44	34	28	25	22
12 44738	Methow above Chewack River near Winthrop	164	133	117	109	102
12 44750	Chewack River near Winthrop	56	41	34	30	27
12 44850	Methow at Winthrop	246	194	168	154	142
12 44890	Twisp near Twisp	41	30	24	22	19

Discharge in cubic feet per second.

Table 28: Average Monthly Flows in Canals Bypassing Gage on Methow at Twisp

Month	Methow Valley Irrigation		Risky Ditch (cfs) (from Twisp)	Total (cfs)
	Diversion from Twisp (cfs)	Diversion from Methow (cfs)		
April	13	23	5	41
May	26	46	8	80
June	44	56	10	110
July	43	65	12	120
August	35	65	11	110
September	19	38	10	67
October	18	30	9	57
November	0	15	2	17
Annual	17	28	6	51

Sources: "Monte Carlo" Estimates using data in Walters and Nassar.

coefficient of 1.0 indicates the flow during the previous months can be used with certainty to predict the monthly flow; a correlation coefficient of 0 indicates no relationship.

The correlation coefficient for monthly flows at three locations in the Methow Basin is given in Figure 11.

Interaction of Ground and Surface Water:

The average monthly flows at the seven stations on the Methow and Chewack River are given in Table 29. The runoff from the incremental areas needed to balance the water output is also given in the table. The major observation is that the indicated runoff of the area between "Methow below Early Winters Creek" and "Methow above Chewack," and between "Methow above Chewack" plus "Chewack near Winthrop," and "Methow at Winthrop" is very high compared to the runoff estimated from a runoff map. This observation suggests that considerable water is moving down-valley in the unconsolidated materials at "Methow below Early Winters Creek" and "Methow above Chewack" (annual flow at 235 cfs at the former and 175 cfs at the latter).

In May 1975 the downstream water table gradient near the mouth of Goat Creek was 0.00526 feet per feet. The width is about 5,800 feet and the saturated thickness is possibly in the order of 60 feet. Assuming a permeability of 0.1 cfs per square feet, the ground water discharge was 180 cfs. The permeability assumed is quite possible; hence the ground water discharge is an important component of the discharge of water in the upper Methow Basin.

Miscellaneous discharge measurements in the upper Methow Basin indicate some large flow losses along the Methow River in the vicinity of Mazama. The following measurements were made on August 25, 1971:

	Drainage Average	Discharge
Methow above Robinson Creek	63.3 in.	49.6 cfs
Robinson Creek	19.7	9.9 cfs
Lost River	146	95.2
Gate Creek	6.2	1.0
Goat Wall Creek	3.6	0
Early Winters Tributaries	39.4	34.4
(total flow measurement upstream)	(278)	(190)
Methow at Mazama	342	145
Indicated loss above Mazama		45 cfs

in a reach of less than 2 miles upstream from Goat Creek. [illegible]
flows were measured weekly at three sites on the Methow from August 2 to September 13, and twice in October. The three sites are listed as No's. 11, 14, and 15 in Table C1 of Bulletin 38, and are shown on Figure 12. Measurements at these locations may be summarized as follows:

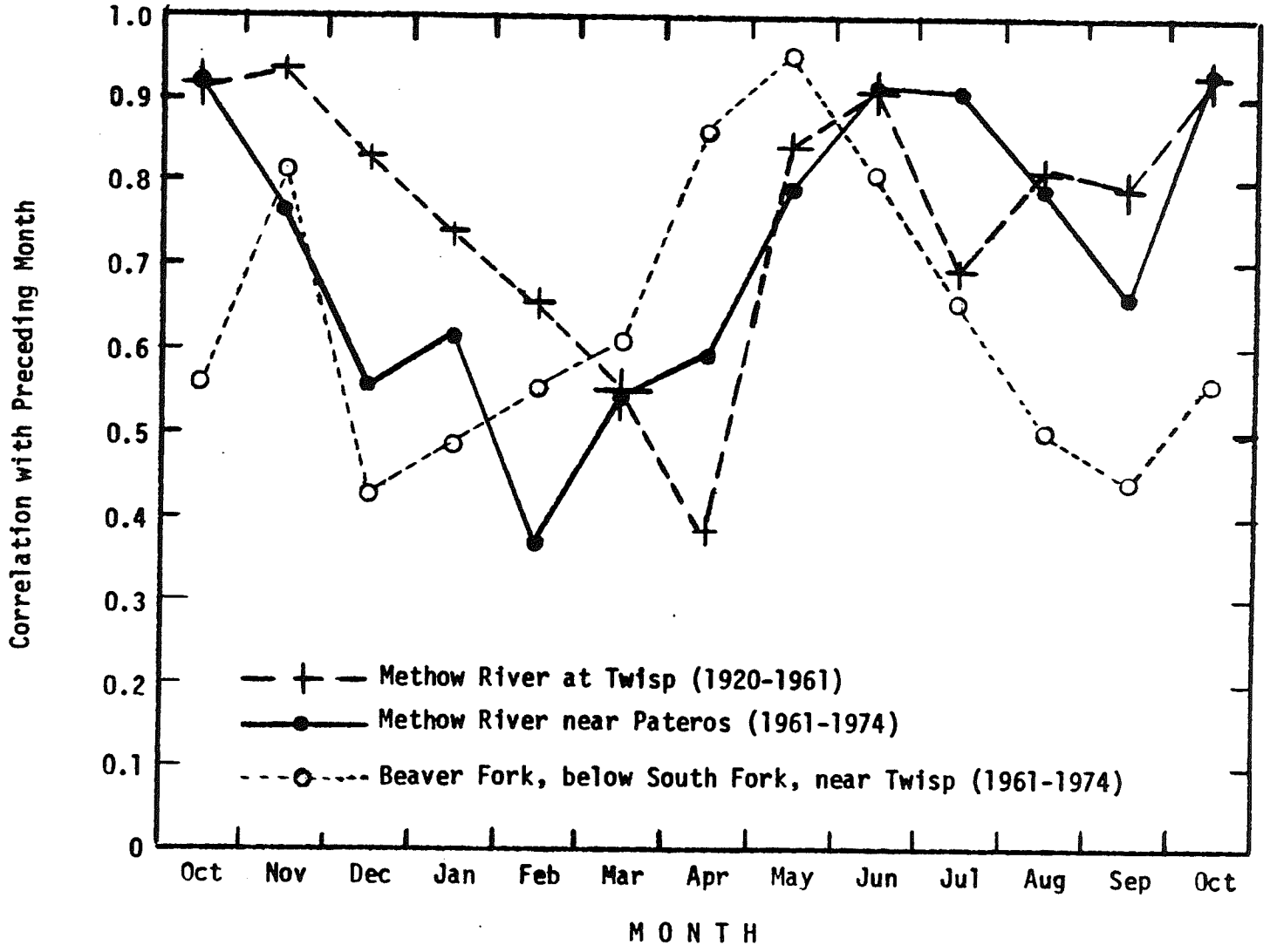
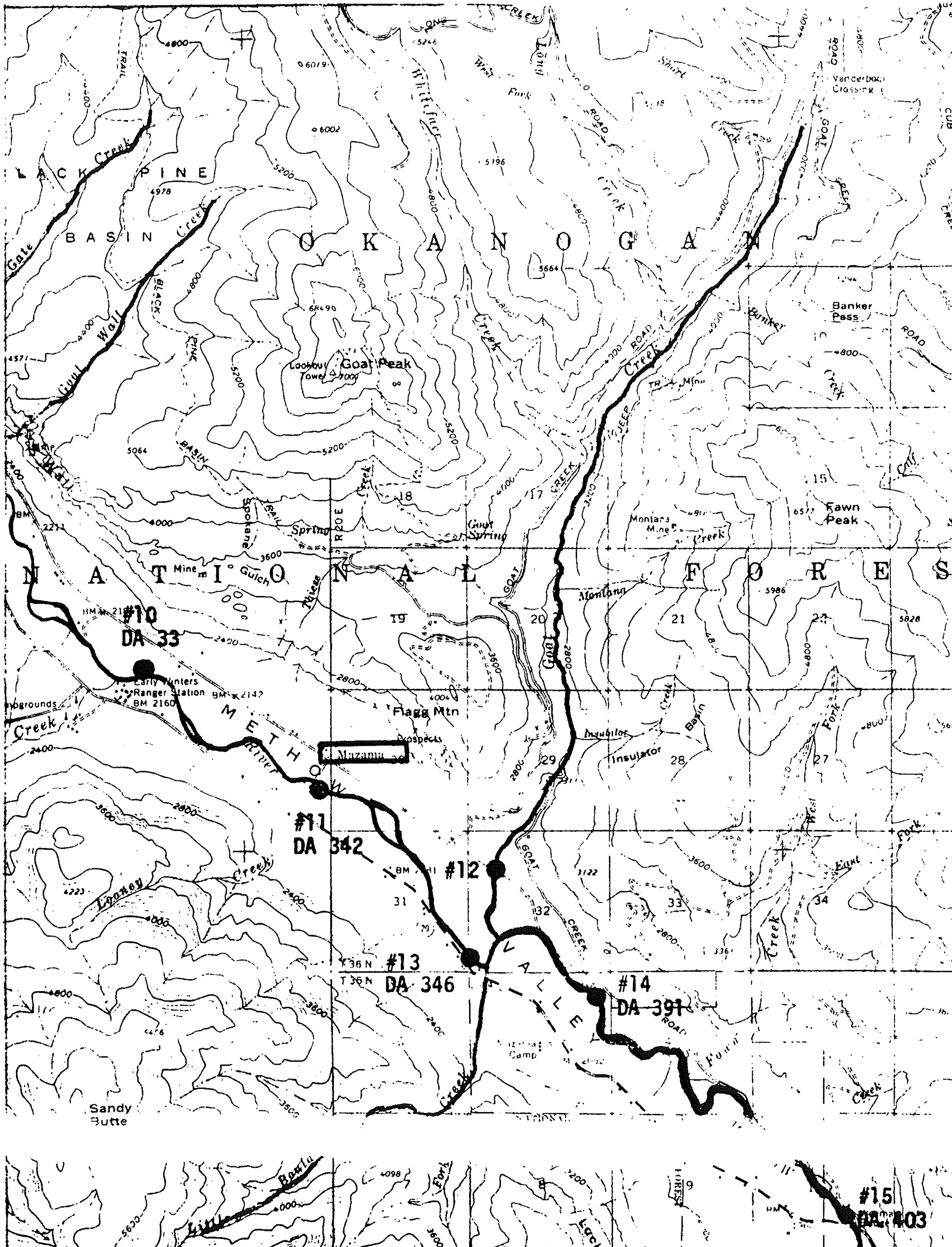


FIGURE 11. Correlation Between Successive Months - Methow River Basin.

Table 29: Average Monthly Flows in the Methow Basin

Month	Metho below Winte (1244	arly s Creek 383)	Incremen- tal Area	Methow above Chewack (12447389)	Chewack near Winthrop (12447500)	Incremen- tal Area	Methow at Winthrop (12448500)	Twisp near Twisp (12448998)	Incremen- tal Area	Methow at Twisp (12449500)	Incremen- tal Area	Methow at/near Pateros 1244995(
Oct.	(		151	213	80	40	333	63	-14	382	120	502
Nov.	(		152	217	82	41	340	65	-14	391	121	512
Dec.			136	190	69	32	291	52	-17	326	114	440
Jan.			126	174	61	29	264	45	-19	290	110	400
Feb.			129	178	63	29	270	47	-18	299	111	410
Mar.			161	234	91	49	374	76	-16	434	126	560
Apr.	2		384	623	309	219	1,151	308	-28	1,431	236	1,668
May	7		961	1,732	1,240	690	3,662	1,071	-175	4,558	584	5,142
June	1,0		1,202	2,217	1,841	799	4,857	1,428	-266	6,019	746	6,765
July	3		526	900	479	361	1,740	489	-53	2,176	319	2,495
Aug.	1		202	304	127	70	501	109	-9	601	144	745
Sept.			42	199	73	35	307	56	-16	347	117	464
Annual	2		345	599	376	201	1,176	317	-54	1,440	238	1,677
Area (sq. mi.)	3		138	480	465	62	1,007	245	49	1,301	483	1,784
Run off: (inches)			34	17	11	44	16	16	--	15	7	12.8
Run off: from Office Report 46 (inches)			11	22	11	6	16	15	3	15	3	11.4



O K A N O G A N
N A T I O N A L F O R E S
Goat Peak
Lookout Tower
Flagg Mtn
Mazama
Prospects
METHOW
Early Winters Ranger Station
Banker Pass
Fawn Peak
Montana Mine
Insulator
Sandy Butte
Goat Creek
#10
DA 33
#11
DA 342
#12
#13
DA 346
#14
DA 391
#15
DA 403

FIGURE 12

	Measured Discharge in CFS -					
	Site 11	Site 14	Site 15	Gain or Loss		
	(D.A. 342)*	(D.A. 391)	(D.A. 403)	11 to 14	14 to 15	11 to 15
Aug. 21, 1942	76.8			-	-	-
Sept. 25, 1942	15.4	(dry at #13)		-	-	-
Jan. 8-9, 1944	7.4(#10)	11.1	23.6	+3.7	+12.5	+16.2
Sept. 10, 1967	51.0			-	-	-
Sept. 15, 1970	24.4			-	-	-
Aug. 26, 1971	145			-	-	-
Aug. 2, 1972	863					
Aug. 3, 1972			843			
Aug. 9, 1972	690		735			+45
Aug. 16, 1972	533	522	576	-11	+54	+43
Aug. 23, 1972	348	365	374	+17	+ 9	+26
Aug. 30, 1972	272	257	288	-15	+31	+16
Sept. 6, 1972	159	147	181	-12	+34	+22
Sept. 13, 1972	118	82.3	149	-36	+67	+31
Oct. 4, 1972	135	95.3	153	-40	+58	+18
Oct. 26, 1972	63.5	31.8	87.9	-32	+56	+24

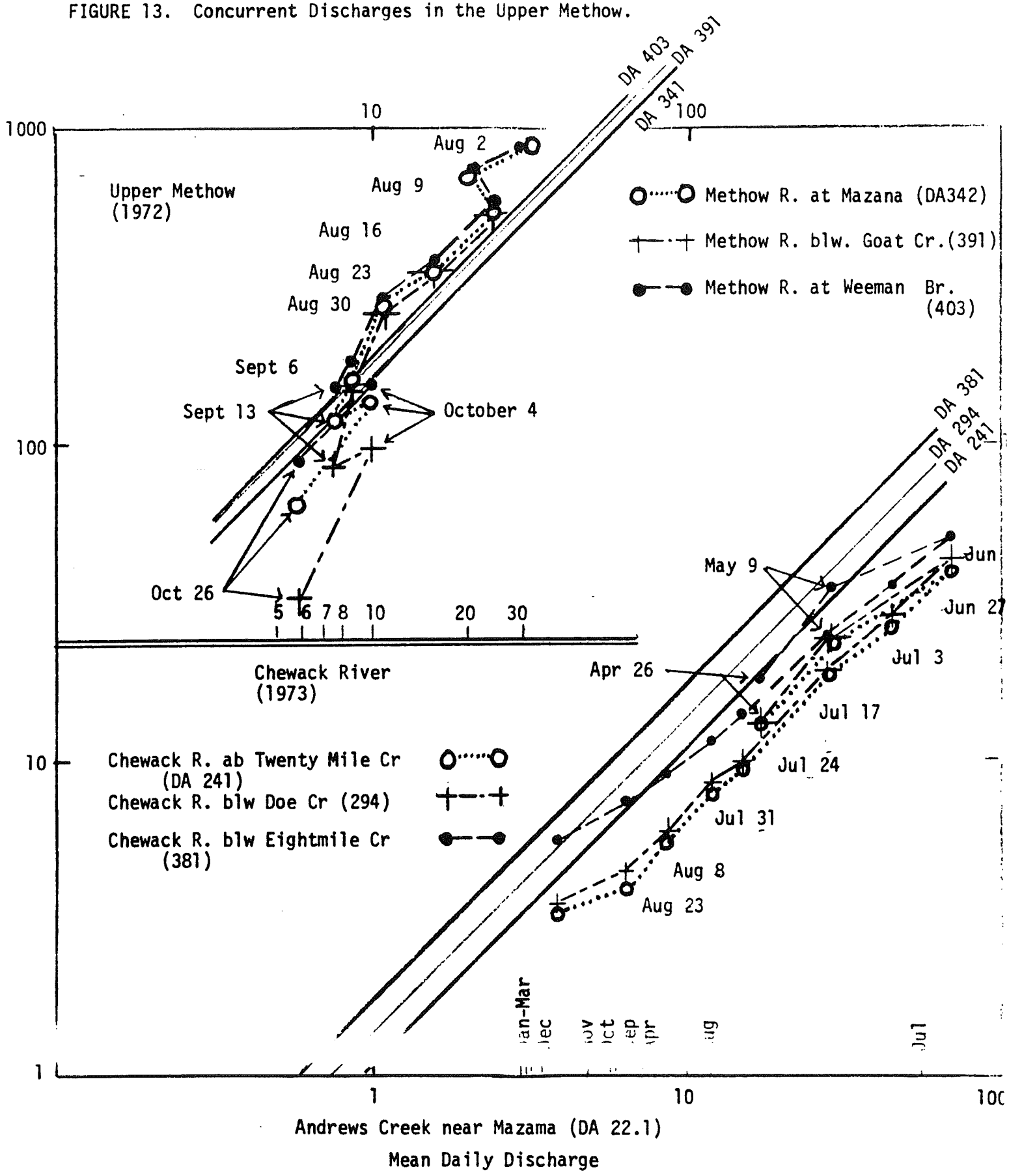
* Drainage area in square miles.

Irrigation diversions would affect the indicated gains or losses, but in the reach between sites 11 and 14 there are no significant diversions, so the losses must represent the interchange of surface and ground water. Likewise, the indicated loss above Mazama in 1971 is far more than can be accounted for by diversions, particularly when all of the tributary flows were not measured. It seems evident that at times the upper Methow River is a "losing" stream, and natural flows near Mazama are lower than might be estimated on the basis of precipitation and surface runoff. The year 1972 was very wet here; hence the losses were probably less than for a more normal water year.

"Natural" monthly flows, under conditions existing in 1972, may be estimated for the three sites near Mazama by comparing the measured discharges with concurrent daily flows at the gaging station on Andrews Creek. A simple regression of the concurrent discharges is shown on the upper graph of Figure 13. In relation to Andrews Creek, upper Methow unit flows (per square mile of drainage area) were greater in early August, decreasing to much lower values by late October, 1972.

This seasonal trend is probably a persistent feature from year to year, and should be considered in estimating average monthly flows of the upper Methow River. For the three sites near Mazama, estimates for the months of August, September and October, based on ratios to Andrews Creek discharge, are as follows:

FIGURE 13. Concurrent Discharges in the Upper Methow.



	August		September		October	
	Factor	cfs	Factor	cfs	Factor	cfs
Methow at Mazama	23	267	16	92	12	67
Methow below Goat Creek	24	278	15	86	8	45
Methow at Weeman Bridge	27	313	19	109	15	84

There are insufficient data to estimate other monthly mean flows at these sites using the same method. However, measurements at three sites on the Chewack River in 1973 may be used in a similar manner. They are plotted with concurrent flows of Andrews Creek on the lower graph of Figure 13, and are the basis of the following estimates:

	April		May		June		July		August	
	Factor	cfs	Factor	cfs	Factor	cfs	Factor	cfs	Factor	cfs
Chewack above Twenty Mile Creek	8.5	60	7.0	875	6.0	1,310	6.2	339	7.0	81
Chewack below Doe Creek	9.5	67	7.5	938	6.5	1,420	6.7	366	7.6	88
Chewack below Eight-Mile Creek	12.5	88	9.5	1,190	7.8	1,700	9.0	491 (hi)	12.5	145 (hi)

The data in Table 29 suggests about 110 cfs may be bypassing the USGS gage at Twisp on the Methow. This probably reappears as surface water when the Methow River crosses the area of low-permability materials near Carlton. The previous water balance present suggests the ground water discharge near Pateros is about 85 cfs.

The location of the gages and control points relative to the location of unconsolidated material is given in Figure 14.

DISCUSSION

This report presents a compilation and analysis of information on the water resources of the Methow Basin. Used in conjunction with the report by Walters and Nassar, a very good understanding of the water resources of the Methow Basin may be obtained.

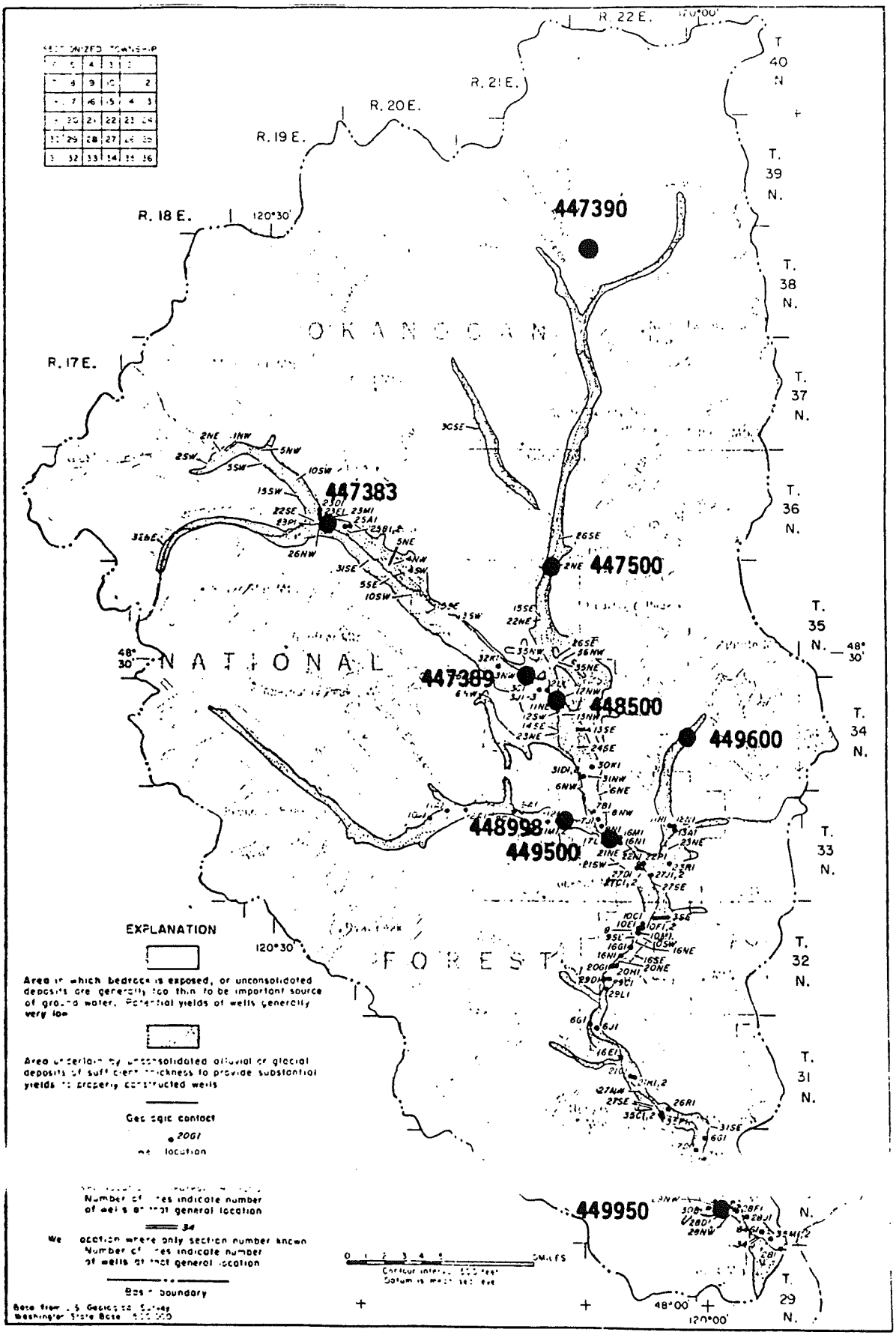


FIGURE 14. Location of gaging stations (area 12) and control points relative to the unconsolidated deposits in the Methow River Basin.

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