WESTERN STATES WATER COUNCIL
May 17, 1984

HOW MUCH WATER DO WE HAVE IN THE WEST?

The most recent information relating to this question can be found in the "National Water Summary 1983," completed by the U.S. Geological Survey. The following illustration contains figures for both consumptive water use and renewable water supply in each of the nine western regions. "Renewable supply" represents the flow potentially or theoretically available for use in the region on an essentially permanent basis. It does not include depletion of ground water storage. As such it represents a simplified upper limit to the amount of water consumption that could occur in a region on a sustained basis.

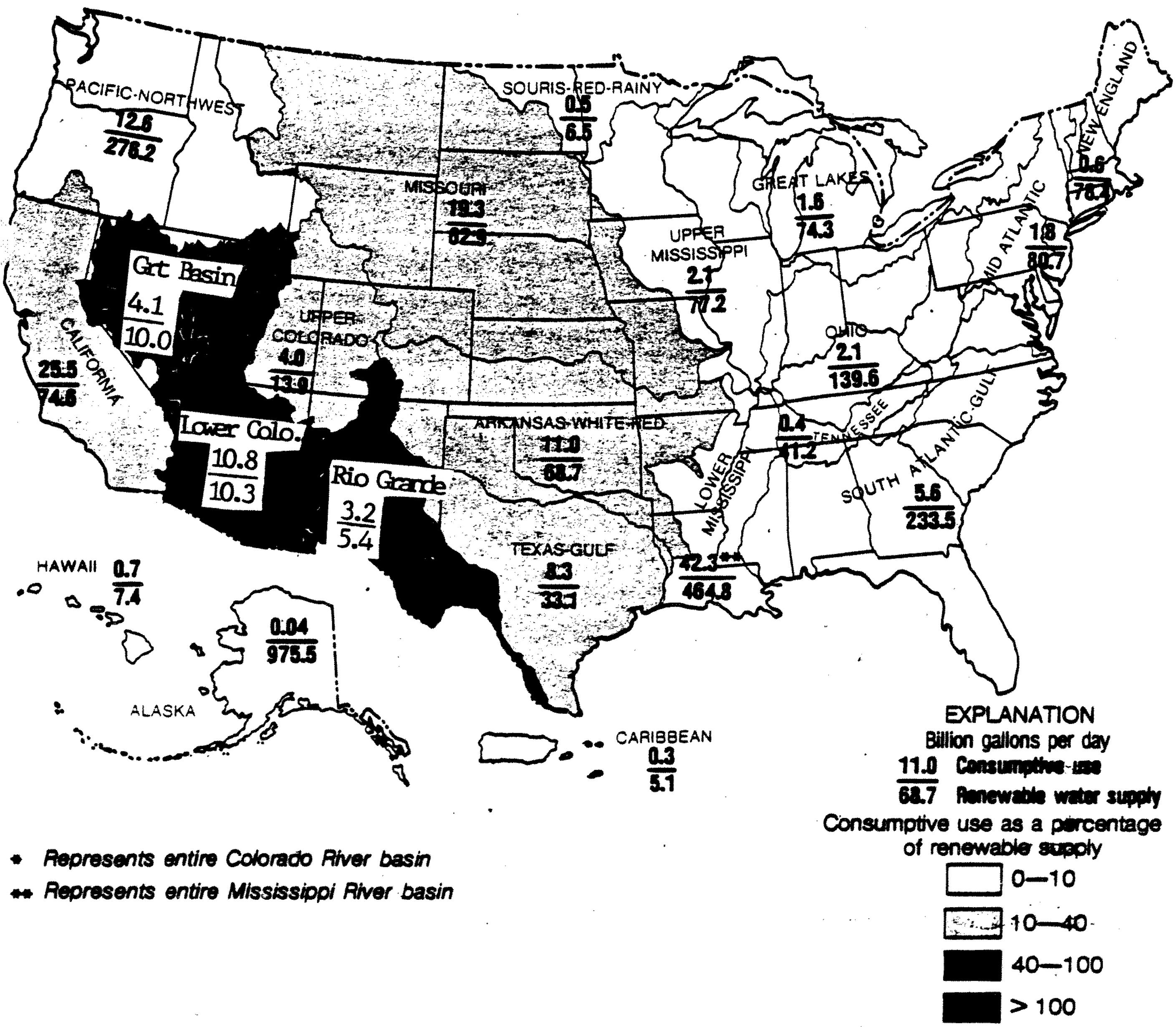


FIGURE 10. Average consumptive use and renewable water supply, by water-resources region.

The renewable supply provides a rough measure of the abundance of the water resource, and when compared to the existing rate of consumptive use, provides an index of the degree to which the resource has already been developed.

On a state-by-state basis, the Westwide Study completed in 1975 under the direction of the Department of Interior estimated the net future water supply by state. The net water supply represents supply available after deduction for estimated compact, legal, and instream 1975 requirements for downstream flows.

Table II-33.—*Estimated net future water supply by State, 1975 (1,000 acre-feet)*

State	Net water supply
Arizona[1]	397
California[1]	26,510
Colorado	1,097
Idaho	53,458
Montana	37,344
Nevada[1]	1,741
New Mexico	236
Oregon	66,029
Utah	1,668
Washington	245,782
Wyoming	3,853

I should emphasize that these figures must be considered as a very rough estimate considering the fact that they rely in part on interpretations of court decrees, interstate compacts, and federal statutes. Nevertheless, they can provide a general idea as to remaining supplies that could be considered available for either instream uses such as for fish, wildlife, recreation, water quality, power, and navigation, or for consumptive use within economic, environmental and physical constraints which could preclude full development.

HOW MUCH DO WE NEED?

A few years ago the WSWC prepared a report entitled "Western Water Resource Development and Financing." In that process, we asked for the amount of developed water in our member states, and estimated future needs to the year 2020.

The amount of developed water totaled 52,938,084 acre feet. The estimated future needs to the year 2020 totaled 23,426,002 The estimated capital expenditure to develop water to meet these future needs amounted to $64.02B, which includes wastewater treat- expenses.

The following is a breakdown by state, according to the 1981 WSWC report:

STATE	Amount of Developed Water (in Acre Feet)	Estimated Future Needs (to 2020) Capital	Acre Feet
Arizona	90,000	2,600,000,000	1,455,000
California	2,200,000	7,500,000,000	4,800,000
Colorado	45,000	3,568,300	2,235
Montana	6,756,186	575,892,000	2,121,837
Texas	15,972,500	51,900,000,000	9,848,700
Utah	544,198	749,000,000	1,498,850
Washington	26,626,700		
Wyoming	703,500	694,673,000	3,699,380
Totals	52,938,084	64,023,033,300	23,426,002

It should be noted that all figures for developed water were estimates. Figures for capital expenditures for future needs represent only the data that was obtainable, and should be considered as minimum estimates.

The estimated future needs in acre feet were derived from available projections where possible, adjusted for known changes and trends since the projections were made. Because of the many uncertainties and variables associated with such estimates, these latter figures were not included in the report published by the WSWC. It should be furthermore noted that only eight of the member states had such information available and were able to respond.

HOW MUCH IS FOR SALE?

This question can be answered in different ways. The following illustration from the Second National Assessment relates to "Total water use as a percentage of streamflow in average and dry years."

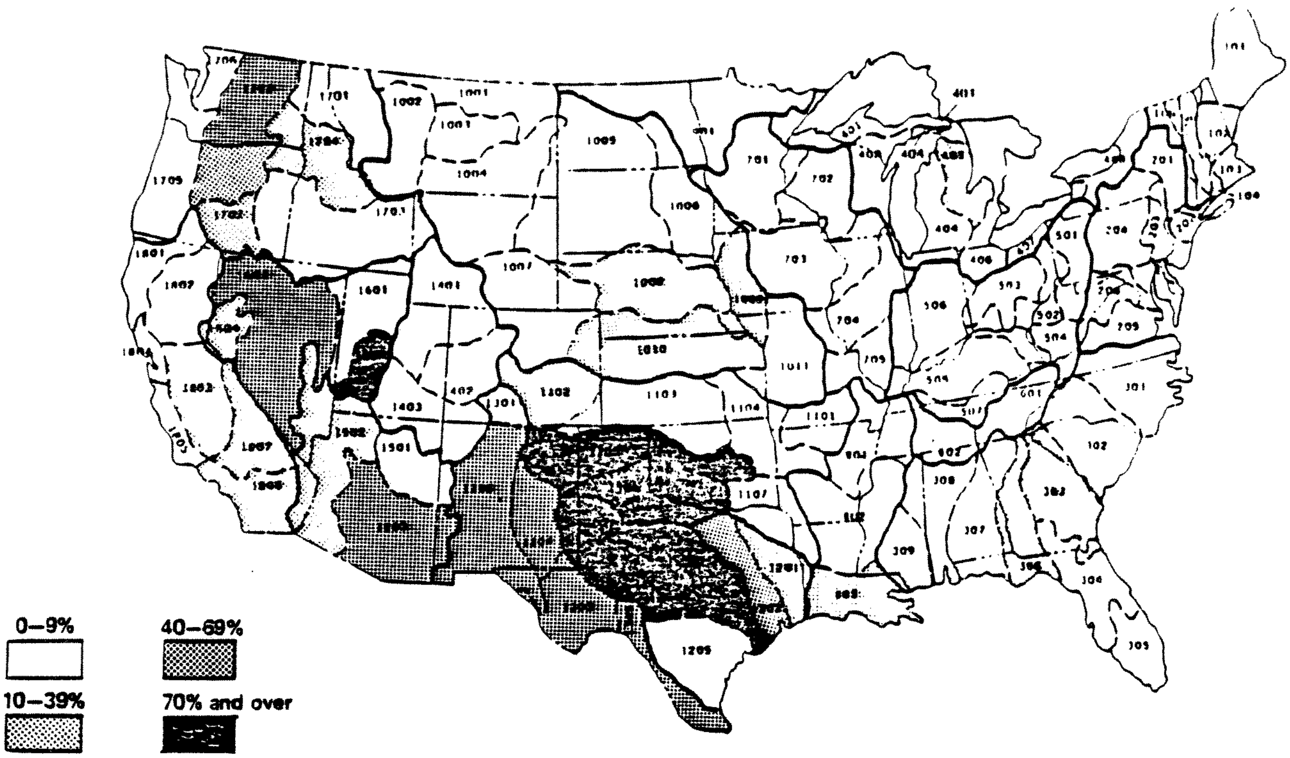
The table's definition of water use includes both instream needs and offstream consumption. The instream needs are defined as the minimum flow necessary for maintenance for fish and wildlife populations or for navigation.

Total Water Use as a Percentage of Streamflow in Average and Dry Years

Region number	Subregion number	Name	Average years	Dry year
14		UPPER COLORADO	84	112
	01	Green-White-Yampa	87	114
	02	Colorado-Gunnison	80	106
	03	Colorado-San Juan	84	112
15		LOWER COLORADO	225	239
	01	Little Colorado	30	103
	02	Lower Colorado Main Stem	225	239
	03	Gila	304	315
16		GREAT BASIN	125	158
	01	Bear-Great Salt Lake	102	125
	02	Sevier Lake	186	204
	03	Humboldt-Tonopah Desert	177	222
	04	Central Lahontan	116	165
17		PACIFIC NORTHWEST	84	102
	01	Clark Fork-Kootenai	62	73
	02	Upper / Middle Columbia	79	94
	03	Upper / Central Snake	91	119
	04	Lower Snake	78	96
	05	Coast-Lower Columbia	85	102
	06	Puget Sound	31	96
	07	Oregon Closed Basin	101	161
18		CALIFORNIA	82	113
	01	Klamath-North Coastal	65	95
	02	Sacramento-Lahontan	76	106
	03	San Joaquin-Tulare	109	131
	04	San Francisco Bay	91	152
	05	Central California Coast	93	169
	06	Southern California	107	116
	07	Lahontan-South	243	290

According to the table, with the exception of a portion of North Dakota, the average water use as a percentage of streamflow exceeded 80% in all of the western United States in 1975. In approximately half of the area, water use exceeded streamflow in an average year of precipitation. In virtually the entire area streamflow is exceeded by water use in a dry year. In areas where water use exceeds streamflow, ground water supplies must be used to supplement surface flows. In many such cases, ground water "mining" occurs. Many areas are currently experiencing the various difficulties associated with serious ground water overdraft. The following figure illustrates the percentage of ground water with-drawn that is excess of natural recharge rates.

THE PERCENTAGE OF GROUNDWATER WITHDRAWN THAT IS IN EXCESS OF NATURAL RECHARGE RATES 1975



(Note: According to the State of Arizona Department of Water Resources the sub-region in the southeastern part of that state should be shaded black.)

The conclusion that could be drawn from this analysis is that there is virtually no water in abundance which could be available for transfer and sale. However, when one examines the nature of a vested water right under the appropriation doctrine which prevasils in the West and the ability of municipalities and industries to purchase water from the agricultural sector, then the question depends much more on issues of public policy i.e. to what extend should laws and policies accommodate the transfer of water.

There are four basic types of water transfers. They are:

1. Change in Point of Diversion;
2. Change in Place of Use;
4. Change in period of use; and
5. Change in nature of use.

Every state has some procedure for allowing transfers of water rights. The general rule regarding water right transfers is that they will be approved if a showing can be made that they will not adversely affect other water rights. The following table shows the number of applications for transfer of water rights filed in each of the western states during the period 1963-1982.

Table 1. Numbers of Applications for Transfer of Water Rights Filed with Each of the Seventeen Western States 1963-1982.

Year	State																
	AZ	CA	CO[1]	ID	KS	MT[2]	NE	NV	NM	ND	OK	OR	SD	TX[3]	UT	WA	WY
1963	2	76	-	22	-	-	6	113	205	-	-	106	No Information Available	-	191	34	369
1964	1	78	-	34	-	-	3	110	432	-	-	97		-	205	52	47
1965	1	169	-	30	-	-	5	110	432	-	-	90		5	213	54	53
1966	2	108	-	30	-	-	3	146	304	-	-	137		2	296	36	69
1967	1	121	-	18	-	-	2	168	304	-	7	149		19	271	66	60
1968	1	108	-	32	-	-	1	122	403	-	4	134		9	337	47	67
1969	4	113	-	29	-	-	4	136	403	-	10	153		8	307	97	129
1970	2	80	257	20	118	-	5	120	430	-	5	162		9	414	44	82
1971	1	63	603	32	153	-	1	90	430	-	8	163		5	329	37	46
1972	-	87	4171	59	163	-	2	155	437	-	3	212		14	463	22	55
1973	-	89	975	69	156	120	3	189	437	-	4	245		20	472	87	62
1974	3	55	524	81	139	120	0	263	419	-	3	284		23	513	86	66
1975	2	82	477	94	176	120	1	212	419	-	7	223		29	492	56	70
1976	-	88	486	72	222	120	4	344	461	-	40	188		22	515	81	85
1977	-	91	499	164	357	120	3	287	461	-	22	508		13	769	30	63
1978	-	56	714	97	440	120	2	354	413	-	23	351		18	562	57	74
1979	-	42	556	84	716	120	4	378	409	-	25	304		21	534	57	61
1980	1	71	563	134	652	120	8	443	419	1	17	393		14	500	30	94
1981	33	113	688	128	680	120	8	436	442	1	44	354		28	532	59	108
1982	27	104	664	123	573	120	4	464	-	1	48	272		24	471	93	98

1/ Colorado information was estimated on basis of ratio of change of water right cases to total cases reported by one of seven water divisions. Estimate for 1972 may be greatly in error due to a water law change which prompted the filing of over 14,000 cases with Colorado's water courts that particular year.

2/ Montana estimated approximately 1200 transfer applications since 1973.

3/ Texas information reported by type of transfer. Total number would be at least as shown.

As the above information demonstrates, literally hundreds of water right transfers take place in the West each year. Undoubtedly, the laws of some states could be streamlined to facilitate the transfer process. Nevertheless, most state laws and institutions, per se, do not prohibit the transfer of water used under existing water rights to new uses as long as the new uses are intrastate and intrabasin. If it is contemplated that under the proposed transfer the water will be used outside of its basin of origin, the numerous difficulties occasioned by "interbasin transfers" come into play.

Protection of location of origin of water has traditionally been extremely important to the western states. There exist numerous large scale plans (or schemes) which would allow the West to "benefit" from enormous interbasin water transfers. Some amount to merely "lines on a map." For others, the engineering feasibility studies are quite complete. However, the proponents of few, if any, have given adequate and complete consideration to the legal, political, and socioeconomic ramifications which must be dealt with before any such plan could become reality. Also, most western states have laws restricting out of state use of water. Although the recent Sporhase cecision has caused these laws to be reconsidered, and in some cases amended, still numerous difficulties exist with regard to out of state use.

Environmental concerns are another limiting factor to large scale water transfers. These may vary from region to region. Of particular importance to the Upper Colorado River Basin states are current Endangered Species Act and concurrent Clean Water Act Section 404 problems.

In summary, western state legal and institutional schemes allow for transfer of water. For the right price a great deal of water is available for purchase in the West. However, other limiting factors make large-scale transfers difficult.

HOW MANY FEDERAL WATER PROJECTS HAVE BEEN PROMISED TO THE WEST, AND WHAT AMOUNT OF MONEY WILL BE REQUIRED TO COMPLETE THESE PROJECTS?

Immediately following this page is a list of active projects of the Bureau of Reclamation funded for construction as of fiscal year 1982, and a list of active Bureau projects which were not funded for construction in FY82.

The information is taken from a report by the Comptroller General dated January 26, 1983 and entitled, "Water Project Construction Backlog - A Serious Problem With No Easy Solution." You will note that the total balance to complete the active projects is approximately $12.8B, considering expenditures through FY81. The balance to complete the active Bureau projects not funded for construction in FY82 amounts to approximately $1.25B.

These figures do not include Corps of Engineer projects. Although the Corps expends significant amounts of money in building projects in the West, these projects are primarlily devoted to flood control rather than water supply.

LIST OF ACTIVE BUREAU PROJECTS

FUNDED FOR CONSTRUCTION

FOR FISCAL YEAR 1982

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	--------------	(000 omitted)	--------------
Arizona:			
Central Arizona Project (California, New Mexico, Nevada, Utah)	$ 2,988,745	$ 781,632	$ 2,207,113
Colorado River Basin Salinity Control Project, Title I (California)	471,624	174,534	297,090
Gila Project	77,820	72,884	4,936
Salt River Project, Stewart Mountain Dam	8,860	125	8,735
California:			
Central Valley:			
Auburn - Folsom South	1,968,434	317,291	1,651,143
Miscellaneous Project Programs	853,632	842,734	10,898
Sacramento River Division	323,663	252,765	70,898
San Felipe Division	338,834	72,344	266,490
San Luis Unit	1,140,348	463,871	676,477
Klamath (Oregon)	39,033	30,835	8,198
Orland Stony Gorge Dam	4,846	603	4,243
Orland East Park Dam	6,904	99	6,805
Recreation Facilities at Existing Reservoirs (Colorado, Nevada)	2,808	1,527	1,281

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	(000 omitted)		
Colorado:			
Colorado River Basin Salinity Control Projects, Title II: Grand Valley Unit	$ 236,969	$ 20,149	$ 216,820
Paradox Valley Unit	84,037	7,982	76,055
Dallas Creek	110,432	36,516	73,916
Dolores	359,322	63,660	295,662
Fryingpan-Arkansas	480,750	425,608	55,142
Grand Valley Projects, Orchard Mesa Division	2,816	-	2,816
San Luis Valley Closed Basin Division	74,869	5,528	69,341
Uncompahgre	5,640	-	5,640
Miscellaneous items (note b)	154,754	29,141	125,613
Idaho:			
Boise, Black Canyon Dam	5,427	179	5,248
Boise, Fayette Division	29,038	25,967	3,071
Little Wood River Project	2,496	2,121	375
Mann Creek Project	4,023	4,007	16
Minidoka Project: Island Park Dam	5,710	2,235	3,475
Minidoka Project: Jackson Lake Dam	6,805	2,404	4,401
Kansas:			
Pick-Sloan Missouri Basin Program: Bostwick Division	57,252	52,939	4,313

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	-------------(000 omitted)-------------		
Montana:			
Huntley Project	$ 7,800	$ 167	$ 7,633
Milk River, Sherburne Dam	4,455	455	4,000
Pick-Sloan Missouri Basin Program: East Bench Unit	24,230	22,835	1,395
Pick-Sloan Missouri Basin Program: Lower Marios Unit	46,660	46,260	400
Sun River Project: Gibson Dam	3,329	2,812	517
Sun River Project: Greenfields Division	8,300	3,997	4,303
Sun River Project: Willow Creek Dam	5,600	362	5,238
Nebraska:			
Pick-Sloan Missouri Basin Program: Farwell Unit	42,836	38,296	4,540
Pick-Sloan Missouri Basin Program: Frenchman-Cambridge Division	4,400	3,170	1,230
Pick-Sloan Missouri Basin Program: North Loup Division	252,080	23,057	229,023
Pick-Sloan Missouri Basin Program: O'Neill Unit	364,560	6,214	358,346
Nevada:			
Colorado River Basin Salinity Control Projects, Title II: Las Vegas Wash Unit	104,365	3,259	101,106

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	------------(000 omitted)------------		
Nevada:			
Newlands, Lahontan Dam	$ 6,700	$ 903	$ 5,797
Southern Nevada Water Supply	173,034	161,062	11,972
Washoe (California)	259,137	33,524	225,613
New Mexico:			
Brantley	243,046	9,086	233,960
Carlsbad	5,987	4,976	1,011
San Juan - Chama	109,363	73,499	35,864
Miscellaneous items (note b)	8,485	3,995	4,490
North Dakota:			
Pick-Sloan Missouri Basin Program: Dickinson Unit	6,454	6,204	250
Pick-Sloan Missouri Basin Program: Garrison Diversion Unit	1,097,592	157,461	940,131
Oklahoma:			
McGee Creek	170,133	15,405	154,728
Mountain Park	41,366	41,166	200
Washita, Foss Dam	40,521	30,813	9,708
Oregon:			
Tualatin	57,302	53,370	3,932
South Dakota:			
Rapid Valley Project Deerfield Dam	8,500	1,083	7,417
Texas:			
Nueces River Project	85,988	64,653	21,335
Palmetto Bend	71,219	70,596	623

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	--------------(000 omitted)		---------------
Texas:			
San Angelo	$ 33,231	$ 29,447	$ 3,784
Utah:			
Central Utah Project Bonneville Unit	1,642,491	292,210	1,350,281
Central Utah Project Jensen Unit	76,484	44,044	32,440
Central Utah Project Upalco Unit	90,424	5,335	85,089
Hyrum Dam	9,487	542	8,945
Modifications and Additions to Completed Facilities (Arizona)	16,218	8,507	7,711
Miscellaneous items (note b)	186,515	48,226	138,289
Washington:			
Chief Joseph Dam: Oroville - Tonasket	71,900	7,390	64,510
Chief Joseph Dam: Whitestone Coulee	8,851	7,491	1,360
Columbia Basin: Irrigation Facilities	3,185,532	847,051	2,338,481
Third Powerplant	667,000	554,255	112,745
Yakima, Grandview Irrigation	2,930	5	2,925
Yakima, Sunnyside Valley Irrigation District	13,221	-	13,221
Yakima-Tieton Irrigation District	62,333	-	62,333
Yakima, Outlook Irrigation District	2,517	-	2,517

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	----(000 omitted)----		
Washington:			
Yakima, Sunnyside Board of Control	$ 13,500	$ -	$ 13,500
Wyoming:			
Pick-Sloan Missouri Basin Program: Owl Creek	6,930	6,525	405
Pick-Sloan Missouri Basin Program: Riverton Unit	41,528	24,143	17,385
Shoshone Project: Frannie Division	1,600	-	1,600
Shoshone Project: Garland Division	6,000	5,773	227
Shoshone Project: Heart Mountain	5,500	-	5,500
Shoshone Project: Willwood Division	1,600	549	1,051
Miscellaneous items (note b)	10,946	4,351	6,595
Total	$19,256,071	$6,454,204	c/$12,801,867

a/Includes actual expenditures through fiscal year 1980 plus allocations for fiscal year 1981.

b/Includes such items as recreational, fish, and wildlife facilities. The Bureau does not count these items as a project.

c/Bureau officials believe this amount should be less as discussed on page 16.

LIST OF ACTIVE BUREAU PROJECTS

NOT FUNDED FOR CONSTRUCTION

FOR FISCAL YEAR 1982

State and project name	Total estimated Federal costs	Expenditures thru FY 1981 (note a)	Balance to complete
	-----------	(000 omitted)	-----------
Colorado:			
Animas La Plata	$ 520,400	$ 4,001	$ 516,399
Pick-Sloan Missouri Basin Program: Narrows Unit	362,235	5,358	356,877
Idaho:			
Upper Snake River Project, Salmon Falls Division	154,114	1,228	152,886
Utah:			
Central Utah Project Uintah Unit	156,953	4,200	152,753
Wyoming:			
Pick-Sloan Missouri Basin Program: Polecat Bench	78,600	755	77,845
Total	$1,272,302	$15,542	$1,256,760

a/Includes actual expenditures through fiscal year 1980 plus allocations for fiscal year 1981.

(085646)

WHAT IS THE PER CAPITA OF WATER CONSUMPTION ON A STATE-BY-STATE BASIS IN THE WEST?

The following table is taken from a publication entitled "Estimated Use of Water in the United States in 1980," completed by the U.S. Geological Survey. The chart indicates not only the per capita use in gallons per day, but also the source and type of withdrawal.

WITHDRAWALS
(includes irrigation conveyance loses)

STATE	POPU-LATION in thousands	PER CAPITA USE fresh water in gpd	By Source and Type					
			Ground Water			Surface Water		
			Fresh	Saline	Total	Fresh	Saline	Total
Alaska	403	550	49	0	350	170	0	170
Arizona	2718	2900	4200	0	4200	3700	0	3700
California	23669	1900	21000	250	21000	23000	9800	33000
Colorado	2889	5400	2800	0	2800	13000	0	13000
Hawaii	965	1400	800	0	800	510	1200	1700
Idaho	944	19000	6300	0	6300	12000	0	12000
Montana	786	14000	260	2.1	260	11000	0	11000
Nevada	799	4500	710	9.1	720	2900	0	2900
New Mexico	1300	3000	1800	0.9	1800	2100	0	2100
North Dakota	652	2000	120	0.2	120	1200	0	1200
Oregon	2614	2600	1100	0	1100	5700	0	5700
South Dakota	695	990	330	3.4	330	360	0	360
Texas	14013	1000	8000	0	8000	6300	6600	13000
Utah	1462	3100	1000	4.0	1000	3500	56	3600
Washington	4127	2000	770	0	770	7500	42	7500
Wyoming	471	11000	540	24	560	4800	0	4800
Total Western States	58,507	4,709	49,779	293.7	50,110	97,740	17,698	115,730
Total United States	229,592	1,600	88,000	930	89,000	290,000	71,000	360,000

The per capita use figures in the Western States greatly exceed the national average, because agriculture must use irrigation to suppliment natural rainfall in the arid West. The nine western water resource regions account for 91% of the total water withdrawn for irrigation in the nation. About 90% of the water consumed in the 17 western United States is for crop production. Thus, efforts in the West to effect water savings through conservation measures have focused primarily on agriculture. One comprehensive report completed under the direction of the U.S. Dept. of Interior analyzed potential savings on 61 existing projects. They estimated that 1.7 million acre feet of water is currently lost to any beneficial use on these projects.

HOW MUCH OF THE CURRENT USES ARE BEING SUPPLIED BY SURFACE WATER AND HOW MUCH BY GROUND WATER?

The above table gives a breakdown of the respective sources of supply for existing uses.

The following figure gives a more graphic illustration of the relative dependence on surface and ground water withdrawals.

Water-Availability Issues 29

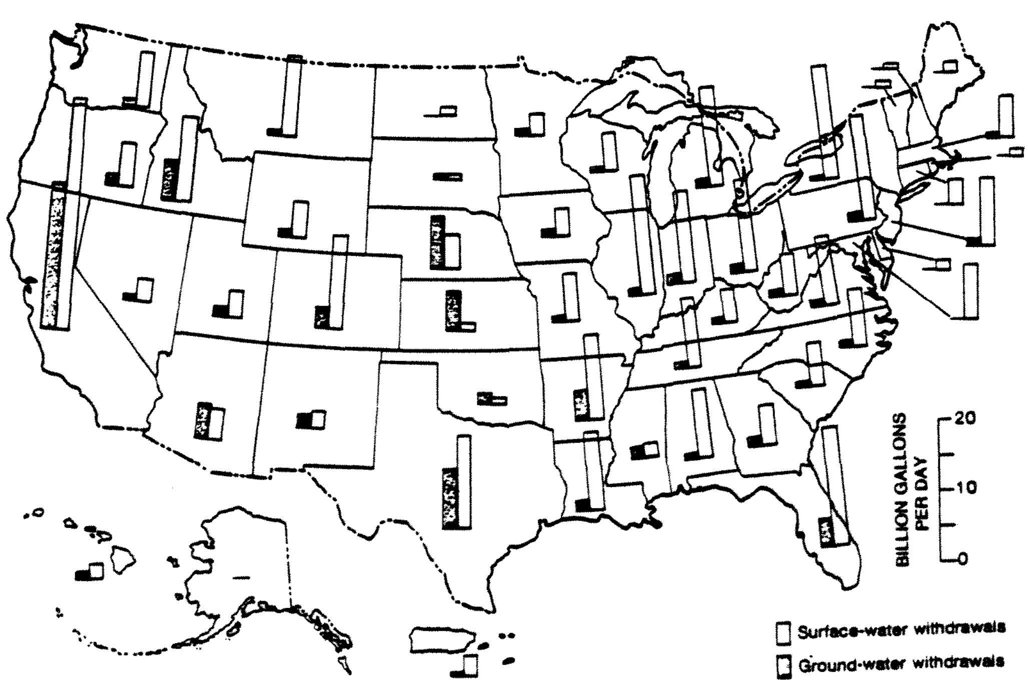


FIGURE 12. Withdrawals from ground water and surface water, by State, 1980. (From Solley and others, 1983.)

Specific percentages of reliance on ground water in the Western States is presented in the following figure.

Figure II-14. Ground-water as percent of total use.

WHAT IS OUR VULNERABILITY TO EXTENDED PERIODS OF DROUGHT

In the time available, we have not been able to locate empirical data on potential impacts and damages associated with an extended drought. It seems that once such a critical period has passed, the impetus for making better preparations for the next drought also dissipates.

Some idea of the potential impacts of an extended drought can be gleaned from an examination of the impacts of the 1977 drought. The drought was pervasive and resulted in one of the largest disaster payments in the nation's history. Many communities experienced acute water shortages and were forced to implement emergency water supply measures. Cattlemen were forced to sell foundation herds at depressed prices and often faced bankruptcy as a result of impaired range conditions and the lack of feed and drinking water. Similarly, in the case of farmers, many suffered acute financial hardship, because soil moisture was insufficient for germination and critical growing stages, and because large private outlays were required for drought mitigation.

Ironically, despite widespread conditions and dire predictions in the early months of the year, 1977 crop production was among the best in history. The drought prevention measures implemented after the droughts of the 30's and 50's (especially the conservation measures encouraged by the U.S.D.A.'s Soil Conservation Service) helped to mitigate potential drought damage. Expensive programs of ground water pumping saved crops in many areas. In addition, many farmers were fortunate in that infrequent rains came at just the right times.

Drought related impacts were not limited to agriculture and municipalities. Other problems stemming from the drought included ski areas with little or snow, dry marinas, aluminum production cut backs, shortages of hydroelectric power, curtailed timber harvests, fishery losses, devastating forest fires, grasshopper infestations, destruction of wildlife habitat, strain on financial institutions, and loss of revenue to state and local governments.

WHAT ARE THE POTENTIAL RAMIFICATIONS OF THE "GREENHOUSE EFFECT" ON THE WATER SUPPLY IN THE WEST?

The "greenhouse" effect of keeping infrared radiation from escaping from the earth's surface, thereby causing higher surface temperatures, could result in the following possible changes in the natural environment:

(1) Altered patterns of precipitation and evaporation;

(2) Shifts in agriculturally productive areas;

(3) Higher sea levels;

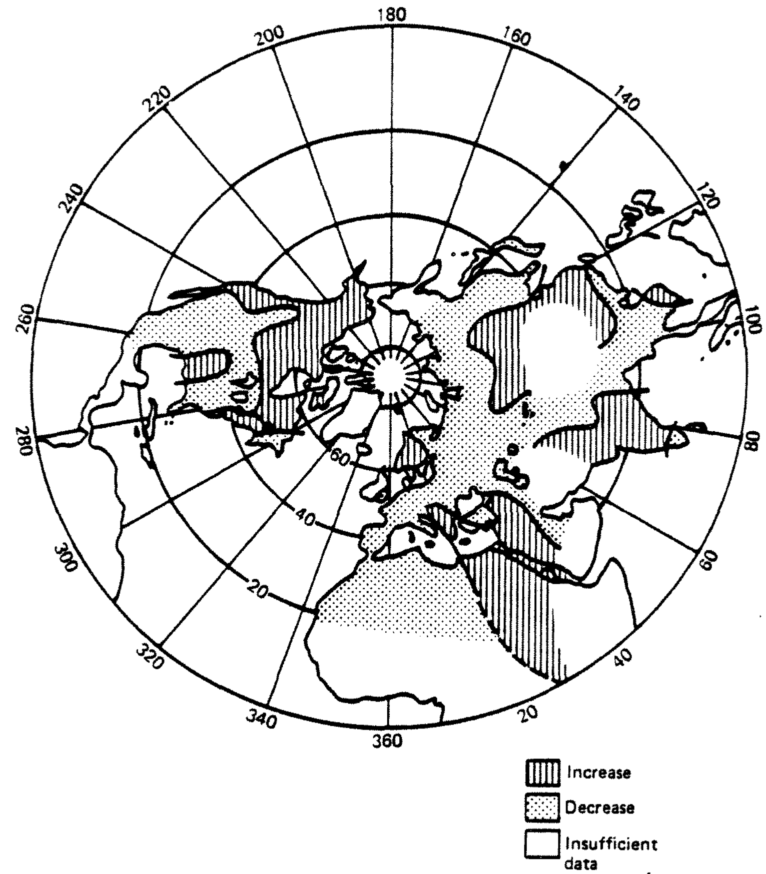
(4) Shifts in fisheries and forests and the occurrence of other effects in the less-managed biosphere.

Review of available material indicates that little statistical data exists regarding the possible consequences of the "greenhouse effect" on the West. Apparently, projected results of this phenomenon for local regions are scientifically difficult to make and are subject to great uncertainty. Nevertheless, the following is offered with regard to the general categories stated above.

1. Effects on Precipitation and Evaporation

A significant increase in the carbon dioxide content of the atmosphere is likely, on a global basis, to warm the earth's surface and increase both precipitation and evaporation. Regional effects are extremely difficult to predict. However, a general idea of such effects can be gleaned from considering results which have occurred in the past under conditions of higher global temperatures (caused by conditions <u>other than</u> increased atmospheric levels of carbon dioxide) compared to periods of lower temperatures. The following diagram demonstrates estimates of changes in precipitation which were obtained by comparing rainfall patterns in warm years of this century with those in cool years.

Figure 4
Mean annual precipitation changes from cold to warm years. Past temperature changes of as little as 0.6°C have caused geographical changes in precipitation, such as decreased precipitation over much of the United States, Europe, Russia, and Japan and increased rainfall over India and the Middle East.



Source: T.M.L. Wigley et al., "Scenario for a Warm, High-CO_2 World," *Nature* 283:10 (1980). Copyright © 1980 Macmillan Journals Limited, reprinted with permission.

It should be emphasized that the decrease in precipitation in most of the western United States resulted from temperature changes as little as .6° centigrade. One study has predicted that a 2.5% annual increase in fossil fuel consumption (comparable to recent trends) would create CO_2 concentrations by the middle of the next century twice as high of those of the pre-industrial level. This doubling could increase average annual global surface temperature by 4° fahrenheit or more, making the temperature higher than it has been for over 100 thousand years.

2. Effects on Agricultural Potential

World agricultural production is dependent on regional climate factors, such as temperature, precipitation, moisture, and water availability, and the interrelationships of these with soil fertility, cloud cover, and other factors too complex for accurate region-specific modeling. The literature on the "greenhouse effect" leads to the conclusion that, in general, there would be significant geographical shifts in the location of agriculturally favorable and unfavorable areas. Gains and losses to agricultural production would be distributed unevenly both within and among nations. No information was located referring specifically to effects on western agriculture.

3. Effects on Sea Levels

Significantly increased atmospheric carbon dioxide levels might result in higher sea levels, primarily from the disintegration of the West Antarctic ice sheet. This disintegration would cause a sea level rise projected to be from five to eight meters which could occur over several decades or several centuries. A five-meter rise would flood areas in the United States occupied by eleven million people, about 5% of the population. An eight-meter rise would flood areas inhabited by about seven percent of the population. In the continental United States 1.5 to 2.1% of the land area would be submerged by a rise of five to eight meters, including as much as one-third of Florida.

4. Effects on Fisheries and the "Less-Managed" Biosphere

Significant increases in atmospheric carbon dioxide might result in the eventual disappearance of the entire Arctic Ocean ice pack in the summer, thereby affecting the climate of the northern hemisphere. Much of the snow cover could vanish, and the permafrost might melt, changing profoundly the habitat and ecology of high latitudes. More specific effects on the world biosphere are difficult to predict. It is imagined that increasing atmospheric carbon dioxide may change the relative growth rates of various species and thus change the species composition of ecosystems. It is impossible to predict whether these changes will increase or decrease ecosystem productivity, diversity, and stability or resource values for man. Ecosystems such as grasslands, forests, tundra, and deserts are made up of a diversity of animals and plants that interact within a natural balance which could be disrupted by the "greenhouse effect."