Columbia River Water Management Report for Water Year 1977

[redacted]

Columbia River Water Management Group

January 1978

ia River Water Management Report for Water Year 1977

COLUMBIA RIVER WATER MANAGEMENT GROUP

I. Purpose

The Columbia River Water Management Group will act as a committee to consider problems relating to operation and management of water control facilities. Upon review and discussion of the problems the group will make tentative recommendations for consideration of the individual agencies having primary responsibilities in these areas. Particular emphasis will be placed on coordination of river system operations including the efficient operation of the hydrometeorological system required for each operation. The basic objective of the group is to facilitate agreement among the agencies in the interest of more effective and efficient public service in the use of the water resources of the Pacific Northwest.

II. Composition

The Columbia River Water Management Group will be composed of representatives of the States and of the Federal agencies involved in the operation and management of water control facilities or forecasting of streamflows related to water management activities, in the Columbia River Basin and contiguous areas in western Washington and Oregon. Each State and member agency will designate an official representative, together with an alternate, who will be delegated to set forth his agency's position on problems related to water management and river regulation. It is envisioned that these representatives will be supervisory personnel who are actively directing or allied with water management problems. Meetings would be open to representatives of other public and private organizations concerned with the activities of the group.

The Chairman of the Group will be from one of the three U.S. Federal Project operating agencies, namely, Bonneville Power Administration, Bureau of Reclamation, and the Corps of Engineers and this position will rotate annually. The Group normally will meet monthly throughout the year, or at such other intervals of time at the discretion of the Chairman. The permanent secretary will be provided by the Corps of Engineers, or as mutually agreed among the three Federal operating agencies.

III. Functions

1. Coordinate seasonal program for system and project operations and the resolution of operational problems.

2. Prepare an annual report of significant water management events and such special reports as warranted.

3. Coordinate compilation of project operation data and water-use requirements, both at the reservoir sites and at downstream locations, for common use by all operating agencies.

4. Coordinate and perform as required the development of seasonal runoff forecasting procedures for Columbia River and Tributaries, and coordinate the use of such forecasts by operating agencies.

5. Explore adequacy and propriety of short and medium range streamflow forecasts, and coordinate the use of such forecasts by operating agencies.

6. Coordinate the maintenance and expansion of the existing cooperative hydrometeorological reporting network for the Columbia River Basin, including automation of reporting, communication requirements, and data bank facilities required for project operation.

7. Such other functions as are mutually agreeable among the operating agencies.

revised 14 Jan 1972

COVER PICTURE: Transporting juvenile salmon to the sea during the 1977 drought.

COLUMBIA RIVER

WATER MANAGEMENT REPORT

FOR WATER YEAR 1977

COLUMBIA RIVER WATER MANAGEMENT GROUP

JANUARY 1978

P R E F A C E

The water resources of the Pacific Northwest are the Columbia River, its tributaries and the Coastal streams of Washington and Oregon. The Columbia River dominates the area from its ultimate source, Columbia Lake in Canada's Selkirk Mountain Range, at an elevation of 2,650 feet above sea level, throughout its course of 1,214 miles to the Pacific Ocean. Ranking 32nd among rivers of the world, and fourth in North America after the Mississippi, Mackenzie and St. Lawrence, it drains 259 thousand square miles ranging from semi-arid country with less than eight inches of rainfall a year to the coastal mountains where more than 100 inches fall annually.

The Columbia River Basin has many outstanding features and includes a wide variety of landscapes, climate, natural resources and scenic and recreational attractions. Abundant forests, agriculture and range lands, minerals and water stimulate the economy of the region. A great variety of fish and wildlife abound in the region. Wildlife species range from small fur bearers to moose, elk, deer and bear. Birds include quail, partridge, pheasant, and a wide variety of water fowl, song and shore birds. Salmon and trout, the most popular sport fish, inhabit many of the region's waters.

Before man's development of the Columbia River, the water resources mainly provided habitat for fish and wildlife, with man living along the shoreline to utilize the available food sources and transportation routes. However, with the growth of settlement and industrialization, development of dams and storage reservoirs has taken place to meet the needs of a region in which the population has grown from approximately 2.8 million in 1933 to more than 7 million today. Projects on the Columbia and Lower Snake Rivers contain more than 43 million acre-feet of storage space, authorized primarily for hydroelectric power production and irrigation, navigation and flood control.

Special hydrologic and geographical features of the Columbia River Basin include extremely high annual runoff, silt-free water, and steep drops within a relatively short distance. These characteristics make the Columbia River especially well suited for many beneficial purposes, including hydroelectric power, irrigation, navigation, flood control, recreation and low flow augmentation for fish and wildlife and other uses. The resources of the Columbia are very valuable to the people of the region and the nation.

Reservoirs are normally filled during the peak flood season of April-August. Once conserved in the storage reservoirs, the water is then released during the period of September-March, with the greatest release occurring during the period of maximum power demands. Columbia River developments now supply an energy equivalent of 195 million barrels of oil annually.

Spring floods in the lower reaches of the river, once a menace to life and property are now virtually a thing of the past. Operation of dams in the Columbia prevent millions of dollars in flood damage.

Waters from the Columbia River system are used to irrigate nearly 8 million acres of highly productive farm land in the Columbia River Basin. This acreage represents about 4 percent of the total land area and 18 percent of the total irrigable acreage. Small grains, potatoes, fruits, beet sugar, vegetables, grass seed, and hops are exported from the area in large quantities. Forage crops, hay, and pasture also support a large beef and dairy industry. The sale value of crops, livestock, and livestock products from the irrigated lands is estimated to exceed $1 billion annually.

Navigation is an important function of the Columbia. It provides access for ocean-going commerce from its mouth to Vancouver, Washington, and Portland, Oregon. Commercial inland navigation on the Columbia extends to the Kennewick-Pasco-Richland area of eastern Washington and to Lewiston, Idaho on the Snake River.

In normal to high runoff years criteria are well established for operation of the reservoir system for flood control, and the water supply is adequate or more than adequate for irrigation, hydropower, and other uses. In 1977 the problem was "not enough" rather than "too much". In drought years the water is needed for everything except flood control, the water supply is in adequate for many of the needs, so operation for any one of the many uses will quite often conflict with other requirements.

Federal, State, and Local Government Agencies met frequently in 1977 to work out regulation of the water supply to meet the needs of all water users insofar as possible within legal limits and established rules. Conflicting interests were resolved by arbitration to benefit the people of the Northwest.

Some water which could have been stored in the reservoirs was released to aid juvenile salmon in their journey to the sea. Without this special release a large percentage of these downstream migrants would have perished in the slack water pools. Arrangements for this "Fish Flow 77" operation were developed by State and Federal agencies and approved by the Governors of the Northwest States.

All possible steps were taken to minimize the effects of lost hydropower resulting from "Fish Flow 77". Voluntary curtailment in the use of electrical energy by people of the Northwest helped to prevent a serious shortage. 1977 will be recorded as the year of the drought, but it should also be remembered as the year of cooperation and compromise.

Drought is a great reminder of our weakness in the face of the extremes of nature. Fortunately, these extremes also trigger the marvelous social capacity of our society for speedy and innovative actions -- actions to help reduce the impact.

COLUMBIA RIVER WATER MANAGEMENT REPORT

for

WATER YEAR 1977

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (CONTINUED)

LIST OF CHARTS

BASIN MAPS

Number

STORAGE AND STREAMFLOW HYDROGRAPHS
July 1976 - August 1977

STORAGE AND STREAMFLOW HYDROGRAPHS
WATER YEAR 1977

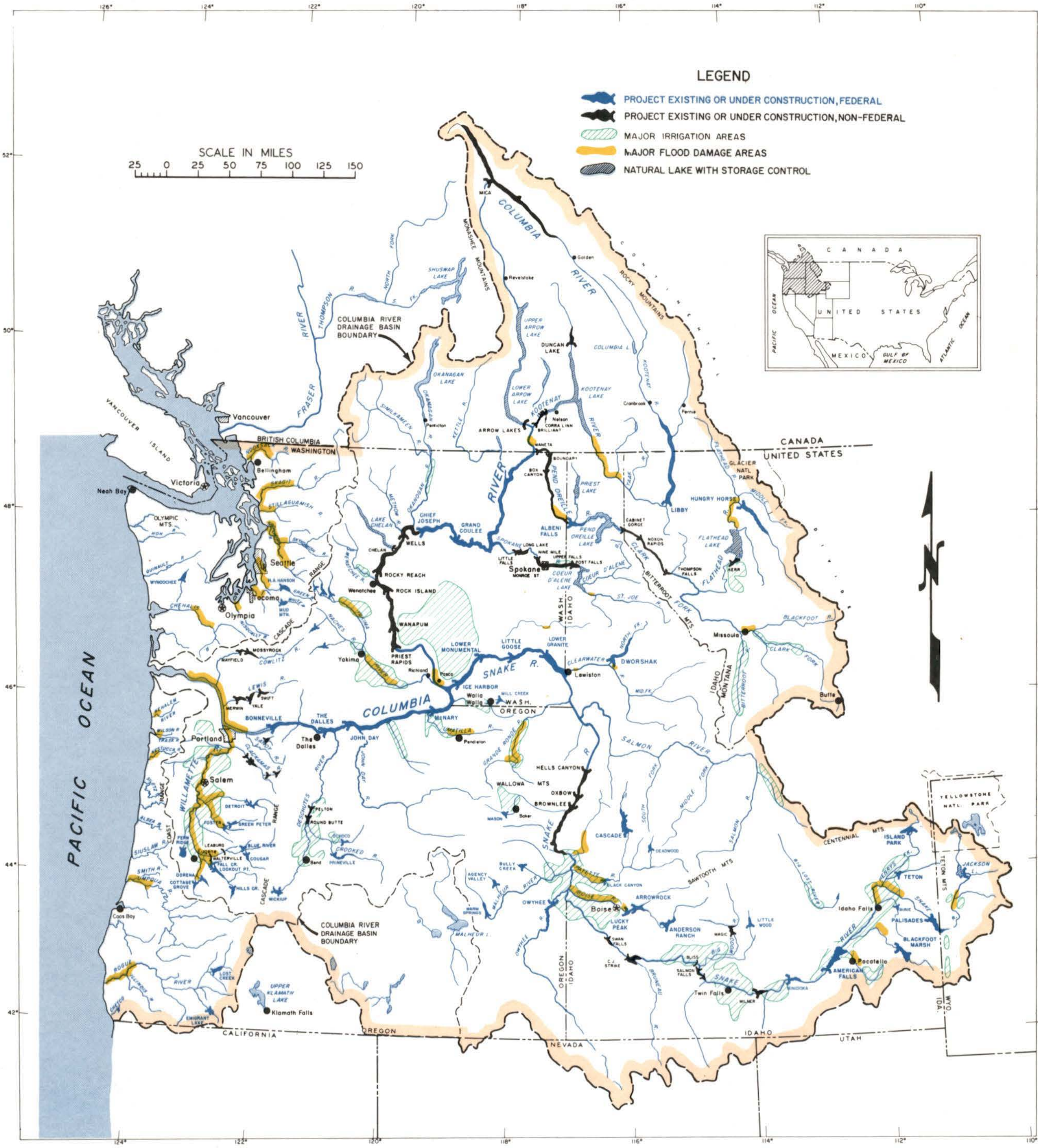
LIST OF CHARTS (Continued
1977 FLOOD REGULATION

Number

SUMMARY AND 1977 HYDROGRAPHS

LIST OF FIGURES

COLUMBIA RIVER AND COASTAL BASINS



I. INTRODUCTION

The Columbia River Water Management Group was created to carry on the functions previously assigned to subcommittees of the Columbia Basin Inter-Agency Committee in the operation and management of multipurpose water control facilities. The following is a brief history and present progress of this effort.

A. Background

The Columbia Basin Inter-Agency Committee (CBIAC) was established in 1946 by the parent Federal Inter-Agency River Basins Commission "to facilitate progress on the multiple-purpose development projects presently authorized by the Congress for the Columbia River Basin...and to implement the coordination of plans...for further development of those areas..." As a means to implementing this coordination, the CBIAC, by 1950, had established 11 subcommittees including a subcommittee on Hydrology and a subcommittee on Operating Plan. In 1951, a Water Management subcommittee was established to carry on for the most part the functions previously assigned the above two subcommittees:

1. Complete and revise, where necessary, the operating plan of the Columbia River Basin dam and reservoir system.

2. Determine methods of forecasting river flows for all purposes relating to water use.

3. Secure the establishment and maintenance of an adequate river reporting network for all using agencies.

4. Coordinate the best dispatching of water at the dams for all purposes related to water use.

In March, 1967, CBIAC was replaced by the Pacific Northwest River Basins Commission (PNWRBC) under terms of the Water Resource Planning Act of 1965 (Public Law 89-90, 79 Stat. 244). The new Commission continued the coordinating functions of CBIAC, with greater emphasis on resource planning. However, it was not assumed to have operating responsibility for existing projects. Therefore, operating agencies initiated formation of a separate Columbia River Water Management Group (CRWMG) to carry on the functions of the Water Management Subcommittee. The purpose, composition, and functions of the CRWMG were defined as shown in the Charter, reproduced on inside of the front cover. Present membership is listed on inside of back cover.

B. Organization

The Columbia River Water Management group meets generally once a month to coordinate Water Management activities in the Columbia River system in the interest of effective and efficient public service. Responsibility for many of the activities of the CRWMG is assigned to subordinate committees, task forces, or work groups, with participants appointed by the Chairman or by each agency representative. A resume of the monthly meetings and accomplishments of various subcommittees, task forces, and work groups is included in Chapter VI of this report.

C. **Purpose and Scope of this Report**

In 1956 the Water Management Subcommittee published a report "Columbia River Flood Control Operation, 1956 Flood." Because of the need for such reports, similar reports were published each year from 1957 to 1967, and were continued by the CRWMG from 1968 to 1970. These earlier reports, however, were mainly confined to presentation of operations for flood control. There were brief discussions of weather and hydrologic conditions, but many activities of the Water Management Group were not considered nor given adequate coverage. Therefore, the CRWMG concluded that the report for water year 1971 would be expanded to include activities and accomplishments of member agencies in the fields of water management, reservoir regulation, data collections, river forecasting, and water quality control.

Since the 1971 report, the Columbia River Water Management Group has continued publication of the expanded annual report and to describe developments and activities of member agencies of the group and the accomplishments of resource management, as related to the Columbia River and tributaries.

This report contains eleven chapters: (I) Introduction; (II) Summary of Hydrometeorological Conditions; (III) Forecasts of Seasonal Runoff Volume and Peak Flow; (IV) Reservoir Regulation; (V) Functional Accomplishments; (VI) Summary of Activities of Water Management Group During 1976 Water Year; (VII) Related Activities; (VIII) Operational Plan for 1977-78, (IX) Project Pertinent Data and Current Status; (X) Glossary; and (XI) Acknowledgements. The charts discussed in this report are appended. Chapters (VIII) and (IX) were added for the first time in 1975.

D. Information of Interest in Past Reports

Certain information published in past reports is not published each year. A summary of this information is as follows:

*Summary on power was updated this year to cover the period 1939-77.

Looking for Water

The Grand Canyon of the Snake River, forming the boundary between Oregon and Idaho, is deeper than the Grand Canyon of the Colorado

II. SUMMARY OF HYDROMETEOROLOGICAL CONDITIONS WATER YEAR 1977

A. Weather

For the entire Columbia Basin and Pacific Northwest, the 1977 water year was undoubtedly the driest year since weather records have been kept. (See Figure 1) The water year started normally with September precipitation near average. Then October, 1976, began the period of recordbreaking drought for the Pacific Northwest. A drier-than-usual regime persisted through the snow-accumulation period ending in April with only the period 20 February to March 30 producing normal winter precipitation. (See Figure 2)

The lack of moisture-producing storms was primarily due to a blocking ridge aloft (about 5500 meters) which had established itself earlier in the year. This mean ridge position held over the Pacific coastal area, shunting most weather systems well to the north into upper British Columbia. As this ridge fluctuated slightly, a few short waves rippled through the area producing brief, light shower activity. Portland, Oregon, recorded 1.38 inches of rainfall in December--the lowest total rainfall for this month since 1940 and Boise, Idaho, recorded 0.75 inch--the driest December since 1864.

After the 1976 Indian summer ended in mid-October, temperatures were predominantly two to five degrees above average with only three extended cold periods centered on November 30, January 6, January 30, and one "hot" spell centered on February 15. (See Figure 2) In the April through June period, when normally both the quantity and effectiveness of precipitation decrease markedly, only May succeeded in exceeding normal precipitation. (See Figure 1) Temperatures in April and June were well above normal, augmenting the "dry" conditions. During this period, Boise, Idaho, recorded a maximum temperature of 88 degrees Fahrenheit on the April 23, which broke a record set in 1910 by 3 degrees Fahrenheit . At the other end of the scale, Salem, Oregon, recorded an average temperature for May of 51.8 degrees Fahrenheit , their second coldest May of record. July's temperatures were cooler than normal with above-normal precipitation in some areas. August had its initial 20-day, persistent, hot and dry conditions change dramatically to cold and wet for the last ten years. Temperaturewise, Pendleton, Oregon, had 21 days with 90 degrees Fahrenheit or higher during August, as compared to a normal of 10 days. August rainfall at Pendleton also set a new record of 2.58 inches. The previous maximum was 2.10 inches in 1899.

In summary, for the period September, 1976, through August, 1977, the temperature and precipitation indices (See Figures 2 through 5) show eight months with below-normal precipitation and seven months with above-normal temperatures. During this 12-month period, only two months showed above-normal precipitation and two months near normal.

1976-77 PRECIPITATION

COLUMBIA RIVER BASIN ABOVE THE DALLES

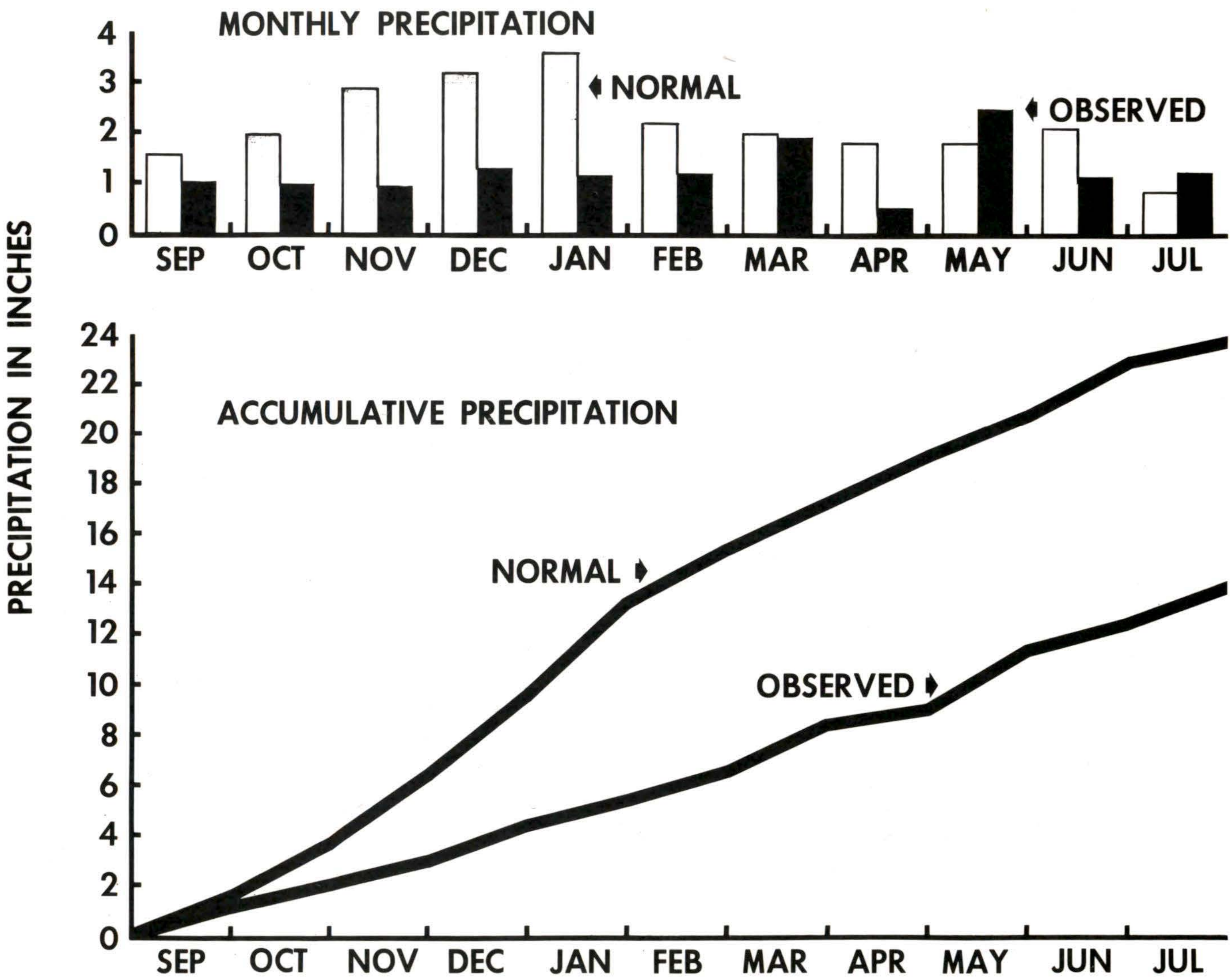


FIGURE 1

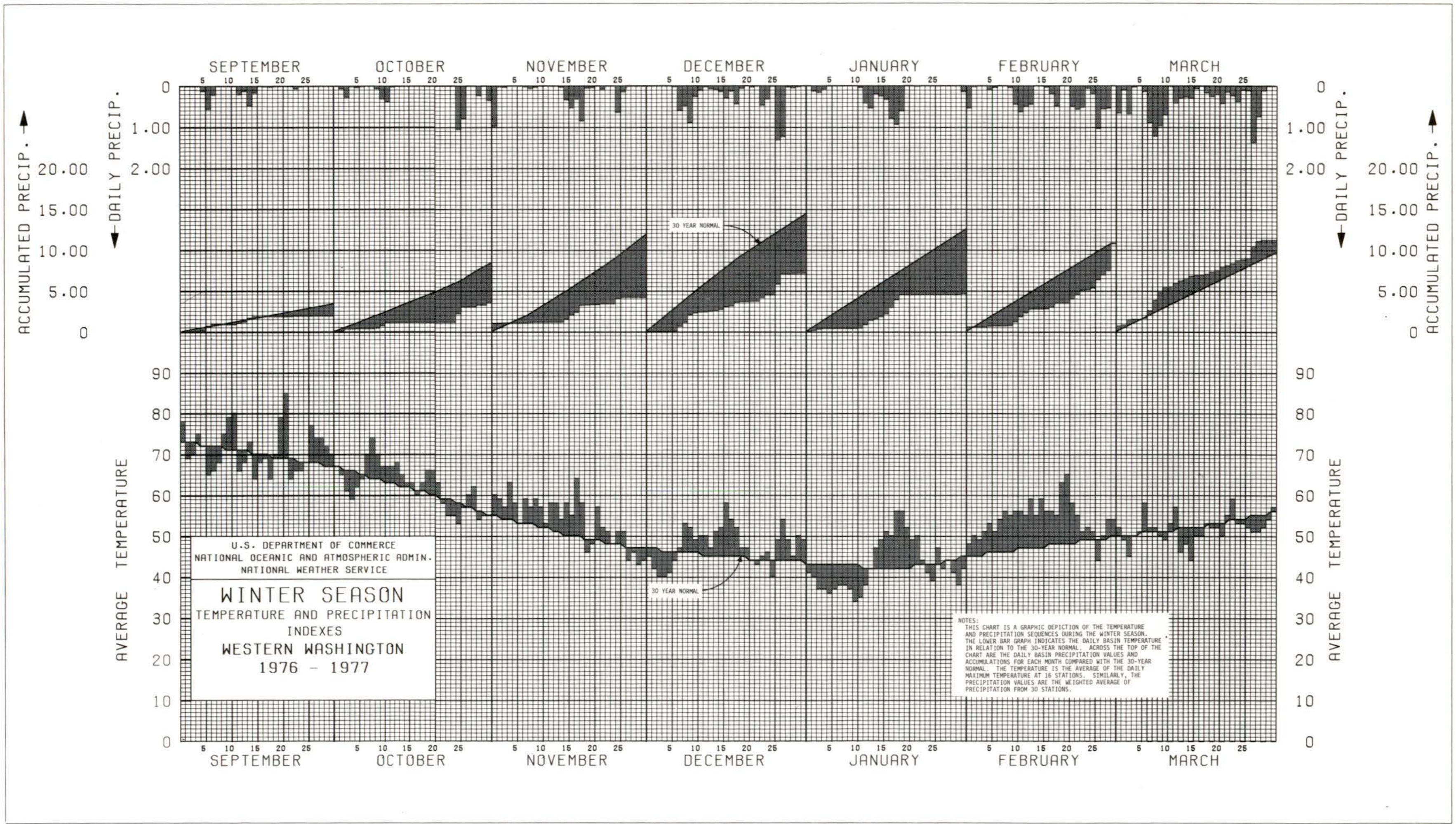
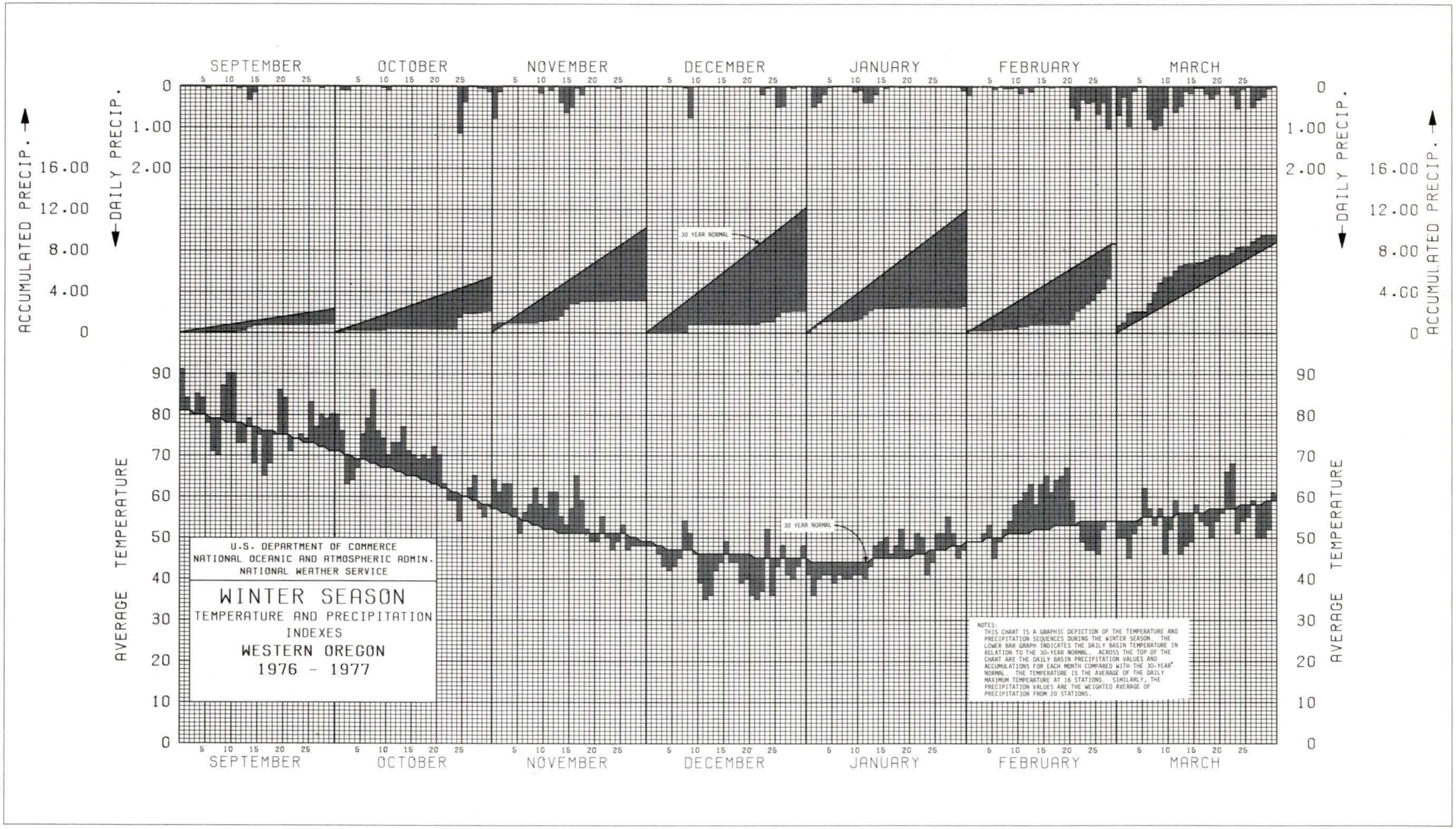

SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
5 10 15 20 25
0
1.00
2.00
DAILY PRECIP.
ACCUMULATED PRECIP.
20.00
15.00
10.00
5.00
0
30 YEAR NORMAL
90
80
70
60
50
40
30
20
10
0
AVERAGE TEMPERATURE
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDEXES
WESTERN WASHINGTON
1976 - 1977
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURE AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON. THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL. ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL. THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS. SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 30 STATIONS.

FIGURE 2

FIGURE 3


U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDEXES
WESTERN OREGON
1976 - 1977
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
ACCUMULATED PRECIP.
DAILY PRECIP.
AVERAGE TEMPERATURE
30 YEAR NORMAL
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURE AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON. THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL. ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL. THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS. SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS.

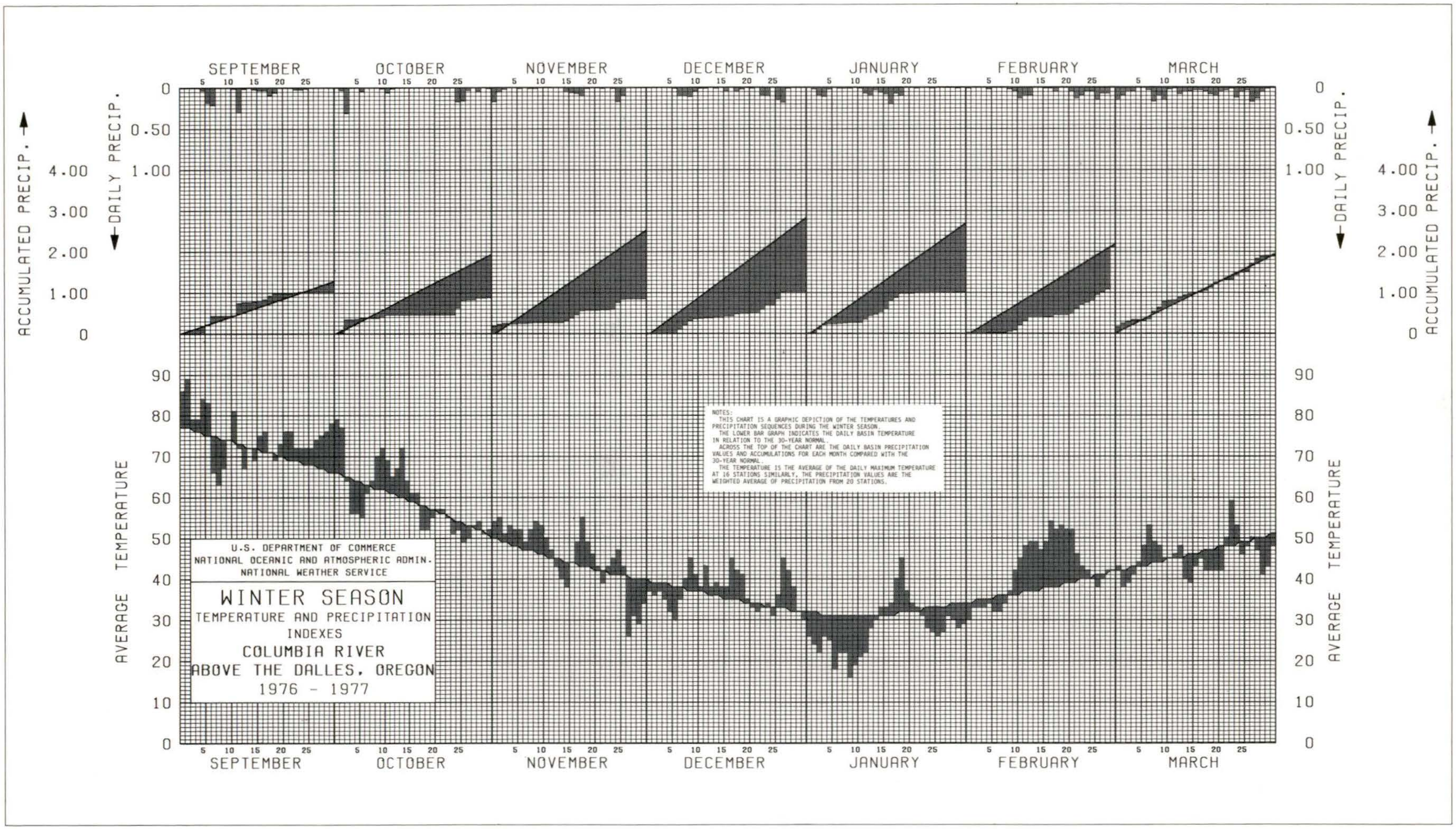
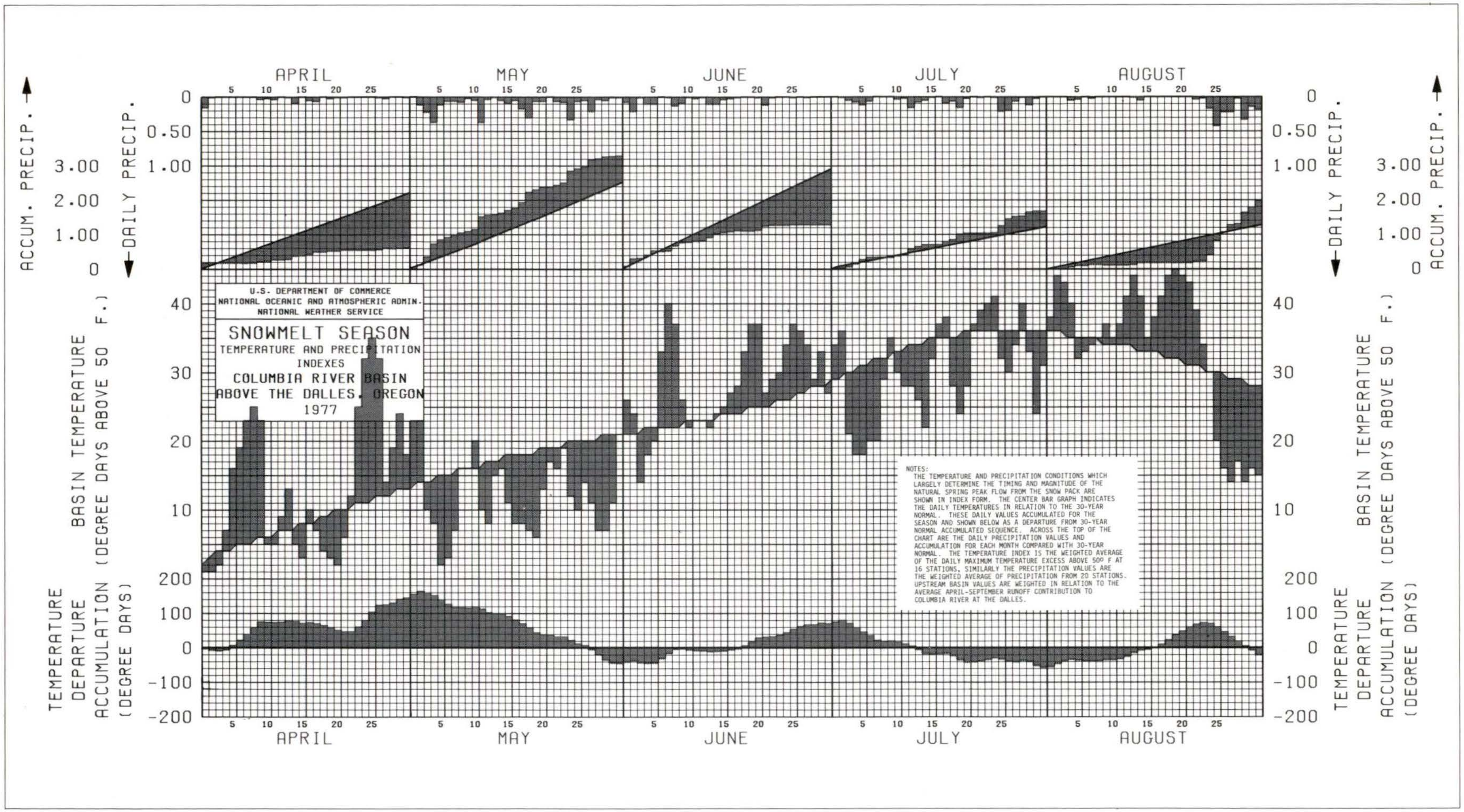

SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
5 10 15 20 25
ACCUMULATED PRECIP.
DAILY PRECIP.
0
0.50
1.00
4.00
3.00
2.00
1.00
0
AVERAGE TEMPERATURE
90
80
70
60
50
40
30
20
10
0
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDEXES
COLUMBIA RIVER
ABOVE THE DALLES, OREGON
1976 - 1977
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURES AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON.
THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL.
ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL.
THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS.

FIGURE 4

FIGURE 5


U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN ABOVE THE DALLES, OREGON
1977
APRIL
MAY
JUNE
JULY
AUGUST
ACCUM. PRECIP.
DAILY PRECIP.
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50 F.)
TEMPERATURE DEPARTURE ACCUMULATION (DEGREE DAYS)
NOTES:
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM. THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATION FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL. THE TEMPERATURE INDEX IS THE WEIGHTED AVERAGE OF THE DAILY MAXIMUM TEMPERATURE EXCESS ABOVE 50° F AT 16 STATIONS, SIMILARLY THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS. UPSTREAM BASIN VALUES ARE WEIGHTED IN RELATION TO THE AVERAGE APRIL-SEPTEMBER RUNOFF CONTRIBUTION TO COLUMBIA RIVER AT THE DALLES.

B. Snowpack

The snowpack which accumulated on the Columbia River Basin during the winter of 1976-77 had the least water equivalent since records were first kept beginning about 1915.

The stage was set with one of the driest fall and early winter seasons on record. The result was an extremely light January 1 snowpack over the entire Columbia Basin. Several of the southern Idaho tributaries to the Snake River had virtually no snow at the measurement sites. On the Snake headwaters the snowpack was only 20 percent of the January 1 normal. Similar conditions of 20 percent or less were found throughout Oregon and Southern Washington. Montana, northern Idaho, and northern Washington tributaries to the Columbia had from 25 to 35 percent of the normal snowpack. The Okanagan River watershed, with 43 percent of average, was in the best conditirn of any tributary surveyed.

The history-breaking dry weather conditions continued over the Columbia Basin during January. As a result, snow surveys conducted about February 1 indicated the basin-wide snowpack was still only about one-third of normal for that date. A general storm during the first week of January provided about the only snowfall during the entire month. The mainstem Columbia in Canada had slightly better than one-half of the normal snowpack. No other areas in the basin had that much snow. The Yakima watershed snowpack was almost nonexistent with only four percent of average. The Snake River snowpack was only 20 percent of normal, and many of Oregon's watersheds had but 5 to 20 percent of their expected February 1 snowpacks. Conditions in Montana and northern Idaho ranged from one-third to one-half of average. A series of storms during the latter part of February temporarily broke the dry weather pattern, adding much needed snow to much of the Columbia Basin. On March 1 the snow depth was only 40 percent of normal. The best conditions were again found in British Columbia where on the upper mainstem of the Columbia the snowpack was about 60 percent of normal. Much of the Cascade mountain range remained very deficient. The Yakima River watershed only had 11 percent of its normal, and the Lewis River snowpack was 8 percent of its March 1 average. Eastern Oregon and Idaho watersheds were in about the same condition, ranging from 15 to 25 percent of average. In the Montana portion of the basin was about 35 to 40 percent of the normal snowpack.

The stormy weather pattern of late February continued through March, resulting in near average additions for the month to the meager snowpack. Still, as of April 1, the basin-wide snowpack level was only one-half of normal. The Cascade range snowfall was heavier than normal during the month of April and snowpack conditions ranged from 32 percent of average on the Yakima up to 68 percent on the McKenzie watershed. These figures represented improvements of 20 to 40 percent since March 1. The upper mainstem Columbia snowpack was only two-thirds of normal, and the upper Clark Fork in Montana had 59 percent of its norm. Central Oregon watersheds also had from one-third to one-half of their April 1 average snowpack. Snake River tributaries had less than one-half of their normal snowpacks, with as little as 15 to 20 percent of average on several Central Idaho watersheds. The Upper Snake in Wyoming stood at 46 percent, and downstream the Clearwater had improved to 50 percent of its April 1 norm.

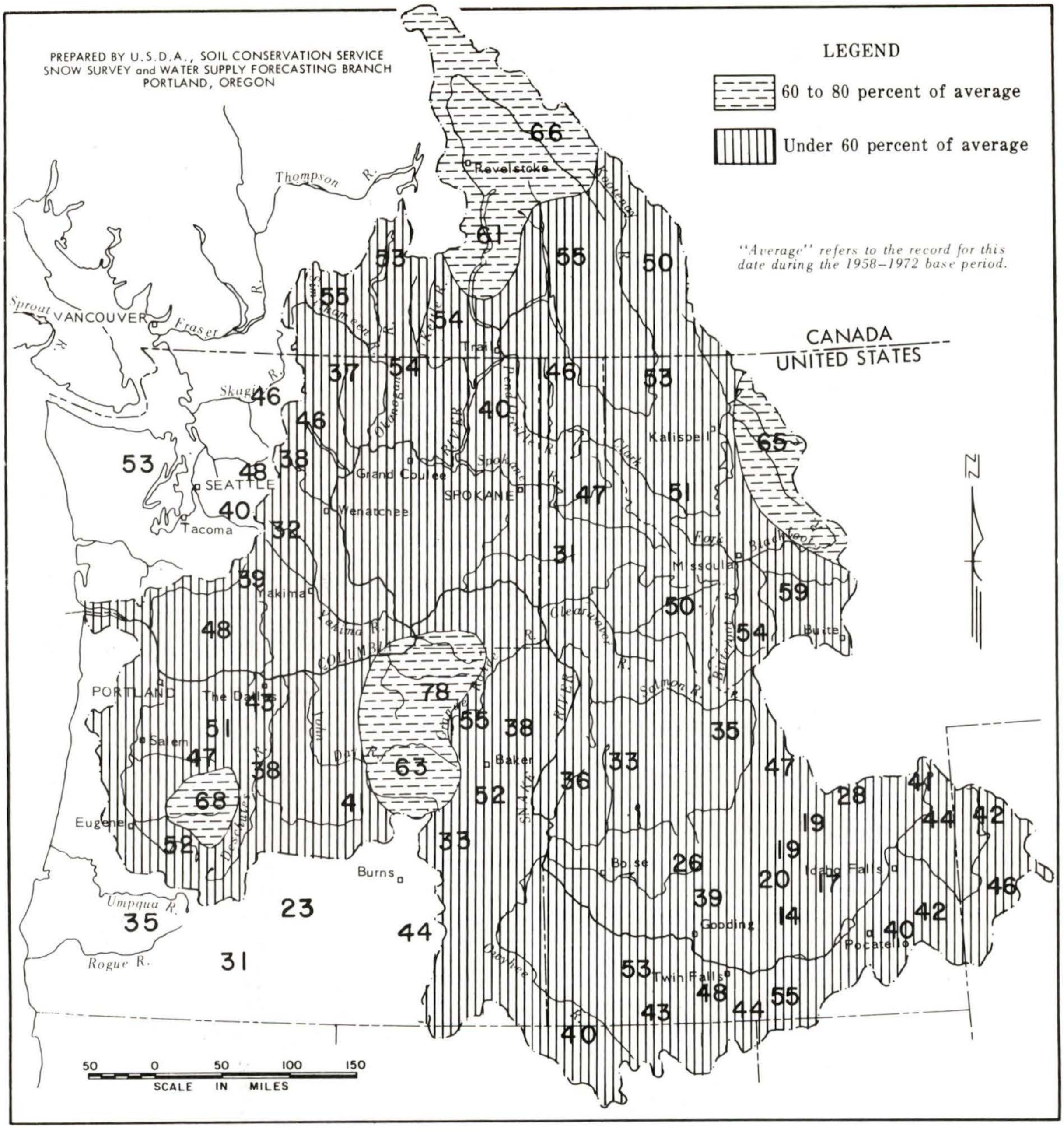
Unseasonably warm, dry weather returned and snowmelt began early in April on many of the basin's watersheds. New snowfall during the month was well below average. Consequently, there was no improvement in the winter-long poor conditions, and as of May 1 the snowpack remained well below normal. Snow surveys indicated there was only 36 percent of the average Columbia Basin May 1 snowpack--the lowest figure in nearly 60 years of record. Conditions remained at about two-thirds of normal on the upper Columbia headwaters in Canada. However, the snowpack was much poorer than one months ago over most of the rest of the basin. Numerous tributaries of the Snake River in Idaho lost what little snow they had during April. Many eastern and southern Oregon watersheds also had no snow at the measurement sites. The Cascades of Oregon and Washington also experienced early rapid melting of the snowpack. The Chelan River watershed was in the best condition, with about one-half of its normal May 1 snowpack. Most other areas only had from 25 to 35 percent of their average snowpacks remaining.

May was a cool, wet month, and provided above-normal May precipitation. However, it fell on bare soil, except at the higher elevation, and yielded less than normal runoff. As a result, watershed soil moisture conditions were greatly improved, but snowpack conditions were not materially helped.

Abnormally warm temperatures returned to the basin about the first of June, and what remained of the lightest snowpack on record was quickly melted. Figure 6 illustrates the snowpack conditions on April 1, 1977, the time of year when the snowpack is normally at its deepest. Figure 7 shows the season's accumulation as compared to the previous record low, high, and average for the basin.

MOUNTAIN SNOW WATER EQUIVALENT
(in relation to the average for this date)

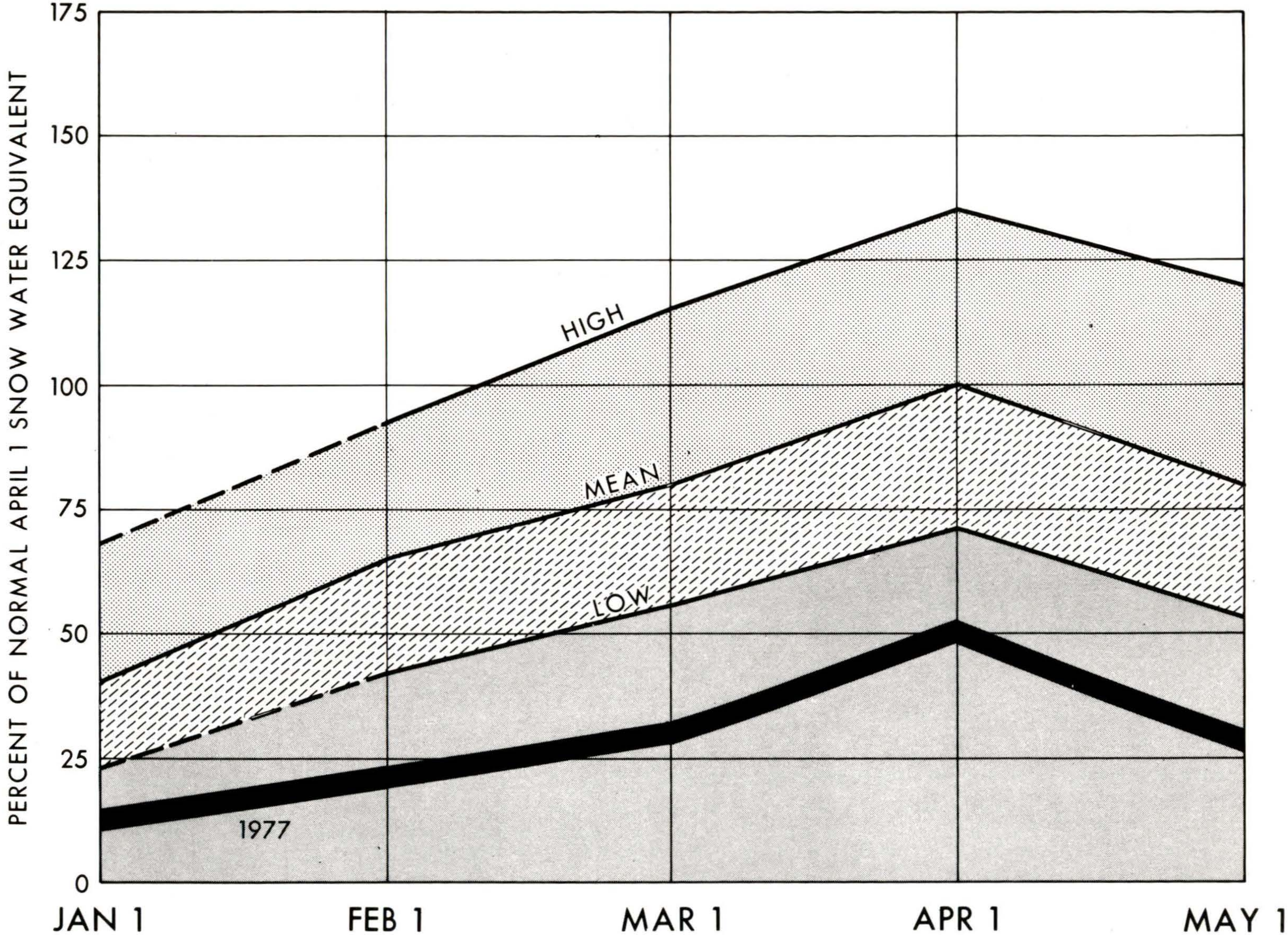
APRIL 1, 1977



UNITED STATES DEPARTMENT of AGRICULTURE ····· SOIL CONSERVATION SERVICE
in collaboration with
THE PROVINCE of BRITISH COLUMBIA ····· DEPARTMENT of LANDS, FORESTS and WATER RESOURCES

FIGURE 6

FIGURE 7



COLUMBIA BASIN SNOWPACK

UNITED STATES DEPARTMENT of AGRICULTURE .... SOIL CONSERVATION SERVICE
in collaboration with
THE PROVINCE of BRITISH COLUMBIA ..... DEPARTMENT of LANDS, FORESTS AND WATER RESOURCES

C. Runoff

Annual mean streamflow in the Northwest during the 1977 water year was generally less than ever experienced since recording of streamflow data began in the late nineteenth century. A table of annual-mean discharges for current reporting stations (See Figure 8) shows the ranking (Highest is one) of 1977 streamflow relative to all the years of record for each station. The 1977 annual-mean discharge ranks lowest of record for one-half of the stations listed, and near lowest for the others.

Record-low monthly flows occurred at practically all of the current reporting stations during some months of the year. Record-low instantaneous or daily flows, however, occurred only at about 10 percent of the stations. This can be at least partly explained by the fact that minimums of record are established even during high-runoff years by unusual events such as, temporary channel blockage upstream, by ice or debris, or by extreme reservoir regulation.

Relative to a 15-year average (1958-72), 1977 annual streamflow for all reporting stations was in the lower quartile. An annual runoff map, included in previous reports, was not prepared this year because streamflow in the entire Northwest, with the exception of the Fraser River Basin in British Columbia, was in the lower-than-normal range. The Fraser River flow was barely in the normal range.

Observed and adjusted annual mean flows at three ungaged sites in the Lower Columbia Basin, computed by routing methods, are shown in the table below.

Location	Drainage Area Square Miles	Estimated 1977 Water Year Runoff		Adjusted Streamflow				Percent of 15-Year Average
				1977		15-Year Average		
		cfs	Inches	cfs	Inches	cfs	Inches	
Columbia River at Vancouver	241,000	126,500	7.13	113,500	6.39	210,123	11.84	54
Willamette River at the Mouth	11,200	13,900	16.85	13,700	16.60	36,939	44.77	37
Columbia River at the Mouth	258,000	155,000	8.16	141,400	7.42	272,793	14.35	52

Modified streamflows have been computed for selected stations by correcting for storage and adjusting to the 1970 level of development for irrigation, for the period 1929, to date, on the Snake River and 1926 to date for all other locations.

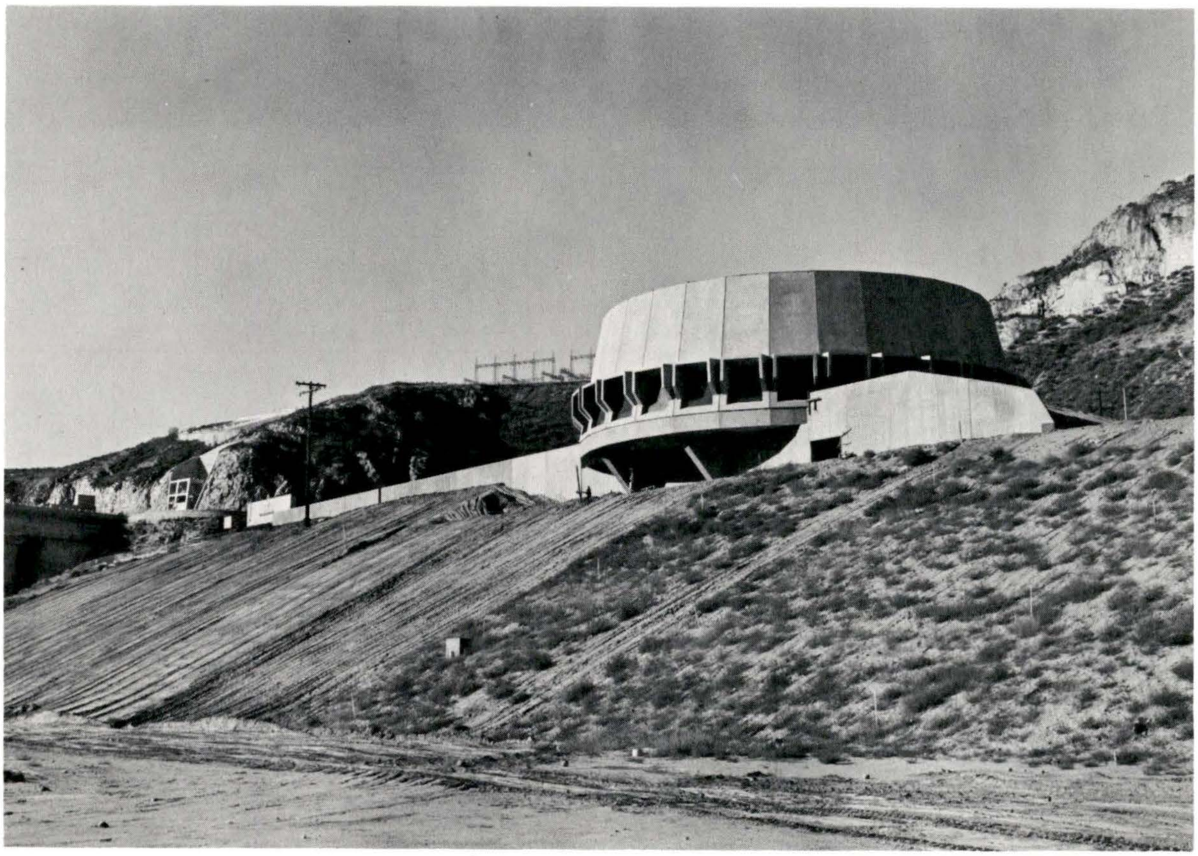
Listed below are 1970-level modified flows for water year 1977, for four stations. Relative magnitude of the flows is indicated by the rank (largest is one) over the period of record.

ANNUAL MEAN MODIFIED FLOWS IN CFS
FOR WATER YEAR 1977
FOR SELECTED STATIONS

STATION	FLOW	RANK	YEARS
Columbia River at Grand Coulee Dam, WA	72,730	50*	52
Snake River below Lower Granite Dam, WA	27,920	48**	49
Columbia River at The Dalles, OR	100,000	52	52
Willamette River at Salem, OR	9,520	52	52

*Lower flows occurred in 1926 (70,760) and 1944 (66,970)

**Lower flow occurred in 1931 (27,760)



New Visitors Center constructed by U.S. Bureau of Reclamation at Grand Coulee Dam, Washington.

PROVISIONAL
SUBJECT TO REVISION

ANNUAL MEAN DISCHARGE FOR WATER YEAR 1977 FOR SELECTED STATIONS

STATION	ANNUAL MEAN 1977	RANK	YEARS
FRASER RIVER AT HOPE, B.C.	97510	30	65
SPROAT RIVER NEAR ALBERNI, B.C.	1005J	58	64
CHEWAUCAN RIVER NEAR PAISLEY, OREG.	36	61	62
CHEHALIS RIVER NEAR GRAND MOUND, WASH.	1109	48	48
SATSOP RIVER NEAR SATSOP, WASH.	1199	48	48
GREEN RIVER BL HOWARD A.HANSON DAM,WASH.	627J	45	46
SKYKOMISH RIVER NEAR GOLD BAR, WASH.	2704	46	49
SKAGIT RIVER NEAR CONCRETE, WASH.	10680J	50	53
COL.R.AB STBT.RAPIDS,NR REVELSTOKE,B.C.	25150J	24	25
KOOTENAY RIVER AT FORT STEELE, B.C.	4457	45	49
KOOTENAI RIVER AT LIBBY, MONT.	7393J	65	67
KOOTENAY RIVER AT CORRA LINN, B.C.	17070J	62	64
SLOCAN RIVER AT CRESCENT VALLEY, B.C.	2295	47	52
COLUMBIA RIVER AT BIRCHBANK, B.C.	54020J	26	26
CLARK FORK ABOVE MISSOULA, MONT.	1540	45	48
BITTERROOT RIVER NEAR DARBY, MONT.	450	40	40
CLARK FORK AT ST. REGIS, MONT.	3607	64	66
M.F. FLATHEAD R.NR WEST GLACIER, MONT.	1603	36	38
S.F. FLATHEAD R.NR COLUMBIA FALLS, MONT.	2017J	47	49
FLATHEAD RIVER AT COLUMBIA FALLS, MONT.	5176J	47	49
FLATHEAD RIVER NEAR POLSON, MONT.	6453J	67	69
CLARK FORK NEAR PLAINS, MONT.	10120J	66	67
PRIEST RIVER NEAR PRIEST RIVER, IDA.	715J	48	48
PEND OREILLE RIVER AT NEWPORT, WASH.	11570J	49	49
COL. R. AT INTERNATIONAL BOUNDARY,WASH.	66580J	26	26
KETTLE RIVER NEAR LAURIER, WASH.	1871	44	48
COEUR D<ALENE RIVER AT ENAVILLE, IDA.	585	38	38
ST. JOE RIVER AT CALDER, IDA.	1080	56	57
SPOKANE RIVER AT SPOKANE, WASH.	2513J	86	86
COLUMBIA R. AT GRAND COULEE DAM, WASH.	75120J	26	26
SIMILKAMEEN RIVER NR NIGHTHAWK, WASH.	1164	48	49
OKANOGAN RIVER NEAR TONASKET, WASH.	1542	61	66
CHELAN RIVER AT CHELAN, WASH.	1042J	73	73

STATION	ANNUAL MEAN 1977	RANK	YEARS
WENATCHEE RIVER AT PESHASTIN, WASH.	1766	47	48
COLUMBIA R. BL PRIEST RAPIDS DAM, WASH.	78660J	26	26
YAKIMA RIVER AT KIONA, WASH.	661J	72	72
SNAKE RIVER NEAR HEISE, IDA.	3518J	67	67
OUTFLOW FROM LAKE OWYHEE(RIVER + TUNNEL)	282J	34	35
BOISE RIVER NEAR TWIN SPRINGS, IDA.	421	66	66
BOISE RIVER NR BOISE(AT DIV.DAM), IDA.	911J	60	60
PAYETTE RIVER NR HORSESHOE BEND, IDA.	1024J	68	68
WEISER RIVER NR WEISER, IDA.	155	56	56
SNAKE RIVER AT WEISER, IDA.	11140	65	67
SALMON RIVER AT WHITE BIRD, IDA.	6039	57	58
GRANDE RONDE RIVER AT LA GRANDE, OREG.	148	50	52
GRANDE RONDE RIVER AT TROY, OREG.	1128	33	33
CLEARWATER RIVER AT OROFINO, IDA.	4649	32	32
CLEARWATER RIVER AT SPALDING, IDA.	7355J	52	52
SNAKE RIVER BL LOWER GRANITE DAM,WASH.1	27300J	61	61
PALOUSE RIVER AT HOOPER, WASH.	118	35	35
S.F.WALLA WALLA R. NEAR MILTON, OREG.	148	38	46
WALLA WALLA RIVER NEAR TOUCHET, WASH.	162	26	26
JOHN DAY RIVER AT SERVICE CREEK, OREG.	630	48	48
DESCHUTES RIVER AT MOODY, OREG.	4652J	67	71
COLUMBIA RIVER AT THE DALLES,OREG.(AVM)	107600J	26	26
KLICKITAT RIVER NEAR PITT, WASH.	777	49	49
M.F.WILLIAM.R.BL.N.FK.NR OAKRIDGE,OREG.	1280J	54	54
WILLAMETTE RIVER AT ALBANY, OREG.	5713J	82	82
NORTH SANTIAM RIVER AT NIAGARA, OREG.	1188J	39	39
WILLAMETTE RIVER AT SALEM, OREG.	9500J	54	54
COWLITZ RIVER AT CASTLE ROCK, WASH.	4912J	49	50
WILSON RIVER NEAR TILLAMOOK, OREG.	519	46	46
UMPQUA RIVER NEAR ELKTON, OREG.	2410	72	72
ROGUE RIVER AT RAYGOLD, OREG.	1432J	71	72

J - ADJUSTED FOR UPSTREAM STORAGE.

1 - SNAKE RIVER NEAR CLARKSTON USED FOR BACK RECORD.

FIGURE 8

Berry Pickers, Young and Old

III. FORECASTS OF SEASONAL RUNOFF AND PEAK FLOW

A. General

Water-related organizations, both in the United States and Canada, use streamflow forecasts in carrying out their individual river-related responsibilities. Forecasts for individual reservoir projects are the responsibility of the project owners or operating agencies, but coordinated forecasts for many key points in the Columbia Basin are prepared by the Columbia River Forecasting Service, which includes the Portland River Forecast Center (National Weather Service), the North Pacific Division Office of the Corps of Engineers, and the Bonneville Power Administration. This coordination of effort and joint use of facilities avoids duplication and provides a better, more consistent product.

The coordinated forecasts are used directly in the water management of the Columbia River system during the power and flood control drawdown season (January through April), and during the flood and refill season (May through July), as well as being necessary input to the daily computer simulations used in day-to-day forecasting and daily operation of reservoir projects. Seasonal runoff volume forecasts for key stations throughout the basin are also prepared by the Soil Conservation Service.

B. Verification of 1977 Seasonal Runoff Volume Forecasts

Forecasts of runoff volume are used in the operation of projects in the Columbia River Basin for flood control, irrigation, and production of power. Forecasted and observed runoff volumes for key stations with errors expressed in percent of the 15-year average, are shown in Figure 9. The forecasts were prepared on April 1, 1977, by the Columbia River Forecasting Service. Figure 10 illustrates the deviation of each month's forecast with the actual runoff and also shows the relation to mean and maximum.

C. Peak Flow Forecasts

Long-range peak flow forecasts are derived from the April 1 volume forecasts, and are expressed as a range of stage or flow within which there is an estimated 50-50 chance of occurrence. A 25 percent chance of peak discharge above the higher limit and 25 percent chance below the lower limit. A verification of the forecasts is shown in Figure 11.

APRIL 1, 1977 FORECASTS AND OBSERVED RUNOFF VOLUME 1/

APRIL-SEPTEMBER 1977

Stream		15-Year Average 1958-72	Apr-Sep Runoff Volume (1,000 AF) Forecast	Observed	Error in Percent of 15-Yr Ave.
Kootenai	Libby Inflow	7,456	4,180	3,979	+ 3
Columbia	Birchbank	46,410	33,200	31,562	+ 4
S. F. Flathead	Hungry Horse Inflow	2,378	1,460	1,241	+ 9
Flathead	Flathead Lake Inflow	7,648	4,200	3,612	+ 8
Pend Oreille	Pend Oreille Lake Inflow	15,710	6,860	6,023	+ 5
Spokane	Spokane	3,177	1,230	1,152	+ 2
Columbia	Grand Coulee Inflow	69,020	41,600	41,056	+ 1
Okanogan	Tonasket	1,723	720	706	+ 1
Methow	Pateros	1,031	402	434	- 3
Wenatchee	Peshastin	1,786	932	853	+ 4
Columbia	Priest Rapids	75,290	45,400	43,415	+ 3
Yakima	Parker	1,730	533	468	+ 4
Snake	Lower Granite	25,060	10,300	10,534	- 1
John Day	Service Creek	752	209	317	-14
Deschutes	Moody	1,873	1,290	1,522	-12
Columbia	The Dalles	104,600	55,200	54,092	+ 1

APRIL-JULY 1977

Stream		15-Year Average 1958-72	Apr-Jul Runoff Volume Forecast	Observed	Error in Percent of 15-Yr Ave.
Snake	Moran	767	304	292	+ 2
Snake	Heise	3,328	1,300	1,188	+ 3
Boise	Boise (nr)	1,495	214	314	- 7
Payette	Emmett	1,191	161	203	- 4
Snake	Weiser	5,042	2,010	1,724	+ 6
Snake	Brownlee Inflow	5,598	2,110	1,870	+ 4
Salmon	Whitebird	6,315	2,050	2,309	- 4
Grande Ronde	Troy	1,219	591	461	+11
N. F. Clearwater	Dworshak Inflow	2,932	1,130	1,241	- 4
Clearwater	Spalding	8,139	3,480	3,694	- 2

1/ Corrected for storage in major reservoirs.
Forecasts prepared by the Columbia River Forecast Service.

RFC-PDX
12-7-77

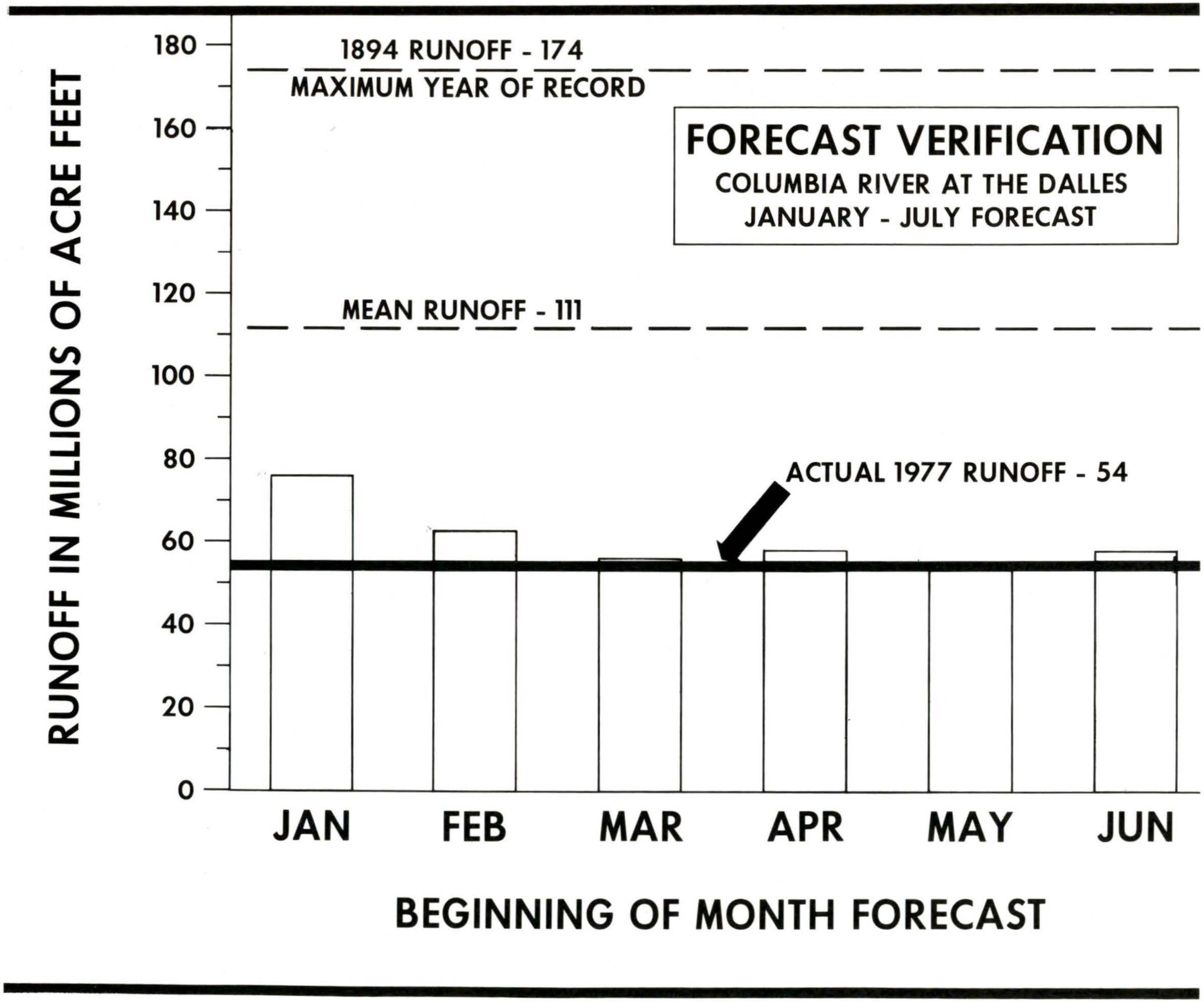
FIGURE 9

FORECAST AND OBSERVED PEAK FLOW AND CREST STAGES
Forecast Issued April 1, 1977
by Columbia River Forecasting Service

STREAM and Station	Flood Stage (Feet)	Peak Regulated Stage (Feet)		Peak Regulated Flow (CFS)		Date
		Forecast	Observed	Forecast	Observed	
KOOTENAI RIVER						
Bonners Ferry, Idaho	74	47.5-48.5	51.78	8,000-12,000	e20,000	May 5
PEND OREILLE RIVER						
Newport, Washington	106,000 cfs			27,000-39,000	26,500	Mar 9
SPOKANE RIVER						
Spokane, Washington	27	21.7-23.4	20.85	10,000-16,000	7,610	May 11
OKANOGAN RIVER						
Tonasket, Washington	15	7.1-10.9	9.7	3,000-9,000	6,680	Jun 9
METHOW RIVER						
Pateros, Washington	10	4.5-6.4	5.0	3,500-7,500	4,410	Jun 8
WENATCHEE RIVER						
Peshastin, Washington	13	6.0-7.5	7.8	5,500-8,500	9,230	Jun 8
COLUMBIA RIVER						
Priest Rapids, Washington	422	404-406	411.03	100,000-125,000	191,500	May 9
YAKIMA RIVER						
Parker, Washington	10	4.3-5.4	3.6	2,000-3,500	1,260	May 2
HENRYS FORK						
Rexburg, Idaho	9	3.9-6.7	5.18	1,300-3,400	2,100	May 27
PAYETTE RIVER						
Emmett, Idaho	16,000 cfs			1,500-3,500	1,740	Apr 10
SALMON RIVER						
Whitebird, Idaho	32	18.2-18.8	19.1	19,000-21,000	22,400	Jun 9
CLEARWATER RIVER						
Spalding, Idaho	18	5.5-8.1	9.52	10,000-22,000	32,160	May 2
SNAKE RIVER						
Lower Granite, Washington	325,000 cfs			32,000-77,000	60,800	May 4
COLUMBIA RIVER						
The Dalles, Oregon	--			130,000-200,000	184,300	May 27
Vancouver, Washington	16	6.0-8.0	7.5			Mar 10

FIGURE 10

FIGURE 11



FORECAST VERIFICATION
COLUMBIA RIVER AT THE DALLES
JANUARY - JULY FORECAST
1894 RUNOFF - 174
MAXIMUM YEAR OF RECORD
MEAN RUNOFF - 111
ACTUAL 1977 RUNOFF - 54
RUNOFF IN MILLIONS OF ACRE FEET
0
20
40
60
80
100
120
140
160
180
JAN
FEB
MAR
APR
MAY
JUN
BEGINNING OF MONTH FORECAST

IV. RESERVOIR REGULATION

A. Summary

As a result of the demands placed on meeting multiple-purpose water uses and low inflow during this year's record low runoff, the reservoir system failed to fill by about 12 million acre-feet. During August the systems reservoirs remained near 12 million acre-feet from being full but the balance changed somewhat in that some of the Canadian reservoirs continued to fill while several of the U.S. reservoirs were drafted. The water shortage caused a severe impact on many water users in the Northwest during the spring, summer, and fall of 1977. A complete discussion of the 1977 drought is included in Section V of this report.

B. Reservoir Regulation and Results

Data used in this report were those available at the time the report was prepared. In some instances, project operating data were used and these may be revised later. Data published by the Geological Survey after review of records may vary somewhat from those shown in this report. However, to postpone publication of this report until final data are available would defeat its purpose which is to present as soon as possible the problems, operation, and general information converning the water management in the Columbia River Basin in 1977. Data shown on the charts are generally mean daily flows.

This year's report is similar in format to the report published last year. Hydrographs covering a fourteen-month period, July 1, 1976, through August 31, 1977, are shown for all major Federal storage projects and some nonFederal projects. Shorter period hydrographs covering times of the highest annual flows are also included to show more detail during these periods. A detailed summary explaining pertinent points of each of these hydrographs is included in the following sectio in downstream sequence. Unregulated flows and reservoir rule curve elevations are shown on many of the hydrographs. The definitions for the terms shown on these hydrographs are defined in the glossary.

1. McNaughton Lake, Mica Dam (Charts 3 and 32)

McNaughton Lake was at elevation 2474.5 feet on October 1, 1976. Mica outflow was adjusted to pass approximately inflow, holding the lake near full until about October 7. Then in preparation for expected low outflows for construction work during the last part of October, Mica outflow was increased to near 30,000 cfs between October 8-16. Between October 18-28, the outflow during the daytime was limited to 700 cfs for construction work. By the first of November, McNaughton Lake was drafted to elevation 2471.3 feet, the flood control requirement on November 1 was elevation 2473.1 feet. Mica outflow in November was held near 15,000 cfs, the monthly average value shown in the Detailed Operating Plan. In December, Units 1 and 2 at the Mica powerplant were commissioned. In March the flow continued to be maintained near 20,000 cfs. A third unit was placed in service at Mica in late March and for the month of April the outflow was held near 30,000 cfs, approximately equal to three units at full load. On April 30 and May 1, Mica outflow was reduced to zero for construction work below the project. The lowest level reach during the drawdown at McNaughton Lake this year was elevation 2414.6 feet on April 29.

The inflow to Mica began to gradually increase during the last part of April, but leveled off near 25,000 cfs in May. At this time there were only two units available at Mica, which, combined with the low-average inflows, held the lake near the minimum elevation reached on April 29. In June, three units were available for service and Mica outflow was maintained near 30,000 cfs. A peak inflow of near 80,000 cfs occurred on June 8. During July and August, the Mica outflow averaged about 21,000 cfs. The lake reached its maximum level, elevation 2455.5 feet, on August 27, and was about 2.1 million acre-feet below full pool.

2. Arrow Lakes, Kennleyside Dam (Charts 4 and 33)

Arrow Lakes was at elevation 1445.4 feet on October 1, 1976. Begins on October 16, it was drafted gradually to meet downstream power requirements. The weekly request during the following winter period, December through February, caused a gradual draft of Arrow Lakes down to elevation 1391.6 feet on February 19. Arrow Lakes was 4.5 feet below the flood control requirement on November 1, and 22.5 feet below on January 1. The draft during the late winter and early spring was to meet power requirements downstream. There was no additional flood control requirement place on Arrow Lakes because of the forecasted low runoff. During the period April 12-14, Arrow Lakes outflow and the Kootenay Lake outflow were controlled to reduce the flow at the confluence of the Kootenay and Columbia rivers to 15,000 cfs. This low flow permitted sewer construction work in the river near Trail, B.C. Also during this period, the low-level ports at the Keenleyside Dam were inspected. Prior to the 5,000 cfs outflow from Arrow for this operation, the Arrow outflow was near 80,000 cfs to provide water downstream that would not be available during the period of April 12-14. The high outflow from Arrow caused the lake to draft to its low point of the year, elevation 1387.9 feet on April 9. Also, during April, B.C. Hydro agreed that the U.S. was entitled to leave water in Arrow Lake and request it later when high inflows would be beneficial to "Fish Flow 1977," as long as the level of Arrow Lakes was not any lower on 31 May than it would have been without this special regulation. During the period when the Arrow outflow was being maintained near 5,000 cfs for construction work, the lake filled to elevation 1392.0 feet. From April 25 to May 8 the Arrow outflow was maintained near 30,000 cfs. The outflow was near 40,000 cfs from May 8-17, and Arrow filled to elevation 1401.4 feet. The 40,000 cfs outflow was coordinated with the operation of the river for Phase I of "Fish Flow 1977." Between May 17 and 20 the outflow was increased to 75,000 cfs and maintained at this level until June 5. During this period, Arrow was drafted to elevation 1396.6 feet. The 75,000 cfs outflow was required to maintain high inflows to Grand Coulee during Phase II of "Fish Flow 1977." During June, Arrow outflow averaged about 50,000 cfs and filled to elevation 1411.0 feet on June 27. The space remaining to be filled to normal full pool, elevation 1444.0 feet, was 3.9 million acre-feet. During July and August the Arrow outflow averaged about 65,000 cfs to meet downstream multipurpose requirements. The level of Arrow on September 30 was elevation 1397.3 feet.

3. Lake Koocanusa, Libby Dam (Charts 5 and 34)

Lake Koocanusa was at elevation 2457 feet on September 30, 1976. Significant reservoir drawdown began in early October and proceeded through the winter, meeting mandatory Upper Rule Curve points and providing power generation. Inspection of the stilling basin at Libby Dam in November indicated serious erosion had occurred, and steps were initiated to effect its repair. On April 26, the reservoir reached its lowest level for the year, elevation 2358.5 feet.

During the refill period in May and early June, the project released near-minimum outflows, which helped offset system overgeneration resulting from the "Fish Flow 1977" operation. In late June outflow was increased to meet system load requirements. Lake Koocanusa reached its maximum elevation of 2415 feet on 6 July, 44 feet below full pool. Repairs began on the stilling basin during August and the work is scheduled to be completed in February 1978. By the end of September the lake was at elevation 2411 feet.

4. Kootenai River at Bonners Ferry (Chart 35)

The runoff from the area between Libby and Bonners Ferry was at a record low this year. Consequently, the maximum stage on the Kootenai River at Bonners Ferry was that caused by the power discharge requirements from Libby Dam. On November 30 the stage at Bonners Ferry reached an elevation of approximately 57 feet for one day which was caused by an outflow of near 40,000 cfs on the previous day from Libby Dam. The bank full stage at Bonners Ferry is 70 feet and flood stage is 74 feet.

Unregulated flows at Bonners Ferry would have caused a maximum stage for the year of 59.7 feet on June 10.

5. Duncan Reservoir (Charts 6 and 36)

Duncan was at elevation 1891.5 feet on October 1, 1976. During October, the Duncan outflow was held near 10,000 cfs to help maintain a Kootenay Lake outflow near 25,000 cfs and also provide some water to fill Kootenay Lake from elevation 1743.4 feet to elevation 1744.6 feet. During the last part of October and until about mid-November, the Libby outflow was high and the Duncan outflow was reduced to average 4,000 cfs. About mid-November, the Libby outflows were on the low side, therefore, Duncan outflow was increased to 10,000 cfs to prevent drafting of Kootenay Lake, which at that time was continuing to release 25,000 cfs. During all of December and most of January and February, the Duncan outflow was maintained near 2,000 cfs. On February 20, the outflow was increased to about 6,000 cfs to prevent the draft of Kootenay Lake that was still maintaining an outflow of 25,000 cfs. In the early part of March, the Duncan outflow had to be increased to 10,000 cfs to meet this requirement. During the last part of March, the outflow was gradually reduced to 100 cfs by March 31 to permit the draft of Kootenay Lake along its International Joint Commission (IJC) Rule Curve. Duncan Lake was drafted to elevation 1794.0 feet by 29 March, normal minimum pool is elevation 1792.4 feet. From March 31 to August 7 the Duncan outflow was maintained at 100 cfs. During this period, the maximum observed daily average inflow was 18,000 cfs on June 8. Duncan Lake reached normal full pool elevation 1892.0 feet on August 14, 1977. Drafts commenced shortly thereafter and by September 30, the elevation was 1875.3 feet.

6. Kootenay Lake (Charts 7 and 37)

In October, B. C. Hydro increased the Duncan outflow to fill Kootenay Lake to elevation 1744.6 feet while continuing to hold 25,000 cfs outflow from the lake. During November the lake continued to be held near elevation 1744.0 feet and the outflow was near 25,000 cfs. In December, the lake was gradually drafted to elevation 1743.0 feet while maintaining an outflow of 20,000 cfs.

Effective January 7 the IJC Rule Curve requires a gradual lowering of the lake level. The lake was gradually drafted during the period January through March reaching its lowest level, elevation 1738.8 feet on April 5. During this period, Duncan and Libby outflows were adjusted, to permit the lake to be drafted along the IJC Rule Curve. Between April 12 and 25, the canal leading to the Kootenay Canal plant was out of service for inspection and maintenance. During this period, there was special outflow regulations at both Duncan and Libby to try and control the inflow to Kootenay Lake to a maximum of 10,000 cfs, thus minimize the amount of spill at the Kootenay River plants. Also, a contractor downstream of the confluence of Columbia and Kootenay River plants. Also, a contractor downstream of the confluence of Columbia and Kootenay rivers took advantage of the low flow to work on a sewer pipeline. Kootenay Lake filled as a result of rising inflows in the spring and was maintained near its natural level until June 13 when West Kootenay Power was notified by the Corps of Engineers that the peak inflow had apparently occurred. This notification permitted the lake to be filled to elevation 1743.32 feet (at Nelson) and the lake remained at this level through August 1977.

7. Columbia River at Birchbank (Chart 38)

The flow of the Columbia River at Birchbank, British Columbia, Canada, was regulated by upstream regulation of Mica, Arrow, Duncan, Libby, and Kootenay Lake. The computed unregulated flow was 154,000 cfs on 25 June. The observed peak discharge was 104,000 cfs on June 4, 1977.

8. Hungry Horse Reservoir (Charts 8 and 39)

Hungry Horse Reservoir remained about one foot above normal full pool until October 6, 1976. During about two-thirds of the period between October 6 and January 15, the project outflow was near powerhouse hydraulic capacity. The reservoir level on January 15 was elevation 3514 feet, about 8 feet below the January 31 Variable Refill Curve. The reservoir drafted at a slower rate during the next three months and reached its minimum level, elevation 3496.1 feet on April 19. Early in April, the project inflow began to rise and peaked near 15,000 cfs on May 3. During "Fish Flow 1977" the Hungry Horse outflow was maintained near minimum. The reservoir filled to elevation 3541.0 feet, 19 feet below full pool, on June 19. During the remainder of the summer, the project was used to meet northwest power loads and the reservoir gradually drafted to elevation 3510.0 feet on October 1, 1977.

9. Flathead Lake, Kerr Dam (Charts 9 and 41)

During early October, Flathead Lake was drafted about one foot, but inflows rose again in late October due to releases from Hungry Horse and the lake refilled to near elevation 2893.0 feet. From mid-November through January, the project outflow averaged near 12,000 cfs, approximately full load on the three powerhouse units. In February and March, the lake drafted along its Energy Content Curve and reached minimum pool elevation 2883.0 feet on March 31.

On April 7-8, the Kerr outflow was reduced to 1,000 cfs during the daylight hours while workmen replaced a transmission structure. On April 9, one of the two units on line was taken out of service on a forced outage with damaged windings. At that time, another unit was already out of service for annual maintenance and was not expected to return to service until about June 20. However, Montana Power Company accelerated work on this unit and it was returned to service on May 9, approximately one month ahead of schedule. The outflow between April 9 and May 9 was approximately 4,500 cfs. From May 9 until June 8, two units were operated near full load, approximately 9,000 cfs, to avoid filling the lake too rapidly and possibly causing spill. On June 1, the forecasted runoff indicated that the outflow from Flathead Lake could be reduced below the hydraulic capacity of the two units on line and not cause spill during the remainder of the summer period. Therefore, Montana Power Company reduced the Flathead Lake outflow, and this combined with an increased outflow at Hungry Horse, which drafted the Hungry Horse reservoir about 9 feet between the period June 19 to July 10, filled Flathead Lake to normal full pool, elevation 2893.0 feet on July 10. The lake remained near full pool through August 31, 1977.

10. Pend Oreille Lake, Albeni Falls Dam (Charts 10 and 42)

From September 24 to November 10, Pend Oreille Lake was drafted at a near uniform rate from 2062.5 feet to elevation 2051.5 feet. The Albeni Falls outflow during this period averaged about 22,000 cfs. After the lake reached elevation 2051.5 on November 10, several complaints were received in regards to the lake being down so early in the season. The lake is usually drafted to elevation 2051.5 feet by November 20, but is normally above elevation 2054.0 feet at the end of October; this year the lake was at elevation 2052.7 feet on October 31. The early drawdown of the lake is reported to be beneficial to the Kokanee which begin spawning about mid-November. The lake remained between elevation 2051.0 and 2051.5 feet from November 10 until January 1. The operating range was then gradually raised to elevation 2052.0--2052.5 feet on January 10. The higher operating range was requested by the city of Sandpoint, Idaho, so they would be able to pump water from Pend Oreille Lake to meet some of their domestic and industrial water supply needs. During this period of extremely low precipitation, Sandpoint's regular water supply from Sand Creek had dropped to a level that was not adequate to supply the city's needs.

The lake remained in the operating range, elevation 2052.0--2052.5 feet, until April 7. At that time, the outflow at Albeni Falls Dam was reduced to 4,000 cfs to start a gradual fill of Pend Oreille Lake. On May 1, the lake had reached elevation 2055.0 feet and the outflow was increased to between 15,000 and 20,000 cfs and continued a gradual fill. This high outflow was used downstream to help maintain the level of FDR Lake during Phase I of "Fish Flow 1977." The peak observed inflow to Pend Oreille Lake was 52,000 cfs on May 16, 1977. During a portion of Phase II of "Fish Flow 1977" (May 23 to June 3) the Albeni Falls outflow was maintained near 7,000 cfs to help reduce excess generation. Between June 4-6, the outflow was gradually increased to pass approximately inflow and the lake level was held near elevation 2060.0 feet until July 5. Then the lake was gradually filled to elevation 2062.0 feet by July 19. The lake was maintained between elevation 2062.0 and normal full pool, elevation 2062.5 feet through August, 1977. The adjusted April--August runoff into Pend Oreille Lake was 36 percent of the 15-year average from 1958-72.

The cofferdam at B. C. Hydro's Seven-Mile project was closed on 13-14 November, 1976. This new project is located on the Pend Oreille River between the Waneta and Boundary projects.

11. Franklin D. Roosevelt (FDR) Lake, Grand Coulee Dam (Charts 11 and 43)

During most of October, the outflow from FDR Lake was maintained near the full-load capability of the available powerhouse units approximately 120,000 cfs. FDR Lake remained within 3 feet of normal full pool until January 1, when the outflow was adjusted to draft the lake in accordance with the Energy Content Curve. The lake reached its low point of the year, elevation 1237.4 feet, on April 22. Beginning May 9 and extending through June 17, Grand Coulee outflows were adjusted to meet the requirements of "Fish Flow 1977." Prior to the start of "Fish Flow 1977," the reparian interests around FDR Lake expressed their concern about refilling the lake this year. In order to meet some of their requirements, goals were set. Elevation 1270.0 feet was set as a level to be reached between June 10-20, and elevation 1280.0 feet was to be reached between June 20 and July 1. As a result of extensive coordination and cooperation of the agencies involved in "Fish Flow 1977," the flows were provided to move the juvenile salmonids downstream and fill FDR Lake to meet the goal levels. The lake reached elevation 1270.0 feet on June 12, and elevation 1280.0 feet on July 3. During July the lake continued to fill and reached elevation 1287.0 feet on July 20 . The lake generally remained within 3 feet of normal full pool, elevation 1290 feet, through July and August 1977.

12. Mid-Columbia River, PUD Projects (Chart 56)

Article 34 of the Federal Power Commission licenses for four of the five public utility district projects downstream of Chief Joseph Dam, stipulates that the storage space for replacement of Lost Valley storage should be provided by these projects under certain conditions. As a result of the low runoff this year, there was no requirement to provide that storage space.

Three PUD's operated their projects to assist in the operation "Fish Flow 1977." Section IV-D, contains a summary of the action taken.

The seven mid-Columbia projects continued to operate under the hourly coordination agreement this year. However, the agreement was not signed by a couple of utilities. Improvements in the agreement are being studied by several participants.

13. Yakima. Project Reservoirs (Chart 27)

The five Yakima Project reservoirs: Keechelus Lake, Kachess Lake, Cle Elum Lake, Bumping Lake, and Rimrock Lake have an active storage capacity of 1,066,000 acre-feet. These reservoirs, although originally constructed as single-purpose irrigation reservoirs are now operated as needed for flood control on an informal basis.

The unregulated October-July streamflow runoff at the Parker, Washington, gage was 1,360,000 acre-feet for 1977 which is 40 percent of the 1958-72 average. The Parker observed peak flow was 2,730 cfs on January 20, which indicates the extreme drought year experienced. The unregulated peak was only 7,360 cfs also on January 20.

The reservoir system was essentially shutoff during the winter storage season from October through March except for a small amount of unavoidable spill from Bumping Lake. Flood control was not a consideration due to the drought. Fortunately, runoff timing was such that little water was lost past the Parker gage that could not be diverted by the irrigators. Maximum content of the five reservoirs was 989,500 acre-feet on May 5. Carryover after the 1977 irrigation season is expected to be about 120,000 acre-feet.

14. Jackson Lake and Palisades Reservoirs (Charts 28, 29, 44, 45, 46)

Storage in the Snake River above Heise, Idaho, is composed of Jackson Lake with 847,000 acre-feet of active storage and Palisades Reservoir with 1,200,000 acre-feet of active storage, for a total of 2,047,000 acre-feet. The system is operated as a multipurpose unit for flood control, irrigation, and power production.

Unregulated volume runoff during the October-July period above Heise was 2,250,000 acre-feet, or 50 percent of the 1958-72 average. The regulated peak outflow from Jackson Lake was 5,020 cfs on June 28, and the unregulated peak inflow was 3,780 cfs on June 3. Downstream at Heise, the regulation point, the regulated peak flow was 13,100 cfs on June 4, and the unregulated peak was 11,900 cfs on June 9.

Winter peaking releases were made through January, but were curtailed in February as the drought developed. A minimum release was then maintained at Palisades until irrigation began the second week in April. Palisades filled for three days in April but Jackson reached only 693,000 acre-feet in June. There was no spring flood-control operation. Carryover in the two reservoirs was very low, about 250,000 acre-feet.

15. American Falls Reservoir

American Falls filled to is restricted content of 1,125,000 acre-feet the first week of April following winter discharges averaging 3,000-4,000 cfs. The spillway was not used at any time during the year. The reservoir was then steadily lowered until the breach with maximum outflow of 11,400 cfs in late June.

The severe drought proved to be a near ideal situation for the replacement of American Falls Dam. The project moved efficiently ahead of schedule due to the dry weather. On September 1, 1977, final blasting was done to complete the breach of the old American Falls dam. On September 10, the low-level outlets of the new American Falls Dam were fully opened to pass water. On this day the new dam was officially transferred to the Bureau of Reclamation. Storage behind the new dam began on October 14. Downstream irrigators would not have been entitled to any more water than they received in 1977 had there been no replacement. Also, the small year allowed perfect control of the reservoir. It would not have been possible to breach the old dam in a large runoff year similar to 1974.

Whether or not the reservoir can fill to 1,700,000 acre-feet next year, which is unrestricted capacity, will depend on the size and timing of runoff. There is a good chance, however, that the restricted level of the past few years will be surpassed.

16. Little Wood Reservoir

Little Wood Reservoir has an active capacity of 30,000 acre-feet. The October-July, 1977, runoff of 38,900 acre-feet was only 32 percent of the 1958-72 average runoff. The peak flow at the Carey gage was 280 cfs on June 10 and 11. The unregulated peak was 220 cfs on June 8. Irrigators experienced severe shortages and the reservoir reached a maximum content of only 17,200 acre-feet on April 22.

17. Owyhee Reservoir (Chart 31)

The Owyhee Reservoir has an active capacity of 715,000 acre-feet and, although constructed as a single-purpose irrigation reservoir, provides significant flood protection along the lower Owyhee River and along the Snake River from Nyssa, Oregon, to Weiser, Idaho.

The December--June runoff volume was 138,400 acre-feet, 23 percent of the 1958-72 average. The peak inflow for the year was 864 cfs on October 30, 1976, while the maximum regulated outflow excluding the diversion tunnel was 150 cfs on April 21. Winter minimum flow was 12 cfs below the dam. There was no flood control operation and the reservoir reached a maximum content of 523,000 acre-feet in early April. Carryover at the end of the year was far below normal and represents about a 25 percent irrigation supply.

18. Boise Project Reservoirs (Charts 30 and 47)

The Boise River reservoir system is composed of Anderson Ranch, Arrowrock, and Lucky Peak reservoirs with a total active storage capacity of 988,000 acre-feet. The system is operated as a multiple-purpose unit for flood control, fish and wildlife, power production, recreation, and irrigation.

Unregulated volume runoff for the October--July period on the Boise River was 599,500 acre-feet or 30 percent of the 1958-72 average. Maximum release from Lucky Peak was 3,730 cfs on July 1, while the maximum unregulated flow at Lucky Peak was 2,850 cfs on June 8. Maximum storage in the system was reached April 13, with 665,000 acre-feet in the three reservoirs. There was no flood control operation.

Stream maintenance flows of 250 cfs were released until early January when a drought was indicated by the January 1 runoff forecast. A flow of 100 cfs was then maintained until the irrigation season began the first week in April. Carryover at the end of the season was minimal.

19. Malheur River Reservoirs

Beulah and Warm Springs reservoirs were originally constructed and operated as single-purpose irrigation reservoirs. Since the construction of Bully Creek Reservoir in 1962, all three reservoirs have been operated for multipurpose. Combined, the three reservoirs have an active capacity of 281,000 acre-feet.

Total reservoir inflow on the Malheur system for the October--July period was 62,400 acre-feet, or 24 percent of the 1958-72 average. As a result of the extreme drought, maximum storage was only about 134,000 acre feet in early April. The system was emptied the latter part of July and severe water supply shortages were experienced.

20. Payette River Reservoirs (Charts 30 and 48)

The Payette River reservoir storage system is composed of Cascade and Deadwood reservoirs with a total active storage capacity of 815,100 acre-feet. These reservoirs were originally constructed for irrigation and power purposes, but now are also informally operated for flood control.

The unregulated October--July runoff volume at Horseshoe Bend was 650,300 acre-feet, 28 percent of the 1958-72 average. The peak regulated flow at the Horseshoe Bend gage was 2,500 cfs on May 24 while the unregulated peak would have been 2,720 cfs on April 10. Maximum system content was 466,000 acre-feet on April 17. The estimated unregulated peak flow of the Payette River near Emmett gage was 2,980 cfs on 10 April, while the observed peak was 1,320 cfs on May 24. No flood control operation was necessary. Carryover storage for the 1978 irrigation season was far below normal.

21. Snake River at Weiser (Charts 31 and 49)

The unregulated hydrograph has been adjusted to include most major upstream irrigation diversions. These diversions, however, were not included in Water Management reports prior to 1971.

Weiser flows are highly regulated by upstream irrigation diversions and reservoir storage operations which normally result in a fairly smooth hydrograph at Weiser. The computed unregulated peak flow at Weiser during the 1977 water year was 27,700 cfs on June 13 and the observed peak of 20,300 cfs occurred on December 5, 1976.

22. Powder River

Phillips Lake is located on the Powder River in Eastern Oregon. The reservoir is used for multiple purposes and includes 17,000 acre-feet for exclusive flood control, 21,000 acre-feet for joint use, and 52,500 acre-feet for active conservation use, for a total active storage capacity of 90,500 acre-feet.

The October--July runoff volume on the Powder River near Baker for 1977 was 17,800 acre-feet, or 21 percent of the 1958-72 average. This extremely small runoff produced a maximum active storage content of only 47,000 acre-feet in early April. No flood control operation was necessary and only a small carryover storage remained at the end of the year.

23. Brownlee-Hells Canyon (Charts 12 and 50)

The Brownlee, Oxbow, and Hells Canyon projects are owned by Idaho Power Company and are operated in accordance with the license issued by the Federal Power Commission (FPC). The FPC license provides for utilizing the project storage space for flood control and requires certain minimum releases from Hells Canyon to provide adequate navigation depths downstream, when possible, during the conservation holding and release season.

The Brownlee reservoir was near full pool elevation 2077.0 feet until October 9, 1976. It was then gradually drafted to elevation 2053.2 feet on January 29, 1977. On 28 January, the Corps of Engineers notified Idaho Power Company that the volume runoff into Brownlee would not require the normal evacuation of 500,000 acre-feet of storage space by March 1. In early February, Idaho Power Company was informed that this year only 200,000 acre-feet of flood control space would be required. At the time of notification, there was about 300,000 acre-feet of space in Brownlee reservoir. During February, the Hells Canyon outflow was reduced to maintain a flow at Lime Point of at least 13,000 cfs. This caused Brownlee reservoir to fill to elevation 2062.0 feet, maintaining the 200,000 acre-feet of space required by the Corps of Engineers. During late March, Brownlee reservoir was drafted to elevation 2057.0 feet to meet power requirements. It remained near this level through April and reached a low point of 2053.8 feet on May 3.

As a result of the low runoff this year, Idaho Power Company applied for and received from Federal Power Commission (FPC), a temporary emergency variance stating that, Idaho Power Company shall not be required to maintain the 13,000 cfs flow in the Snake River at Lime Point. Also, the minimum flow shall be at least 5,000 cfs at Johnson's Bar and at the same point, the maximum variation in the river stage would not exceed 1 foot in 20 minutes. This reduction of flow at Lime Point was subject to the condition that, during the period of the "Fish Flow 1977" which was requested by the fisheries agencies of Idaho, Washington, and Oregon, the operation of the project was such that there was an average of 13,000 cfs during each 24-hour period at Lime Point. This variance was effective as of April, 1977, and continue until July 1, 1977, or until further order of the Commission. Prior to this variance, Article 43 stated that the regulated flow at Lime Point could not be less than 13,000 cfs except during the months of July, August, and September, and that the normal minimum flow at Johnson's Bar is 5,000 cfs with the maximum river stage fluctuation not to exceed 1 foot per hour. The only period between April 7 and July 1 that the combined minimum outlfow of 5,000 cfs at Hells Canyon and the flow of the Salmon River did not exceed the minimum requirement of 13,000 cfs at Lime Point, was April 7-24. From May 3 to June 3, the Hells Canyon outflow was reduced to about 5,000 cfs and Brownlee reservoir filled to elevation 2070.0 feet. The temporary variance was terminated on June 7, 1977, by order of Federal Power Commission. Later in June, the reservoir filled to elevation 2074.0 feet. During the last part of June and early July, power requirements again caused the Brownlee reservoir to draft to elevation 2065.0 feet. During July and August, the minimum instantaneous outflow from Hells Canyon was reduced almost daily to 5,000 cfs, and the daily average flows were near 7,000 cfs. The flow at Lime Point remained above 13,000 cfs until about mid-July and by the end of July was near 10,000 cfs. During August, the projects continued to be operated in a manner similar to that in July, but with the continued natural recession of the tributary flows above Lime Point, the flow at Lime Point dropped to 8,500 cfs. Idaho Power Company agreed to continue special releases to maintain adequate flows for the mailboat operation on Tuesday and Wednesday of each week. On August 31, the Brownlee Reservoir was near elevation 2069.1 feet.

24. Dworshak Lake (Charts 13 and 51)

On October 1, Dworshak Lake was at elevation 1586.0 feet. Due to an outage of one of the 90 megawatt units, some water had to be spilled to reach this storage space requirement. Between October 1 and November 15, the steelhead harvest season, the outflow was restricted to about 1,300 cfs over inflow. Between November 15 and December 10, Dworshak outflow was maintained near full load on the two available units. The lake level on December 15 was elevation 1557.3 feet, 0.7 feet below the flood control requirement. The January 1 volume runoff forecast for Dworshak was 65 percent of normal. Based on this low volume runoff forecast, the lake had already been evacuated below that needed for flood control. However, power demands and low runoff throughout the basin caused the lake to be drafted to its low point, elevation 1510.5 feet on March 10. In order to refill the reservoir as much as practical during the high flow season, the outflow was reduced to a minimum of 1,000 cfs from March 11 until May 22, the beginning of Phase II of "Fish Flow 1977." During the following two week period, the outflow was increased on weekdays to about full load to provide water at McNary and John Day to help move juvenile salmonids downstream. During the middle of June the outflow was returned to 1,000 cfs and on June 23, the lake reached its maximum level, elevation 1571.0 feet. During July and August, the outflow averaged 5,000 cfs and 2,500 cfs, respectively. The lake was near elevation 1550.0 feet on August 31.

On July 6, the selector gates used for withdrawing water from the reservoir that is of a desired temperature, were adjusted to release water that was 50 degrees F. The cooler water was requested for the operation of the Dworshak Steelhead Hatchery, because the warmer water was reported to have caused some smolts to die.

25. Clearwater River at Spalding (Chart 52)

Streamflow regulation for the Clearwater River at Spalding, Idaho, is provided by Dworshak reservoir on the North Fork Clearwater River. The observed peak flow at Spalding during this low runoff year was only 29,300 cfs on May 3. The unregulated peak flow was 42,100 cfs on May 3.

26. Lower Snake River Projects (Chart 53)

Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects are run-of-river projects operated primarily for hydropower and navigation. Their pondage was used effectively this year to conserve energy during scheduled powerhouse outages, assist construction work, and improve fish passage and recreation. A special regulation was provided at Ice Harbor, Lower Monumental, and Little Goose between July 21 and September 13 to study the effect of low project outflows on adult fish passage. A schedule was set at these projects to vary the outflow from 0 cfs to 20,000 cfs during the graveyard hours (2300-0700 hours). Fish counts at these projects will be analyzed later to determine the effect of the flow conditions on adult fish passage. There were several occasions during this 7-week period when the test schedule could not be followed because of conflicts with power, project inflows, and navigation. A similar test was conducted between September 20 and October 4 at Ice Harbor and Lower Monumental.

The navigation channel below Lower Monumental was deepened and cleared of debris during a period between January 23 and May 11. Before this work was completed, the Ice Harbor forebay had to be maintained above elevation 438.0 feet to provide adequate depths for barges using the channel. From January 23 to February 4, the Ice Harbor pool was held above elevation 439.0 feet to provide adequate depths for the barges while they were being rerouted away from the portion of the area being dredged.

As a result of the low runoff this year, an extended effort was made to trap and haul juvenile salmonids from the Lower Granite and Little Goose projects. Special arrangements were made to convert two barges to move the juvenile salmonids downstream during the expected peak of the run. In order to trap as many smolts as possible, special considerations were given to avoid spill at Lower Granite and Little Goose. However, this did not prove to be a problem as the maximum daily average inflow to Lower Granite was 62,000 cfs on May 3.

On April 25, the Lower Granite project began a special operation of the powerhouse units to attract downstream migrants into the units and fingerline bypass system. In May a similar operation began at Little Goose; both of these projects continued to operate their units in several special ways to attract the juvenile salmonids into the units until late June, when only a small number of smolts were passing the projects.

27. Lake Umatilla, John Day Projects (Chart 14)

Lake Umatilla has an operating range of 11 feet, elevation 257 feet to 268 feet, which provides approximately 500,000 acre-feet of flood control storage space. Normally, the pool is maintained between elevation 262 feet and 268 feet from May through September, and between elevation 262 feet and 265 feet from November through April. Lake Umatilla may be lowered to minimum pool elevation 257 feet for a short time to provide additional flood control storage space for floods and for occasional power demands. The pool is usually lowered prior to the spring freshet for the control of springtime snowmelt floods. Until October 15 and then it was maintained between elevation 262 feet and 265 feet. The lake remained in this 3-foot operating range except for two periods. During the first period, March 2 through March 15, water was stored above elevation 265 feet to reduce spill at Bonneville which would have caused a loss of energy in the Northwest. Also during late May, Phase II of "Fish Flow 1977," the lake was filled to near normal full pool, elevation 268 feet, to provide water that could be released during Phase III of "Fish Flow 1977." The water above elevation 265 feet was released between June 5-10. The reservoir was held above elevation 262 feet to maintain an adequate operation of the fingerling bypass system.

During the last part of June and all of July and August, a special attempt was made to hold Lake Umatilla above elevation 263.5 feet several days each week. This was done to improve pumping conditions for an irrigator, who when the pool was near normal minimum pool elevation 262 feet, had trouble pumping.

28. Upper Deschutes River Basin

This is a multiple-reservoir system composed of Ochoco and Prineville on the Crooked River; Crane Prairie, Wickiup, Haystack, Crescent Lake, and Wasco reservoirs on the Deschutes River. They have a combined total active storage capacity of 559,000 acre-feet. Only Prineville and Ochoco are operated formally for flood control.

The 1977 Water year was extremely dry and storage carryover was poor. Since the basin depends to a large extent on groundwater for runoff production, and groundwater has above a one-year lag, prospects for next year are not favorable.

29. Chief Joseph, McNary, The Dalles, and Bonneville Projects (Charts 54, 55, and 57)

These run-of-river projects are operated for navigation, power generation, recreation, and other multipurpose uses. Generally, the projects are not utilized for flood control although their limited amount of storage is used whenever possible to provide a small measure of final shaping for downstream flow conditions.

Construction work at Chief Joseph, for raising the forebay and adding the additional 11 generating units, required many periods of special regulation. The Chief Joseph forebay was limited to a maximum elevation of 943 feet from July, 1976, until February 17, 1977, to reduce the hazard of possible overtopping of the spillway gates when construction workers were in the area downstream of the gates. During July, 1976, the forebay was drafted to 940 feet to lower the tailwater elevation at Grand Coulee thus aid in the placement of riprap. On December 6, BPA changed the line-load-dropping scheme at Chief Joseph from three lines to two lines. This reduced the required freeboard from 3 feet to 2 feet and the new maximum forebay became elevation 944 feet. During the period of special regulation for the contractor working downstream of the spillway, there were periods when the forebay had to be filled to near full pool elevation 946 feet. Two of these occasions were on December 13 when a cofferdam cell was floated into the forebay area and again on January 3 when two pairs of cofferdam cells were moved to the upstream face of the dam. On February 7, the last pair of nonoverflow cofferdams were removed from the construction area. The maximum forebay limit was raised to normal full pool, elevation 946 feet, on February 17 when the contractor completed his work with the removal of debris from the stilling basin. The first new generating unit, #17, became commercially available for service on June 17. During the period of August 22 to September 2, the forebay was maintained between elevation 940 and 941 feet to repair damage to a spillway gate trunnion.

During daylight hours on weekends, between October 22 and February 16, the McNary pool was maintained in the top foot to improve conditions for waterfowl hunters. On January 4 and January 6, the McNary pool was regulated to assist in the removal of two spans of the Union Pacific Railroad bridge and placement of a new span to replace the two old ones.

The Gold Cup Hydroplane races were held in the Tri-Cities area on the McNary reservoir between July 27-31. The pool was maintained above elevation 339 feet for this event.

On February 5, the FMC Corporation launched the tanker Chevron Arizona. The stage required for this launch was only two feet and no special regulation was required. On February 16, the Port of Portland successfully moved the barge Alaska from its construction area to a dry dock for launching. Bonneville Dam outflow was maintained near full load, approximately 135,000 cfs, to ensure at least a 2-foot stage for this operation.

Phase II of "Fish Flow 1977" began on May 23 and affected the flow in this reach of the river. Details about this special operation are found in Chapter VI in Section D. The above normal flows during this low runoff year caused by the special fish flow operation were used to the advantage of the firm trying to load barges with material and modules for the Alaska North Slope oil fields. The barge loading was set to coincide with the high flows in Phase II of "Fish Flow 1977," because the operation produced the required 5-foot stage for the loading. The barges were loaded during the period May 23-27. During the annual Portland Rose Festival, many U.S. and Canadian Naval ships were in the Portland area and docked against the Willamette River seawall. During the period when the ships were in the harbor, they required a minimum stage of 1-foot. According to the U.S. Navy, this provided only about a foot of depth below their largest vessel.

The January-July volume of runoff at The Dalles this year was 54 million acre-feet. This was the lowest runoff in 100 years of record. As a result of the low flow and reduced demand for electrical energy, the outflow from Bonneville Dam was less than 80,000 cfs on several occasions, and on two of these occasions the river stage at Vancouver was less than zero. On July 6, the stage was -0.4 feet; on July 10 it was -0.7 feet. The tidal swing on these days was about 3.5 feet. Numerous special regulations were performed at McNary, The Dalles, and Bonneville projects during the reporting period in the interest of power, construction, navigation, recreation, fish passage, fish studies, nitrogen tests, and streamflow measurements. Special criteria at all these projects were requested by the fishery agencies in the interest of fish passage.

30. Willamette Basin Reservoirs (Charts 15 and 25)

There are 11 storage reservoirs and two reregulating reservoirs in the Willamette River Basin operated by the Corps of Engineers for flood control, power, water supply, irrigation, navigation, recreation, low flow augmentation, fishery enhancement, and other multipurpose uses.

The draft at Fern Ridge was delayed until October 5, 1976, because of high recreational use, although some draft occurred due to evaporation, irrigation demands and minimum flow requirements on the Long Tom River. Drafting of the projects with power facilities; Hills Creek, Lookout Point, Cougar, Green Peter, and Detroit, began in August, 1976, when the federal power storage system could utilize the extra power.

The Foster reservoir draft was delayed from October 1 to October 18 to continue the supply of warm water for improved rearing conditions at the hatchery immediately downstream of Foster project. Beginning on August 14 and lasting for about 4 weeks, the Detroit--Big Cliff outflow fluctuated to attract adult salmon and steelhead to the Minto egg collection station. The full evacuation of all storage projects was accomplished within their respective rule curve requirements. Both Fall Creek and Cottage Grove reservoirs were drafted below their minimum flood control pools at the request of the Oregon Department of Fish & Wildlife to assure all the downstream migrants had left these reservoirs.

As a result of the critical lack of precipitation during the fall and winter of this year, the runoff conditions were at the lowest point of historic record during most of January and February. Early forecasts of reservoir refill, based on normal minimum outflow and normal precipitation, indicated only a 70 percent refill of major reservoir and 85 percent refill of minor reservoirs. With 75 percent of normal precipitation during Feburary-April, 30 percent of the space in major reservoirs would be filled. Therefore, action was taken to reduce the outflow below normal minimum to conserve water. The reductions in outflow were coordinated with federal and state fishery agencies, Oregon Department of Environmental Quality, and the Oregon Drought Council. This action resulted in storing additional water in the Willamette reservoirs. The additional storage plus near normal precipitation during the period March through May permitted the refill of all reservoirs by June 1, except Hills Creek, Lookout Point, and Fern Ridge. Six reservoirs: Cottage Grove, Fall Creek, Cougar, Blue River, Green Peter, and Detroit were filled above maximum conservation pool to provide extra water for low flow augmentation and improved fish rearing conditions. The planned and actual flow levels for the Willamette River were lower this summer than during recent years because of the low natural flows and lack of reservoir storage to provide the flow. On June 24, reservoir drawdown was required to augment the flow and meet the 4,000 cfs planned minimum flow at Albany. The actual flows during the summer period were maintained above the values shown below:

Date	Willamette River at Albany (cfs)	Salem (cfs)
Through August 15	4,000	5,000
August 16-31	5,000	6,000
September	5,000	7,000
October	6,500	9,000

From August 15 to September 23, the Big Cliff outflow was fluctuated on a weekly cycle to attract salmon and steelhead to the Minto egg collection station.

31. Western Washington Reservoirs

There are three storage reservoirs in western Washington which are Federally owned and operated for flood control by the Corps of Engineers. The Corps of Engineers also regulates the level of Lake Washington and specifies regulation during flood emergencies for Ross and Baker reservoirs and the Mayfield-Mossyrock project in accordance with the Federal Power Commission license.

a. HOWARD A. HANSON DAM on the Green River, is a flood control and conservation storage project. Water is stored in the spring for release in the summer and fall to augment low flows for fishery enhancement. Drawdown for winter flood control this year was completed by November 15. No flood control regulation was required this season. A small pool was maintained to assist debris removal and to reduce turbidity at the city of Tacoma municipal water diversion, 3-1/2 miles downstream of the dam. On April 29, the project began to accumulate conservation storage and reached maximum conservation storage level, elevation 1141 feet, on May 24. The pool was maintained to within 10 feet of the maximum conservation storage level for the remainder of the summer season due to the prevailing dry climate conditions.

b. MUD MOUNTAIN DAM on the White River, is a single-purpose flood control project and normally maintains no significant pool except during high inflow events. No flood control regulation was required this season. The reservoir was raised to about elevation 1016 feet on April 10 to allow for the removal of debris from the trash racks.

On several occasions, special regulations were made to assist Puget Sound Power and Light Company (PSP&L) which diverts water for power generation five miles downstream of the dam. Outflow was reduced on May 4 to assist PSP&L during emergency repair work on a blown-out portion of their diversion flume. The reservoir rose to elevation 1031 feet during this regulation, the maximum pool for the year. Occasional fluctuations occurred throughout the summer season during debris removal and repair operations.

c. WYNOOCHEE DAM on the Wynoochee River, provides flood control, water supply, fishery enhancement, recreation, and irrigation benefits. Drawdown for winter flood control was completed by November 3. No flood control regulation was required this season. On February 9, outflow was reduced to allow filling to normal full pool elevation of 800 feet. Filling was initiated a month early this year due to the sparse snowpack and persistent dry climatic conditions. Full pool was reached on June 12. Storage releases through the summer augmented the natural river flow and lowered the reservoir to elevation 778 feet on September 30. The river below the city of Aberdeen municipal and industrial water diversion would have essentially dried up during mid-August had supplemental flow from Wynoochee project not been available.

d. LAKE WASHINGTON SHIP CANAL AND HIRAM CHITTENDEN LOCKS (LWSC-HCL) PROJECT controls the level of Lake Union and Lake Washington and allows navigation between Puget Sound and the upstream lakes. Lock facilities include a saltwater drain and barrier that are designed to reduce saltwater intrusion upstream. Lake levels in 1977 were maintained within the normal, 20- to 22-foot (LWSC-HCL datum) range by water released through the lock facilities, spillway structure, and fish ladder. The lake level gradually reached its low elevation of 20 feet on December 1. After over 30 days of lake levels near 20 feet, the lake began filling on January 19. The lake gradually reached its usual summer level, near 22 feet, on April 28, and was held between elevations 21.8 and 21.9 feet through July 1. The lake level dropped throughout the summer to a low elevation of 20.55 on 22 August. Late August rainfall brought the lake level up to a range of 20.9 to 21.1, where it remained for the rest of the summer season.

e. ROSS DAM on the Skagit River, is owned and operated by Seattle City Light as a power generation and flood control project. The Federal Power Commission license gives the Corps of Engineers limited authority to specify project regulation during a flood emergency. Evacuation of flood control storage must begin by October 1 and be completed by December 1 to provide storage of 120,000 acre-feet (above elevation 1592 feet). The space must remain available until at least March 15. The reservoir this year was drafted from elevation 1601.6 feet on October 1 to elevation 1569.6 feet on December 1. Unusually dry, winter weather and accompanying inflows, lower than those required for power operation, caused the reservoir to be drafted to elevation 1511.0 feet, 81 feet below the required flood control elevation. No flood control regulation was required this season.

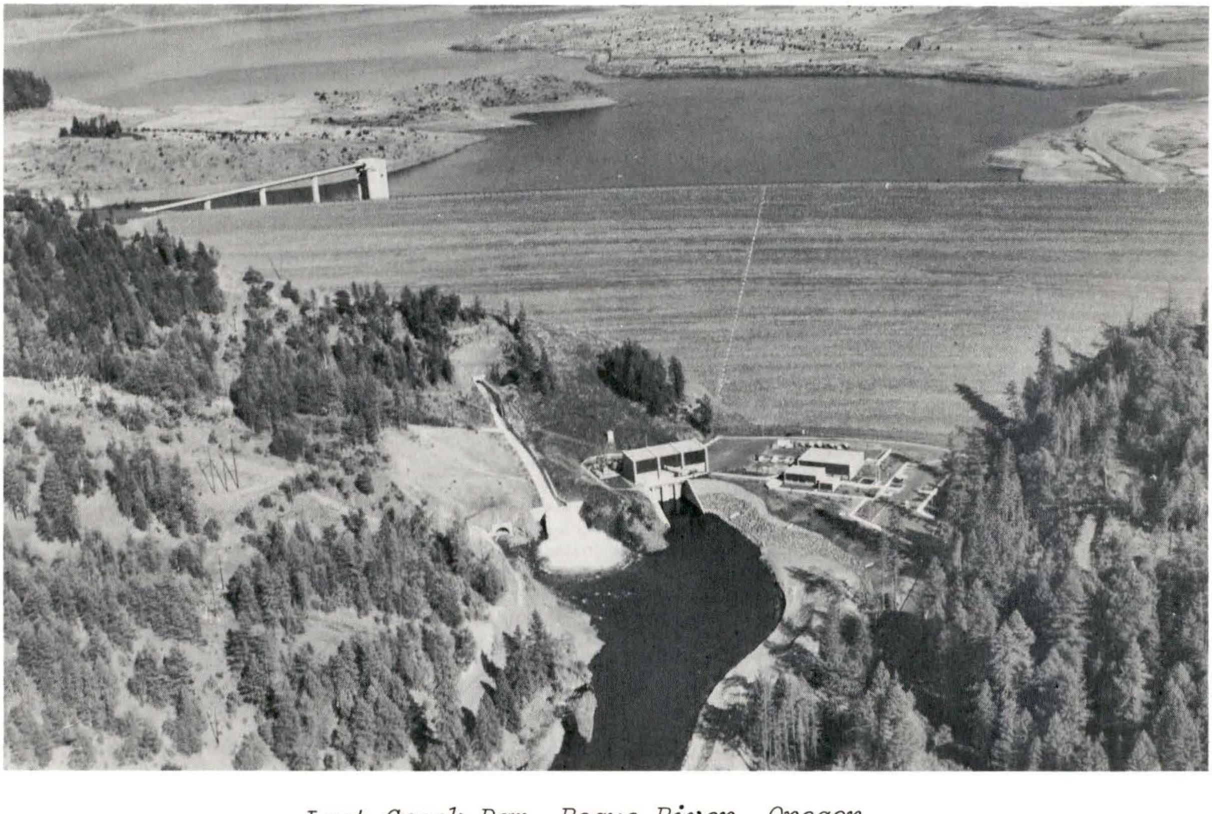
f. MAYFIELD-MOSSYROCK PROJECT on the Cowlitz River, is owned and operated by Tacoma City Light for power generation and flood control. The impoundment behind Mossyrock Dam has been named Riffe Lake. The Federal Power Commission License gives the Corps of Engineers limited authority to specify project regulation during a flood emergency. The plan of operation for flood control at Mossyrock provides for a maximum of 360,000 acre-feet to be reserved for flood regulation between normal full pool, elevation 778.5 feet, and elevation 745.5 feet during December and January. Storage space in Mayfield reservoir which consists of 21,000 acre-feet may be substituted at any time for an equal amount of storage reserved in Riffe Lake. During the fall and winter period of 1976-77, the lake was drafted to meet power requirements which exceeded the flood control requirement previously stated. As a result of the low inflows and near normal power demands, Mossyrock was drafted to elevation 667 feet by 18 March. The lake then began a gradual fill reaching elevation 761 feet by mid-July 1977, 17.5 feet below normal full pool.

32. Lost Creek (Chart 26)

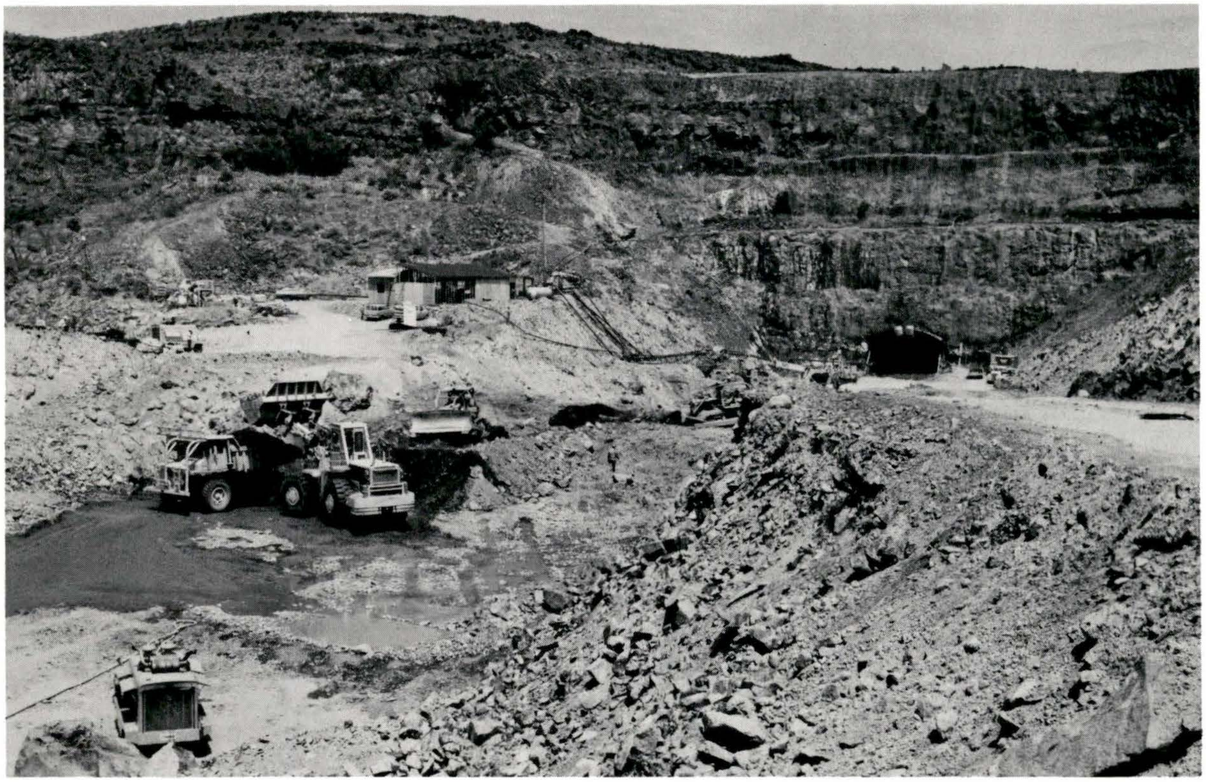
The filling of Lost Creek Lake was originally scheduled to begin between October 15 and December 1, 1976. The closure of the diversion tunnel was dependent upon inflow. Whenever the inflow was between 1,000 and 1,500 cfs and expected to go above 2,000 cfs in a few hours, the stoplog could be lowered into place and the filling begun. However, the high flow did not materialize during this period. The Corps and various state agencies continued to review plans for initial fill of the lake. A decision was made that the lake should begin its initial fill on February 2, 1977; however, the State of Oregon intervened and asked that the fill be delayed. Following additional discussion by the Corps and state officials, it was decided jointly to schedule the closure to begin at 1000 hours on February 18.

Prior to the closure, special arrangements to protect aquatic life downstream of the Lost Creek project were made. Pacific Power and Light increased the flow in Big Butte Creek immediately downstream of the dam and also sprinklers were used to keep salmon redds wet until flow again was passed through the Lost Creek Dam. As a result of the closure, the river flow at Raygold, 34 miles below Lost Creek, dropped from 1,050 cfs to 300 cfs on February 18, but by February 22 was back to about 900 cfs. The Lost Creek outflow was uncontrolled but generally less than 800 cfs until the pool reached elevation 1648 feet, 81 feet above the starting level. At the time the flow was then reduced from about 800 cfs to 700 cfs. The temporary outlet was plugged and all of the flow began passed through the regulating outlet at 1330 hours on March 28. The Lost Creek outflow was increased from 700 cfs to 1,000 cfs on June 8 to help lower the water temperatures downstream. The maximum level reached this year was elevation 1752.3 feet on June 24. Minimum conservation pool is elevation 1751.0 feet and maximum full pool is elevation 1872.0 feet.

Unit #1 began producing power on July 7 and the first 632 megawatt hours of power were delivered to Pacific Power and Light to replace the power they lost when their Eagle Creek plan was shut down during the closure of Lost Creek. All of the power generated at Lost Creek goes into the Pacific Power and Light's transmission system and is then scheduled into the Federal Transmission System. The Lost Creek pool continued to draft in July and it was decided that the units could continue to operate even though the pool was below the minimum conservation level, elevation 1751.0 feet. Throughout the summer there were periods when the Lost Creek outflows were made through the units and/or through the regulating outlets to control river temperatures and oxygen levels in the river downstream of the project. On August 31, the lake level was at elevation 1737.6 feet.



Lost Creek Dam, Rogue River, Oregon



Bacon Siphon and Tunnel. Second Unit, being constructed as part of the Columbia Basin Project, Washington

V. FUNCTIONAL ACCOMPLISHMENTS

A. Water Management For The 1977 Drought

1. Corps of Engineers

For the Corps of Engineers, the 1977 drought spelled an intense period of involvement in interagency coordination and public interaction as multiple-purpose operating objectives became affected by the low river and reservoir levels. Fish and wildlife, recreation, irrigation, and navigation interests as well as power generation were impacted by the drought, and during the course of the operating year several difficult decisions had to be made when conflicts in operating objectives arose. Several decisions involved the governors of the Pacific Northwest states as well as federal and state agencies of various authorities.

One aspect of the Corps' drought activities was simply a stepped-up involvement in ongoing operational activity such as runoff forecasting, reservoir system forecasting, and public involvement. Such activities generally took place through established subcommittees of the Water Management Group and the Northwest Power Pool. Runoff forecasting presented special problems this year because of the unprecedented low magnitudes involved, and in some cases subjective adjustments and special forecasting methods had to be developed. Periodic forecasts of the hydro-system capability for meeting projceted loads had to be made to inform the public and to guide operating decisions. Monthly press briefings were arranged through the Water Management Group for the SCS, USGS, BPA, and the Corps to address the questions of the public.

As the seriousness of the drought became known during the winter of 1976-1977, the governors of the Pacific Northwest states saw the necessity of forming ad-hoc drought committees with which they could coordinate drought-related problems. Corps of Engineers representatives participated in the Washington, Oregon, and Idaho committees, acting as liaison in matters dealing with reservoir regulation. In Oregon, the coordination of out-flow amounts from Willamette projects during their springtime filling was accomplished through the Oregon Drought Council. The resulting close contact with state Fish and Wildlife representatives enabled outflows to be reduced to below-normal minimum levels, thus enhancing the filling of the reservoirs. Corps personnel also participated in presenting testimony before special hearings conducted by the state legislatures.

A major activity involving the Corps, the National Marine Fisheries Service, and state fisheries agencies was the intensifying of the program for trapping downstream migrant fish and hauling them past dams on the Snake and lower Columbia rivers. It was realized months before the spring migration period that survival of downstream migrants would be particularly precarious this year since little or no spill would be in the offing, and fish would have to pass through turbines. For the first time since the inception of the fish hauling program, barges were employed to augment the use of tank trucks. This operation called "Fish Flow 1977" is described in more detail in Chapter VI, Section D.

While the fish hauling operation provided a means of handling downstream migrants originating in the Snake River tributaries because of trapping facilities at Lower Granite and Little Goose Dam, those migrants, originating in the mid-Columbia, could not be trapped and thus their migration had to be handled by flow augmentation and special spill. The operation that resulted, termed "Fish Flow 1977," was a highly publicized plan coordinated through the Committee on Fisheries Operation. This operation, described in detail in Chapter VI, Section D was considered highly successful.

2. **Bureau of Reclamation**

The 1977 drought had tremendous impact on Bureau of Reclamation activities as the winter progressed and the usual accumulation of snow and rain did not materialize. January 1, 1977, forecasts all showed the lack of accumulated snowpack, but the situation was not critical at that time, because most Bureau reservoirs had above normal carryover storage from the 1976 irrigation season. That carryover turned out to be an extremely important part of the 1977 water supply. Below normal amounts of snow and rain continued throughout the winter and spring, and the usual forecasting methods were supplemented with base flow and minimum runoff studies.

The Bureau worked very closely with water districts and irrigation districts in order to estimate individual district supplies. The percent of water supply available for various Bureau projects during the 1977 irrigation season varied from 20 to 100 percent depending on holdover storage and runoff.

Communication with the water districts and their water users assisted in decisions to how best use their estimated water supplies. For some districts this meant very little change from past years' operations, but for most districts the water supply caused some cropping pattern changes, lands left idle, and shorter irrigation season than usual. The Bureau also worked with some water districts on accounting procedures so the use of storage water by each district could be updated periodically. This required research and contract interpretation for proper allocation of storage water to each district.

Many avenues for supplemental sources of water were investigated. These proving to be economical and feasible were implemented. Use of uncontracted storage water aided districts in the Boise, Payette, and Crooked River systems. Other investigations undertaken included pumping dead storage from reservoirs, pumping water from rivers where available (such as the Columbia), drilling wells for irrigation, livestock, and domestic use where possible, and pumping water from drains and return flow sources. Nearly all of these alternatives required power which was also in short supply.

Other types of programs were made available when Congress passed the Emergency Drought Act of 1977. The Bureau was responsible for implementing most of the programs under the Act which included emergency loans for construction, loans to individuals for construction, a water bank program, fish and wildlife mitigation, deferment of operation and maintenance and construction costs, state grants, and a study of future actions which could be effectively implemented should the drought continue.

The loans could be made available to a district or an individual for a multitude of purposes to aid in supplementing or conserving water. A water bank program provided for the Bureau to act as a bank to buy water from districts in order to sell water to the districts in short supply. This program was not utilized too well. The fish and wildlife programs were to provide supplemental water supplies and temporary facility construction at various fish hatcheries and other fish and wildlife drought relief measures. Deferments of annual operation and maintenance and construction costs were another portion of the act which permitted the Bureau to defer such costs up to five years in lieu of other expenses facing the districts during this drought year. The state grants were used to provide water for livestock, tanks to put the water in, water for M&I purposes, and irrigation scheduling for some crops. This water was provided by hauling and through the development of wells. The study portion of the Act was to identify and evaluate actions to lessen the effects of a continuation of the drought.

Recreation on Bureau reservoirs also was curtailed during 1977. Although very little could be done to facilitate recreation, the Bureau did project drawdown curves for their reservoirs along with available boat ramp information which was made available to boat dealerships and other agencies to help inform recreationers of the facilities available for use.

3. Bonneville Power Adminstration (BPA)

The drought had a severe effect on BPA and the power utilities in the Pacific Northwest to meet power demands. Because of the dry conditions, power and water demands for irrigation were greater than normal. The drought increased the requirement on reservoir storage to mitigate damage to fish and to enhance pollution abatement. By the end of the refill period, the reservoir system was 12.7 million acre-feet below full, equivalent to 14.1 billion kilowatt-hours of energy. Actions were taken earlier in the year by BPA and the utilities to conserve water in the reservoirs. Record low flows resulted in many utilities buying high cost power, resulting in higher rates to their customers. A public request that all consumers effect a 10 percent voluntary curtailment in their use of electricity was made February 10, 1977. Electroprocess industries dropped load and laid off about 600 workers due to the unavailability of electrical energy.

This year's drought brought about water management problems of such regional impact that the governors of the PNW states became directly involved in water management decisions affecting the area. The governors endorsed the plan for water releases and spill to be provided to enhance the downstream fish migration. They also were responsible for setting up a regional load curtailment plan to manage the regional electric energy deficiency. This curtailment plan, prepared by the Pacific Northwest Regional Commission and endorsed by each of the governors, ranged from voluntary curtailment to interrupting service on a rotational basis.

4. National Weather Service

In response to the continuing deficiency of precipitation, special bimonthly water supply forecast, with frequent weekly update, were prepared by the National Weather Service River forecast Center for the Columbia Basin Forecast Service. Analyses of observed precipitation for the various areas in the basin were distributed weekly over CBTT and to news media.

Interagency media briefings were held to discuss irrigation, power and runoff conditions and forecast with U.S. Corps of Engineers, Soil Conservation Service, Bonneville Power Administration, and National Weather Service participating.

State offices of National Weather Service expanded their routine monthly climatological analyses, summaries, and news releases. A formal drought information program was established early in the year. As various existing and newly established local, state, and federal agencies, committees and commissions responded to the developing drought, requests for climatological data and analyses increased dramatically.

Special provisions for dissemination of river information for recreation-related interests such as river drifters, boaters, and fishermen were required because of the impact of low water on these activities. Industries depending on water navigation in the tidal areas of Willamette and Columbia rivers required forecasts of time and elevation of four-per-day river levels nearly all spring.

5. Environmental Protection Agency (EPA)

During the Summer, 1977, drought period, EPA Region X engaged in several activities to document the water quality effects of the record low flows. A summary of these activities is as follows:

a. Diurnal Studies at National Water Quality Surveillance System (NWQSS) Stations

Diurnal measurements of dissolved oxygen, pH, temperature, and specific conductance were obtained every two hours for a 24-hour period at principal-fixed network monitoring sites throughout the region. The field work was accomplished by EPA, the respective state environmental agencies or by contract with the U.S.G.S.

b. Special Studies

Intensive water quality studies were conducted by EPA on the following reaches to assess the impact of the drought: (1) Lower Granite Reservoir; (2) Lower Columbia River, Yakima River; and (3) Grays Harbor, Washington. In addition, aerial photography was used to document water quality conditions in areas of irrigation return flows to the Upper Snake River.

6. Geological Survey (USGS)

Special efforts were made by each of the districts in the Northwest (Idaho, Oregon, Washington, and Montana) to document the effect of the drought on natural water supplies, including quantity and quality. Based on preliminary analysis of the data collected, the 1977 drought appears to be the most severe since streamflow records have been collected, beginning late in the last century. Significantly low flows occurred in the Oregon coastal area. For example, the 1977 annual peak on the Umpqua River near Elkton was 13,000 cfs. The next lowest annual peak recorded in the 61 years of record at that station was 33,000 cfs in 1915. An anomaly attributable to the drought occurred on the Applegate River near Copper where the minimum and maximum annual flows occured only 16 days apart (minimum, 19 cfs, September 12 and maximum, 860 cfs, September 28). The minimum flow at Copper was the lowest recorded in the 38 years of record.

a. Special low-flow discharge measurements

Through joint efforts by USGS, State of Idaho and other Federal agencies, special low-flow discharge measurements were made at over 700 sites in Idaho. Comparison with past records at a few of the sites indicates this year's low flows range from 25 to 80 percent of normal. Several springs entering American Falls reservoir and 25 springs along the Snake River from Kimberly to Bliss were measured especially for low-flow documentation.

In Washington, 1,050 discharge measurements were made at 350 statewide study sites.

Discharge measurements at about 170 ungaged stream and spring sites were made in Oregon.

b. Water-quality drought data

Special water quality data were collected in all districts, but mostly as part of ongoing data collection programs. See Water Quality, page 82.

c. Ground-water levels

Many special measurements of ground water levels were made in each district in addition to those made periodically as part of State cooperative programs. For example, measurement of 250 wells were made in March and September in Idaho, in addition to measurement of 410 wells regulary scheduled. Groundwater fluctuations during the year present a very complex picture. In general, water levels in shallow aquifers throughout the Northwest were at extremely low levels relative to past records for an extended period. These low levels reflected the lack of normal recharge due to the drought conditions. As a consequence, numberous shallow wells in the shallow aquifers went dry during the period. The effect of the drought on deeper aquifers in the region, however, is more difficult to assess because water level fluctuations may lag from a few weeks to a year or more behind climatic changes.

d. Special drought-related studies

Three studies were made of alternate water supplies for the Yakima Valley of eastern Washington. These included the feasibility of obtaining water from abandoned coal mines near Roslyn and Cle Elum; the assessment of the effects of increasing the pumpage of ground water from the Ahtanum-Moxee area; and the evaluation of the potential ground-water supplies from the Untanum and Roza synclines and the Kittitas Basin. As a result of these latter studies, funds have been obligated for the drilling of three deep (1,000 to 2,000 feet) wells and the deepening of one test well into the basalts of eastern Washington. These wells are expected to demonstrate the availability of large quantities of water from previously unexplored aquifers. A data summary is being prepared for the Upper Yakima Basin. This summary will be a compilation of the data and will provide a preliminary analysis of the water supply potential.

Information was developed to assist the Yakima Indian Tribe in evaluating the effects on existing domestic wells from the increased pumpage from large irrigation wells.

7. U.S. Forest Service (USFS)

Considering the severity of the 1977 drought, the impact on the National Forests was not as severe as expected. Some areas were closed because of fire danger; however, the supply of logs available to the lumber mills was not significantly reduced because of the "open winter" which did not inhibit logging.

The primary impacts of the drought were some reductions in grazing use and loss of young, newly planted trees. Some recreation uses were restricted on reservoirs in the Deschutes area because of low water at boat launching sites.

There were 2,400 forest fires which burned 12,500 acres which is slightly above the five-year average of 2,000 fires and 8,300 acres. There were fewer mancaused fires probably due to increased awareness of the public. However, it was the fourth worst year since 1908 in the number of lightning caused fires. In spite of this, most of these fires were kept small.

8. Soil Conservation Service (SCS)

The unprecedented drought conditions which prevailed over the Columbia River Basin during 1977 resulted in major increases in water supply forecasting and water conservation activities. The potential severity of the drought was first revealed by snow surveys conducted on January 1, after which the Soil Conservation Service mounted a Drought Awareness Campaign, aimed primarily at agricultural water users.

Informational materials such as brochures containing water conservation tips, news releases, and water supply outlook bulletin inserts were prepared in February for distribution beginning about March 1. These materials were released to the public as soon as the snow surveys were conducted and the continued severe snowpack deficiency confirmed.

As the public awareness of the pending water shortage was heightened, the Soil Conservation Service experienced an overwhelming increase in demand for information from the news media. An estimated four-fold increase in the normal number of news stories and interviews were generated during this time.

Field offices of the SCS report that requests for technical assistance in 1977 from farmers and ranchers who wished to improve irrigation systems and implement other water conservation measures increased by as much as 100 percent over the previous years volume.

9. Fish and Wildlife Agencies

The 1977 drought placed an increased workload on fisheries and wildlife agencies' research and management staffs. Considerable effort was devoted to coordination and monitoring of fish passage and flow conditions during "Fish Flow 1977," to facilitate downstream passage of juvenile fish on the Columbia River. On the lower Snake River a large scale juvenile fish transport program was undertaken. These programs are described in detail in Chapter VI. As a result of the drought and irrigation withdrawals, some reaches of the Yakima River were literally dried up and both adult and juvenile fish had to be trapped and transported around these areas.

10. State of Oregon

The 1977 drought had a very serious impact on the water supplies of some 47 cities and community water systems in Oregon. Voluntary and mandatory programs of conservation were required. Many private wells went dry in the Willamette Valley and southwestern Oregon requiring water to be hauled for domestic and livestock use. The impacts on agriculture were primarily of two types--stock water hauling and shortages of irrigation water and forage on grazing lands. This caused many cattle ranches to sell off part of their herds. Other impacts were high forest fire hazard, low streamflows with higher water temperatures affecting fish life, and virtual elimination of the ski season. An unexpected impact was the largest winter tourism season of record in the coastal area.

The Water Resources Department adopted a five-part program of drought-related actions. Dissemination of drought information was started prior to the irrigation season to advise special interest groups of the water availability and the laws relating to the appropriation and use of water. There was participation in 16 public awareness meetings held across the state, and publication of nearly 100,000 brochures on water conservation which were distributed to the public through schools, libraries, trade associations, and governmental agencies. A toll-free telephone (1-800-452-2826) provided information and assistance to many with drought-related problems.

During the first six months of the year, the Department received twice the normal number of applications for water-use permits. The Department diverted employees from various sections to help process these applications and hired additional employees to keep up with the work load. Fifteen additional Watermasters were hired to regulate and distribute the available water supply to users holding valid water rights and to prevent waste.

A water conservation study was initiated to recommend actions to effect a more efficient use of water. The study will cover both short- and long-term actions to be taken if drought conditions continue. A report will be issued in December of 1977, and a second report during the summer of 1978. Current forecasted water availability reports are made to the State Drought Council of which the Department is a member.

11. State of Washington

The drought, which dominated Pacific Northwest weather during the past year, had its greatest impact in Eastern Washington where Palmer Index values measuring drought severity dropped to an unprecedented low value of -9 during the past summer period.

To counter the problems created by the drought and coordinate all efforts, early in 1977 the Governor established an "Ad Hoc Executive Water Emergency Committee." This group, composed of state, federal, and local government agency representatives, has prepared biweekly reports on drought conditions, held periodic meetings and coordinated responses to the various problem situations as they developed.

A total of 34 counties in the State of Washington were designated as Emergency Drought Impact Areas by an Interagency Drought Coordinating Committee. These counties are eligible to apply for assistance through various federal drought relief programs.

Agriculture and the aluminum and ski industries suffered most, and it is forecasted that the drought will decrease gross production in Washington during 1977 and 1978 as much as 330 to 410 million dollars. Eighty percent of this loss is expected to occur in 1977.

The availability of 33 million dollars in state funds through emergency drought legislation helped to ease agricultural and domestic water supply problems. Through August, a total of nearly 600 temporary emergency authorizations and supplemental groundwater permits were issued by the State Department of Ecology to individuals and other entities to allow the immediate development of supplemental water supplies. In addition, a total of 13 contracts were prepared for grants and loans to public organizations to assist in the construction of emergency water supply facilities.

Although irrigated orchard crops fared better than originally anticipated, many row crops were not planted because of the expected water supply shortage, and dryland grains suffered appreciable losses from lack of rainfall during critical periods. The 1977 dryland wheat production, estimated at 86.4 million bushels, is only about 60 percent of last year's record amount. If poor soil moisture conditions continue, the fall planting of winter wheat will be precluded in much of the Columbia Basin area.

Through August, 1977, a total of 105 community and municipal water supply systems in Washington were experiencing or anticipating drought-related problems. Most of these were associated with dry wells as a result of declining shallow groundwater levels. (The state legislature earmarked 15 million dollars for domestic water supply problem relief.)

Early in the year, the "Fish Flow '77" program was implemented on the Snake and Columbia rivers in an attempt to preserve migrating fish populations. The program consisted of increasing flows through additional generation and spill at several Columbia River dams and trapping and transporting operations on the Snake River. Reports indicate that the program was successful although it was expected that later summer runs would be seriously affected by low flows and high water temperatures. Similar operations were conducted on smaller streams in the state.

The extreme fire danger from the dry weather was aggravated by heat wave conditions in mid-summer, and on state-owned lands alone, through August, there was a total of 1,042 fires which burned nearly 6,600 acres. The incidence of fires has been about double the normal rate, but through intensified efforts in detection, the total area burned has been relatively small.

12. State of Idaho

When snow measurements in February continued to indicate a major drought was developing, Governor Evans established the Idaho Drought Committee to anticipate drought caused problems and find solutions. He designated the Director of the Department of Water Resources as chairman and requested assistance from federal as well as state agencies and private interests. Seven task forces were established: Agriculture; Municipal and Industrial; Energy; Fish, Wildlife and Recreation; Economics and Employment; Data; and Public Information.

Efforts of the task forces were initially directed at predicting the severity of drought, then toward solving problems as they arose. Projections of streamflows, reservoir fills, and hydropower generation were made from the monthly seasonal water supply forecasts. These were used to project energy supplies, reservoir recreation, and water supplies for irrigation systems based upon their water rights and reservoir storage space ownerships. Projections of economic losses were also made.

A public awareness program was undertaken including a campaign for water and energy conservation. A drought information center was established to coordinate news releases regarding the drought. Communities were surveyed for the adequacy of their water supply systems to meet peak summer loads. A series of meetings followed by a very active campaign by the Extension Service was used to advise farmers regarding plantings and efficient water management. An irrigation scheduling information service based upon computed daily consumptive use was provided through newspapers in Southern Idaho.

Communities were encouraged to develop emergency water supply plans in the event their normal sources became inadequate. Water tanks for hauling domestic water were constructed and provided for use by communitites having problems. Funds from a Bureau of Reclamation grant were used to assist livestock operators hauling water for stock.

Above normal rains in July and August significantly reduced the drought severity through the state. Although nearly all rivers experienced record low runoff volumes for the water year, low flows during the summer generally did not fall to record minimums. Irrigation systems having major storage generally got through the season without severe shortages. Those with only small amounts of storage ran out of water early in the summer. The Wood and Weiser River basins and numerous other smaller basins suffered servere shortages. Dry land agricultural production was also far below normal.

13. Summary

In high runoff years, flood control is one of the more important considerations in the operation of the reservoirs system. Reservoirs are filled during the flood season and evacuated during the low-runoff period, providing water supply for irrigation and hydropower. Water quality, fish and wildlife, and recreation, usually benefit from this operation which provides for reduction in high flows and increased low flow. Criteria are quite well established for regulation of high flows, but it is more difficult to regulate flows during a drought. Regulation for any one of many needs will quite often conflict with the other water use.

In 1977, the water supply was less than adequate for production of hydroelectric power, irrigation, water quality, fish and wildlife, municipal and industrial water supply, and recreation. Federal, State, and Local Government Agencies met frequently to work out regulation of the water supply to meet the needs of all water users insofar as possible within legal limits and established rules. Conflicting interests were resolved by arbitration to benefit the people of the Northwest.

Activities of Federal and State Agencise dealing with the drought are described in preceeding paragraphs. Water was needed for everything except flood control. The year 1977 can be remembered as the year of cooperation and compromise.

Transporting Juvenile Salmon to the Sea

B. Flood Control

The geographical area covered by the Columbia River Basin usually has two annual flood seasons. October through March is considered the flood season west of the Cascade Mountains and is caused by heavy rains. The second flood season, May through July, occurs as a result of snowmelt generated east of the Cascade Mountains. Rainstorms may occur east of the Cascades during the spring and summer adding to the snowmelt flood and causing floods in tributary streams. Operation of reservoirs in the United States and Canada has reduced the magnitude of spring snowmelt floods in the Lower Columbia to the point where only extreme floods exceed bankfull. West of the Cascades, reservoirs control fall and winter floods in a number of locations but many streams remain uncontrolled.

1. Winter Floods

The period October, 1976, to February, 1977, was the driest of record throughout the entire Pacific Northwest. Normal winter weather returned to the region in late February and continued through March. Some stations reported 150 percent of normal precipitation for the month of March, but there were no severe storms and no flood flows in any of the streams. Both peak discharge and runoff volume were the lowest, or among the lowest, of record on the Columbia River and its tributaries. The Willamette River Basin is typical of those river basins west of the Cascade Range. The peak discharge for water year 1977 in the Willamette River at Salem, Oregon, was 33,000 cfs on March 10. Storage in 11 reservoirs was equivalent to 18,000 cfs on March 8 and 9, so the peak unregulated discharge at Salem would have been about 50,000 cfs. From records at Salem and Albany, the lowest annual peak at Salem for the period 1893-1976 was 63,700 cfs on November 6, 1943. The water year runoff at Salem was 7.09 million acre-feet in 1977. The previous minimum was 9.89 million acre-feet in 1931. (See charts 15 through 25 for an illustration of the reservoir operation in 1977)

2. The Spring and Summer Snowmelt Flood

Major reservoirs in the Columbia Basin were drawn down during the fall and winter for the production of power and to satisfy other needs. It was apparent, after the extremely low precipitation and runoff during the winter, that space was more than adequate for flood control and that operation should be accomplished for maximum conservation of water and to serve the demand for power and other functions insofar as possible. (Charts 3 through 14 illustrate operation of major projects during the 14-month period, July, 1976, through August, 1977)

Unregulated streamflow was computed for the April-July runoff period for selected locations throughout the basin by correcting discharges for some of the major irrigation diversions, and then routing these adjusted flows through uncontrolled lakes, reservoirs and channel reaches. See the glossary for a definition unregulated streamflow. (Charts 32 through 55 show observed and unregulated discharge at selected locations for the period of snowmelt runoff)

The Columbia River streamflow was controlled during the entire 1977 water year. The maximum daily discharge during the year, 183,000 cfs on May 27, for the Columbia River at The Dalles, occurred during the special release for fish. (See Chapter VI, Section D) The minimum daily discharge, 53,900 cfs, on July 10 occurred on a Sunday when the demand for power was low. The unregulated peak day was 276,000 cfs on June 12. See chart 54 for an illustration of the storage effect on streamflow. The maximum stage observed on the Columbia River at Vancouver, Washington, was 7.5 feet on March 9. The computed unregulated peak stage was 9.2 feet on June 12. See chart 55.

Runoff volumes corrected for storage in major reservoirs and lakes, and adjusted to the 1970 level of development for irrigation, (modified flows) are shown in the following tabulation for the years 1926, 1973, 1974, 1975, 1976, and 1977.

1970 LEVEL MODIFIED STREAMFLOW *
(1,000 Acre-feet)
FOR SELECTED YEARS
COLUMBIA RIVER AT THE DALLES

Month	WATER YEAR						52 Year Average 1926-1977
	1926	1973	1974	1975	1976	1977	
October	4420	5664	4669	4193	6064	5067	5512
November	3963	4834	6920	4294	7093	4237	5492
December	4492	5470	8713	4882	11154	3868	5848
January	3922	5900	13244	5326	8147	3497	5671
February	5145	4220	8508	5240	6586	3383	5788
March	6119	6117	10883	7274	7495	3499	7254
April	10848	7111	20005	10134	16441	7170	12940
May	14480	17899	29225	26126	35675	13367	25581
June	10621	17982	49061	36220	26485	14552	28019
July	8479	10570	23919	20863	20543	7163	15654
August	5694	6186	10207	8498	13964	6278	8276
September	4529	4052	5406	5623	8342	4347	5638
TOTAL	82712	96005	190760	138678	167762	76428	131676

* Corrected for change in storage in major lakes and reservoirs and adjusted to reflect irrigation depletion for the 1970 level of development.

These modified flows were developed by the Depletions Task for the period 1928-68 and extended by the Streamflow Adjustment Committee to encompass the period 1926-77. (See Chapter VI, Sections E and F.) Modified flow is also defined in the glossary. Runoff for water year 1977 was the lowest in the 52-year period, 1926 was the next lowest, 1974 was the highest, 1973 was the lowest in recent years, and the two recent years, 1975 and 1976, were included to show a complete five-year continuous record.

3. Flood Damages - 1977

A detailed summary of the operation of individual reservoirs and of the effect of regulation at several key gaging stations was presented in a previous section of this report. The effects of regulation are determined by routing and combining regulated and unregulated flows.

In past years, flood damages corresponding to observed discharges were determined for selected locations and the unregulated discharges described in the preceeding paragraphs used for determination of damage prevented. Damage in 1977 was caused by not enought water rather than too much.

4. Summary of Columbia River Basin Flood Control: 1949-1977

Prior to the 1930's, most water resource developments in the Pacific Northwest were constructed to serve single purposes such as power generation, irrigation, flood control, or municipal and industrial water supply. Between 1930 and 1940, construction of two major Federal multiple-purpose projects was undertaken and completed. Bonneville project was built on the Lower Columbia River by the Corps of Engineers to provide electrical energy and slackwater navigation. The Grand Coulee project was constructed by the Bureau of Reclamation to provide water for irregation and power generation. Following World War II, the Federal Government continued its policy of multipurpose water resource development. The devastating flood of 1948 placed additional emphasis on flood control and on the utilization of storage for reduction of the flood peak. Figure 12 is a list of major storage projects showing total active storage and the year of initial filling. A significant part of the active storage is usable for flood control on a forecast basis. Figure 13 is a tabulation of Maximum Annual Flood Peak Discharges in the Columbia River at The Dalles, Oregon, for the years 1949 through 1974, as computed without regulation and as observed. Damages prevented in the Lower Columbia and totals for the basin are also shown and represent the damage for the price and development of the year of occurrence. At today's price and development level, the amounts would be much larger. The damage prevented by control of winter floods on tributary streams is not shown, but should be noted.

Operation of Grand Coulee and other Bureau of Reclamation projects, in the interest of flood control was initiated in 1949 and the benefit resulting from reduction of the 1950 flood peak discharge from 823,000 to 744,000 cfs in the Lower Columbia was nearly 10 million dollars.

Between 1950 and 1956, Hungry Horse, Albeni Falls, Palisades, and Lucky Peak projects were completed. In April, 1956, the runoff volume of the April-September period was forecasted to be in excess of 130 million acre-feet. Steps were taken to obtain as much vacant space as possible for storage of flood water. The computed unregulated peak discharge of 940,000 cfs was reduced to 823,000 cfs and the resulting damage prevented was $38 million in the entire basin with $25 million being in the Lower Columbia.

In 1964, the Columbia River Treaty between the United States and Canada was ratified and construction was started on Hugh Keenleyside, Duncan, and Mica projects in British Columbia, Canada and Libby project on the Kootenai River in Montana. Between 1956 and 1971, Hugh Kennleyside, Duncan, Noxon, John Day, and Brownlee projects were added to the system. The Dworshak project in Idaho and the Libby project in Montana were under construction in 1972, and some of the storage in these two projects was used to reduce the 1972 flood peak. In 1973, McNaughton Lake behind the Mica project began filling. Details of the 1977 regulation are described in the preceeding section of this report.

MAJOR STORAGE PROJECTS
COLUMBIA RIVER BASIN

River	Reservoir	Total Active Storage 1,000 AF	Year of Initial Filling
Columbia	McNaughton Lake (Mica)	12,000	1973
Columbia	Arrow Lakes (Hugh Keenleyside)	7,145	1968
Duncan	Duncan Lake	1,411	1967
Kootenai	Lake Koocanusa (Libby)	4,934	1972
S.F. Flathead	Hungry Horse	2,982	1951
Flathead	Flathead Lake (Kerr)	1,219 1/	1938
Clark Fork	Noxon	231	1959
Pend Oreille	Pend Oreille Lake (Albeni Falls)	1,155 1/	1952
Columbia	F.D.R. Lake (Grand Coulee)	5,232	1938
Chelan	Lake Chelan	676	1927
Yakima	Total of 5 Reservoirs	1,066	1910-1932
Snake	Jackson Lake	847	1916
	Palisades	1,200	1956
	American Falls	1,125 2/	1926
Owyhee	Owyhee	715	1932
Boise	Anderson Ranch	423	1945
	Arrowrock	287	1914
	Lucky Peak	278	1956
Payette	Deadwood	162	1930
	Cascade	653	1947
Snake	Brownlee	980	1958
N.F. Clearwater	Dworshak	2,016	1972
Columbia	Lake Umatilla (John Day)	535	1968
Middle Fork Willamette	Hills Creek	200 3/	1961
	Lookout Point	337 3/	1955
Fall Creek	Fall Creek	115	1965
Row	Dorena	70	1949
Coast Fork Willamette	Cottage Grove	30	1942
South Fork McKenzie	Cougar	155 3/	1963
Blue	Blue River	85	1968
Long Tom	Fern Ridge	110	1941
Middle Santiam	Green Peter	270 3/	1967
South Santiam	Foster	30	1967
North Santiam	Detroit	300 3/	1953

1/ Natural lake storage, preserved in flood regulation by operation of project under free-flow condition during flood runoff period.

2/ New operating restrictions effective in 1972 reduced the active storage from 1,700,000 acre-feet to 1,125,000 acre-feet.

3/ The indicated Active Storage Capacity is that amount between minimum flood control pool and normal full pool. Exclusive power storage is not included.

FIGURE 12

EFFECT OF RESERVOIR REGULATION
ON FLOOD PEAKS
COLUMBIA RIVER BASIN

Year	Maximum Annual Flood Peak at The Dalles, Oregon (1,000 cfs) Unregulated 1/	Observed 2/	Damage Prevented Millions of Dollars Lower 3/ Columbia	Total 4/ Columbia Basin
1949	660	624	.67	NA
1950	823	744	9.80	NA
1951	652	602	.80	NA
1952	597	561	.34	NA
1953	672	612	1.18	NA
1954	590	560	.26	NA
1955	614	551	.62	NA
1956	940	823	25.00	37.67
1957	820	705	6.60	11.11
1958	735	593	3.55	7.83
1959	642	555	.88	2.60
1960	493	470	.08	.58
1961	789	699	6.50	7.70
1962	508	460	.09	1.79
1963	481	437	.03	.65
1964	764	662	7.60	22.91
1965	669	520	1.44	7.81
1966	455	396	None	.43
1967	781	622	14.21	20.80
1968	533	404	.26	1.07
1969	628	449	2.61	5.51
1970	634	426	1.16	6.34
1971	740	557	8.49	25.73
1972	1053	618	213.10	260.49
1973	402	221	0	0.52
1974	1010	590	239.73	306.36
1975	669	423	9.41	40.97
1976	637	419	15.65	43.08
1977	276	183	0.00	0.00

NA - Not Available

1/ Unregulated discharge 1949 to 1955 from House Document No. 403, 87th Congress, 2nd Session. 1956 to 1976 from Columbia River Water Management Group Annual Reports.

2/ Observed discharges from U.S. Geological Survey Water Supply papers.

3/ Damages are for the Columbia River below McNary Dam. Damages prevented for 1949 to 1955 are from House Document 403, and 1956 to 1976 are from Columbia River Water Management Group Annual Reports.

4/ Damages are for the Columbia River and selected major tributaries. Totals are those shown in Columbia River Water Management Group Annual Reports and represent damages prevented by major projects during the spring and summer high runoff periods. Winter flood damage in the Willamette and other tributaries and damage prevented by levees and channel improvements are not included. Damage prevented in Canada is not included.

C. Electric Power

1. Power Operations

The 1976-77 drought, one of the worst in history, had a severe effect on the power supply situation in the Pacific Northwest (PNW) and Southwest. In the Northwest, voluntary conservation was requested by the Coordinated System's utilities; industries' nonfirm loads were dropped resulting in loss of jobs and production, and some utilities paid inflated prices for energy purchased from outside the Coordinated System resulting in price increases for many of the utilities' customers. The drought in the PNW also had an adverse effect on the Pacific Southwest, since there was very little low-cost surplus energy available to help with their energy situation. The governors of the PNW became more involved in some of the water management and regional energy problems this year because of the drought. The governors endorsed the decision to spill water to enhance the downstream fish migration and set up a Northwest Electricity Task Force to develop a regional load curtailment plan. Both of these items are discussed in greater detail elsewhere in this report.

This power year started off in top shape with all storage reservoirs filled by July 31, 1976, and record high August runoff as calculated for the Columbia River at The Dalles, Oregon. The combination of full reservoirs and record-high streamflows in August caused the Federal Columbia River Power System (FCRPS) to be in a surplus status. This surplus energy, not usable in the Pacific Northwest nor storable for future use, was ample to load the California intertie to its capacity. Reservoirs stayed full and the FCRPS continued delivering surplus energy to the Southwest until September 13, 1976, when streamflows had receeded to the point that it became necessary to discontinue surplus energy deliveries and to begin drafting reservoirs to meet the load requirements of the Northwest. This ended a surplus period that began in December, 1975.

BPA energy sales to Southwest utilities from July 1, 1976, to September 13, 1976, totaled 5.1 billion kilowatt-hours. This energy is equal to about 8.4 million barrels of oil that would otherwise have been used for generation. During the period July through December, 1976, nonFederal utilities in the Pacific Northwest sold about 4.2 billion kilowatt-hours of energy to Southwest utilities, equal to about 7.0 million barrels of oil. See Figure 14 for fiscal year 1976-77 monthly energy deliveries to the Pacific Southwest via the intertie.

September, 1976, marked the beginning of the worst fall and winter drought in the history of the Pacific Northwest. Snowpacks on May 1, 1977, over the Columbia Basin were the lowest on record for that date, averaging only about 36 percent of normal--the lowest since measurements began 60 years ago. Streamflows reflected the dearth of winter storms and many streams, including the mainstem of the Columbia River, recorded the lowest October-July runoff of the 49-year record.

BPA discontinued direct deliveries of nonfirm energy to its industrial customers and secondary energy sales to private utilities on November 1, 1976. Secondary energy sales to public agencies were discontinued December 1. Because of the curtailment, industries reduced production to lower their load requirements and also obtained energy from numerous sources to meet a small remaining portion of their nonfirm load requirements. These energy sources included a special purchase of firm energy from BPA, advance energy from the provisional draft of U.S. reservoirs and from emergency draft of Columbia River Treaty reservoirs, a purchase of a portion of the output of the Centralia steamplant, and purchases from British Columbia and other industries in the Pacific Northwest. The special firm energy was a part of excess energy in the 4-year period, 1976-80, that could be shaped into the first year of the 4-year critical period. This excess firm energy was made available to the preference customers to replace their higher-cost Hanford extension energy and to industrial customers and investor-owned utilities. Between November, 1976, and early July, 1977, industries reduced their loads normally served with nonfirm power by about 68 percent or about 650 megawatts. The utility load normally served from secondary energy from the Federal System was carried by higher cost thermal generation from their own system or from purchases from British Columbia Power System.

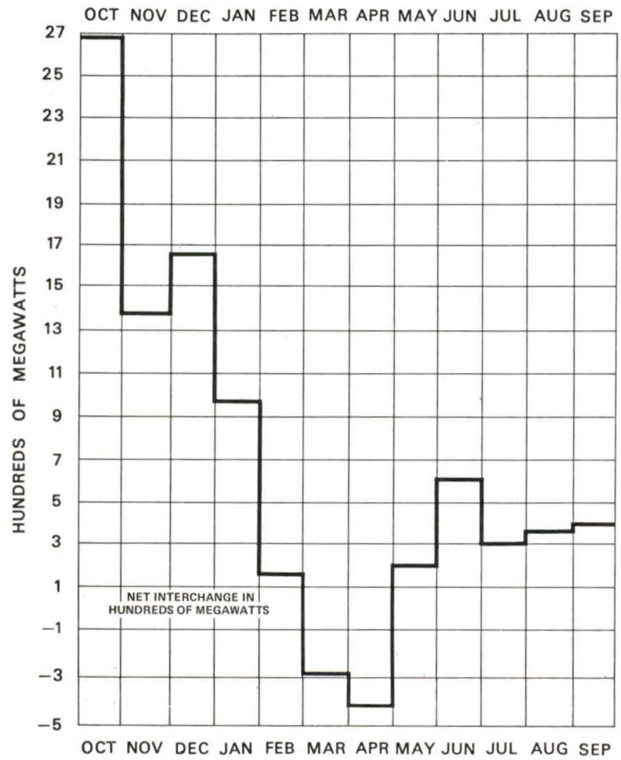
A condition on the delivery of advance energy is an obligation on the part of the industries to return the energy plus losses if it is required to serve firm loads. Return would be through purchase of energy from other sources or curtailment of their own firm energy purchases from BPA. Because of the continued extreme drought, the provisional storage draft from U.S. reservoirs was replaced by BPA through reduced sales so as to reduce any adverse impacts on recreation and other reservoir uses that might result from the energy advance. In spite of the replacement by BPA, the industries remain obligated for return of the advance energy should it be needed to carry firm loads later in the year.

The record-low runoff in the spring of 1977 resulted in unseasonably low storage reservoir levels throughout the region. The reservoir storage deficiency on July 31, 1977, the time when reservoirs normally are full, was 12.7 million acre-feet, equivalent to 14.1 billion kilowatt-hours of energy. This deficiency is about 30 percent of the energy that can be generated by drafting all reservoirs in the area from full content to empty. A slight amount of the refill deficit was due to operation "Fish Flow 1977," which released water to aid the downstream migration of juvenile salmon and steelhead trout during the period May 9 through June 17. Operation "Fish Flow 1977" is discussed in detail elsewhere in this report.

The impact of the drought on power resources has been reduced by loads underrunning the estimates. BPA firm energy load have underrun 5 to 7 percent each month during the operating year and the total Northwest loads have underrun 2 to 8 percent. Loads have been down due to the generally mild weather, depressed economic conditions, and conservation efforts by electric users. On February 14, 1977, BPA joined with other utilities in the area and concerned officials in a public request that all consumers effect a 10 percent voluntary curtailment in their use of electricity. Load data collected subsequent to this request indicate reductions on the order 7% were attained in spite of the extremely dry conditions which resulted in power and water demands for irrigation substantially greater than anticipated. Figures 15 and 16 graphically illustrate the load and resource status of the Federal and Coordinated Power Systems from July, 1976, through November, 1977. This period includes the 1977 water year. The Coordinated System includes the Federal and nonFederal loads and resources in the Pacific Northwest.

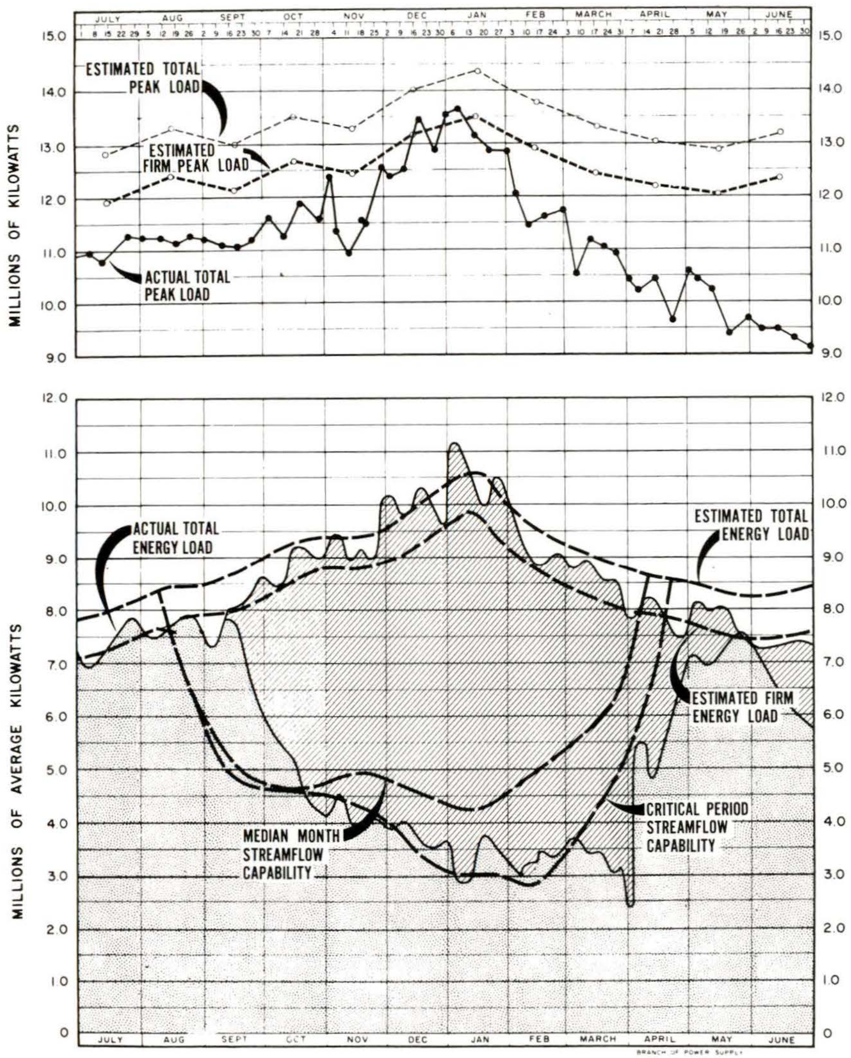
Only three generating units have been added to the Federal Columbia River Power System since July, 1976. These were the three large unit at Grand Coulee, G-21 (600-megawatt), unit 17 and 18 at Chief Joseph, placed in commercial operation on June 17 and July 26, 1977, respectively. Also, initial generation began at the Corps of Engineers' Lost Creek project on the Rogue River on July 6, 1977.

ENERGY DELIVERIES TO PACIFIC SOUTHWEST
VIA
PACIFIC NW SW INTERTIES



October 1976 — September 1977

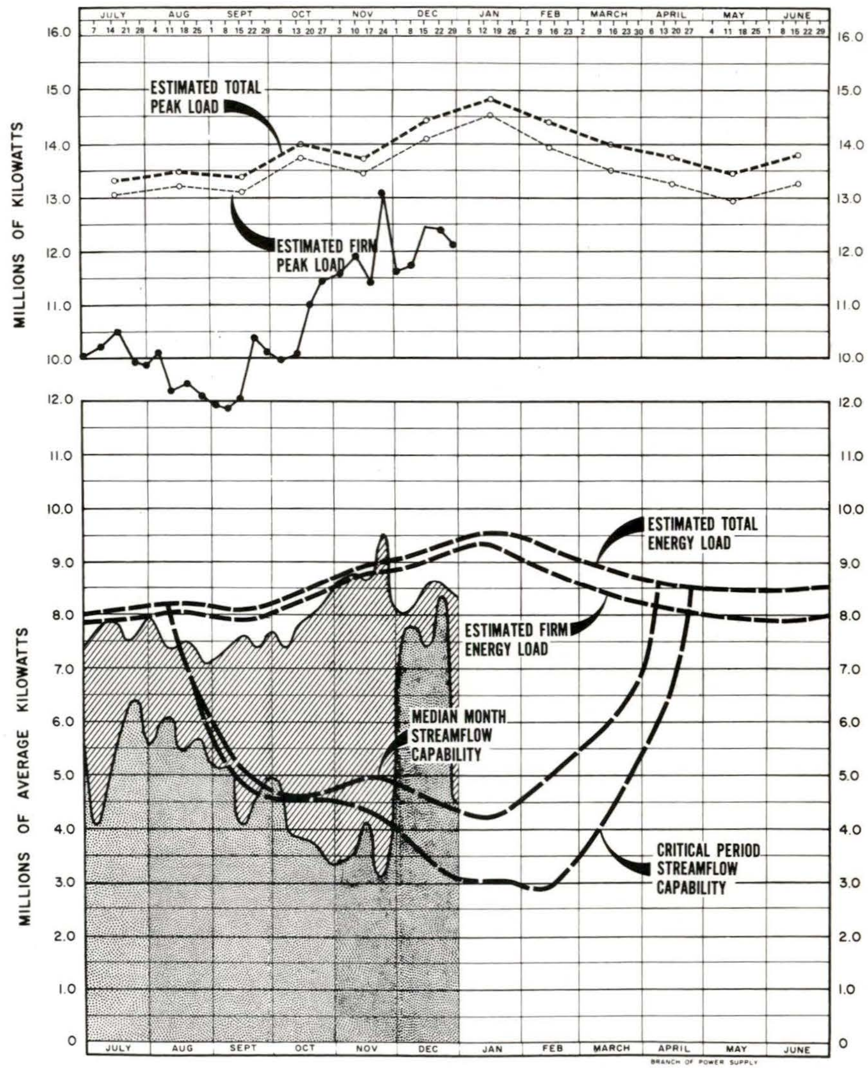
FIGURE 15



LOADS AND RESOURCES
BONNEVILLE POWER ADMINISTRATION
JULY 1976 - JUNE 1977

STREAMFLOW GENERATION
OTHER GENERATION STORAGE, THERMAL, MISC.

109394

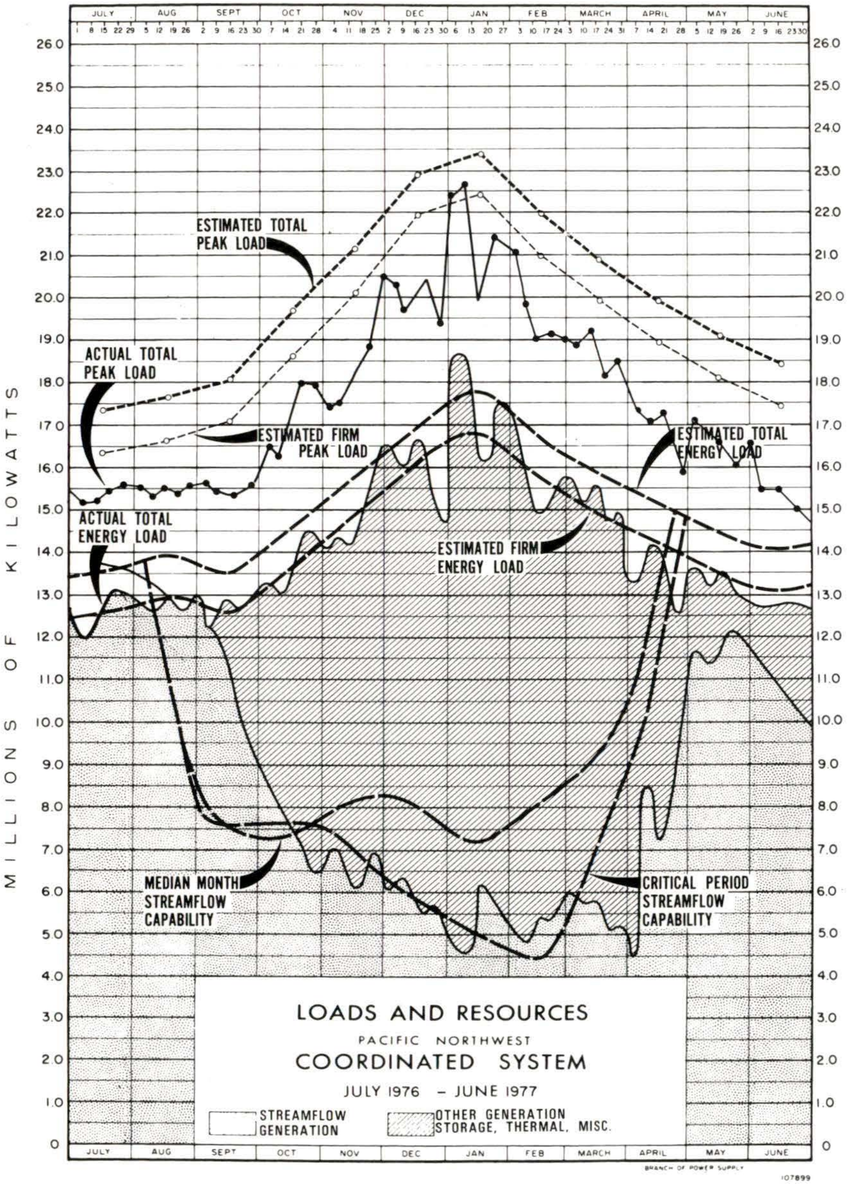


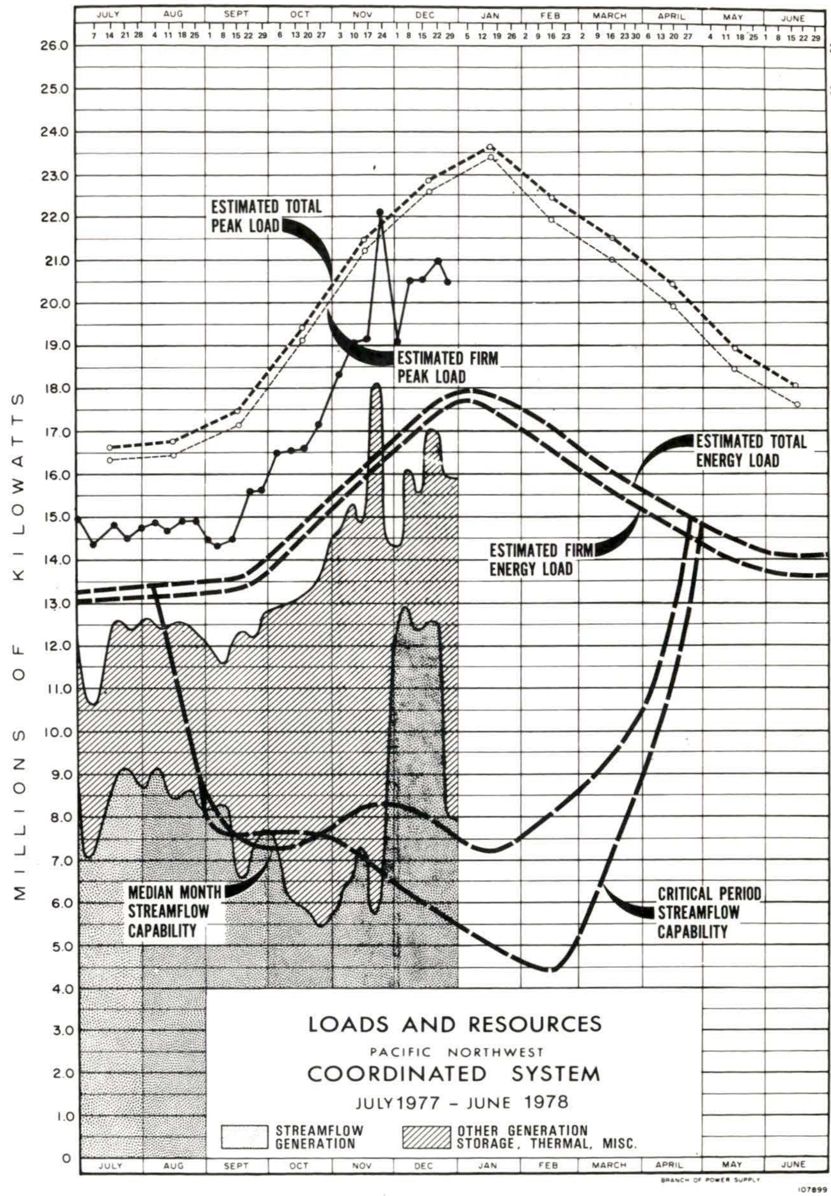
LOADS AND RESOURCES
BONNEVILLE POWER ADMINISTRATION
JULY 1977 JUNE 1978

STREAMFLOW GENERATION
OTHER GENERATION STORAGE THERMAL, MISC.

109394

FIGURE 16


ESTIMATED TOTAL PEAK LOAD
ACTUAL TOTAL PEAK LOAD
ESTIMATED FIRM PEAK LOAD
ESTIMATED TOTAL ENERGY LOAD
ACTUAL TOTAL ENERGY LOAD
ESTIMATED FIRM ENERGY LOAD
MEDIAN MONTH STREAMFLOW CAPABILITY
CRITICAL PERIOD STREAMFLOW CAPABILITY
MILLIONS OF KILOWATTS
JULY AUG SEPT OCT NOV DEC JAN FEB MARCH APRIL MAY JUNE
LOADS AND RESOURCES
PACIFIC NORTHWEST
COORDINATED SYSTEM
JULY 1976 – JUNE 1977
STREAMFLOW GENERATION
OTHER GENERATION STORAGE, THERMAL, MISC.
BRANCH OF POWER SUPPLY
107899


ESTIMATED TOTAL PEAK LOAD
ESTIMATED FIRM PEAK LOAD
ESTIMATED TOTAL ENERGY LOAD
ESTIMATED FIRM ENERGY LOAD
MEDIAN MONTH STREAMFLOW CAPABILITY
CRITICAL PERIOD STREAMFLOW CAPABILITY
MILLIONS OF KILOWATTS
JULY AUG SEPT OCT NOV DEC JAN FEB MARCH APRIL MAY JUNE
LOADS AND RESOURCES
PACIFIC NORTHWEST
COORDINATED SYSTEM
JULY 1977 – JUNE 1978
STREAMFLOW GENERATION
OTHER GENERATION STORAGE, THERMAL, MISC.
BRANCH OF POWER SUPPLY
107899

2. Power Outlook 1977-78

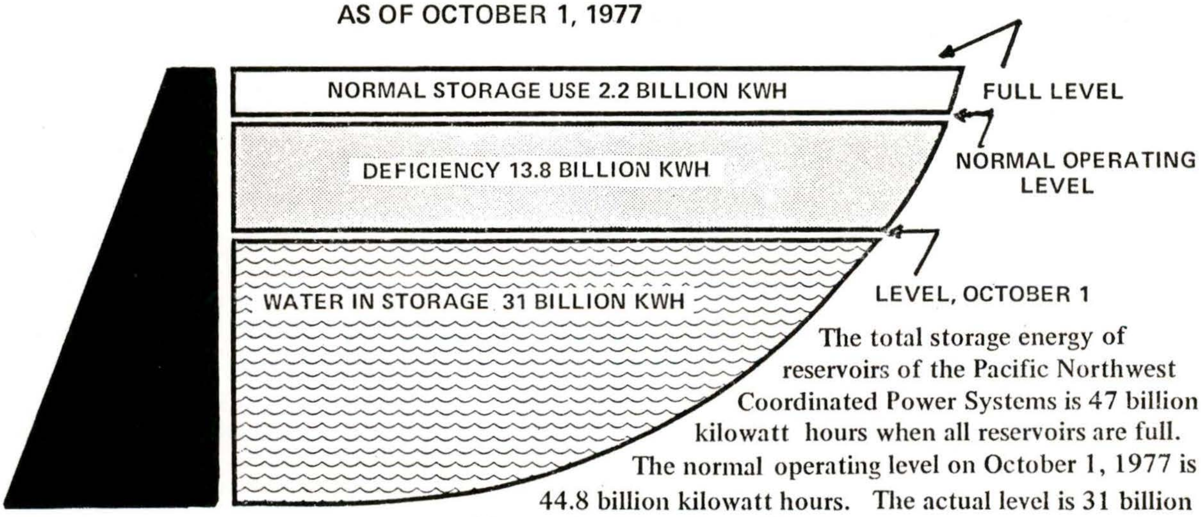
The failure to refill reservoirs during the summer of 1977 is cause for serious concern if low flows occur this winter. Although the region's firm loads can be met into next winter, we face a potential shortage in energy as reservoirs are depleted early next spring. If reservoirs emptied prior to next spring's freshet, only about one-half the region's electric loads could be met under some conditions of natural streamflow.

On July 31, 1977, the storage deficit in the region's reservoirs was 12.7 million acre-feet. Studies indicated that reservoirs would empty and firm loads could not be served through April, 1978, with a recurrence of August, 1936, through April, 1937, streamflows. To avoid drafting reservoirs to empty, one or more of the following actions would be required; continued and perhaps increased voluntary curtailment, the initiation of mandatory curtailments, operations of and/or purchase of output from high-cost generating facilities.

August runoff this year was the third lowest in the record dating back to August, 1925. By the end of September reservoirs were 16 billion killowatt-hours below full. (See Figure 17 for a graphical representation of reservoir conditions as of October 1, 1977)

STATUS OF PNW STORAGE RESERVOIRS

AS OF OCTOBER 1, 1977



The total storage energy of reservoirs of the Pacific Northwest Coordinated Power Systems is 47 billion kilowatt hours when all reservoirs are full. The normal operating level on October 1, 1977 is 44.8 billion kilowatt hours. The actual level is 31 billion kilowatt hours.

FIGURE 17

3. Revenues and Repayment of Power Costs

The severe drought conditions in FY 1977 resulted in a very adverse impact on BPA operating revenues which totaled $237 million for the full fiscal year. This represents a reduction of over $76 million (24.4 percent) from FY 1976, and is about $79 million (25 percent) below the estimate for FY 1977. These are preliminary figures subject to audit.

The drought conditions resulted in revenues of only $258 thousand in intertie sales compared with sales of over $62 million in FY 1976. Sales to the aluminum companies were also down more than $23 million from FY 1976. Fourth quarter availability credits reduced revenues by sales to the aluminum companies and other industrials by $5.2 million. While sales to the publicly owned utilities were $10 million lower than the FY 1977 estimate, this was the only customer category that exceeded the levels reached in FY 1976.

D. Federal Power Commission

Pacific Northwest power values, updated to July 1, 1977, for a complete range of plant factors, were supplied to the North Pacific Division, U.S. Army Corps of Engineers.

Annual operation inspections were make of licensed projects throughout the Pacific Northwest. Periodic inspections were made of the construction at the Rock Island second powerhouse, Project No. 943-WA, the Noxon Rapids fifth unit, Project No. 2075-MT, and the American Falls replacement power plant, Project No. 2736-ID. Construction of a fifth unit at the Brownlee power plant, Project No. 1971-ID, has begun and is inspected on a regular basis. The Commission granted an amendment to the license for the Skagit River Project No. 553-WA that allows the city of Seattle to increase the height of Ross Dam to provide for a reservoir at elevation 1725 feet. Construction has not started on this project.

The text of the preliminary draft of the Water Resources Evaluation Report for the Glines Canyon Development, Project No. 588-WA, was completed.

Water supply data for the Pacific Northwest were monitored for the Federal Power Commission/Federal Energy Administration Report on Impacts of the Western Drought. Data were furnished to the U.S. Bureau of Outdoor Recreation on the Power potential for the John Day River and the Snake River From the town of Asotin to the Hells Canyon National Recreation Area. Reviews and comments were made on feasibility studies for installing power at the existing Lucky Peak Project; the Meadow Creek and Moyie Canyon Projects on Moyie River; and on Priest River No. 4 hydroelectric site. A review was made of the draft report on the Columbia River and Tributaries Review Study, Base System Description for the mid-1980's; and the draft of the "Basic Source Material" Comprehensive Coordinated Joint Plan of the Pacific Northwest River Basins Commission. The staff also reviewed and commented on the drafts of Level B studies for water and related land uses, prepared by Pacific Northwest River Basins Commission State Study Teams, on the Yakima, Okanogan, Methow, and Snohomish River basins in Washington, and the Flathead River Basin in Montana. Environmental Impact Statements for projects in the Columbia River Water Management Area were also reviewed. A study of the reasonableness of the transmission rate schedule for Bonneville Power Administration was made.

E. Irrigation

The Bureau of Reclamation projects in the Pacific Northwest have 3.1 million acres of irrigable area. Fifty-seven reservoirs, with an active capacity of about 9,675,000 acre-feet, provide storage for irrigation use. This does not include the 8,214,000 acre-feet of storage in FDR Lake and Hungry Horse Reservoir. Water supplies during the 1977 irrigation season on Bureau of Reclamation Projects ranged from critically short to a full supply. This supply was influenced by carryover storage from 1976, storage accrual during the 1976-77 storage season, spring runoff, and natural flow rights.

Irrigation storage delivery was about 6,000,000 acre-feet compared to only 3,500,000 acre-feet in 1976. This was due to much drier conditions this year and a much earlier draft of storage water because the natural flows were not adequate to satisfy demand. Storage holdover at the end of the season was approximately 1,500,000 acre-feet which is nearly 3,000,000 acre-feet less than median. It is imperative that next year produces a better runoff or nearly all areas of the region will be facing critically short supplies except for the Columbia basin project.

F. Navigation

The Columbia-Snake River Inland Waterway extends from the Pacific Ocean to Lewiston, Idaho, a distance of 465 miles. The waterway has the capability of providing safe passage for oceangoing vessels and shallow draft tugs, barges, log rafts, and recreational boats.

The history of commercial navigation along the Columbia River and its tributaries dates from the early 19th century when fur traders used the waterways extensively. Later, oceangoing vessels reached Vancouver on the Columbia River, as well as Portland and Oregon City on the Willamette River. Steamboats navigated sections of the Columbia River upstream from Vancouver, But rapids, notably Cascade Rapids and Celilo Falls, and swift currents greatly curtailed waterborne commerce.

Navigation on the Columbia River to Pasco, Washington, is made possible by the four locks on the mainstem of the river. The four locks elevate the level of the river from 8.2 feet MSL at Bonneville Dam to 340 feet MSL at McNary Dam. Navigation of the Snake River to Lewiston, Idaho, is also made possible by four locks elevating the level of the river from 340 feet MSL at Ice Harbor Dam to 738 feet MSL at Lower Granite Dam.

The nominal dimensions of all locks, except at Bonneville, are 86 feet wide and 675 feet long. The Bonneville Locks are 76 feet wide and 500 feet in length. This lock is the bottleneck on the waterway and often requires that two lockages be made for the normal tows navigating the river. Replacement of the Bonneville Lock is currently under study.

Under normal conditions, navigation requirements on the Columbia are provided by streamflows and pool levels determined from other project requirements, and by periodic, maintenance dredging. Occasionally, however, unusual navigation requirements may demand special regulation of either streamflow and/or pool levels. These special requirements do not, however, generally alter the Columbia River regulation enough to have a significant effect on other project purposes.

A summary of traffic through the locks for the year ending 30 September 1976, is shown in Figure 18. No attempt has been made, in this report, to summarize the commerce in the Lower Columbia, which consists primarily of deep-draft, transocean shipping.

Japanese training ship in the Willamette River at Portland, Oregon.

COMMERCIAL CARGO THROUGH NAVIGATION LOCKS (1977 WATER YEAR)
(TONS)

	Willamette Falls	Bonneville	The Dalles	John Day	McNary	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Oct 76									
Up Bound	48,888	169,658	156,419	158,952	156,471	2,992	2,992	2,992	1,842
Down Bound	33,945	442,288	356,966	355,524	317,415	190.352	163,797	137,777	66,387
Nov 76									
Up Bound	25,141	171,166	155,699	152,966	156,373	365	365	365	365
Down Bound	31,980	383,469	303,374	291,677	272,413	173,431	164,289	145,214	61,674
Dec 76									
Up Bound	10,934	150,751	136,229	134,994	135,887	430	430	430	430
Down Bound	66,587	395,139	315,213	308,040	294,055	168,627	150,872	133,497	56,319
Jan 77									
Up Bound	13,685	102,280	97,785	97,785	99,633	4,387	4,377	4,377	4,377
Down Bound	57,685	357,798	259,872	274,937	257,046	156,573	144,915	133,355	53,117
Feb 77									
Up Bound	12,070	120,210	106,718	106,718	109,238	4,499	4,449	3,508	2,491
Down Bound	49,593	377,077	295,967	292,196	260,150	175,364	150,134	126,294	61,162
Mar 77									
Up Bound	16,293	129,099	100,736	106,449	100,148	3,370	3,340	4,281	392
Down Bound	41,863	412,120	344,087	319,900	307,088	188,584	173,528	161,083	67,200
Apr 77									
Up Bound	19,606	118,376	94,085	89,600	92,701	7,084	7,084	7,084	640
Down Bound	25,210	369,347	303,561	295,491	283,710	165,714	140,997	131,992	57,244
May 77									
Up Bound	17,534	93,380	86,060	86,881	85,572	2,456	2,456	2,456	2,456
Down Bound	28,758	468,450	354.469	355,815	347,972	226,733	207,808	193,388	95,674
Jun '77									
Up Bound	20,446	113,560	97,041	97,231	90,083	3,427	3,427	3,427	640
Down Bound	30,295	250,596	180,752	179,599	168,254	128,367	107,930	97,594	56,033
Jul 77									
Up Bound	18,195	136,839	107,292	106,178	111,211	2,711	1,739	1,739	820
Down Bound	22,384	407,809	356,023	347,347	304,302	190,459	144,526	133,889	60,100
Aug 77									
Up Bound	22,798	105,206	102,196	102,196	101,703	1,320	2,022	1,922	980
Down Bound	33,991	424,013	336,965	321,227	287,651	180,317	155,357	146,197	69,171
Sep 77									
Up Bound	19,085	142,465	143,628	143,628	145,066	11,624	11,207	11,207	670
Down Bound	33,795	331,690	266,590	261,560	238,096	184,529	167,392	149,407	96,854
TOTAL									
Up Bound	244,675	1,552,981	1,383,888	1,383,578	1,384,086	44,665	43,888	43,788	16,103
Down Bound	456,086	4,619,796	3,673,839	3,603,313	3,338,152	2,129,050	1,871,545	1,689,687	801,935

FIGURE 18

G. State Activities

1. Idaho

In December, 1976, the Idaho Water Resource Board adopted Part II of the Idaho Water Plan containing 37 policies and programs, many of which would require legislative action to implement. The plan includes allocation of water for 850,000 additional acres of irrigation, proposed minimum flow legislation, and limitation of future appropriations to maintain certain flows in the Snake River. In March 1977 the legislature passed House Bill 14 requiring that no part of the State Water Plan could take effect without prior adoption of the plan by the legislature.

> Section 42-1736 Idaho Code was amended as follows: "The state water plan adopted by the Idaho Water Resource Board, pursuant to authority of Section 42-1734, Idaho Code, shall not become effective until it has been submitted to the legislature of the State of Idaho and has been affirmatively acted upon in the form of a concurrent resolution which may adopt, reject, amend or modify the same. Thereafter, any change in the state water plan shall be submitted in the same manner to the legislature prior to becoming effective."

This new provision in the Idaho Code creates some uncertainty as to the impact of the State Water Plan as adopted by the Idaho Water Resource Board and no resolution has yet been determined. However, an interim legislative committee is conducting additional hearings on the State Water Plan and it is expected that the Second Regular Session of the 44th Legislature will consider legislation pertinent to implementing Part II of the State Water Plan.

The Department of Water Resources continued work with the University of Idaho and NASA under a Pacific Northwest Regional Commission grant to develop remote sensing methods for monitoring irrigation development. Results thus far indicate that irrigated acreages can be determined with about a 90 percent accuracy using satellite imagery. It appears that annual changes may determined with about 80 percent accuracy. Aerial photography and LANDSAT data are now being used for water-related land use mapping. It is hoped that remote sensing methods developed in the project can be use to provide basic data for river depletion studies and water rights inventories.

The Department of Water Resources continued development of groundwater evaluation capability. Digital models of the Snake Plain aquifer and the Rigby Fan aquifer were recalibrated. The University of Idaho completed development of a model of the Silver Creek aquifer and tested management alternatives to predict impacts on the groundwater and the flow of Silver Creek. The University and the Department continued development of a model of the Henrys Fork aquifer.

The onset of the 1977 drought caused substantial modification in water-related programs in the state.

In September the Department received a grant from the Pacific Northwest Regional Commission to complete development of a computerized water rights filling system.

Administrative programs of the Department of Water Resources included:

a. Safety inspections were completed on 209 dams in the state and repair orders were issued on 11.
b. Adjudication procedures were underway for eight basins in the state.
c. Permits were granted for 18 waste disposal wells. Well drillers' licenses were issued to 174 drillers. Six geothermal permits were issued.
d. Proposals for stream channel alterations were reviewed and permits issued on 369 sites.

2. Washington

Governor Dixy Lee Ray and Mr. Wilbur G. Hallauer, Director of the State Water Agency (The Department of Ecology) promised new emphasis on water resources.

A major amount of time was spent in drought-related activities reported elsewhere in this report. Washington's other water resource activities included:

a. State Water Program

The major elements of the state water management program are basin management programs, statewide water resource management policies and project assessment activities.

Each basin management program establishes base flows for the rivers and streams in that basin. It determines priorities for future use and allocates the water resources among the water uses. When the quantity of water diminishes to the point where it is insufficient for all uses, the program provides for the regulation of water use according to a previously identified set of priorities. Streams may be closed to further allocation when water supplies are not adequate to preserve instream uses. Existing water rights are not adversely affected by these programs.

The Little Spokane, Chehalis, and Okanogan River Basin Programs were adopted in water year 1976. The Methow River Basin Program was adopted on December 28, 1976, and the Colville River Basin Program was adopted on July 21, 1977. The Walla Walla, Yakima, John Day/McNary (reaches of the Columbia River), and Cedar River programs are in the final stages of completion and are scheduled for adoption during water year 1978. All necessary basin management programs will be completed by the end of 1981 under current scheduling.

Statewide policies are being developed for critical issues where an overall water management policy is desirable. The statewide policies supplement the individual basin management programs.

The Water Resources Information System (WRIS) was also established in accordance with the State Water Resources Act of 1971. Its purpose is to collect and store information relative to Washington's water resources.

Mr. Hallauer, announced on August 19, that the Department is "reviewing the many feasibility studies on projects proposed for the full development of the water resources through the state." He further stated, "These projects are being studied as a means of providing better long- and short-term solutions to ongoing as well as emergency situations with priority being given to the Yakima Basin." The announcement was made at a joint hearing of the House and Senate Committees on Energy and Utilities, Agriculture, and Ecology held in Richland, Washington.

b. Water Policy Study

President Carter announced on May 23 that he was initiating a comprehensive review of federal water resources policy. He directed the Water Resources Council, the Office of Management and Budget, and the Council on Environmental Quality to review existing water resource policy and present recommendations for policy coordination and reform.

The study is focusing on specific issue areas such as: (1) revision of water resources planning and evaluation criteria, (2) cost-sharing for federal projects, (3) institutional arrangements, (4) water conservation, and (5) federal reserved water rights. Water quality, water resources research, Indian water rights, and dam safety policy issues are also being reviewed.

President Carter directed that the review be conducted in consultation with the public and Congress. A hearing was held in Seattle on August 1 and 2 as one of eight regional hearings on "issue and option papers" prepared for the study and published in the Federal Register. Mr. Spencer, Assistant Director for Water Programs for the Department of Ecology, presented testimony on behalf of the state of Washington. A total of 51 citizens, agency representatives, and elected officials also testified.

Regarding federal reserved and Indian water rights, Mr. Spencer said, "We can think of no higher priority in the area of water law than to resolve the disrupting effects of the Federal Reserved Rights Doctrine." Indian and federal claims pose "a real potential to upset the state allocation systems and, even more devastatingly, to set aside long established economic and social bases of many communities in the West," he said. Spencer stated that "no interests of Indians should be confiscated," but emphasized that "interests of the vast remainder of Americans outside the Indian community must be kept in mind."

In reponse to criticism of study scheduling, the original study period has been extended from six to nine months.

c. USGS Cooperative Program

In the state of Washington, the Department of Ecology is the principle agency involved in the U.S. Geological Survey Cooperative Program. Currently, through the basic data program, the state is providing support for about 35 stream-gaging stations that are needed for statistical evaluation of surface water resources and for water management activities. In addition, eight lake-level stations are included in the program. A total of 138 observation wells are also funded under this program for evaluating water level fluctuations in the aquifers of the state. Flood profile investigations and extreme flow studies to measure and evaluate low flows and flood peaks are also part of the program.

The cooperative program also involves water quality monitoring of both surface and groundwater sources. A total of about 79 surface water sites are currently being sampled by the department and analyzed by the USGS. Groundwater quality is being monitored to meet responsibilities under PL 92-500 and PL 92-523.

Other cooperative projects include model studies of groundwater resources in the Spokane Basin, a coarse grid model of the entire Columbia River basalt aquifer, a study of saltwater intrusion in coastal areas, computerization of groundwater data and hydrologic data summaries for the Skagit, Upper Yakima, and Sanpoil River basins, and for the Horse Heaven Hills area.

d. Water Right Activity

During fiscal year 1977 (July, 1976, through June, 1977) the Department of Ecology processed a total of 1,811 applications for new water rights. Of these, 603 were for emergency authorizations associated with legislation to alleviate the effects of the drought. Nearly all of the emergency authorizations were for groundwater development in the Yakima Valley area.

In addition, during this time, 1,968 water appropriation permits were issued, of which 491 were drought related temporary emergency permits. A total of 1,754 permits were also processed to certificates of water right and 386 filings were cancelled.

Prompted by water shortages, action was taken by the department to investigate the need for a major adjudication of water rights in the Yakima Basin.

3. Oregon

a. Water Rights

The unusually short supply of water caused an increase in applications for permits to appropriate and use public waters. There were 2,784 applications received of which 1,525 have been approved by issuance of permits. Seventy-four requests for authorization to construct reservoirs and store a total of 50,000 acre-feet of water were also approved. Requests to change the location of use or point of diversion for existing water rights increased dramatically during this drought year with 345 requests being approved.

b. Hydrologic Data Collection

The Water Resources Department operated 155 stream-gaging stations in a cooperative program with the U.S. Geological Survey. In addition to the cooperative stations, 196 state-owned gaging stations were operated during the 1977 water year. Records from these stations are published in the annual publications of the Water Resources Department or the U.S. Geological Survey. A compilation of previously unpublished surface-water records collected by the state of Oregon prior to 30 September, 1965, has been published and is available upon request to the Water Resources Department. The cooperative program for collection of hydrologic data with the Soil Conservation Service (SCS), and U.S. Forest Service (USFS) has been continued.

c. Ground Water

Measurements of ground-water level have identified two areas in which use of ground water must be controlled to maintain a stable level. The Ordinance area encompasses approximately 175 square miles within the northeast corner of Morrow County and the northwest corner of Umatilla County. The Butter Creek area encompasses approximately 234 square miles of north-central Oregon lying south of the Columbia River near Hermiston, Oregon. Findings, conclusions, and order for each area have been made by the Director of the Water Resources Department. New construction standards for water well construction within the State of Oregon have been completed. The enforcement program for these standards is being implemented.

d. Dam Safety

During the 1977 water year the Division of Dams and Hydraulic Structures reviewed and approved plans and specifications for 37 proposed projects. The inspection of active construction projects was maintained and inspection for safety was made on 104 existion structures.

H. Water Quality

1. The Environmental Protection Agency (EPA)

EPA was involved in a number of water quality monitoring and assessment activities in 1977. In addition to the regularly programmed activities, several special water quality studies were completed during the extreme low flows brought about by the drought condition in the Northwest. A summary of the Agency's activities in the Columbia River Basin are briefly discussed below:

a. National Water Quality Surveillance System (NWOSS)

The U.S.G.S., EPA, Washington DOE, Idaho DHW, and Oregon DEQ are continuing to collect and analyze water quality samples from approximately 50 NWQSS stations in the Columbia River Basin. EPA has collected bottom sediments during low flow for organic and inorganic toxicant analysis at each of these stations.

b. Biological Monitoring Program

The Regional biological monitoring program designed to interface with the NWQSS program has been further expanded to include the entire Snake River system (including the major tributaries), the entire Spokane River system, and the Columbia system including all of the major tributaries. Idaho DHW, Washington DOE, and EPA personnel are responsible for collecting samples. EPA provided the analyses of the benthic macroinvertebrate samples from the sampling network.

c. Water Quality 1977 Intensive Surveys

The major intensive surveys completed by EPA in 1977 were primarily for the purpose of investigating the low flow water quality conditions brought about by the drought. The two major water quality surveys in the Columbia Basin were conducted in the Lower Granite Reservoir on the Snake River and the Lower Columbia River in the reach from Washougal to approximately 10 miles below Longview. Both surveys collected data to satisfy the following objectives: (1) document baseline water quality conditions during an extended low flow period, (2) determine water quality impacts of municipal and industrial waste sources, and (3) provide supportive data for low flow verfication of water quality models.

The Lower Granite survey was conducted the week of August 8-12. This survey covered approximately 32 miles of the Snake River from Lewiston, Idaho, to the Lower Granite Dam in Washington. Synoptic sampling of the reservoir and the waste discharge in the reservoir reach was accomplished through a joint effort by HIDW, EPA, and the Walla Walla District of the Corps of Engineers.

The Lower Columbia River survey was conducted the week of August 23-25 and covered approximately 72.7 miles. The field data collective and laboratory analysis was a multiagency cooperation effort with Washington DOE, Oregon DEQ, and EPA. The U.S.G.S. provided sampling and analytical support under contract to EPA. Eight municipal and eight industrial sources for a total of twenty-three discharge pipes were sampled concurrently with five mainstem Columbia and six tributary sites. A major emphasis of the survey in addition to temperature and dissolved oxygen considerations was sampling of effluents and river sediments for toxic substances.

The Region X office conducted a nonpoint source study in selected areas of the Yakima River Basin. The emphasis of this study was collecting water samples from irrigation return flows into the mainstem of the Yakima River. The main objective was to evaluate the effects of irrigation return flows on receiving waters during the drought period.

Water quality specialists and aquatic biologists from Region X of EPA have conducted joint water quality surveys with various BLM district offices within the Columbia River Basin during 1976 for the purpose of determining the effect of grazing activities upon water quality. The studies are being conducted in the Salmon River Basin near Challis, Idaho, John Day River Basin, and Burns area in Oregon. These studies continued through 1977 with less emphasis on the physical/chemical conditions and more emphasis on the biological aspect within these two basins. Intensive sampling of the benthic macroinvertebrate communities was completed during the summer of 1977. When hydrologic conditions again approach normal, intensive surveys during runoff conditions are planned. During the remainder of 1977, BLM will continue to collect samples on a monthly basis at key sites for analysis by EPA.

d. Nonpoint Source Assessment

A nonpoint source assessment is being finalized by the technical staff of EPA for every river basin in Oregon, Washington, and Idaho. The biological, recreation, and water quality status of every significant stream segment in each basin was determined based upon specific criteria. The segment status was related generally to land use, land ownership, hydromodification and other factors in each basin. Biological and recreational status was determined by field biologists from various federal and state agencies. The results of this study will be extremely helpful in determining nonpoint source priorities, data needs, potential standards revisions, and to determine the relationship between various land use practices. Completion of this project for all fourteen basins in EPA, Region X, is projected for December, 1977.

e. Water Quality Related Reports Published in 1977

Environmental Quality Profile - 1977

Additional information on the Environmental Protection Agency Water Quality studies may be obtained by contacting Bill Schmidt, Chief, Water Quality Surveillance and Investigation Section (206) 442-1210.

2. Corps of Engineers

a. Columbia River Regulation

A special regulation for the movement of fish, "Fish Flow 1977," was conducted during the period May 9 through June 17, 1977, in three phases of about 14 days each. This operation was first conducted between Wells and Priest Rapids projects; then through McNary and John Day projects and finally through The Dalles and Bonneville projects. It appears "Fish Flow 1977" successfully fulfilled the purpose for which it was intended.

b. Willamette River Regulation

Salem's minimum observed flow for water year 1977 was 3,900 cfs on February 19-20. On August 16, 1977, the Oregon Department of Environmental Quality (DEQ) measured a minimum dissolved oxygen (DO) level of 5.1 ppm at the SP & SRR bridge in the Portland Harbor; this value is still above the DEQ's minimum requirement of 5.0 ppm.

c. Gas Supersaturation (Nitrogen)

The only project spill that occurred was in May and June and was associated with operation "Fish Flow 1977." Therefore, nitrogen gas levels remained at or slightly below normal readings in the Lower Columbia and Lower Snake Rivers project reservoirs.

(1) Data Collection

No formal plans were made by the National Marine Fisheries Service (NMFS) or other agencies to take any dissolved gas samples due to the forecasted low runoff. However, any data that was collected by the NMFS and/or other agencies is available upon request from the Corps' North Pacific Division's (NPD) Water Quality Section.

(2) Data Report

Additional copies of the NPD 1975-76 Dissolved Gas Data Report are now available from the Water Quality Section. This report presents two years of dissolved gas and related data from projects along the Columbia River from Grand Coulee to the NMFS sampling station at Prescott, Oregon. Also, for the same period, the report covers the Lower Snake River project data from Lower Granite through Ice Harbor.

d. North Pacific Division District Activities

Because of the low-flow water conditions throughout the Columbia River Basin, each District office augmented their normal water quality monitoring program at all projects since early Spring 1977. Consequently, each District make a special effort to appraise any potential project water quality problems by obtaining additional data for the temperature, dissolved oxygen (DO), conductivity, and pH parameters. Whenever possible, the water samples would be taken at the project's inflow and outflow stations. Also, if possible, a profile of the above parameters would be taken at the project's forebay station.

(1) Portland (NPP)

Lost Creek Dam was closed February 18, 1977, and project personnel have continued their data collection efforts using the USGS's remote monitoring collection program. The daily data are fed via the Columbia Basin Teletype Network directly into the Corp. of Engineers computer in Portland. The Lost Creek data output are included in the daily NPP Reservoir Control Center (RCC) briefings. NPP will continue regular daily project water quality monitoring because of low river flows and include supplemental downstream water temperatures, dissolved oxygen (DO) and other related parameters. Also, whenever possible at the other NPP projects, special effort was made to collect the additional parameter data as requested by the Division office for the overall monitoring program.

(2) Walla Walla (NPW)

The District has been conducting their normal quarterly water quality monitoring program at the Lucky Peak project and in July they started taking supplemental temperature, DO, pH, and conductivity measurements in the discharge tunnel water.

At the Dworshak project, water quality personnel continued the quarterly monitoring program for the desired parameters and added a nutrient count due to the low river flow. Also, at Dworshak, Dr. Mike Falter, University of Idaho, conducted a study on Primary Productivity (Biological) as a follow-up to the project post-impoundment study.

Lower Snake River activities consisted of: (1) beginning the last year of the Lower Granite project post-impoundment study; (2) taking more temperature profiles in the Lower Momumental and Ice Harbor project's forebay and tailwater areas (approximately one mile up-and-downstream) due to the low river flow; (3) installing two thermograph recorders at the 50-foot forebay depth at the Lower Granite and Ice Harbor projects; and

(4) obtaining cross-section water temperature profile data from four locations in the confluence area of the Snake and Columbia rivers through a cooperative effort with the University of Idaho as part of a fish migration study that lasts until October 31, 1977.

(3) Seattle (NPS)

The District in coordination with seven other interested agencies conducted an intensive short-term (24-hours on August 16) study of the Lake Koocanusa aquatic environment during August 15-17, 1977. The purpose of these particular intensive in-lake studies was to gain information on lake processes that cannot be obtained through routine biological, chemical, and fishery sampling. These studies included sediment chemistry, sediment-water nutrient exchange, nutrient uptake by algae, zooplankton grazing rate on the algae, fish utilization of the zooplankton, and relative fish abundance, plus species composition. Also during this period, the simultaneous taking of routine Lake Koocanusa biological, chemical, and fishery sampling occurred. The principle sampling location was the established forebay station but other sites were also sampled. A special study report will be issued to interested parties at a later date.

At Pend Oreille Lake the District conducted a limnological study in conjunction with the Idaho Fish and Game Department to determine the status of the Fishery and lake productivity. The study results will help determine the effects of the operation at Albeni Falls.

There was continued effort by the District to monitor Lake Washington's salinity content. This is necessary to watch for any movement of the salt water wedge at the canal locks into Lake Washington. Also, timely measurements of the temperature, dissolved oxygen, conductivity, and pH parameters were taken at this project location.

The aforementioned efforts were conducted in addition to their usual water quality monitoring program for all projects. This year's ongoing monitoring program was especially important because of the adverse water conditions throughout the District. The water quality data collected will be helpful to interested agencies as they face the task of solving future water control problems within the Columbia River Basin.

3. Bureau of Reclamation

The water quality investigations include studies related to project planning, advanced planning, construction, operating projects, recreation, and energy. Several of these studies are ongoing programs and will continue with little change from previous years. The only new starts are in conjunction with energy studies.

As in past years, the water quality program includes the monitoring of water quality on water supplies, wasteways, and drainage ditches on the Yakima and Columbia Basin Projects. These studies are coordinated with studies being conducted by other Federal and State agencies to avoid duplication of programs.

Studies will continue on the three water management areas--Southwest Idaho, Upper Snake, and Yakima. Planning projects included in the General Investigation program which have water quality monitoring sites are the Hungry Horse Powerplant Enlargement and Reregulating Reservoir study in Montana; Anderson Ranch Powerplant Third Unit, Minidoka Powerplant Rehabilitation and Enlargement, and Oakley Fan Division in Idaho; and Grants Pass and Medford Divisions and Tualatin Project, Second Phase, in Oregon. Three projects will be studied in the advanced planning stage. They are the Kennewick Division Extension and the Oroville-Tonasket Unit Extension in Washington, and the Salmon Falls Division in Idaho.

Operating projects, in addition to the Yakima and Columbia Basin mentioned above which have continuing water quality studies, are the Boise, Minidoka, and East Greenacres in Idaho; and Grand Coulee and Manson in Washington. The program at Grand Coulee includes the projects continuing monitoring of dissolved gas levels at sites in Franklin D. Roosevelt and Rufus Woods Lakes. Another activity at Grand Coulee that will require water quality investigations is the Bureau's study to restore Crescent Bay Lake to a usable recreation lake. The lake is located near the town of Grand Coulee. Presently, the lake is highly eutrophic, caused by the sewage effluent from the town of Grand Coulee's treatment plant. Future plans call for the treatment plant to be moved and the elimination of the effluent from the lake.

New or enlarged power generation unit studies on Hungry Horse, Minidoka, and Anderson Ranch Dams require water quality investigations in the reservoirs and rivers. Computer models will be used to evaluate the data.

4. U.S. Geological Survey

The U.S. Geological Survey (USGS), in cooperation with the Environmental Protection Agency (EPA) operates a number of water quality surveillance stations on streams in the Northwest. In this program, the Kootenai, St. Joe, Coeur d'Alene, Spokane, Boise, Salmon, Snake, and Columbia rivers are sampled periodically at one or more sites for a number of constituents. Water temperature is one of the most important factors affecting water quality. Water temperatures are monitored at selected locations throughout the Northwest. Maximum and minimum temperature for the 1977 water year at 40 of these locations are shown in Figure 19.

In cooperation with State and Federal agencies, Indian organizations, counties, municipalities, and public utilities, the USGS operates water quality stations for surveillance of surface and ground water at over a hundred sites on streams, lakes, springs and wells in the Northwest. The USGS also operates a number of water quality stations in their National Stream Quality Accounting Network and Hydrologic Benchmark Network programs.

Activities involving water quality studies are increasing significantly mostly in monitoring, and definition of, constituents associated with pollution of the water resource. Data are needed not only to determine the occurrence but also to establish the source, distribution, and fate of constituents considered toxic or detrimental to the environment. Techniques for sampling, calibration, and analysis have had to be perfected and standardized to ensure data comparability throughout the Nation.

Following are water quality studies conducted for specific purposes:

a. Hanford Operations. A network of twenty wells in the Hanford Atomic Reservation, near Richland, Washington, are monitored yearly for selected radioisotopes and for other constituents and characteristics.

b. Spokane Valley aquifer. An intensive ground-water-quality study of the Spokane Valley aquifer is being conducted to assess the impact of septic tank effluent in the aquifer.

c. Irrigation return flow. Two studies of the quality of return flow waters from irrigated lands are being conducted. One is in the Sulphur Creek Basin of the Yakima Valley, the other in the Royal Slope area of the Quincy-Columbia Basin Irrigation District near Royal City, Washington. These studies are designed to assess the sediment and nutrient from irrigation return flows, and to quantify the changes brought about by improved farming practices.

d. A special drought water quality study was instituted in Oregon, consisting of the following programs:

(1) 28 stream sites spread across the state, each sampled twice, in cooperation with EPA and DEQ;

(2) 6 stream sites on Bear Creek (near Medford), each sampled three times in conjunction with Rogue Valley Council of Governments (RVCOG) and DEQ programs;

(3) 11 stream sites in the Evans, Siuslaw, and Molalla basins, sampled once or twice in cooperation with DEQ;

(4) 4 sites on the lower Columbia River, sampled on 3 consecutive days, in cooperation with EPA; and

(5) about 20 sites across the state, each site visited once in cooperation with several agencies. Preliminary analyses of the data collected by each of these programs are summarized below:

(1) Maximum diel (sampling over a 24-hour period) dissolved oxygen fluctuation ranged from 70 to 140 percent of saturation with a minimum concentration of near 6 mg/l.

(2) Diel water temperature fluctuations ranged from 0 degrees Centigrade on cloudy days to 10 degrees Centigrade on sunny days.

(3) Maximum diel pH fluctuations ranged from 7.0 to greater than 9.0.

(4) No significant diel alkalinity fluctuations.

(5) No large bacteria populations.

(6) Specific conductance values were higher than normal.

(7) Wide variation in types and numbers of phytoplankton, periphyton, and benthic invertabrates.

The Oregon District plans to correlate these data with streamflow, geology, and land use in an interpretive report at sometime in the future.

e. In similar drought-related studies in Washington, 700 measurements of specific conductance and temperature were make at 350 statewide sites. Measurements of pH, NO_3, NO_2, NH_4, KjN, PO_4, T-PO_4, and turbidity were made at 69 statewide sites. Twenty-four hour studies of nutrients, turbidity, suspended solids, and common constituents were made at 45 statewide sites.

Additional sampling for selected water quality parameters was conducted on three streams in an urban study area; two streams in an irrigated agriculture study area; on several sites in an urban lake; and from the last downstream station on the Yakima River.

Intake for the turbidity conduit at Lost Creek Dam

MAXIMUM AND MINIMUM WATER TEMPERATURES (°C) FOR CURRENT REPORTING STATIONS, WATER YEAR 1977
(PROVISIONAL DATA, SUBJECT TO REVISION)

															EXTREMES FOR PERIOD OF RECORD THRU 1976	
STREAM AND LOCATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR	TEMP	YEARS
COLUMBIA RIVER AT REVELSTOKE, B.C.	MAX	10.0	7.5	5.0	3.5	3.5	3.5	6.0	7.5	9.5	12.0	12.0	10.0	12.0	14.5	9
	MIN	7.0	4.0	3.0	1.0	2.5	2.5	3.5	5.0	7.0	8.0	9.0	--	1.0	.0	
KOOTENAI RIVER NEAR COPELAND, IDAHO	MAX	12.0	9.0	9.0	6.0	7.0	6.0	7.0	10.0	21.0	17.0	19.0	14.0	21.0	24.0	11
	MIN	7.0	6.0	5.0	2.0	4.0	4.0	5.0	7.0	10.0	12.0	13.0	10.0	2.0	.0	
KOOTENAY RIVER BELOW NELSON, B.C.	MAX	15.5	10.5	8.5	4.5	4.5	5.0	7.0	9.0	15.5	18.5	20.0	18.5	20.0	20.5	11
	MIN	10.0	8.5	5.0	4.0	4.0	4.5	5.0	7.0	9.0	15.5	18.5	--	4.0	.5	
COLUMBIA RIVER AT TRAIL, B.C.	MAX	14.5	10.5	8.0	5.0	4.0	4.5	8.0	9.5	16.5	17.0	20.0	19.0	20.0	19.5	12
	MIN	10.5	8.0	5.0	4.0	3.5	4.0	5.0	7.0	9.0	15.5	18.0	14.0	3.5	.5	
PEND OREILLE R.AT ALBENI FALLS DAM, IDA.	MAX	17.0	10.5	5.0	3.0	4.0	4.5	13.5	13.5	20.0	21.0	23.0	18.5	23.0	24.0	13
	MIN	10.5	5.5	3.0	1.0	1.0	3.0	4.5	10.0	12.0	19.0	19.5	14.5	1.0	.5	
COLUMBIA RIVER AT NORTHPORT, WASH.	MAX	--	--	--	4.5	--	--	--	--	--	--	--	--	--	21.1	25
	MIN	--	--	4.0	--	--	--	--	--	--	--	--	--	--	.0	
SPOKANE RIVER AT LONG LAKE, WASH.	MAX	17.0	15.0	11.0	9.0	10.0	11.0	14.0	16.0	20.0	20.0	20.0	19.0	20.0	23.3	12
	MIN	14.0	11.0	7.0	7.0	8.0	10.0	11.0	12.0	15.0	17.0	18.0	16.0	7.0	.0	
COLUMBIA R. BELOW GRAND COULEE DAM,WASH.	MAX	15.5	14.5	10.5	6.0	3.0	--	--	--	--	--	--	--	--	19.0	19
	MIN	14.0	10.0	5.5	2.0	2.0	2.5	--	--	--	--	--	--	2.0	.0	
COLUMBIA RIVER AT CHIEF JOSEPH DAM,WASH.	MAX	16.5	14.5	10.5	6.5	3.5	5.0	8.5	11.0	13.0	16.5	18.0	19.0	19.0	21.0	11
	MIN	14.5	10.5	6.5	3.5	3.0	3.5	5.0	7.5	10.5	12.0	16.0	18.0	3.0	1.0	
SIMILKAMEEN RIVER AT NIGHTHAWK, WASH.	MAX	17.5	7.0	4.0	.0	7.0	9.0	17.0	15.0	19.0	23.0	25.0	20.0	25.0	29.5	10
	MIN	4.0	.0	.0	.0	.0	.0	5.0	6.0	8.0	12.0	14.0	9.0	.0	.0	
COLUMBIA RIVER AT ROCK ISLAND DAM, WASH.	MAX	17.0	13.5	9.5	6.0	3.5	5.0	8.5	11.5	15.0	16.5	20.0	19.0	20.0	20.0	31
	MIN	14.0	10.0	6.5	3.0	2.5	3.5	5.5	8.5	11.5	14.5	17.0	17.0	2.5	.5	
COLUMBIA RIVER AT VERNITA BRIDGE, WASH.*	MAX	17.5	13.0	--	--	3.5	5.5	10.0	12.5	16.5	17.5	20.5	--	20.5	20.0	15
	MIN	13.0	--	--	--	2.5	3.5	5.0	9.5	11.5	15.5	17.5	--	2.5	.5	
COLUMBIA RIVER AT RICHLAND, WASH.	MAX	18.0	13.5	8.0	5.0	4.5	6.5	11.0	14.0	18.5	--	21.5	--	21.5	22.0	11
	MIN	12.5	7.5	5.0	2.5	2.5	3.5	6.0	9.5	12.0	--	18.0	--	2.5	.0	
YAKIMA RIVER AT KIONA, WASH.	MAX	18.5	--	--	--	--	10.5	--	18.5	28.0	26.5	27.0	--	28.0	28.9	24
	MIN	7.0	--	--	--	--	5.5	--	10.5	10.5	16.5	17.0	--	--	.0	
SNAKE RIVER AT KING HILL, IDAHO	MAX	15.5	13.0	8.0	8.0	10.5	11.0	16.5	16.0	20.0	20.0	20.0	18.0	20.0	22.8	26
	MIN	11.0	6.5	6.0	5.0	6.0	8.0	10.0	13.0	16.0	17.5	17.0	14.0	5.0	3.0	
SNAKE RIVER AT SWAN FALLS DAM, IDAHO	MAX	18.5	11.5	8.0	5.5	8.5	9.5	16.5	18.5	23.5	24.5	24.5	21.5	24.5	27.0	17
	MIN	11.0	7.0	4.5	2.0	4.0	6.5	8.5	14.0	16.5	19.0	20.0	15.5	2.0	.0	
SNAKE RIVER AT WEISER, IDAHO	MAX	13.5	6.0	--	--	6.0	11.0	--	21.5	26.5	26.5	26.5	24.5	26.5	28.0	10
	MIN	3.5	.0	--	--	.5	3.5	--	12.0	17.0	18.0	18.0	14.0	.0	.0	
SNAKE RIVER AT HELLS CANYON DAM, IDAHO	MAX	19.5	14.0	9.0	4.5	2.0	5.5	10.5	16.0	21.5	24.5	25.5	22.0	25.5	20.5	4
	MIN	13.0	9.0	4.5	.5	.5	2.0	5.0	10.0	11.5	15.0	16.0	15.0	.5	.5	
SALMON RIVER AT WHITE BIRD, IDAHO	MAX	19.0	12.0	5.0	6.0	10.0	11.0	16.0	15.0	22.0	28.0	28.0	26.0	28.0	26.0	10
	MIN	9.0	.0	1.0	1.0	4.0	5.0	9.0	10.0	14.0	18.0	16.0	12.0	.0	.0	
CLEARWATER RIVER AT SPALDING, IDAHO	MAX	15.0	9.5	5.0	4.5	6.5	8.0	11.0	12.0	20.0	20.0	23.0	18.0	23.0	27.8	17
	MIN	8.5	4.5	1.5	1.0	3.5	5.0	6.5	8.0	12.0	15.5	12.0	--	1.0	.0	
SNAKE RIVER AT LITTLE GOOSE DAM, WASH.	MAX	19.5	14.5	8.0	4.5	3.5	5.5	11.0	13.0	19.0	20.0	22.0	21.5	22.0	24.5	7
	MIN	15.0	8.5	4.5	1.5	1.5	3.5	5.5	12.0	13.0	19.5	20.0	17.0	1.5	.0	
SNAKE RIVER AT LOWER MONUMENTAL DAM,WASH	MAX	19.0	13.5	9.0	5.0	4.0	5.5	11.0	13.0	18.0	20.0	21.0	21.5	21.5	24.0	6
	MIN	13.5	9.0	5.0	2.0	2.0	3.5	5.5	11.5	13.0	18.5	20.0	18.0	2.0	.5	
SNAKE RIVER AT ICE HARBOR DAM, WASH.	MAX	19.5	13.5	9.0	4.5	4.5	6.0	11.0	13.5	19.0	21.0	23.0	21.5	23.0	24.5	15
	MIN	13.5	9.5	4.5	2.0	2.0	4.5	5.5	11.5	13.5	19.5	21.0	18.0	2.0	.0	
COLUMBIA RIVER AT MCNARY DAM, OREG.	MAX	19.0	13.5	8.5	6.0	5.0	6.0	12.0	13.5	20.0	20.0	23.0	20.5	23.0	23.0	23
	MIN	13.5	8.5	5.5	2.0	2.0	4.5	6.0	10.5	13.5	18.5	19.5	17.0	2.0	.0	
COLUMBIA RIVER AT UMATILLA, OREG.	MAX	19.0	13.0	--	--	4.5	6.5	11.5	13.5	20.0	20.5	--	--	--	21.5	7
	MIN	12.5	7.5	--	--	2.5	4.0	6.5	11.0	13.5	18.0	--	--	2.5	.0	
COLUMBIA RIVER AT JOHN DAY DAM, OREG.	MAX	18.5	12.5	8.5	5.0	4.5	5.5	12.0	13.5	19.0	21.0	23.5	20.0	23.5	21.5	5
	MIN	12.5	9.0	5.0	1.5	2.0	3.0	6.0	11.0	13.5	18.5	20.5	16.5	1.5	.5	
DESCHUTES RIVER AT MOODY, OREG.	MAX	14.0	10.0	--	--	--	8.0	12.0	13.5	18.0	18.5	19.5	16.5	19.5	22.2	21
	MIN	8.0	2.0	--	--	--	3.5	5.0	6.5	10.5	11.0	12.0	9.5	--	1.0	
COLUMBIA RIVER AT THE DALLES DAM, OREG.	MAX	18.5	13.0	9.5	5.5	5.0	6.5	11.5	14.0	19.0	20.5	23.0	21.5	23.0	22.8	18
	MIN	13.5	9.5	5.5	3.0	3.0	5.0	6.5	12.0	14.0	19.0	21.0	17.0	3.0	.5	
COLUMBIA RIVER AT BONNEVILLE DAM, OREG.	MAX	18.5	14.0	9.0	5.5	6.0	8.0	13.0	15.0	19.0	21.0	23.5	21.0	23.5	24.0	39
	MIN	14.0	9.5	6.0	3.5	3.5	6.0	7.0	12.0	15.0	19.0	21.0	18.0	3.5	.0	
COLUMBIA RIVER AT VANCOUVER, WASH.	MAX	18.5	13.5	8.0	4.5	5.5	7.0	13.5	14.5	20.0	21.5	23.5	20.5	23.5	23.5	28
	MIN	12.5	7.5	4.5	2.0	2.5	5.0	6.5	12.0	13.5	18.0	19.5	16.5	2.0	.0	
WILLAMETTE RIVER AT EUGENE, OREG.	MAX	17.0	14.5	9.0	7.0	10.5	11.0	16.5	15.5	20.0	20.0	20.0	18.0	20.0	21.0	9
	MIN	13.0	8.5	6.0	2.0	5.0	5.5	8.5	9.5	13.0	14.5	14.5	12.0	2.0	1.0	
WILLAMETTE RIVER AT SALEM, OREG.	MAX	17.5	12.5	--	--	--	--	--	--	--	--	24.0	18.5	24.0	25.6	26
	MIN	11.5	--	--	--	--	--	--	--	--	--	16.5	13.5	11.5	.0	
WILLAMETTE RIVER AT PORTLAND, OREG.	MAX	18.0	13.0	8.0	6.0	9.0	10.0	15.0	14.5		24.5	27.0	21.5	27.0	25.5	7
	MIN	11.5	7.5	5.0	2.0	4.0	6.5	8.5	11.5	12.5	19.0	18.0	15.5	2.0	1.0	
KALAMA RIVER NR KALAMA, WASH.	MAX	13.0	9.5	7.0	7.5	7.5	8.0	12.5	11.5	18.0	19.5	21.5	15.5	21.5	20.5	7
	MIN	5.5	1.5	2.0	.0	3.0	4.5	6.0	6.5	8.0	11.0	12.0	10.0	.0	.0	
COLUMBIA RIVER AT KALAMA, WASH.	MAX	18.5	13.5	8.5	5.5	5.5	7.5	13.5	14.5	20.0	21.5	23.5	20.5	23.5	22.5	8
	MIN	13.5	8.0	4.5	2.0	2.0	5.0	6.5	11.5	13.5	18.5	19.5	16.5	2.0	.0	
COWLITZ RIVER AT CASTLE ROCK, WASH.	MAX	13.5	11.0	9.5	8.0	8.0	8.0	13.5	13.5	19.0	19.5	20.0	16.5	20.0	22.2	18
	MIN	8.5	8.0	5.5	4.5	4.5	4.5	6.0	8.0	10.5	13.0	12.0	11.0	4.5	2.0	
COLUMBIA RIVER AT ALTOONA, WASH.	MAX	18.5	13.5	8.5	5.5	5.5	8.0	--	14.5	20.0	21.5	23.0	20.5	23.0	23.0	8
	MIN	13.0	8.5	5.0	2.5	3.0	5.0	7.5	12.0	13.5	18.0	19.5	16.5	2.5	.5	
CHEHALIS RIVER NEAR GRAND MOUND, WASH.	MAX	18.0	9.5	5.5	5.5	8.5	9.0	16.0	16.0	19.0	23.5	24.0	17.0	24.0	26.7	25
	MIN	9.0	1.5	2.0	.0	1.5	5.0	7.0	10.5	11.5	16.5	15.0	11.5	.0	.0	
GREEN RIVER NEAR PALMER, WASH.	MAX	14.0	8.0	5.5	5.0	5.5	6.0	9.5	8.5	13.5	14.5	15.5	14.0	15.5	18.0	23
	MIN	7.0	2.0	3.0	.5	2.0	3.5	4.0	6.0	8.0	11.0	12.0	11.0	.5	.0	
ROGUE RIVER AT RAYGOLD, OREG.	MAX	15.5	10.0	4.5	4.5	8.0	10.0	14.0	16.0	20.0	19.0	20.0	19.0	20.0	24.0	19
	MIN	7.0	3.0	1.0	1.0	3.5	5.5	8.0	10.0	13.0	13.5	14.5	11.5	1.0	.0	

* BACK RECORD IS FOR STATION BELOW PRIEST RAPIDS DAM, 6 MILES UPSTREAM.

FIGURE 19

I. Fish and Wildlife

1. Influence of Stream Hydraulics on Migration and Survival of Salmon and Steelhead Trout

Early in the year it became apparent that river flows would be below normal during the spring freshet. By mid-April it appeared likely that flows would even reach record lows. Faced with the recurrence of the disastrous fish losses experienced during the 1973 low flow year the federal and state fisheries agencies developed a plan advocating that special river flows be provided during certain periods to protect the seaward migrations of juvenile salmon and steelhead trout. In 1973 approximately 95 percent of the juvenile salmon and steelhead trout migrating out of the Snake River failed to survive the trip downstream to the ocean. This was largely attributed to the fact that because of low flows there was no spill at dams and all of the fish were forced to pass through the turbines.

Through the combined efforts of state and federal fisheries agencies and the federal and private water management entities, a plan called "Fish Flow 1977" was implemented on the Columbia. Basically, the plan was to provide an artificial freshet to help move the juvenile fish downstream through the rivers and reservoirs and to establish spill schedules at dams to reduce the number of juvenile fish that passed through the turbines.

On the Snake River the National Marine Fisheries Service trapped as many juvenile salmon and steelhead trout as possible at Little Goose and Lower Granite Dams and transported these fish by barge, truck, and plane to below Bonneville Dam. This program eliminated fish losses that would have been incurred at from two to three dams on the Snake River and four dams on the Columbia River. A detailed account of this program is given in the section entitled Commettee on Fishery Operations.

Extensive monitoring of the passage of juvenile salmon and steelhead at dams on the Columbia and Snake rivers indicated that "Fish Flow 1977" may have increased the survival of downstream migrants within the reach of the river from above Priest Rapids Dam to The Dalles Dam by about 20 percent. Monitoring studies in the Snake River indicated that the outmigration was only about one-third of the number of fish that had been expected. This was attributed to delayed migration and poor survival due to the low runoff in the tributaries. 1/

1/ Columbia Basin Salmon and Steelhead Report No. 5., July 29, 1977.

Adult salmon migrating upstream probably experienced fairly good passage conditions at most dams because of the low flows and lack of heavy spill. The adult were not exposed to high concentrations of dissolved air that results at some projects from heavy spill. At Bonneville, at least, they were not subjected to the hazards of falling back downstream through the spillway after having once ascended the dam. The adult fish, even though experiencing good passage conditions, may have suffered to some extent because of being exposed to above normal water temperatures resulting from low flows. This may have impeded migration rates and made them more vulnerable to disease. Certain reaches of some spawning tributaries were literally dried up because of the drought and irrigation withdrawals. In at least one instance, adult fish had to be trapped and hauled by truck around these impassable reaches of the river.

2. Anadromous Fish Runs

The 1977 spring chinook run above Bonneville Dam was an improvement over runs in recent years but was still below average for the past two decades. The run was large enough, however, to permit a limited sport and Indian fishery above Bonneville. No Indian and nonIndian sport and commercial fishing in the Columbia River or in Idaho had been permitted in 1975 and 1976 because the runs were so low.

The spring chinook run is composed primarily of stocks destined for the mid-Columbia River or the Snake River. The number of fish counted at Lower Granite, the uppermost dam with fish passage facilities on the Snake River, was 38,770, only slightly below th 40,000 escapement which the fisheries agencies consider is required for an adequate spawning population. The count at Priest Rapids Dam, the first project on the Columbia above the mouth of the Snake River was 21,217, the highest count on record.

The 1977 spring chinook run in the Willamette River was also improved over recent years. About 38,000 adult fish were counted at Willamette Falls which is the third highest count in the last ten years.

The summer chinook run is destined primarily for spawning areas in the Salmon River in Idaho and tributaries of the Columbia River above Priest Rapids Dam. This run has remained at a low level despite the elimination of the Columbia River fisheries since 1964. The count of summer chinook at Bonneville Dam was 41,023, the lowest count since 1947.

The fall chinook run above Bonneville Dam was smaller than had been expected resulting in premature closure of the commercial and Indian fisheries. By September 15, only 151,906 fall chinook had been counted over Bonneville Dam. This is 4,277 less than the 10-year average for this date. The count of adult chinook salmon at Willamette Falls by mid-September was about 12,400, slightly more than one-half the number counted by this time in 1975 and 1976.

The sockeye count at Bonneville Dam was about 100,000, well above the 10-year average and the 80,000 goal considered necessary for an adequate spawning escapement.

The 1977 upriver coho run in the Columbia was considerably below average. Only 19,428 fish were counted at Bonneville Dam as compared to the 10-year average of 65,738. This is the lowest coho count since 1962.

The steelhead trout run in the Columbia was much better than the runs in the past several years. By mid-November about 193,000 fish had passed Bonneville Dam. This is over 40 percent greater than the average count for this date during the last 10 years. The summer steelhead run in the Willamette River was excellent. The count at Willamette Falls was the highest on record. The healthy condition of this run has been attributed to increased hatchery production and survival rates of these fish.

The shad run this year was well above average. The counts at Bonneville Dam do not accurately reflect the total number of fish ascending the river as many fish pass through the navigation locks and are unobserved by the fish counters. The number of shad counted at The Dalles Dam was about twice that reported at Bonneville Dam.

BONNEVILLE DAM FISH COUNTS--1977
(As of November 15)

	Spring Chinook (1)	Summer Chinook (2)	Fall Chinook (3)	Coho	Sockeye	Steel head	Shad
Mar	3,569					1,159	
Apr	98,710				1	4,121	
May	17,229				38	4,115	51,709
Jun		21,790			74,551	11,395	431,540
Jul		19,233		55	25,178	67,554	11,818
Aug			21,992	1,134	61	35,161	568
Sep			171,309	15,163		66,084	76
Oct			11,767	2,581		3,298	12
Nov			1,016	495		588	
Season Total	119,508	41,023	206,078	19,428	99,829	193,475	495,723
10-Year Average (1967-76)	127,836	69,957	213,149	65,738	73,122	136,833	275,511

(1) March 1 to May 31
(2) June 1 to July 31
(3) August 1 to November 15

J. Recreation

1. River Drifting

There has been a dramatic increase in the number of "Wildwater Touring" enthusiasts using wilderness or white water rivers in the Columbia Basin. This sport is accomplished by navigating rivers in canoe, kayak, drift boat, and rubber raft. Motivation to engage in this ever-increasing sport involves wanting adventure and freedom, viewing and picture-taking of beautiful and seldom-seen scenery, attempting to catch native fish species, and other factors.

The need to plan safe white water drifting tours during times of optimum river flow has impacted the National Weather Service's hydrologic real-time data collection systems and both short- and long-range river flow forecasting services. The U.S. Forest Service and some state agencies have placed restrictions on river-running some rivers in the Pacific Northwest, which further requires daily monitoring and river flow forecasting services.

Several books published in the last five years give details and suggestions for planning and preparing for wildwater tour. These books cover such items as evaluating river difficulty, type of wildwater boats, boating accessories and repair, training for wildwater tours, camping gear and personal equipment, food, river-running and safety, and river tour guides.

Some of the more popular rivers where real-time data and river flow forecasts are required to meet wildwater touring needs as follows

Idaho -- Bruneau
Lochsa/Selway
Salmon & Tributaries
Snake

Montana--N.F. Flathead
Blackfoot

Oregon - Clackamas
Deschutes
Grand Ronde
Illinois
John Day
Owyhee
Rogue
Sandy
North Santiam
South Santiam

Washington - Skagit (and other Puget Sound drainages)
Toutle
Yakima

Other Pacific Northwest rivers are drifted at optimum flow periods to a lesser degree than those listed above.

It can be expected that more persons will be attracted to this river-use sport and that additional rivers will be drifted.

2. Corps of Engineers

Recreational usage of water resource projects developed by the Corps of Engineers continues to increase at an average annual rate of about 10 percent. During 1977 a total of 12.5 million visitors were reported at approximately 205 developed recreation sites on 43 projects. Three of these projects are experiencing usage well in excess of one million persons per year. Additionally, uncounted thousands of recreationists visit the many nonreservoir-type developments along major rivers and the Pacific coastline where little or no formal recreation facility developments have been provided.

Heaviest usage continues to be from sightseers, although many of these visitors normally participate in other water-associated activities such as boating, swimming, water skiing, picnicking, overnight camping, fishing, or just plain relaxing beside a body of water. With the continued efforts by the Corps of Engineers in the provision of visitor centers and interpretive facilities, sightseer participation is expected to remain heavy in the future.

Endeavoring to keep pace with the everchanging trends in the field of recreation, the Corps continues to broaden the perspective in the development of recreation facilities. The provision of such features as hiking, bicycling, and equestrian trails, and the designation of off-road vehicle areas on project lands help serve to round out the recreation experience of the project visitor.

All levels of government, federal, state, and local, participate in the development and management of project recreation areas. Planning for the expansion of existing areas and the development of new sites is continuing on a cooperative basis. The funding of recreation site developments on existing projects is generally subject to cost-sharing agreements with interested nonfederal public entities. However, recent policy resulting from extended discussions between the Department of the Army and OMB places certain limits on the extent of Corps involvement in recreation development of structural local flood protection projects, and also places restrictions on the types of recreation facilities which are eligible for federal financial assistance at such projects.

Significant benefits are realized from associated recreation opportunities and the more than 55 million capital investment so far expended for recreation facility developments.

3. Bureau of Reclamation

The Bureau of Reclamation reservoirs provide a major source of water-based outdoor recreation in the Pacific Northwest. The Bureau currently administers a portion or the entirety of 66 reservoirs and 5 major div- ersion dams totalling 384,000 acres of water surface and 2,300 miles of shoreline. In 1977, almost 12 million people visited these facilities. Nearly half of these visitors are sightseers, although many visitors are recreationists who participate in the great variety of activities available at Reclamation reservoirs. Fishing, camping, and picnicking are the favorite recreations; while swimming, water-skiing, boating, and a host of other sports are enjoyed.

The Bureau has also started developing the cultural and historical aspects of its dams. Construction has recently been completed on a new visitor center at Grand Coulee Dam. Self-guided tours of the dam are available to the public. This signals the beginning of construction of several other visitor centers. Two dams and powerplants in Idaho have been placed on the National Register of Historic Places. Both the Diversion Dam and Powerplant on the Boise River and the Minidoka Dam and Powerplant on the Snake River have been opened for public view.

Much of the construction of recreation facilities at Reclamation reservoirs is accomplished under cost-sharing agreements with nonfederal public agencies, in accordance with P.L. 89-72. Several reservoirs are managed in conjunction with other Federal agencies. An increasing number of reservoirs are administered solely by the Bureau of Reclamation. New recreation facilities at reservoirs under Reclamation administration are being designed and constructed to accomodate the handicapped. Special designs are employed in restroom facilities, short trails, and some docks to be used as fishing floats.

4. U.S. Forest Service

The number of recreation visits have not been tabulated for water year 1977 since the data is currently collected on a calendar year basis. However, from all indications, it appears that there was a very significant reduction in winter sports visits. However, because of the more open winter and warm, dry summer and fall, other recreation uses seem to have increased, somewhat compensating for the low winter use. It is therefore, expected that recreation use of the National Forests may be slightly higher than normal.

Jackson Lake Dam and Reservoir with the Grand Teton Mountains towering in the background

VI. SUMMARY OF ACTIVITIES OF THE WATER MANAGEMENT GROUP DURING 1977 WATER YEAR

A. Meetings

The Columbia River Water Management Group (CRWMG) met every month during the 1977 water year except August. At each meeting, reports were presented by agency representatives summarizing events of interest over the preceding month for which their agencies have major water management interest and activities as follows: Weather by the National Weather Service (NWS), Streamflow by the U.S. Geological Survey (USGS); Snow Accumulation by the Soil Conservation Service (SCS); Outlook for Power by the Bonneville Power Administration (BPA); Outlook for Water Supply in Irrigation Reservoirs, by the U.S. Bureau of Reclamation (USBR); Flood Control Operations and Reservoir Regulation, by the USBR, and U.S. Corps of Engineers (USCE); and Water Quality, by the Environmental Protection Agency (EPA). Task forces and committees reported on their activities and submitted recommendations to the CRWMG for approval and further action. Many of these activities are described in subsequent paragraphs.

Meeting No. 253

Meeting No. 253 was held September 15 in Portland. All major reservoirs in the Columbia Basin, including McNaughton Lake (Mica) were filled during the summer of 1976. Precipitation was above average in the month of August, so the reservoirs remained full or nearly full throughout the entire summer. The outlook for water for power production, irrigation and other uses was considered excellent. A presentation was made on "Electromagnetic Measurement Techniques for Moisture Measurements" by representatives of the National Bureau of Standards, Electromagnetic Division, in Boulder, Colorado 80302. The presentation covered techniques and application for use in determination of moisture in snow, soil, and concrete.

Meeting No. 254

Meeting No. 254 was held October 14 in Portland. The streamflow adjustment committee developed 1970-level adjustments for irrigation at selected locations and recommended that 1970-modified flows be computed and included in monthly reports. A proposal was also received through the Depletions Task Force to update depletion adjustments in the Snake River Basin.

Meeting No. 255

Meeting No. 255 was held November 18 in Portland. Precipitation was reported below normal in September, October, and the first 18 days of November. Streamflow was reported below normal. The proposal by the Nitrogen Task Force to join the fishery committee was accepted. Items of special interest to the Nitrogen Task Force will be emphasized at annual or semi-annual meetings of the Fishery Committee. The streamflow adjustment committee proposed that streamflow at selected stations be corrected for storage and adjusted to the 1970-level of development for irrigation, and that these modified streamflows be computed and published by the Northwest Data Center in their monthly report. A proposal was made by representatives from the Idaho Power Co. and by the Bureau of Reclamation that modified flows be corrected and updated for that reach of the Snake River from Buhl to Weiser.

Meeting No. 256

Meeting No. 256 was held on December 16 in Portland. It was reported that precipitation and streamflow was much below average throughout the Pacific Northwest. It was reported tha the Columbia River Operational Hydromet Management System (CROHMS) contract was awarded for installation of an automated data reporting network and central facility for the Willamette River Basin in Western Oregon. The contract for $2.9 million was awarded to EG&G from Albuquerque, New Mexico.

Meeting No. 257

Meeting No. 257 was held January 12 in Portland. The below normal run-off continued. The October-December precipitation was less than 20 percent of average on a significant portion of the Columbia River Basin and less that 50 percent of average on most of the remainder.

It was foreseen that, without above-average precipitation in the remainder of the winter and spring, reservoirs would not fill. Discussions were held on the conservation of water and power.

A proposal was made by Streamflow Adjustment Committee to correct monthly mean streamflow for storage and adjust to the 1970 level of development for irrigation at four locations. These data will be compiled and published by the USGS Northwest Data Center, in monthly reports, for the following stations.

STATION	PERIOD OF RECORD
Columbia River at Grand Coulee, WA	1926-
Snake River at Lower Granite, WA	1928-
Columbia River at The Dalles, OR	1926-
Willamette River at Salem, OR	1910-17 & 23-

This proposal was approved.

Meeting No. 258

Meeting No. 258 was held on February 23 in Portland. The below-average precipitation which began in September, 1976, had continued to mid-February. Runoff was below average throughout the basin. Based on the latest forecasts, which use average precipitation from forecast date forward in time, the Columbia River Reservoir System would refill to about 85 percent of its capacity, and the Willamette System would fill to about 60 percent of its capacity. State and Federal agencies are all actively engaged in conservation programs and studies to determine priority in water use. The Depletions Task Force developed a procedure for using information on 1970-75 irrigation depletion in the upper Snake River Basin to update modified streamflow to the 1975 level. This procedure was prepared by the Depletions Task Force and made available to all recipients of Modified Flow Reports.

Meeting No. 259

Meeting No. 259 was held on March 15 in Portland. The dry weather finally ended in mid-February when normal precipitation returned to the region. Forecasts indicated that with normal precipitation for the remainder of spring and summer season, Columbia Basin reservoirs would fill to 75 percent of their capacity, and Willamette Basin reservoirs would fill to about 80 percent of their capacity. States and Federal agencies will doing everything possible to encourage conservation, and to make best use of the short water supply. The Acoustic Velocity Meter (AVM) Task Force was established to consider replacement or updating of the AVM gage on the Columbia River at The Dalles, Oregon.

Meeting No. 260

Meeting No. 260, the 40th annual meeting of the Columbia River Basin Water Supply Outlook was held at the Public Service Building, Pacific Power and Light Company, Portland, Oregon, on April 7, 1977. The meeting was attended by 23 individuals from the United States and three from the Dominon of Canada, representing national, state, and provincial government agencies, and private power companies. Reports on snow cover, runoff, and forecasts were submitted by representatives from various sections of the United States and Canada, along with the outlook for power, irrigation, flood control, regulation to permit movement of migratory fish, and other water uses. Reports were much the same. The 1 April snow water content for the Columbia River Basin as a whole ranged from 20 to 65 percent of normal. The overall snow accumulation for the basin was the lowest on record. The accumulated precipitation for the period from September to March was less than 25 to about 50 percent of normal. The forecasted runoff for the Columbia River at The Dalles for the January-July period was 58,000,000 acre-feet or 53 percent of normal. This, too, establishes a new minimum-flow volume of record. The Pacific Northwest power system reservoirs were not expected to fill by 12,000,000 acre-feet, representing storage of about 70 percent of capacity. Following the regular meeting a news briefing was held and represnetatives from various agencies summarized the gloomy situation.

Meeting No. 261

Meeting No. 261 was held on May 10 in Portland. It was now almost a certainty that many of the reservoirs would not fill. The May 1 forecast of the April-September runoff for the Columbia River at The Dalles was 50 million acre-feet. This is 48 percent of the 1958-72 average. It was reported that arrangements would be made to spill at selected times at selected projects in the mid-Columbia and Lower Columbia to assist juvenile migrants in their downstream journey. Over a million juvenile migrants were transported from the Lower Snake River by barge, truck, and airplane. So far, reports of "FISH FLOW 1977" are very favorable.

Meeting No. 262

Meeting No. 262 was held on June 14 at Grand Coulee Dam, Washington. There was discussion of special drought problems in the different states, and problems faced by the different groups of water users. Every effort will be made to meet priority needs insofar as possible. The Acoustic Velocity Meter (AVM) Task Force reported that spare parts were no longer available for the Westinghouse equipment at the AVM gage in the Columbia River at The Dalles, and maintenance of that facility without spare parts was no longer possible. The AVM Task Force submitted six alternative proposals ranging from: (a) scrap everything to (b) move the Willamette AVM to The Dalles and replace the Willamette AVM with new equipment. Dr. Charles Stockton from the Unviersity of Arizona and Dr. George Hinman from Washington State University submitted a proposal for evaluation of tree rings as related to streamflow and development of long term hydrographs for evaluation of the water supply for hydropower and other uses.

Meeting NO. 263

Meeting No. 263 was held on July 13 in Portland. Most of the Columbia River reservoirs had filled to their maximum elevation for the year, and some were being drafted to provide water for power. The operation was considered very successful and the success was due to the cooperation of the many state and Federal agencies, private power companies, public utility districts, local governments, and other organizations and groups. The acoustic velocity meter (AVM) for the Columbia River at The Dalles is about ten-years old and spare parts for the equipment are not longer available. It was agreeded that this equipment should be replaced.

Meeting No. 264

Meeting No. 264 was held September 13 in Portland. There was some discussion concerning the outlook for power, irrigation, and other uses of the

Participants at Columbia River Water Management Group Meeting, Grand Coulee Dam - June 14, 1977

Left to Right, back row:

Wray Carroll, Bureau of Reclamation, Grand Coulee, WA
Alan Robertson, Idaho Dept. of Water Resources, Boise, ID
Harold Brush, Bureau of Reclamation, Boise, ID
James Donaly, Bonneville Power Administration, Portland, OR
Stan Kapustka, U.S. Geological Survey, Portland, OR
Thomas Caine, Bonneville Power Administration, Portland, OR
Bill Gordon, Bonneville Power Administration, Portland, OR
Tony Laenen, U.S. Geological Survey, Portland, OR
Jim Anderson, Corps of Engineers, Portland, OR

Front row:

Jack McLeod, Bureau of Reclamation, Boise, ID
Dave Rockwood, Corps of Engineers, Portland, OR
I. Paul Chavez, Federal Power Commission, San Francisco, CA
Nick Kallio, U.S. Geological Survey, Portland, OR
Newt Perry, Oregon Water Resources Dept., Salem, OR
Cliff Watkins, Bonneville Power Administration, Portland, OR
Vail Schermerhorn, National Weather Service, Portland, OR
Wilbur Simons, U.S. Geological Survey, Menlo Park, CA

water supply if the low runoff continues. The Portland office of the River Forecast Center (RFC) has a terminal connected to the National Weather Service's main computer in Suitland, Maryland. This will provide the RFC with access to temperature, precipitation, and GOES data. An IBM 370-155 computer system has been installed at the Office of the Corps of Engineers in Portland.

Meeting No. 265

Meeting No. 265 was held October 12 in Portland. It was decided that members of the CRWMG should develop a satatement summarizing effects of the 1977 drought for release to the news media. Evaluation was to be made of effects on hydropower, irrigation, fisheries, water quality, recreation, and other items affected by the drought. It was decided that the U.S.G.S. should make arrangements through its procurement section to purchase equipment needed for installation of the new AVM for the Columbia River at The Dalles, Oregon.

There was some discussion concerning operation of Hungry Horse, Libby, Dworshak, and Grand Coulee for power, without jeopardizing other requirements for use of the water.

B. Automated System Development

1. Columbia River Operational Hydromet Management System (CROHMS)

Several years ago the Corps of Engineers adopted the acronym (CROHMS) to describe the Columbia River Operational Hydromet Management System. This term is now widely used in the region when referring to data collection, transmission, processing, and management. The need for hydromet data management had its beginning more than four decades ago when the first hydroelectric projects were constructed on the Columbia River. The Columbia River basin now contains more than 80 major multiple-purpose reservoirs and single-purpose hydroelectric projects.

Until recently, hydromet data collection for project operation was manual, and the data reached the user via the Columbia Basin Teletype System, telephone, or mail. The last decade, however has witnessed the automation of approximately 300 key stations in the system which are now interrogated and reported automatically. In addition to VHF radio, which is the dominant mode of communication, other modes include UHF radio, meteor burst, land lines, and satellite communication. Through the efforts of the Columbia River Water Management Group and its individual member agencies, the development of a hydrometeorological network embracing nearly 400 stations has been realized. The hydromet data is used in the streamflow forecasting programs and provides information for the coordination of operating of these Pacific Northwest water resource projects.

Automation of key stations in CROHMS evolved from the necessity to handle an ever increasing volume of data that could no longer be manually processed in the time frame required for determining daily project operation. When completed, the automated portion of the system will contain more than 600 hydrometeorological stations that will report to a central data bank which is being installed in the new Federal Building in Portland by the Corps of Engineers.

2. The Interagency Memorandum of Understanding

The Hydromet Data Committee was formed by the Columbia River Water Management Group to oversee the development of CROHMS and to provide a sound basis for coordinating the development of the automated system. The following agencies on this committee are automating stations: Corps of Engineers, Bonneville Power Administration, U.S. Geological Survey, U. S. Forest Service, U.S. Bureau of Reclamation, National Weather Service, and Soil Conservation Service. With the exception of the Soil Conservation Service, all of these agencies have signed an interagency memorandum of understanding dated June 11, 1970. The overall responsibilities outlined in this memorandum are: (1) to prevent unnecessary duplication of facilities; (2) provide maximum utility and uniformity in collection and use of hydromet data; (3) ensure the highest degree of reliability at a minimum cost; and (4) gain the economies of multiple use of existing and proposed facilities consistent with individual agency responsiblilities. The Environmental Protection Agency and the Washington State Department of Natural Resources have also signed this memorandum.

3. Participating Agencies

The principle Federal users of CROHMS data are the Corps of Engineers for flood control, navigation, power production, and low-flow augmentation, Bonneville Power Administration for power scheduling; and the U.S. Bureau of Reclamation for power production, and irrigation. The U.S. Geological Survey collects and records data from stream and reservoir gages and provides data for many Federal, state, and private users. The National Weather Service utilizes the data for streamflow forecasting. The Soil Conservation Service collects and records snow course data for agricultural purposes and provides its users with snow data and runoff forecasts. The U.S. Forest Service uses CROHMS data for forest management and fire warning. Additional users include other federal, state, and private entities.

The Pacific Northwest has been divided into CROHMS coordination areas for which lead agencies have been assigned. The Corps of Engineers coordinates automation activities in the Willamette area, the Lower Snake area, and the Pend Oreille-Kootenai-Spokane area. The Bureau of Reclamation coordinates the Upper and Central Snake area, the Deschutes portion of the mid-Columbia area, and the Yakima area. The Geological Survey Coordinates the Puget Sound, Lower Columbia, and coastal area in the state of Washington. The National Weather Service coordinates the coastal area in the state of Oregon. Finally, the Bonneville Power Administration coordinates the remainder of the mid-Columbia and John Day area, the upper Columbia, and the Clark Fork-Flathead area.

4. Bureau of Reclamation

The Yakima project, in central Washington, during 1977, completed the installation of hydromet euqipment at 15 remote data sites in the Yakima Basin. This system provides Yakima Basin weather, reservoir, and streamflow data to the project headquarters control center in Yakima, Washington. The initial network consists of 15 automated remote data stations. Three repeater stations, and a programmable minicomputer for data acquisition and processing. The system has the capacity to handle up to 127 remote stations and will ultimately include supervisory control to facilities at the project's dams and diversion headworks. Radio and logic control equipment at remote data sites plus the central interrogation unit was furnished and installed under a contract with EG&G, Inc., Alburquerque, New Mexico.

At the present time the data from the Yakima controller is fed to the Bureau's CYBER system in Denver once a day. A paper tape is then punched in the Boise Regional Office from the CYBER files via a time-share terminal. The tape in turn is put in the CBTT for data distribution to other agencies. When CROHMS becomes operational, the Yakima data will go direct to the CROHMS Central Facility in Portland.

The Bureau of Reclamation is also planning a comprehensive hydromet system in the Snake River drainage above Hells Canyon Dam. This system was originally planned to be two separate systems, one operated from Burley, Idaho, the other from Boise. It has since been reconfigured and is now planned as one system with a single data controller located in the Boise area. Present plans call for the central interrogation station and 40-50 remote stations to be operable in 1979.

During 1977, the Central Snake Project Office in Boise completed the installation of automated data stations at: (1) Owyhee River near Rome, Oregon, and (2) Lake Owyhee near Nyssa, Oregon. These stations will report a combination of weather data, pool elevation, and stream discharge via the projects existing UHF radio system. At a later date these two stations will be added to the combined Snake River Hydromet system as previously discussed.

5. National Weather Service

The National Weather Service (NWS) program of automating streamflow and/or precipitation stations consists of using communications via satellite or telphone. Of the 37 authorized stations scheduled for relay by Geostationary Operational Environmental Satellite (GOES), 19 were equipped with new radio gear during the summer of 1977 and the remainder will be instrumented with new radios as funds are available. Presently, GOES reports are retrieved from the NWS computer in Suitland, Maryland, via a remote job entry terminal in the Portland River Forecast Center (RFC) and input to the interim CROHMS data base.

Telephone telemetered stations (32 in number) are interrogated by the Medford, Oregon, mini-computer which automatically records and relays the data to the RFC automatic terminal which has both hard copy and magnetic tape readout. The data on magnetic tape is input into the interim CHOHMS file. Data from this network will ultimately be input directly into the CROHMS data file.

By 1981, with implementation of the NWS Automation of Field Operations and Services (AFOS) at RFC Portland, a new dimension of automatic data relay will be possible, incorporating mini-computers at NWS offices for communications and on-site retrieval and display. The communication link between AFOS and CROHMS will permit automatic transfer of data and forecasts in both directions.

Conventional (manual) telephone telemetry at about 70 other streamflow and/or precipitation stations scattered through the Columbia River Basin are maintained and collected to fill operational streamflow forecasting requirements. These will be gradually converted to automatic interrogation as funds become available.

6. Bonneville Power Administration

The Bonneville Power Administration (BPA) has completed the automation of 41 remote data collection facilities under Phase I, II, and III contracts. These facilities include streamflow stations, snow courses, and climatic stations, and is a reduction from the 44 stations which were automated last year. One of the stations which was dropped by BPA had also been automated by the National Weather Service. In lieu of maintaining this station, BPA furnished the NWS with a "Silent 700" terminal for taping incoming data from the CBTT to enable inputting this data to the computer via magnetic tape rather than by hand-punched cards. One additional station should be automated via VHF radio by January 1. BPA is currently testing five GOES satellite data collection platforms (DCP's) prior to initiating Phase IV construction. Under Phase IV, BPA will install nine new DCP's, and convert five existing stations from VHF telemetry to GOES DCP's to increase reliability. Also under Phase IV, three additional stations will bring BPA's hydromet data system to a total of 54 automated stations.

7. Corps of Engineers

The North Pacific Division, Corps of Engineers, now has operational in its hydromet system, three subsystem controllers, 37 remote data stations and 17 repeater stations. One subsystem, centered in Walla Walla, uses seven repeaters and 19 data stations in the operation of Dworshak Dam on the North Fork Clearwater River in Idaho. The other subsystems centered in Seattle, are used in the operation of Libby Dam on the Kootenai River in Montana and Wynoochee Dam in the Olympic Mountains of Western Washington. Besides the alternate controller at Wynoochee Dam, this subsystem contains 18 data stations and 10 repeaters.

Plans are in various stages of completion for two more subsystems. One, located in the Green and Puyallup River basins of Western Washington, will contain up to 16 data stations, one repeater and an auxillary controller. Another, located in the Rogue River Basin of Western Oregon, will consist of a controller, two repeaters, and up to 15 data stations.

A contract was awarded in June, 1977, for the construction, installation, and test of a land-based radio, hydromet subsystem in the Willamette River Basin in Western Oregon. Field installation of 60 data stations, 14 repeaters, and controller is now underway. Operational testing will begin in February, 1978. Plans are underway for a second phase installation to contain approximately 26 data stations. These stations will be incorporated in the present subsystem with a completion date in the fall of 1978.

This contract also includes the installation of the CROHMS Central Facility Data Controller (CFDC). Completion of installation and beginning of operational testing of the CFDC is expected by July, 1978. The main central computer complex, located in the Federal Office Building in Portland, will be the heart of the CROHMS System. This complex consists of the CFDC computer and a general purpose mainframe computer. The CFDC, sometimes called the "front end," is a redundant computer data controller system with manual switch over. This includes two computers, two storage devices, two operations consoles, and two communication links to the mainframe computer. The object of the duplicity is to have "up time" of virtually 100 percent. This high degree of availability is essential because it will be the only source of data for the many interagency users.

The mainframe computer, also called the "back end," is the Corps general purpose IBM 370/155 which is also used for engineering and other applications work. The only equipment to be added to the 370/155 for CROHMS work is a critical data storage device for storing 60 days of important data necessary to compute reports and forecasts.

In general, the CFDC will (1) control the flow of data from Network Controllers to the mainframe computer, and (2) the flow of processed data from the mainframe to the users. Raw data will come into CFDC on a contention basis, i.e. when the network controllers complete polling of their data stations the information will be sent directly and without delay to the CFDC. The CFDC will first place the data in a raw data disk file, to prevent the loss of all data if the mainframe computer should fail. Next the raw data is forwarded to the mainframe computer for checking, validation, preparation of reports and temporary storage. These reports are then sent back to the CFDC where they are placed in a report file, to await retrieval by users.

Users will be able to obtain these reports on CRT, teletype-compatible devices, or high-speed printers by connecting their equipment to one of the CFDC output modems and calling for a special report. In some special cases, the data in the critical data file of the back-end computer can be similarily accessed for the preparation of special reports.

8. Soil Conservation Service

The Soil Conservation Service is not, at present, a signatory to the hydroment memorandum of understanding. They are, however, cooperating in the exchange of hydromet data, and the SCS system in the Columbia River Basin interfaces with CROHMS.

In April of 1977 the first SNOTEL remote data sites became operational in the Columbia basin. By July, first radio communications equipment had been installed at about 60 SNOTEL sites. Data are transmitted to one of two-base stations at Boise, Idaho, and Ogden, Utah, via VHF radio using meteror-burst signal reflection. Final testing of the system is scheduled for about February 1, 1978, which is the time of year when the occurrence of useable meteor trails is at its annual low level. Data are transmitted from the base stations to a control computer facility in the Portland office of SCS. Data archiving will be accomplished using the U.S. Department of Agriculture computer facility at Fort Collins, Colorado.

Sensors at these remote sites provide data on water equivalent of the snow pack, precipitation, and air temperature. System capacity allows for up to twelve additional sensors to be installed at any site. Radio communications gear and sensors will be installed at about 140 more sites in the Columbia Basin by 1979, at which time the SNOTEL project is scheduled to be completed.

The design of computer interfacing to facilitate the flow of data into the CROHMS system is underway. Policy and technical decisions on how this interfacing is accomplished are or will soon be made to allow full access by user agencies.

9. Geological Survey

Land System Telemetry. The U.S. Geological Survey (USGS), in cooperation with the city of Tacoma and Puget Sound Power and Light Company operates an automated hydromet data-acquisition network of 21 data stations and three repeater stations in western Washington. Data acquisition, processing, and distribution are controlled by a computerized central facility in Tacoma. The data acquired include river stage, air temperature, water temperature, and snow water content. Data processing includes conversion of river stage to discharge. Processed data are automatically distributed to the cooperators and to National Weather Service, Seattle, by teletype. Data for 6:00 a.m. weekday readings are also manually distributed to U.S. Corps of Engineers (USCE), Seattle, and to USCE-NPD, NWS River Forecast Center, and USGS Northwest Water Resources Data Center in Portland, Oregon, via the Columbia Basin Teletype Network.

Satellite System Telemetry. The USGS has installed and is operating LANDSAT instrument platforms at one snow station and two gaging stations in Washington, two gaging stations in western Montana, one gaging station in Idaho, two gaging stations in Oregon, and one water temperature station in Oregon. LANDSAT, formerly called Earth Resources Technology Satellite (ERTS), is a polar-orbiting satellite by which data can be relayed on an average of two to three times daily. Some of the platforms contain memory units wherein data are stored and then relayed in batches two or three times daily.

Ten Geostationary Operational Environmental Satellite (GOES) platforms have been installed in the Sandy River basin (mostly Bull Run) watershed in Oregon. These platforms are located at nine streamflow sites and one site where reservoir stage and precipitation data are collected. The precipitation data are obtained from an NWS rain gage at the reservoir site. The purpose is to test the feasibility of utilizing a geostationary satellite data-relay system to collect data for real-time needs as well as for documenting the water supply. The data will be furnished to Portland City Water Bureau for water management purpose. The test has identified problems in the platform hardware which were repaired by the manufacturer. These types of problems are common in newly developed, complex instruments and part of the testing process is to isolate and correct them.

Comsat General Corporation, in collaboration with the USGS, proposes to conduct a six-month test of their commercial satellite data-collection system and have installed five data collection platforms in the Rogue River basin. Data transmitted during this test will include river stage at four sites, forebay elevation at Lost Creek Reservoir, and water quality parameters (pH, trubidity, specific condutance, and water temperature) from one of the river stage sites. Comsat General will utilize an existing Canadian ANIK geostationary satellite for this demonstration. The starting date for this test will be in early November, 1977.

All USGS data relayed by satellite are entered into a USGS record file in Reston, Virginia, and are available to USGS field offices by way of computer terminals.

10. Treaty Stations

Embodied within CROHMS is the hydromet network required under the Columbia River Treaty between Canada and the United States. The Columbia

River Treaty Hydrometerological System consists of hydromet data collection facilities, a plan for methods and frequency of reporting, and a communication system to provide information for the operation of Duncan, Mica, Arrow, and Libby reservoirs. It includes hydromet stations which provide operational and forecasting data relevant to the flow of the Columbia River at Birchbank, British Columbia, or at an equivalent streamflow gage, and in addition certain key streamflow and reservoir gages on the Columbia River downstream from Birchbank and on the Clark Fork--Pend Oreile tributary. The bulk of this system is operational. Regulation of the Columbia River in Canada is very important for the downstream flood control and power operations in the United States. The U.S. and Canadian Entities are responsible for the continued operation of the Treaty hydromet system. The U.S. Entity is comprised of both the Administrator of BPA and the Division Engineer, USCE-NPD.

C. Hydromet Data Committee

The Hydromet Data Committee (HDC) serves a technical-coordination function for the Columbia River Water Management Group on hydrometeorological data acquistion activities. Since 1967 the work of this Committee has been directed primarily to the coordination and development of an automated Columbia River Operational Hydromet Management System (CROHMS).

1. Data Station Information File

One of the steps taken by the Hydromet Data Committee to uphold the responsibilities of the memorandum of understanding is the Interagency Hydromet Automation Status Report. This is a computerized listing of each agency's automated hydromet stations, both existing and proposed.

In a consolidation effort the Radio Frequency Station Listing has been combined with the Interagency Hydromet Automation Status Report.

As an aid to agencies and individuals involved in hydromet and water management, the Hydromet Data Committee compiled a glossary of ACRONYMS that generally are used relative to this field of work. Copies are available through the Hydromet Data Committee.

As a separate and related task, a listing of important water management and forecasting stations has been developed. This list contains over 500 streamflow and reservoir stations in the Northwest and identifies the operating and funding agencies, the primary purpose (classification) of each station, and the type of telemetry. This listing is intended to serve as an inventory of the source of funding for these important stations and is updated yearly. Copies of the listing may be obtained from the Northwest Water Resources Data Center, U.S. Geological Survey, Portland, Oregon.

2. Radio Frequency Assignments

The Radio Frequency Subcommittee (RFS) was established for coordinating remote hydromet station radio frequency requests from the agencies represented on the Hydromet Data Committee (HDC). Individual agency requests for radio frequency assignments are reviewed by each agency on the HDC to make sure there are no interference problems or duplication of siting. After review, the request is sent to the Hydrology Committee, Water Resource Council, NOAA, NWS, Silver Spring, Maryland. Following review at this level, the request is then forwarded to the Interagency Radio Advisory Committee (IRAC) for final frequency assignment.

The Subcommittee has also maintained and periodically updated an Interagency Cooperative Hydromet Radio Frequency Network Map. This map shows the locations of the automated stations using radio frequencies in the hydrological band in the CROHMS plan, both existing and proposed. A listing of stations on the Radio Frequency Network Map are included in the Interagency Hydromet Automation Status Report.

Since most of the planned radio frequency assignments hav now been made, the RFS has disbanded and the HDC wil handle the infrequent requests for future radio frequency assignments.

3. Presentations

The Hydromet Data Committee sponsored a presentation by Mr. Rod Morrison of Idaho Industrial Instruments, on nuclear snow water equivalent and precipitation sensors. Mr. Morrison presented comparative results of data collected from sites automated with both nuclear and conventional snow water equivalent and precipitation sensors.

D. Committee on Fishery Operations

The Committee on Fishery Operations met nine times during the 1977 water year. During the 1977 calendar year, John Hodges, National Marine Fisheries Service, and Gordon Green, Corps of Engineers, were co-chairmen of the committee.

At the committee's first meeting on February 10, 1977, it was faced with a much below normal runoff forecast. The low runoff forecast was the result of precipitation in the Columbia River Basin between September, 1976, and January being about 45 percent of normal. Also, the committee had received a copy of the December 22, 1976, letter from Regional Director of the National Marine Fisheries Service, to the North Pacific Division Engineer of the Corps of Engineers, Administrator of Bonneville Power Administration, and Regional Director, Bureau of Reclamation, expressing the concern of the state and federal fishery agencies for the "...welfare of the Columbia River anadromous fish if low flow conditions prevail in the spring and summer of 1977." At this first meeting the committee discussed four alternative spill and flow plans with varying degrees of effect on fisheries, power, irrigation, and other water users. Also explained was the plan developed by the Corps of Engineers and National Marine Fisheries Service for a barging program to transport the peak of the juvenile salmonid outmigration from the Snake River.

On February 24, 1977, the directors of the involved agencies agreed that some action was necessary to prevent disastrous and possibly irreparable damage to the Northwest's salmon and steelhead runs. The main alternative presented at this meeting was "Plan B." It was estimated that when compared to an alternative without special flow and spill, and additional 525,000 adult salmon and steelhead would return to above Bonneville Dam from the young fish protected by this proposal. However, this plan would require an estimated release of 3.8 million acre-feet of water over the estimated flow to meet the Northwest firm power load.

At a special meeting of the Pacific Northwest Regional Commission on March 8, 1977, to consider drought-associated problems, the Commission supported the request for a special fishery operation and asked that agency admistrators cooperate in implementing the concept of "Plan B."

During subsequent weeks, the flow and spill recommendations were reviewed and refined by the many agencies involved in managing the Northwest water resources. By April an operation, "Fish Flow 1977," was developed by the Corps of Engineers, Bonneville Power Administration, and the Bureau of Reclmation as a compromise to the fishery recommendation, "Plan B." The modified operation was developed to reduce the impacts on other water uses, and to utilize the water more efficiently.

Along with augmented flows and spill, "Fish Flow 1977" involved extensive monitoring of juvenile salmonids and adjusting the operation of the power system by altering maintenance schedules and exchanging power. The combined effects of these elements were instrumental in reducing the total storage requirement from the 3.8 million acre-feet. Most of the 1.4 million acre-feet was delivered as energy outside of the Northwest and will be returned during the summer and winter of 1977. Water spilled during this period is equivalent to about 150,000 acre-feet.

Augmented flows and spill enhanced survival of juvenile spring chinook and sockeye salmon migrating downstream from areas above Priest Rapids Dam. Their survival to The Dalles Dam was 29 percent--over three times the rate that is estimated would have occurred without "Fish Flow 1977." In contrast, survival of coho Salmon and steelhead trout smolts was only 13 percent and 16 percent, respectively. Subsequent sampling with purse seines confirmed that there were large numbers of both steelhead trout and coho salmon in the John Day Reservoir; it is assumed that flows were insufficient to move these fish through the reservoir.

A conservative estimate of the benefits from "Fish Flow 1977" is that an additional 332,000 to 367,000 adult salmon and steelhead will return above Bonneville. These additional fish are estimated to be worth 8.7 to 10.0 million dollars.

Three federal storage reservoirs, Libby, Hungry Horse, and Dworshak, provided the 1.4 million acre-feet of water used for this operation. As of October 1, 1977, about 52 percent of the energy stored outside the federal system had been returned. Most all of the energy is expected to be returned by February 28, 1978. Energy not returned will be purchased by the receiving utility. Energy losses due to spill and transmission amounted to 263,400 MWH. Operational cost of wheeling and storage charges amounted to 1.3 million dollars.

Augmented flows or spill were not required in the lower Snake River because of the hauling program. This year two barges were added to the trucks and airplane (experimental) already being used, in a program referred to as "Fish Haul 1977." About 2.8 million juvenile salmonids were transported from the lower Snake River to below Bonneville Dam. This was the largest juvenile transportation operation in history.

It is estimated that because of "Fish Haul 1977" between 70,000 to 106,000 adult fish will return to the Columbia River. Without hauling, 90 to 95 percent of the juveniles would not reach Bonneville Dam and only 11,000 adult fish would have been expected to return. Deducting the fish returning without hauling, the net benefit would be 59,000 to 95,000 fish valued at 4.0 to 6.5 million dollars. The hauling program is part of an ongoing Corps of Engineers research program carried out in cooperation with the National Marine Fisheries Service and other fishery agencies. Total cost of "Fish Haul 1977" was about 960,000 dollars.

Combined fishery benefits for both the "Fish Flow 1977" and "Fish Haul 1977" operations are estimated to range between 391,000 and 462,000 adults, valued at between 12.7 and 16.5 million dollars. Costs of the programs are estimated to range between 3.2 and 9.4 million dollars. A detailed report of these activities has been prepared and is available from Columbia River Water Management Group.

The role of the Committee on Fishery Operations was critically important this year in view of the record low runoff. As a supplement to the committee's operations, a representative of the fishery agencies attended briefings of the Corps of Engineers on river operations held at the Corps' Reservoir Control Center in Portland, Oregon. This provided an opportunity for exchange of information, coordination of hatchery releases with periods of flow augmentation, and coordination of various operational procedures adopted for fishery purposes. In addition, it was necessary for fishery agency representatives to be in daily contact with the Reservoir Control Center in implementation of "Fish Flow 1977."

E. Depletions Task Force

The Depletions Task Force has continued its review and analysis of the data on irrigation and water use for various segments of the Columbia River Basin. Engineers from the Idaho Power Company (IPC) and the U.S. Bureau of Reclamation (USBR) advised the task force of an increase from 1968 to 1975, of over 100,000 acres of irrigated land located in the Snake River Basin between Buhl and Brownlee Dam. This additional diversion of water has had a significant impact on the summertime flow of the Snake River. The task force reviewed other currently available information on new irrigation since 1968, and concluded that the need for the computation of a 1975 level of development was indicated. The task force recommended that: (1) the data developed by the IPC and USBR be used to compute incremental modifications for the 1975 level of development for the Central Snake Region and (2) that data for other portions of the Columbia Basin be modified by using a factor of two percent per year of the projected 1970-2020 incremental adjustment. Sample computations and tables of data needed to compute a 1975-level of development were sent to all recipients of 1970-level and 2020-level Modified Flow Reports.

The determination of irrigated areas by the use of satellite imagery is being tested in several areas in the Pacific Northwest. It appears that this procedure could be adopted for use in future depletion studies. The Depletions Task Force has initiated preliminary discussions with the Ad Hoc Committee on Remote Sensing to gain additional information about this subject.

F. Streamflow Adjustment Committee

The Streamflow Adjustment Committee developed a procedure for adjusting current streamflow to the 1970-level of development for irrigation. These 1970-level "modified" flows are extensions to those developed by the Depletions Task Force for the 40-year period 1928-68. Depletions for those years between 1970 and 2020 are found by straight line interpolation of the 1970-2020 incremental adjustments which were developed by the Depletions Task Force, and based on 1972 OBERS projections of irrigation development.

The Streamflow Adjustment Committee recommended to the CRWMG that 1970 level modified streamflow, at selected stations, be computed each month and published in the monthly reports which are prepared and distributed by the Northwest Water Resources Data Center of the U.S. Geological Survey.

That recommendation was accepted by the CRWMG. The four stations for which these data are computed and the periods of record are:

Columbia River at Grand Coulee, WA	1926-1977
Snake River at Lower Granite Dam, WA	1929-1977
Columbia River at The Dalles, OR	1926-1977
Willamette River at Salem, OR	1910-17 and 1923-77

These data have been used for comparison of the low runoff in 1977 and for other statistical evaluations.

The committee will study and develop methods for adjustments and analyses of streamflow for various conditions and various time periods.

G. Capacity Table Coordinating Committee

The primary function of this committee is coordination of the preparation and distribution of capacity tables for reservoirs in the Pacific Northwest (see 1976 report for membership). A new capacity table for FDR Lake has been prepared by the Bureau of Reclamation and the Northwest Water Resources Data Center and will soon be ready for distribution.

H. Acoustic Velocity Meters (AVM)

Conventional methods of stream gaging (stage-discharge, or stage-slope-discharge) are not adequate at sites where there is variable backwater and relatively flat water-surface slope. An AVM provides a continuous measure of stream velocity that is more precise than can be determined from the slope of the water surface. Four AVM gages have been installed in the Pacific Northwest, through joint funding of capital costs, by Corps of Engineers (USCE), Bonneville Power Administration (BPA) and Bureau of Reclamation (USBR). The U.S. Geological Survey (USGS) calibrates, maintains, and operates these stations. For a description of an AVM installation, see "Columbia River Management Group Report for Water Year 1972."

1. Columbia River at Grand Coulee Dam. The AVM, in operation since October, 1972, produces a 10-minute record of reservoir outflow that assists USBR with operational control of Grand Coulee Dam. Comparisons of AVM, Project, and slope-gage discharge values continued to show close agreement during the water year. Placement of rip-rap armor on the river banks caused only a slight adjustment to the cross-section area coefficients for discharge, but also caused some problems with dust in the instrument shelter. Four discharge measurements, made during the water year to check the discharge coefficients in use, were all within 2.7 percent of the discharges computed by the AVM. Acoustic transmission problems associated with water turbulence and aeration were much improved by the Third Powerplant, and the excellent cooperation and assistance of USBR has helped to maintain a high level of performance and minimal down time for this AVM. An appraisal of AVM operation for the part of the 1977 water year preceding June indicated that 81 percent of the AVM record was unflagged and immediately acceptable.

2. Snake River at Lower Granite Dam. This AVM has been in operation since October 1972, producing a 10-minute record of flow passing Lower Granite Dam. Discharges computed by the AVM generally compare well with Project values, but discharge measurement using boat equipment is too dangerous to confirm the AVM coefficients at high discharge values. One discharge measurement was made by boat during the water year, and it was within 3.1 percent of the discharge computed by the AVM. This AVM is generally visited only at scheduled monthly intervals, and the record of performance is less than other AVM's because much time may elapse before

problems are detected and corrected. An appraisal of AVM operation between January and April, 1977 indicated the presence of 74 percent unflagged and immediately acceptable data. However, data from this AVM are soon to be observed in operational applications, and the record should improve as AVM problems are found sooner and resolved.

3. Columbia River at The Dalles. The AVM has operated satisfactorily from April 1969 through the 1974 water year. However, electronics associated with the sonic signal transmission and interpretation, which had been functioning almost flawlessly, began to break down during the 1975 water year. The electronic circuitry broke down beyond field repair capability in May. No concentrated effort has been made to repair the instrumentation because of considerations to have a contractor update and repair or completely replace the existing equipment. A total of 63 velocity--meter measurements now define the discharge rating and no significant changes in the rating have been detected since its development in 1969.

The AVM Task Force, which disbanded in 1974, was reinstated for the purpose of studying the maintenance and repair problem at The Dalles, and to prepare recommendations to the Columbia River Water Management Group (CRWMC). Of several alternatives considered, the Task Force recommended that the existing instrumentation be replaced by new AVM equipment acquired through competitive bids. The CRWMC endorsed this recommendation and the Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation agreed to share in the acquisition cost. As with the other AVM's, the Geological Survey will assume financial and technical responsibiity for operating and maintaining the equipment.

4. Willamette River at Portland. The AVM has operated satisfactorily since installed in November 1972. The equipment is located in one of the towers on the Morrison Street Bridge. One transducer is on the piling of the drawspan and the other is on the sea wall. The path length of the Sonic Signal is about 740 feet and takes in about three-fourths of the total channel width. The streamflow regime, under which it operates, is entirely different from the Columbia River at The Dalles in that during low runoff periods there is reverse flow, and the transducers are located in a shallower cross section. The electronic equipment (associated transducer circuitry, onsite computer, and the teletype and punch) seems to operate very well. A computer failure occurred during the year which caused considerable lost record. A total of 33 velocity-meter measurements have been made at this site thus far. The dishcarge rating is now reasonably well defined for conditions of higher flow. For low flows and reverse flows, it will probably not be possible to define the rating closer than 15 percent because of variations in the vertical velocity profile through the tidal cycle, and limitations in the accuracy of low-flow current-meter measurements.

I. Radio - Isotope Gages

Radio-isotope snow gages are operated at numerous sites in the Columbia River basin. The 1975 annual report describes the various designs currently in use. The 1976 report provides updated information. There has been no change in the status of use of radio-isotope gages. No additional gages were added to the "network" during 1976.

A one-year moratorium on procurement of snow sensors was declared in 1977 by the administrator of the SCS. During the one-year suspension of procurement, a U.S. Department of Agriculture study team was organized and charged to review the performance of radio-isotope snow gages and snow pressure pillows. Their report will form the basis for deciding which type(s) of sensors SCS will be using at future SNOTEL sites.

Isotopic snow gage on Trinity Mountain near Boise, Idaho

VII. RELATED ACTIVITIES

A. Columbia River Treaty

The Columbia River Treaty between the United States and Canada, formally adopted on September 16, 1964, provided for the construction and operation of Mica, Arrow, and Duncan dams in Canada, and Libby Dam in the United States. Under the terms of the Treaty, each nation has designed an operating entity. The Canadian entity is British Columbia Hydro and Power Authority, while the United States entity consists of the Administrator of BPA and the Division Engineer, USCE-NPD. The entities have in turn appointed representatives to two committees: The Operating Committee and the Hydrometeorological Committee, which are charged with the carrying out the operating arrangements necessary to implement the Treaty.

During the course of the year, the Operating Committee met periodically to coordinate the details of the operation of the Treaty projects and to prepare plans for future operations. The Committee prepared four reports which are issued each year by the entitites; the Assured Operating Plan for Operating Year 1982-1983, the Determination of Downstream Benefits Resulting from Canadian Storage for Operating Year 1982-1983, the Detailed Operating Plan for Operating Year 1977-1978, and the annual report on Operation of Treaty Projects. The operating plans are based on systems analysis studies conducted by the Operating Committee.

The Hydrometeorological Committee met twice to coordinate the exchange of hydromet data between the entities, to coordinate forecasting procedure development, and to plan for hydromet automation.

B. Pacific Northwest Coordination Agreement

Operation of System storage for power generation during the 1976-77 operating year was extensively governed by the Pacific Northwest Coordination Agreement. This contract, providing for planned electric power operation among the major generating utilities of the Pacific Northwest, was finalized in August, 1964, after a long period of negotiation, and is scheduled to terminate on June 30, 2003. The Agreement provided operation guarantees which ensure usability of Columbia River Treaty Storage to the downstream generating plant and specifies restoration of pre-Treaty capabilities to certain plants under certain conditions.

The contract provides procedures for establishing system operating criteria for each succeeding operating year. Normally, the planning process is initiated on February 1 and is largely completed by July. The studies determine the system firm load carrying capability; energy exchanges, schedule of levels that each storage reservoir should follow in order to assure meeting system load and ensure refill, a determination of headwater benefit payments and establishes rights and obligations of each party for the use of stored water at headwater projects.

The 1976-77 operating year began with all storage reservoirs filling by July 31, 1976. There followed the wettest August on record which resulted in loading the California intertie to capacity with surplus energy. September, 1976, began the worst Pacific Northwest drought in recorded history. On September 18, BPA deliveries of surplus energy to the Pacific Southwest were discontinued. BPA direct deliveries of nonfirm load to industrial customers were discontinued November 1 and secondary sales to public services agencies were discontinued December 1.

Activities of members of the committee have been intensely devoted to planning operations in accordance with the Coordination Agreement under the record low water conditions. They have also included load curtailment plans, fish flow operations, and hydro and thermal system scheduling arrangements outside the coordinated system to reduce the impact of the drought.

During this year's planning for the 1977-78 operating year, there continued to be some difficulties. The Detailed Operating Plan preliminary study resulted in a three-year critical period and subsequent deep draft of Canadian reservoirs. The Canadians have therefore requested that their planned operation correspond to the 1977-78 Assured Operating Plan (AOP). The Coordinated system therefore adopted first-year critical rule curves from the AOP, retaining the firm energy load carrying capability indicated by the fourth-year system regulation study performed in 1974-75.

C. Pacific Northwest River Basins Commission (PNRBC)

The PNRBC was created by Presidential Executive Order in 1967 at the request of the Governors of Idaho, Montana, Oregon, Washington, and Wyoming. In addition to the five states, the Commission also includes eleven federal departments or entities. Statutory responsibility of the Commission are to:

(1) serve as the principal agency for coordinating federal, state, interstate, local, and nongovernmental plans for developing water and related land resources;

(2) prepare and keep up to date a comprehensive coordinated joint plan for federal, state, interstate, local, and non-governmental development of water and related resources;

(3) recommend long-range schedules of priorities for the collection and analysis of basic data and for investigation, planning, and construction of projects; and

(4) foster and undertake such studies of water and related land resources problems as are necessary to prepare and keep up to date the comprehensive coordinated joint plan.

A preliminary (staff) draft report on the comprehensive, coordinated joint plan (CCJP) is in the final stages of completion. The report, which is entitled "Water--Today and Tomorrow, Pacific Northwest Regional Program for Water and Related Land Resources," will contain three volumes: a summary, a volume addressing the region and a volume addressing the individual states. The report is based largely on completed Commission studies including the recent level B studies of subareas within the region; state water plans and water management programs; and completed and ongoing lead agency studies. Following regional review the final report will be forwarded for review and necessary modification, and comment by the Water Resources Council and subsequent transmittal to the President and the Congress. Subsequently, the Commission will focus on preparation of regional priorities report which will be based on and represent a refinement of the regional program report (CCJP).

In other major activities during the year, the Commission continued its efforts on the 1975 National Water Assessment by serving as regional sponsor under an agreement with the U. S. Water Resources Council. Statutory responsibility for the Assessment rests with the Council, and the Commission is providing assistance in the undertaking by providing needed regional information. The objective of the Assessment is to identify and describe, from both the state/regional and national viewpoints, the Nation's severe existing and emerging water and related land resources problems. The Commission's Assessment activities during the year included the identification of severe problems in the region and the development of regional perspectives on future condition scenarios.

The Commission is sponsoring the "Stewards of the River" program which seeks to focus greater attention on the educational and recreational potential of the Columbia River and its major tributaries. Development of scientific, historic, educational, and cultural activities and facilities is emphasized, along with the river's general recreational use. During FY 1977 a Slide-tape show and a brochure were prepared for use in presenting the concept. A quarterly newsletter was started which reports on activities and points of interest up and down the river. A roster of individuals and agencies interested in the "Stewards" idea was compiled and distributed. A handbook of the facility inventory information and other source materials available at the Commission also was compiled and published.

The Commission serves as a coordinating entity for federal agency involvement in the Columbia River Estuary Study program (CREST). Ten local government entities are working with the two states and the federal agencies to prepare an initial water and land resources management program for the estuary. The inventory and policies portion of the management program was completed by CREST during FY 1977, with the balance of the program scheduled for completion during FY 1978. A study proposal to develop needed data about the estuary's resources for refinement/improvement of the management program was submitted by the Commission to the U. S. Water Resources Council in FY 1977. Federal funds were appropriated for the Plan of Study refinement beginning in FY 1978, for development in a comprehensive water and related resources plan for the basin.

Seven of the Commission's nine standing technical committees met regularly during the year to exchange information, discuss problems, prepare material for publication, or hold workshops and symposiums, etc., thereby providing assistance to agencies and other entities involved in planning and management of water and related land resources. The committees also provided information to Commission staff engaged in the task of preparing the regional program (CCJP).

D. Columbia River and Tributaries Review Study

The Columbia River and Tributaries Study (CR&T) is being conducted by the Corps of Engineers in response to requests by Congress for a review of previous reports and development plans for the Columbia River in light of recent physical and economic changes in the region. This review focuses on systemwide development plans for the Columbia River and its tributaries, and will update and extend plans submitted to the Congress and published 10 May, 1962, as House Document 403 87th Congress, Second Session. Requested studies are to be of detailed feasibility scope in order that specific recommendations may be transmitted to Congress for authorization and subsequent implementation.

The study is emphasizing two major areas: (a) A review of project and system operations and refinement of definite project and system operations criteria; and (b) analysis of new development alternatives needed to supplement the existing resource development plans for the basin. The latter area will include consideration of structural modifications to include additional functions, nonstructural programs relating to areas such as flood control and recreation, and possible new project development.

Some of the major activities completed include: An inventory of problems and areas of concern, a base system description for the mid-1970 level of river development, a system description for the mid-1980's level of river development, an inventory of riparian wildlife habitat, an assessment of the impact that future irrigation development and alternative minimum instream flow levels would have on the existing use and operation of the Columbia River system, and a reconnaissance inventory and evaluation of potential pumped-storage sites in the basin. The study has also completed the following feasibility reports: (1) McNary Second Powerhouse; (2) Yakima River at Union Gap Flood Control; (3) Bonneville Lock Replacement; and (4) adding power at Lucky Peak Dam.

Some of the major activities underway at this time include the development of a mid-1990's System Plan for the Columbia River, an evaluation of the adequacy of the Columbia River storage system, a review of the feasibility and desirability of future hydropower development, the adequacy of the existing lower Columbia River levees, and a recreation needs assessment for the Columbia and lower Snake rivers. Detailed interim project reports currently underway include: The feasibility of expanding the hydropower generating capacity at Chief Joseph Dam beyond 27 units, the feasibility of constructing a pumped-storage project at Omak Lake, the feasbility of providing flood protection to the cities of Richland and West Richland, Washington, located along the Yakima River, and a review of the Willamette Basin projects to determine the feasibility of adding new or additional power to these projects.

The study is being actively coordinated with Federal, State, and local agencies, citizens' groups, and the general public. Overall coordination is being maintained with the Pacific Northwest River Basins Commission.

E. Data Collection from Wilderness Areas

In 1976, a memorandum of understanding was signed between the Forest Service (FS) and the Soil Conservation Service (SCS) regarding the temporary installation of automated data sites in wilderness areas.

During the past year, the two agencies have met on numerous occasions to review, outline, and define the several criteria to be met with automating sites.

Installations may be permitted at existing snow courses on a temporary basis, generally not to exceed 10 years, for the purpose of correlation with data sites outside the wilderness area. In wilderness study areas, temporary installation of automated equipment may be permitted at both existing and new sites. In either case, the installations will be removed when adequate correlations are established.

Only miniaturized and unobtrusive types of equipment may be installed and must be camouflaged to blend with the terrain as much as possible. It is anticipated that agreement can be reached on general guidelines for these criteria in the next few months.

The provisions of this agreement have been incorporated into Forest Service interim directives. Consequently, they apply not only to SCS but to any agency or organization engaged in collecting water resource and related climatological data in the national forest system.

F. Operational Streamflow Forecasting

The complex operation of the Columbia River reservoir system and the commonality in responsibilities of the various Federal agencies have created a need for cooperation and coordination. The Columbia River Forecasting Service (CRFS), in which the NWS, USCE, and BPA participate is responsible for coordination of both daily and seasonal operational forecasts. The overall goal of the CRFS is to pool certain resources of these three agencies in the interest of improving streamflow forecasting methods in the Pacific Northwest Region, to avoid dupliation of forecasts and to increase the efficiency of operation. The CRFS prepares forecasts of river stage and streamflow conditions in the Columbia River Basin, coastal basins of Oregon and Washington, and the Great Basin in Oregon. The NWS makes the public releases of the forecasts.

The NWS River Forecast Center provides routine 365-day, 12-hour (0600-1800) river surveillance, with extended hours of operation under potential flood conditions.

G. Data Storage and Retrieval

1. NAWDEX

The National Water Data Exchange (NAWDEX) has been established to help users of water data to locate and acquire needed data. NAWDEX is not a large depository of water data. Rather, its objective is to provide the user with sufficient information to define what data are available, where these data may be obtained, in what form the data are available, and some of the major characteristics of the data.

NAWDEX has been organized using guidelines and design characteristics developed by the Federal Interagency Water Data Handling Work Group.

The U.S. Geological Survey has the lead-role responsibility for NAWDEX. In this capacity, it has established the NAWDEX Program Office at its National Center in Reston, Virginia. This office provides the central management for NAWDEX. It also has the responsibility for coordinating all operational activities within the program. This includes serving as liaison between NAWDEX members and users of the system.

The service capabilities of NAWDEX are supported by a nationwide network of Local Assistance Centers established in the offices of NAWDEX members to provide local and convenient access to NAWDEX and its services. In the Northwest, the Local Assistance Centers are the District Offices of the Water Resources Division of the Geological Survey. Their locations and NAWDEX representatives are as follows:

Idaho District, Boise - Luther Kjelstrom
Oregon District, Portland - Larry Hubbard
Washington District, Tacoma - John R. Williams
Montana District, Helena - Jay Diamond

This network initially consists of 51 Centers located in 45 states and Puerto Rico.

Organizations that become participating members of NAWDEX form the base units of the organization. Current membership includes representation from the Federal, State, academic, and private sectors of the water-data community. Participating members work together as a confederation to provide ready and convenient access to their water data.

A variety of services are provided by NAWDEX. Those of major significance are:

The NAWDEX Program Office maintains a Water Data Sources Directory. This directory identifies organizations that collect water data, locations within these organizations from which water data may be obtained, the geographic areas in which water data are collected by these organizations, the types of water data collected, alternate sources for acquiring the organization's data, and the media in which the data are available.

A computerized Master Water Data Index is also maintained. This index identifies individual sites for which water data are available, the locations of these sites, the organizations collecting the data, the hydrologic disciplines represented by the data, the periods of record, water data parameters, the frequency of measurement of the parameters, and the media in which the data are available. More than 61,000 water data sites are currently being indexed from information contributed by 19 Federal organizations and more than 300 non-Federal organizations. The contents of the index will grow significantly as the NAWDEX membership increases.

Through its Water Data Sources Directory, its Master Water Data Index, and indexes and other reference sources made available by its participating members, NAWDEX assists its users in locating data of special interest. These data include water data in computerized and in both published and unpublished forms. The user is then referred to the organization(s) having the needed data. NAWDEX thus serves as a central point of contact for locating water data that may be held by several different organizations. Data search assistance may be obtained from the NAWDEX Program Office or from any of the Local Assistance Centers.

Membership in NAWDEX is voluntary and open to any water-oriented organization that wishes to take an active role in NAWDEX activities. There are no fees or dues associated with membership.

Users requesting data or services through NAWDEX may be required to pay charges assessed at the option of the member organization supplying the data or service. In general, charges will apply to those requests that require extensive computer usage or manpower for response.

2. WATSTORE

The U.S. Geological Survey (USGS), through its Water Resources Division, investigates the occurrence, quantity, quality, distribution, and movement of the surface and underground waters that comprise the Nation's water resources. The Geological Survey currently collects data at approximately 10,000 stream-gaging stations, 1,300 lakes and reservoirs, 4,300 surface-water quality station, 4,100 water-temperature stations, 880 sediment stations, 2,500 water-level observation wells, and 1,500 groundwater quality wells. Each year many water-data collection sites are added and others are discontinued; thus, large amounts of diversified data, both current and historical, are amassed by the Survey's data-collection activities. The U.S.G.S. collects and disseminates about 70 percent of the water data currently being used by numerous state, local, private, and other Federal agencies to develop and manage our water resources. As part of the Geological Survey's program of releasing water data to the public, a large scale computerized system has been developed for the storage and retrieval of water data collected through its activities.

The National Water Data Storage and Retrieval System (WATSTORE) was established in November 1971 to modernize the Geological Survey's existing water-data processing procedures and techniques and to provide for more effective and efficient management of its data-releasing activities. The system is operated and maintained on the central computer facilities of the USGS at its National Center in Reston, Virginia. WATSTORE was made available to other Federal agencies and selected in 1975. The WATSTORE system consists of several files in which data are grouped and stored by common characteristics and data collection frequencies. The system is also designed to allow for the inclusion of additional data files if the need should arise in future years. Currently, files are maintained for the storage of (1) surface-water, quality-of-water, and ground water data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analysis for surface and groundwater sites, and (4) geologic and inventory data for groundwater sites. In addition, an index file of sites for which data are stored in the system is also maintained.

Authorization to use WATSTORE must be obtained from the Chief hydrologist, U.S. Geological Survey, National Center, Mail Stop 409, Reston, Virginia 22092. When the request is approved, a notice of authorization along with an assigned agency user code and account number are provided to the requester. WATSTORE then is available to the user for the use of data placed in the system by others, unless the data are of a proprietary nature, and also for entry and retrieval of a user's own data.

3. STORET

STORET contains water quality data on samples taken from more than 200,000 unique collection points located on essentially all of the nation's rivers, lakes, streams, and other waterways. Some 1,800 unique water quality parameters are defined within the system. The system now has available 40 million observations, 80 percent of which pertain to parameter groups characterizing radiological, biological, bacteriological, general organics, pesticides, solids, metals, and physical quality of water. Individuals and organizations actively participating in the collecting, storing, retrieval and analysis of water quality data include state agencies, cities and counties, interstate commissions, water quality managers, environmental planners, sanitary engineers, EPA regional offices, EPA laboratories, Federal agencies, Canadian agencies and U.S. territories. All utilize STORET and its variety of output summaries, statistical reports and plots in program areas such as basin planning, research, monitoring and surveillance, waste discharge permits, standards and criteria, toxic substances, etc. Data reports can reflect the latest, most current information available, or it can draw upon the historical depth of the data, going back as far as the late 1950's. Most users obtain their reports from small portable computer terminals conveniently located in or near their offices. STORET utilizes two IBM 370's at Computer Network Corp. (COMNET), Washington, D.C.

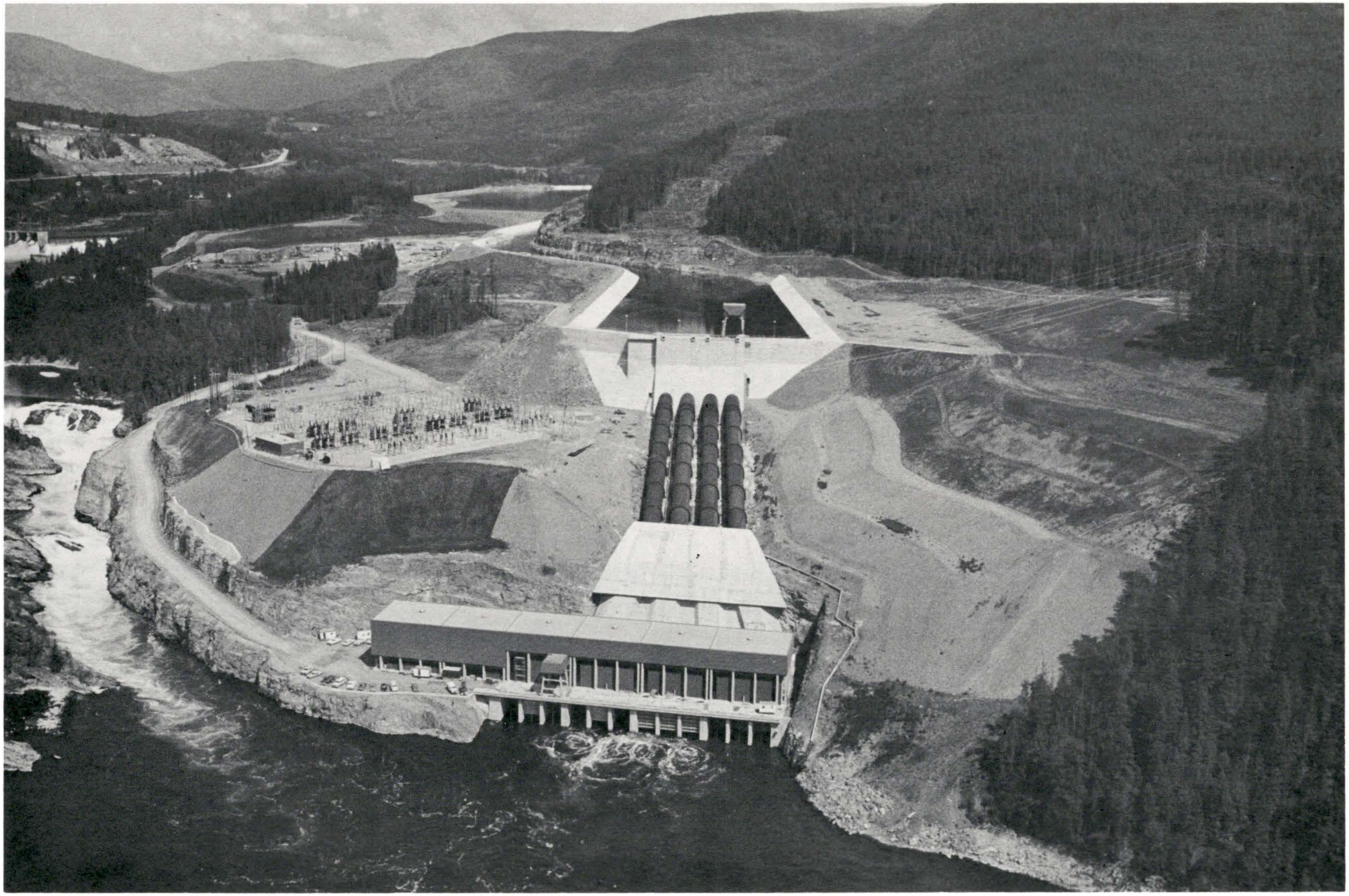
4. National Weather Service

The Office of Hydrology, National Weather Service, NOAA, has arranged to have all available hydroclimatic data in the U.S. to be stored on three tape files; these include (1) daily climatic stations, (2) recording precipitation gages, and (3) synoptic data from first-order stations of NWS, Similiar Canadian data for British Columbia is to be added.

The data are stored on tapes in a format designed for efficient data access, manipulation and processing for computer hydrologic modeling. Associated software has been written and is operational.

Data tapes and processing programs are on-line on IBM 195 in Suitland for use by NWS River Forecast Centers. However, tapes, formats, associated processing software, and documentation on their use is available from NWS.

Corps of Engineers Computer Center in Portland, Oregon



B.C. Hydro's Kootenay Canal hydro-electric development on the Kootenay River

VIII. ANNUAL OPERATING PLAN FOR 1977-78

Each year the regulation of the Columbia Basin reservoir system is unique in many details but similar in seasonal characteristics. While most of this annual report describes the "uniqueness" of the past year's operation, it is the objective of this section to briefly describe (1) basic seasonal hydrologic similarities, (2) how annual reservoir regulation plans are developed, (3) routine seasonal considerations for regulating individual reservoirs and finally (4) the general operating plan for the coming water year for major reservoirs.

A. Annual Regulation Cycle

There are three principal reservoir regulation seasons for the Columbia River east of the Cascade mountains: (1) the summer holding or storage conservation season, (2) the fall and winter storage control or drawdown season and (3) the spring snowmelt runoff or refill season. West of the Cascade mountains the hydrology differs mainly in that the winter is the flood season due primarily to rain storms. Therefore, there are four drainage areas: (1) the summer holding season, (2) the fall drawdown season, (3) the winter flood season and (4) the spring refill season. There are variations in the weather each year so that the exact timing and magnitude of these reservoir regulation seasons varies each year.

The reservoir system east of the Cascades usually fills in July or early August. Reservoirs west of the Cascades are usually full or nearly so by early May. After a reservoir fills it usually is then held as full as possible during the summer to enhance recreation and conserve water for later use for other functions. However, some drawdown (draft) of reservoir storage occurs in the summer when necessary for irrigation, water supply, power generation and low flow augmentation to improve downstream flows. Also, there is evaporation and seepage into ground water during the summer. The amount and timing of the drawdown varies at individual reservoir projects depending upon weather, local conditions and the purpose for which the project was originally constructed.

The draft of the reservoir system begins to accelerate in the fall, usually in late September or October when temperatures begin to drop and daylight is shorter. At this time power demands begin to increase and recreational use of the lakes and reservoirs decreases. There is also a need to draft storage space by November or early December for winter flood control, especially in reservoirs west of the Cascades as well as a few east of the mountains.

Most of the reservoirs west of the Cascades begin to fill in February as the flood potential from winter rains begins to diminish. The amount of space maintained in these reservoirs for possible flood control use gradually decreases as the floood potential decreases until the reservoirs fill, normally during May.

The high flow period on the Columbia River and its tributaries east of the Cascades usually occurs during the spring due to snowmelt runoff. Measurements of the accumulated snowpacks are made monthly after the first of January, and these measurements are used to forecast the total seasonal runoff and are then drawn down in preparation for controlling the expected volume of runoff. These reservoirs usually reach their lowest elevations in March or April. Snowmelt typically begins to increase significantly about mid-April and usually reaches a peak in June. A portion of the resulting high flows are stored to reduce flood stages and refill the reservoirs.

B. Types of Reservoir Projects

Many so-called "reservoir" projects are actually "run-of-river" or "pondage" projects that have little or no storage capacity in comparison to the magnitude of streamflow. Bonneville, The Dalles, McNary and projects on the mid-Columbia (Priest Rapids, etc) and lower Snake River (Ice Harbor, etc) are examples of "pondage" projects. These may be large projects and generate considerable electrical energy but the amount of their reservoir storage is relatively small. Reservoir elevations at pondage projects usually fluctuate up and down on a daily basis.

Some projects are for reregulating outflows from an upstream project on a daily basis. Big Cliff in the Willamette Basin is an example of this type of reservoir, because it reregulates and smooths out discharges from Detroit Dam. The Big Cliff reregulating reservoir usually fills and empties once a day. Outflows from Detroit may fluctuate hourly while Big Cliff outflows remain relatively constant.

The West Kootenay Power and Light Company projects; Upper Bonnington, Lower Bonnington, South Slocan and Brillant plants on the Kootenay River below Kootenay Lake are examples of "run-of-river" projects. The forebay elevation at this type of project usually change only slightly. Flow regulation is normally accomplished by an upstream reservoir project, such as Corra Linn, which, in this case, controls the Kootenay Lake outflow.

A true storage reservoir is one that generally fills and nearly empties once each year. Some are true "annual" storage reservoirs which refill each year even if drafted to the minimum conservation pool. John Day, Albeni Falls and Kootenay Lake are examples of annual reservoirs. Other storage reservoirs are termed "cyclic" reservoirs because they may not refill each year if all the live storage is withdrawn. Therefore, each year drawn down of cyclic reservoirs is based on volume inflow forecasts. Dworshak, Libby, Hungry Horse, Mica, Arrow, and Duncan are examples of this type.

Another basic difference in types of reservoirs are those that have at-site power generating facilities and those that do not--Arrow and Duncan, for example, do not. Upstream or headwater reservoirs have significant power benefits even though they may not have at-site generation because water released from them pass through many powerhouses downstream. All of the Federal and most non-Federal reservoir projects are operated for multipurposes such as flood control, hydropower, navigation, water supply, and irrigation, recreation fishery and wildlife, water quality and low flow augumentation.

C. Operating Guidelines and Rule Curves

Some operational guidelines for reservoirs are established on a continuing basis and not changed each year, whereas, other guidelines are recomputed annually or seasonally to meet varying conditions. These operating guidelines are known as "rule curves." Such curves indicate a schedule of reservoir elevations that are desirable and provide guidance in meeting project functions such as: to ensure adequate space is available for flood control, to assure adequate water to meet electric power demands by utilizing storage and natural flow efficiently, and also to reasonably assure refill. Refer to Figure 20.

In some cases these curves are established on a relatively permanent basis in pre-construction documents. In other cases annual operating curves are developed in part based on computer studies of many years of historical streamflows adjusted for current conditions. During the refill season, computations of expected inflow are made monthly or more frequently for those reservoirs where appropriate. Annual operating curves for individual reservoirs are usually based on system operating plans such as those made in accord with the Pacific Northwest Coordination Agreement, the Columbia River Treaty Flood Control Operating Plan and the Willamette River Low Flow Augmentation Plan.

The Coordination Agreement provides that prior to the start of each operating year, August 1 to July 31, a reservoir operating and storage schedule be developed to provide the optimum firm energy load carrying capability (FELCC; see Glossary) for each reservoir in the coordinated system. System regulation studies are made wherein the most adverse historical streamflow sequence (critical streamflow period) for the Pacific Northwest as a whole is regulated by the existing hydroelectgric system to serve the estimated load demands for the critical period. These studies define reservoir elevations as critical rule curves (CRC; see Glossary) on a monthly basis to ensure that adequate firm energy will be available from the coordinated system if there is a recurrence of the critical flow conditions.

Energy content curves (ECC; see Glossary), consisting of monthly reservoir elevations, are also determined from studies provided under terms of the coordination agreement to limit reservoir drafts and guide refill of reservoirs. This curve provides a high degree of assurance that a reservoir will refill by the end of the operating year. In some cases reill target elevations are recomputed each month during the refill season based on the latest snowpack and precipitation measurements and these are called variable energy content curves (VECC; see Glossary).

Each individual reservoir usually has several sets of curves. In Figure 20 a listing of monthly upper rule curve elevations or flood control rule curve elevations (see Glossary), critical rule curve elevations, and energy content curve elevations is given for some major reservoirs. This table indicates a range of month-end elevations which are used as a guide in regulating individual reservoirs, as well as the total reservoir system. Obviously, flexibility in operations and deviation from exact planned elevations, must be made to provide for changes in weather, inflows, load demands, plant outages, etc., as well as the usual general seasonal considerations give in Figure 21.

A July 1977 view of Chief Joseph project showing construction of the spillway modification and eleven additional generating units. The modification will increase the normal maximum pool elevation and add 1,045,000 kilowatts to the name plate rating of the project.

1977 - 78 ANNUAL OPERATING PLAN RESERVOIR RULE CURVE
(ELEVATION IN FEET)

PROJECT	RULE CURVE	1977 JULY	AUG 15	AUG	SEPT	OCT	NOV	DEC	1978 JAN	FEB	MAR	APR	MAY	JUN	JUL
MICA	Upper Rule Curve	2474.5	2475.0	2475.0	2475.0	2473.1	2473.1	2473.1	2466.9	2461.3	2454.9	2456.8	2460.8	2467.9	
	Energy Content Curve	2474.5	2474.5	2474.5	2474.5	2469.9	2464.0	2453.7	2440.2	2426.3	2414.9	2409.6	2421.8	2451.0	2474.5
Norm Full Pool 2475.0 ft.	1st year Critical Rule Curve	2474.5	2474.5	2474.5	2474.5	2469.9	2464.0	2453.7	2440.2	2426.3	2414.9	2407.3	2412.6	2441.9	
	2nd year " " "	2467.5	2473.4	2475.0	2475.0	2470.8	2464.1	2453.2	2436.5	2419.7	2407.5	2407.5	2416.7	2445.7	
Minimum Pool 2320.0 ft.	3rd year " " "	2471.7	2473.2	2475.0	2475.0	2471.2	2465.3	2454.3	2434.1	2414.1	2400.5	2400.5	2401.4	2422.6	
	4th year " " "	2459.4	2460.7	2462.0	2457.9	2450.8	2441.4	2426.7	2407.2	2400.5	2400.5	2400.5	2417.0	2452.6	
ARROW	Upper Rule Curve	1444.0	1440.0	1444.0	1440.0	1442.1	1442.1	1436.2	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	1444.0	1444.0	1443.5	1443.2	1442.5	1442.7	1431.6	1416.9	1405.6	1404.5	1391.8	1412.3	1442.5	1444.0
Norm Full Pool 1440.0 tt.	1st year Critical Rule Curve	1444.0	1444.0	1443.5	1443.2	1442.5	1442.7	1431.6	1416.9	1405.6	1404.5	1390.5	1412.3	1442.5	
	2nd year " " "	1430.9	1431.2	1426.4	1424.5	1422.3	1412.6	1392.9	1380.8	1392.1	1395.3	1393.2	1404.6	1425.2	
Minimum Pool 1377.9 ft.	3rd year " " "	1416.9	1416.8	1416.8	1416.1	1412.6	1403.1	1381.0	1381.0	1380.9	1378.5	1401.8	1403.5	1396.6	
	4th year " " "	1390.4	1388.5	1386.6	1383.6	1387.0	1389.0	1386.1	1391.9	1377.9	1379.1	1388.1	1415.2	1444.0	
DUNCAN	Upper Rule Curve	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0	1868.6	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	1892.0	1892.0	1885.2	1868.2	1861.7	1861.7	1850.5	1835.8	1835.3	1837.2	1834.2	1848.6	1872.0	1892.0
Norm Full Pool 1892.0 ft.	1st year Critical Rule Curve	1892.0	1892.0	1885.2	1868.2	1861.7	1861.7	1850.5	1835.8	1807.7	1807.7	1807.7	1826.5	1862.9	
	2nd year " " "	1886.0	1884.8	1872.5	1842.8	1811.8	1807.7	1807.7	1803.5	1803.5	1803.5	1803.5	1807.7	1840.7	
Minimum Pool 1794.2 ft.	3rd year " " "	1864.9	1859.1	1852.7	1836.1	1804.1	1794.2	1794.2	1794.2	1794.2	1794.2	1794.2	1802.7	1837.0	
	4th year " " "	1884.8	1892.0	1892.0	1863.9	1836.9	1815.5	1800.3	1794.2	1794.2	1794.2	1795.5	1831.4	1876.3	
LIBBY	Upper Rule Curve	2459.0	2459.0	2459.0	2459.0	2459.0	2447.9	2409.9	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	2459.0	2459.0	2459.0	2455.7	2452.6	2433.9	2410.0	2403.6	2402.2	2400.9	2399.4	2423.9	2454.5	2459.0
Norm Full Pool 2459.0 ft.	1st year Critical Rule Curve	2459.0	2459.0	2459.0	2455.7	2452.6	2433.9	2410.0	2386.4	2375.1	2374.5	2374.2	2406.2	2454.5	
	2nd year " " "	2459.0	2459.0	2459.0	2450.1	2439.1	2416.9	2399.1	2379.3	2372.4	2361.4	2378.2	2410.1	2444.9	
Minimum Pool 2287.0 ft.	3rd year " " "	2459.0	2459.0	2459.0	2452.4	2439.3	2425.5	2408.6	2386.4	2385.8	2386.1	2385.1	2416.2	2446.4	
	4th year " " "	2439.7	2442.8	2432.1	2430.8	2413.1	2392.5	2365.2	2330.9	2287.0	2287.0	2304.0	2378.4	2449.8	
HUNGRY HORSE	Upper Rule Curve	3560.0	3560.0	3560.0	3560.0	3560.0	3560.0	3541.6	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	3560.0	3560.0	3560.0	3558.0	3554.0	3543.4	3527.1	3518.0	3518.9	3521.3	3524.9	3551.3	3560.0	3560.0
Norm Full Pool 3560.0 ft.	1st year Critical Rule Curve	3560.0	3560.0	3560.0	3558.0	3554.0	3543.4	3527.1	3507.5	3504.4	3504.0	3504.0	3534.7	3560.0	
	2nd year " " "	3559.4	3560.0	3560.0	3552.8	3545.1	3532.1	3517.7	3495.5	3482.6	3467.2	3482.2	3511.6	3529.5	
Minimum Pool 3336.0 ft.	3rd year " " "	3553.2	3553.7	3553.5	3542.1	3560.0	3525.0	3487.9	3452.6	3454.1	3457.8	3469.2	3509.2	3524.3	
	4th year " " "	3446.1	3433.1	3408.1	3384.2	3385.4	3388.3	3388.8	3348.8	3336.0	3351.6	3383.4	3460.7	3503.0	
FLATHEAD LAKE	Upper Rule Curve	2893.0	2893.0	2893.0	2893.0	2893.0	2893.0	2893.0	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	2893.0	2893.0	2893.0	2891.7	2891.2	2890.3	2888.8	2887.3	2883.7	2884.1	2883.0	2890.0	2893.0	2893.0
Norm Full Pool 2893.0 ft.	1st year Critical Rule Curve	2893.0	2893.0	2893.0	2891.7	2891.2	2890.3	2888.8	2887.3	2883.7	2883.0	2883.0	2890.0	2893.0	
	2nd year " " "	2893.0	2893.0	2893.0	2892.1	2890.6	2889.1	2887.6	2885.6	2884.1	2883.0	2885.8	2890.0	2893.0	
Minimum Pool 2883.0 ft.	3rd year " " "	2893.0	2893.0	2893.0	2892.1	2890.6	2889.1	2887.6	2885.6	2884.1	2883.0	2883.0	2890.0	2893.0	
	4th year " " "	2893.0	2893.0	2893.0	2891.4	2889.8	2888.2	2885.7	2883.8	2883.0	2883.0	2885.4	2890.0	2893.0	
ALBENI FALLS	Upper Rule Curve	2062.5	2062.5	2062.5	2062.5	2060.2	2056.3	2056.3	2056.3	2056.3	2056.3	2061.2	2062.5	2062.5	
	Energy Content Curve	2062.5	2062.5	2062.5	2060.0	2054.0	2051.0	2051.0	2051.0	2051.0	2051.0	2054.0	2059.2	2062.5	2062.5
Norm Full Pool 2062.5 ft.	1st year Critical Rule Curve	2062.5	2062.5	2062.5	2060.0	2054.0	2051.0	2051.0	2051.0	2051.0	2051.0	2054.0	2056.0	2062.5	
	2nd year " " "	2062.5	2062.5	2062.5	2060.0	2054.0	2051.0	2051.0	2051.0	2051.0	2051.0	2056.0	2056.0	2062.5	
Minimum Pool 2049.7 ft.	3rd year " " "	2062.5	2062.5	2062.5	2060.0	2054.0	2051.0	2051.0	2051.0	2051.0	2051.0	2053.0	2056.0	2062.5	
	4th year " " "	2062.5	2062.5	2062.5	2060.0	2054.0	2051.0	2051.0	2051.0	2049.7	2049.7	2056.0	2062.5	2062.5	
GRAND COULEE	Upper Rule Curve	1290.0	1290.0	1290.0	1290.0	1290.0	1290.0	1290.0	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	1290.0	1290.0	1289.0	1289.0	1289.0	1289.0	1289.0	1287.1	1277.2	1256.6	1256.0	1276.5	1290.0	1290.0
Norm Full Pool 1290.0 ft.	1st year Critical Rule Curve	1290.0	1290.0	1289.0	1289.0	1289.0	1289.0	1289.0	1287.1	1277.2	1256.6	1256.0	1268.5	1290.0	
	2nd year " " "	1290.0	1290.0	1290.0	1289.0	1289.0	1289.0	1288.0	1274.7	1257.8	1239.3	1251.9	1279.5	1288.8	
Minimum Pool 1208.0 ft.	3rd year " " "	1289.5	1288.9	1288.5	1289.0	1289.0	1289.0	1283.2	1273.8	1246.1	1216.7	1209.6	1262.9	1288.0	
	4th year " " "	1289.5	1289.0	1287.8	1289.0	1282.4	1271.9	1254.9	1226.9	1208.0	1208.0	1267.6	1281.1	1290.0	
DWORSHAK	Upper Rule Curve	1600.0	1600.0	1600.0	1600.0	1580.1	1558.2	1558.2	FCRC	FCRC	FCRC	FCRC	FCRC	FCRC	
	Energy Content Curve	1600.0	1600.0	1598.1	1585.9	1580.5	1558.2	1554.5	1550.0	1546.1	1539.7	1566.8	1600.0	1600.0	1600.0
Norm Full Pool 1600.0 ft.	1st year Critical Rule Curve	1600.0	1600.0	1598.1	1585.9	1580.5	1558.2	1554.5	1550.0	1546.1	1523.7	1523.7	1575.4	1600.0	
	2nd year " " "	1599.0	1597.8	1596.2	1585.9	1581.4	1558.0	1554.5	1538.6	1508.4	1474.8	1535.4	1568.0	1579.3	
Minimum Pool 1445.0 ft.	3rd year " " "	1600.0	1600.0	1597.0	1585.9	1581.4	1558.0	1554.5	1545.0	1541.4	1539.8	1566.3	1600.0	1600.0	
	4th year " " "	1582.1	1580.3	1578.1	1574.1	1570.3	1552.0	1523.2	1476.1	1445.0	1445.0	1446.7	1544.5	1585.2	

FIGURE 20

FIGURE 21 SHEET 1

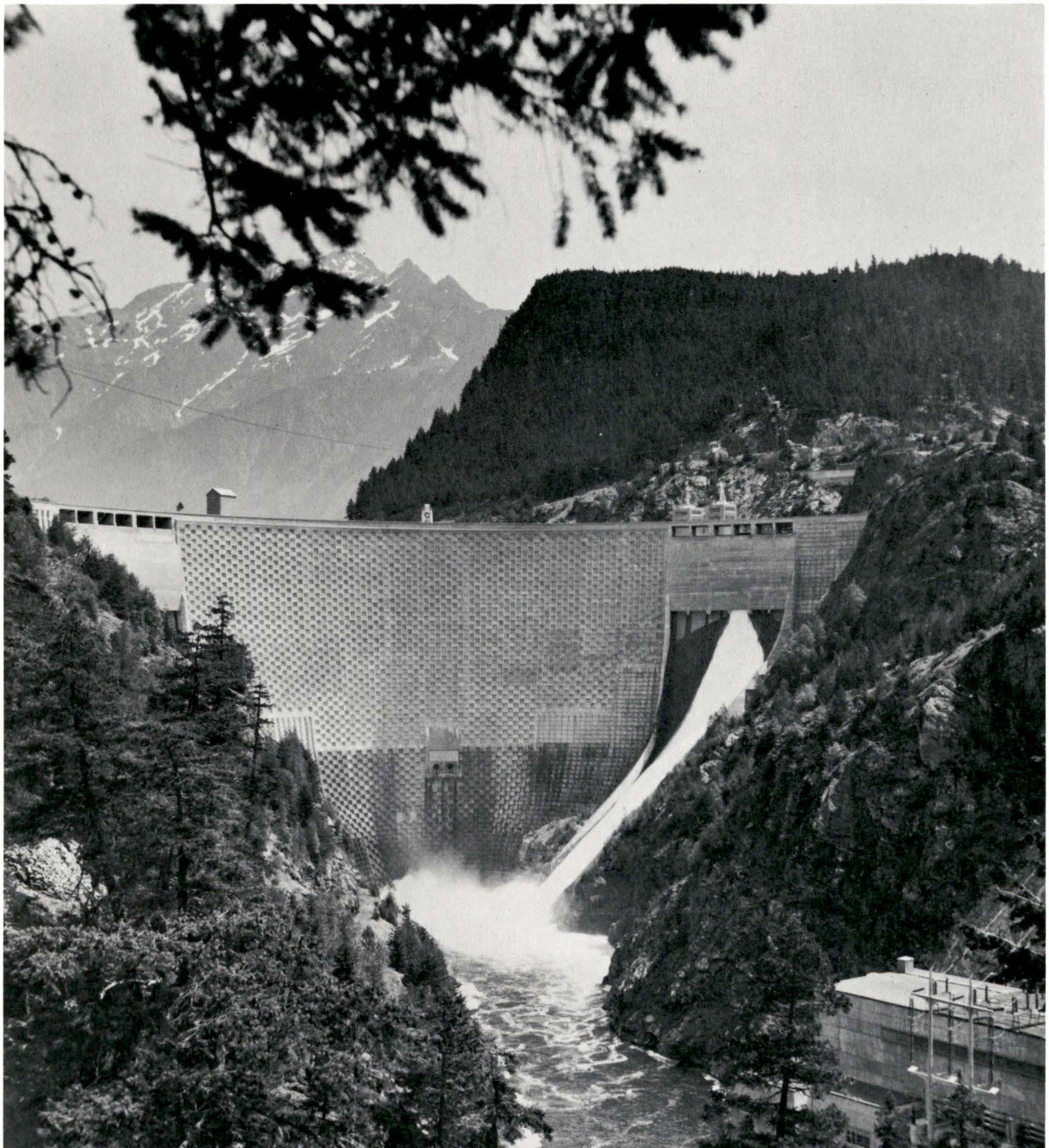
PROJECT SEASONAL REGULATION CONSIDERATIONS
(Actual Operations may deviate from these "Normal Operations")

	LIBBY	DUNCAN	KOOTENAY LAKE	MICA	ARROW	HUNGRY HORSE
JUL	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.	Hold Lake elevation in accordance with IJC Order to allow drainage.	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.
AUG						
SEP	Optional draft.	Optional draft.	Fill to normal full and hold as streamflows permit.	Optional draft.	Optional draft.	Optional draft
OCT					Mandatory draft.	
NOV	Mandatory draft.				Optional draft.	
DEC		Mandatory draft.			Mandatory draft.	
JAN	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.	Draft Lake in accordance with IJC Order.	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.
FEB						
MAR	Fill as required for flood control or assured refill	Fill as required for flood control or assured refill		Fill as required for flood control or assured refill.		
APR			Operate in accordance with IJC Order. Lake operated on free flow once spring runoff begins.		Fill as required for flood control or assured refill.	
MAY						Fill as required for flood control or assured refill.
JUN						

PROJECT SEASONAL REGULATION CONSIDERATIONS
(Actual Operations may deviate from these "Normal Operations")

	ALBENI FALLS	GRAND COULEE	BROWNLEE	DWORSHAK	JOHN DAY	WILLAMETTE PROJS	
JUL	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.	Complete filling and hold full as long as possible.	Generally hold reservoir in a three-foot operating range - Elevation 265-268 feet.	Reservoirs maintained as high as possible, but some storage releas must be made to meet minimum flow requirements.	JUL
AUG							AUG
SEP	Optional draft.	Reservoir generally operated in top five feet	Optional draft.	Mandatory draft.		Mandatory draft for winter flood control regulation.	SEP
OCT	Mandatory Draft.			Mandatory draft. Draft limited to 1.3 KCfs over inflow.			OCT
NOV				Mandatory draft.	Generally, hold reservoir in a three-foot operating range - Elevation 262-265 feet. Flood Control operation may require the reservoir to be drafted to Elevation 257 feet and filled to Elevation 268 feet.		NOV
DEC	Hold reservoir near level.	Optional draft.		Optional draft.		Operate to control winter floods.	DEC
JAN	Refill permitted up to Elev. 2060 ft but Lake level must be at or below elev. 2056 by 30 Mar. Draft normally not permitted below Dec. 1 elevation.	Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.		Draft for flood control and/or power requirements is dependent upon volume inflow forecasts.			JAN
FEB			Mandatory to be at or below 2034 by end of February.			Gradually fill from snowmelt and rainfall runoff.	FEB
MAR		Operate as in January and February. Begin monitoring possible requirements for fisheries.	Variable flood control draft dependent upon volume inflow forecasts.				MAR
APR	Mandatory to be at or above 2054 by end of April.		Regulate as required dependent upon runoff conditions.	Fill as required for flood control or assured refill.			APR
MAY	Fill as required for flood control.	Fill as required for flood control or assured refill.	Fill as required for flood control or assured refill.			Hold near full for summer recreation.	MAY
JUN	Normally try to fill by end of June.						JUN

FIGURE 21 SHEET 2



Ross Dam - Seattle City Light project on the Skagit River

IX. INFORMATION ON SELECTED DAMS AND RESERVOIRS

A. Pertinent Data

This section provides a comprehensive list of dams and reservoirs in the Columbia and Coastal Basins. The criteria for selecting the listed projects were to include all impoundments having 5,000 acre-feet or more of active storage or a minimum of 5 megawatts of hydroelectric generating capacity. Reference sources used were:

1. Reclamation Project Data, United States Department of Interior.
2. Reservoirs and Hydroelectric Stations, Northwest Power Pool.
3. Electric Power Plants in the Pacific Northwest and Adjacent Areas, Bonneville Power Administration, December 1975.
4. Columbia-North Pacific Region Comprehensive Framework Study, Pacific Northwest River Basins Commission, September 1972.
5. Other miscellaneous reports.

The pertinent data shown in Figure 22 was the most complete information available at the time of publication. Any additions or corrections to the tabulation will be noted in future publications. Pertinent data included in the tabulations are:

1. CBTT Ident. The three or four letter abbreviation used to identify projects when data are reported on the Columbia Basin Teletype Circuit (CBTT).

2. Year of Completion. The year the project began controlling the impoundment of water. However, available information on the project completion dates is not consistent. For example, some projects show the date of completion of the latest modification or the last generator unit.

3. River. River on which the project is located, or, for offstream impoundments, the stream from which the major water supply is derived.

4. River Mile. The distance from the mouth of the river on which the project is located to the axis of the dam, as measured along the main river channel.

5. Owner or Operator. Abbreviations are expalined on last page of tabulations.

6. Project Functions. Water resource uses for which the project is operated.

7. Normal Maximum Forebay. The top of the normal operating pool range. Some projects may have surcharge above the listed maximum forebay elevation, either by adding flashboards or because the added head is required to pass inflow through the outlet structure. Some large natural

lakes such as Kootenay, Pend Oreille, Coeur D'Alene and Flathead, will experience involuntary storage above the listed normal maximum pool, during periods of unusually high inflows due to the constrictions at the natural outlet of the lake.

8. Normal Minimum Forebay Elevation. The bottom of the normal operating range. Under special conditions some reservoirs may be drawn below this limit for a limited period of time.

9. Storage in 1,000 Acre-Feet. Active. Storage between normal maximum and normal minimum forebay elevations. Top Foot. Self-explanatory.

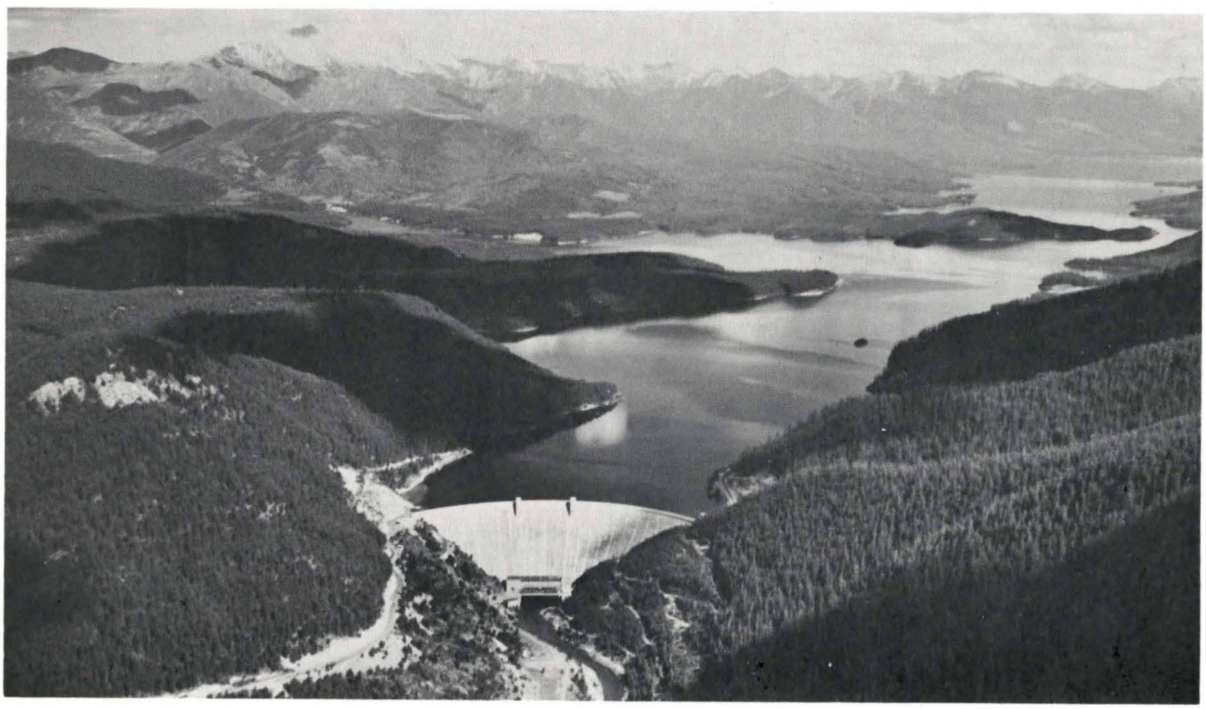
10. Installed Generation. Number of Units. The number of existing units or the number being installed under existing contracts.

Capacity in MW. This is the rated capacity as given in Northwest Power Pool tabulation of electric power plants in the Pacific Northwest and adjacent areas.

11. Normal Maximum Head. The difference between the normal maximum forebay and the average tailwater elevation with all units operating. The heads shown in this preliminary tabulation are those given in the Northwest Power Pool list of projects or the Reclamation Project Data publication.

12. Average Annual Discharge CFS. Data are the average annual modified streamflow for the 40-year period 1928-1968, for the 1970 level of irrigation development. These data were compiled by the Depletion Task Force of the CRWMG.

13. Remarks. Self-explanatory.



Hungry Horse Project on the South Fork of the Flathead River.

PERTINENT DATA FOR SELECTED DAMS AND RESERVOIRS

DAM	CBTT IDENT	YEAR COMPLETION	LOCATION RIVER	LOCATION MILE	OWNER OR OPERATOR	FUNCTION	NORMAL MAX FOREBAY	NORMAL MIN FOREBAY	STORAGE (1000 AC FT) ACTIVE	STORAGE (1000 AC FT) TOP FT	INSTALLED GENERATION NO OF UNITS	INSTALLED GENERATION CAP IN CFS	INSTALLED GENERATION CAP IN MW	NORMAL MAX HEAD	AVE ANN DISCH (CFS)	REMARKS
UPPER COLUMBIA RIVER																
MICA	MCDB	1973	COLUMBIA	1018.0	B.C. HYDRO	FP	2475.0	2320.0	12,046.0	106.00	4	40,000	1,740 NP	615	20.510	McNAUGHTON LAKE
REVELSTOKE			COLUMBIA	932.8	B.C. HYDRO	FP	1800.0				4 UC		1,800 NP	425		UNDER CONSTRUCTION
WHATSHAN		1971	WHATSHAN	5.0	B.C. HYDRO	P	2104.0	2084.0	83.8	4.36	1	1,330	50.0	677		
HUGH KEENLEYSIDE	ARDB	1968	COLUMBIA	780.0	B.C. HYDRO	FRPN	1444.0	1377.0	7,257.0	128.90	0		0.0	69	40,100	ARROW RESERVOIR
ABERFELDIE		1922	BULL	8.4	B.C. HYDRO	P	2880.0						5.0	275		
LIBBY	LIB	1973	KOOTENAI	221.9	CE	FPR	2459.0	2287.0	4,933.4	46.40	4	22,400	420 NP	337	11,350	LAKE KOOCANUSA
MOYIE UPPER		1941	MOYIE	1.8	B.FERRY	P	2035.3						2.0	200		
ERICKSON		1933	GOAT	7.7	W.KOOENAY	P							1.3	65		
DUNCAN	DCDB	1967	DUNCAN	8.3	B.C. HYDRO	FRP	1892.0	1792.4	1,412.0	18.25	0		0.0	120	3,534	DUNCAN RESERVOIR
CORRA LINN	CORB	1932	KOOTENAY	16.1	W. KOOTENAY	FPIR	1745.3	1738.0	787.0	111.67	3	12,600	48.0	58	27,570	KOOTENAY LAKE
KOOTENAY CANAL		1975	OFF STREAM		B.C. HYDRO	P	1745.3	1729.0			4	27,000	528 NP	245		DIVERTS WATER FROM KOOTENAY LAKE
UPPER BONNINGTON		1907	KOOTENAY	14.8	W. KOOTENAY	P	1682.7				6	13,500	60.0	71		
LOWER BONNINGTON			KOOTENAY		W. KOOTENAY	P					3	9,500	41.0	66		RUN-OF-RIVER PROJECTS D/S CORB
SOUTH SLOGAN		1928	KOOTENAY	13.4	W. KOOTENAY	P	1543.5				3	10,500	54.0	72		
BRILLIANT		1944	KOOTENAY	1.0	W. KOOTENAY	P	1477.0	1472.0			4	18,000	125.0	98	30,650	
GEORGETOWN L.		1905	FLINT CREEK	38.8	MONTANA	IPW	6429.5	6398.0	31.0	3.00			1.0	717	30	
EAST FK. ROCK CR.		1937	E. FK. ROCK CREEK			I	6055.5	5990.0	16.0	0.44					148	
NEVADA CREEK		1938	NEVADA CREEK		S. MONT.	IR	4616.0	4551.5	12.6	0.38					37	
PAINTED ROCK LAKE		1940	W. FK. BITTERROOT			IR	4725.5	4625.5	31.7	0.66					294	
COMO LAKE	CMO	1909	ROCK CREEK	3.6	USBR	I	4242.4	4190.5	34.8	0.94					148	
HUNGRY HORSE	HGH	1953	S. FK. FLATHEAD	5.2	USBR	FPIR	3561.0 1/	3336.0	3,004.9	23.91	4	8,900	328.0	484	3,517	
ASHLEY LAKE			ASHLEY CREEK	26.2	ASH	I			30.0	3.00					29	
KERR	KER	1938	FLATHEAD	72.0	MONTANA	FPR	2893.0	2883.0	1,219.0	125.56	3	14,380	185.0	187	11,550	FLATHEAD LAKE
L. BITTERROOT LAKE		1918	LITTLE BITTERROOT			I	3906.5	3898.0	26.0	2.90						
HUBBART		1924	LITTLE BITTERROOT			IR	3219.0	3140.0	12.1	0.46						
PABLO		1914	FLATHEAD		BIA	I	3210.2	3179.0	27.1	2.04						
LOWER CROW		1933	CROW CREEK	3.4	BIA	I	2877.0	2800.0	10.4	0.34						
MISSION		1935	MISSION CREEK	16.7	BIA	I	3406.0	3340.7	7.3	0.29						
TABOR		1919	DRY CREEK			I	4024.0	3911.5	23.3	0.29						ST. MARYS LAKE
McDONALD		1919	PAST CREEK	12.4	BIA	I	3598.0	3545.0	8.2	0.20						
KICKING HORSE		1930	CROW CREEK		BIA	I	3061.9	3042.0	8.4	0.79						
NINEPIPE		1911	FLATHEAD		BIA	CI	3010.0	2895.4	14.9	1.60						
LOWER JOCKO LAKE		1937	M. FK. JOCKO	15.0	BIA	IR	4340.0	4267.0	6.4	0.12						
BLACK LAKE		1967	JOCKO CREEK		BIA	I			5.1							
THOMPSON FALLS	TOM	1915	CLARK FORK	208.0	MONTANA	P	2396.0	2380.0	15.0	1.45	6	11,100	40.0	63	19,820	
NOXON RAPIDS	NOX	1959	CLARK FORK	169.7	WWP	P	2331.0	2295.0	231.0	7.93	4	40,400	430.0	156	19,370	
CABINET GEORGE	CAB	1953	CLARK FORK	149.9	WWP	P	2175.0	2160.0	42.8	3.19	4	35,700	230.0	111	21,850	
ALBENI FALLS	ALF	1955	PEND OREILLE	86.9	CE	FPR	2062.5	2049.7	1,155.0	94.60	3	24,200	49.0	30	25,340	LAKE PEND OREILLE
PRIEST LAKE	PSL	1950	PRIEST	43.9	WWP	PR	2437.6		70.8	23.40					1,162	STORAGE FOR POWER
BOX CANYON	BOX	1955	PEND OREILLE	34.5	PEND	P	2031.0	2027.0	6.9	2.78	4	26,500	77.0	42	15,970	
SULLIVAN LAKE		1931	HARVEY CR.		PEND MINES	P	2538.0		31.0	1.29		31,210	23.5	548		
BOUNDARY	BDY	1967	PEND OREILLE	17.0	SEATTLE	P	1990.0	1970.0	27.1	1.65	4	33,000	650.0	275	26,720	
SEVEN MILE			PEND OREILLE	7.0	B.C. HYDRO	P	1714.0				3		606.0	197	26,800	UNDER CONSTRUCTION
WANETA	WANB	1944	PEND OREILLE	0.0	W. KOOTENAY	P	1517.8	1501.0	4.2	0.36	4	25,000	375.0	205	27,820	
TWIN LAKES			STRANGER CR.			I			15.1	1.89						
POST FALLS	COEI	1906	SPOKANE	102.1	WWP	P	2128.0	2120.5	225.0	42.45	5	4,140	15.0	61	6,219	COEUR D'ALENE LAKE
HAYDEN LAKE		1948	HAYDEN CREEK		HAYDEN	IRC			73.0						72	
UPPER FALLS		1922	SPOKANE	76.2	WWP	P	1870.5	1864.3	0.8	0.14	1	2,500	10.2	64	6,675	
MONROE ST.		1890	SPOKANE	74.2	WWP	P	1806.0	1806.0			5	2,200	6.0	72	6,864	
NINE MILE		1900	SPOKANE	58.1	WWP	P	1606.6	1590.0	4.6	0.42	4	5,000	18.0	70	7,220	
LONG LAKE	LLK	1915	SPOKANE	33.9	WWP	P	1536.0	1512.0	104.2	5.00	4	6,300	72.5	174	7,793	LAKE SPOKANE
LITTLE FALLS		1910	SPOKANE	29.3	WWP	P	1362.0	1351.0	2.2	0.26	4	7,200	36.0	84	7,793	
GRAND COULEE	GCL	1942	COLUMBIA	596.6	USBR	FIPR	1290.0 2/	1208.0	5,228.0	80.53	21	163,000 3/	4,063.0	343	107,700	FRANKLIN D. ROOSEVELT LAKE

1/ Includes one foot flashboards annually installed during the summer season.
2/ Includes 2 foot flashboards annually installed during the summer season.
3/ Hydraulic capacity of each 600 MW unit assumed to be 23,700 cfs for maximum head of 343 feet.

JANUARY 1978
Figure 22
Sheet 1 of 5

PERTINENT DATA FOR SELECTED DAMS AND RESERVOIRS

DAM	CBTT IDENT	YEAR COMPLETION	LOCATION RIVER	LOCATION MILE	OWNER OR OPERATOR	FUNCTION	NORMAL MAX FOREBAY	NORMAL MIN FOREBAY	STORAGE (1000 AC FT) ACTIVE	STORAGE (1000 AC FT) TOP FT	INSTALLED GENERATION NO OF UNITS	INSTALLED GENERATION CAP IN CFS	INSTALLED GENERATION CAP IN MW	NORMAL MAX HEAD	AVE ANN DISCH (CFS)	REMARKS
MIDDLE COLUMBIA RIVER																
DRY FALLS	BNK	1951	OFF STREAM		USBR	IPR	1580.0		761.8	27.00	2	3,400	100.0	280		(PUMP-TURBINE GENERATORS) BANKS LAKE
NILE VALLEY		1918	WILSON CREEK		NVR	I			6.7							
PINTO		1948	WILSON CREEK		USBR	ICR			76.5							BILLY CLAPP LAKE
SODA LAKE		1952	OFF STREAM		USBR	I			10.2							
O'SULLIVAN		1951	CRAB CREEK		USBR	I	1047.0	1020.0	470.0	29.00						
LONG LAKE		1948	OFF STREAM		USBR	I	1351.0		22.0	1.02						
OWHI			LITTLE NESPELEM			I			5.3	0.54						
CHIEF JOSEPH	CHJ	1958	COLUMBIA	545.1	CE	P	946.0	930.0	116.0	7.80	16 1/	116,000	1,280.0	167	108,000	RUFUS WOODS LAKE
SPECTACLE LAKE		1969			USBR	IR			14.1							
CONCONULLY #2		1921	SALMON CREEK		USBR	I	2324.3		10.5	0.31					3	
CONCONULLY #1		1910	SALMON CREEK		USBR		2287.0		13.0	0.45					29	
LEADER LAKE		1910	LOUP LOUP CREEK		P.V.P	IP			5.3							
WELLS	WEL	1967	COLUMBIA	515.1	DOUGLAS	PFR	779.0	771.0	74.0	10.70	10	220,000	842.0	72	112,500	LAKE PATEROS
CHELAN LAKE	CHL	1927	CHELAN	4.8	CHELAN	PR	1100.0	1079.0	677.0	32.90	2	2,030	58.0	393	2,024	
ROCKY REACH	RRH	1962	COLUMBIA	473.0	CHELAN	PFR	707.0	703.0	36.0	9.20	11	210,000	1,290.0	93	114,700	LAKE ENTIAT
SNOW LAKES			SNOW CREEK			CI			12.5	0.18						
ROCK ISLAND	RIS	1933	COLUMBIA	453.4	CHELAN	P	606.9	602.9	9.5	2.50	10	82,000	249.0	54	118,200	
WANAPUM	WAN	1964	COLUMBIA	415.8	GRANT	PFR	571.5	560.0	161.0	13.80	10	178,000	986.0	83.5	118,300	
PRIEST RAPIDS	PRD	1961	COLUMBIA	397.1	GRANT	PFR	488.0	481.5	44.0	7.00	10	187,000	912.0	82.5	118,400	
KEECHELUS	KEFW	1917	YAKIMA		USBR	I	2517.0	2425.0	157.8	2.56					330	
LAKE KACHESS	KEEN	1912	KACHESS		USBR	I	2262.0		239.8	4.54					285	
CLE ELUM	CLEW	1933	CLE ELUM		USBR	I	2240.0	2110.0	436.9	4.80					909	
BUMPING LAKE	BUM	1910	BUMPING		USBR	I	3426.0	3389.0	33.7	1.30					291	
CLEAR LAKE	CLR	1914	N. FK. TIETON		USBR	I	3015.0		5.3	0.27						
TIETON	TIWA	1925	TIETON		USBR	I	2918.0		198.0	2.53					489	RIMROCK LAKE
NACHES		1906	NACHES	9.7	PP&L	P	1496.4				2	495	4.5	151		
ROZA		1939	YAKIMA	127.9	USBR	P	1186.5				1	1,080	12.9	160		
CHANDLER		1954	YAKIMA	47.1	USBR	P	618.5				2	1,405	13.0	122		
UPPER SNAKE RIVER																
JACKSON LAKE	JCK	1911	SNAKE	1000.2	USBR	IF	6769.0	6730.0	847.0	25.50					1,361	
PALISADES	PAL	1957	SNAKE	901.6	USBR	IFP	5620.0	5497.0	1221.0	16.24	4	8,025	135.0	245	6,028	
HENRYS LAKE	HEN	1923	HENRYS FORK	123.7		I			79.4	6.36					51	
ISLAND PARK	ISL	1938	HENRYS FORK	93.3		I	6302.0	6230.0	127.2	7.80					569	
GRASSY LAKE		1939	GRASSY CREEK	0.4	USBR	I	7210.0	7135.0	15.2	0.31					33	
TETON	TET	1976	TETON		USBR	IP									641	FAILED JUNE 5, 1976
GRAYS LAKE		1924	WILLOW CREEK			I			40.0	22.00						
BLACKFOOT RES.	BLK	1909	BLACKFOOT		BIA	I	6118.5	6086.0	350.0	17.30					160	
RIRIE	RIR	1976	WILLOW CREEK		CE-USBR	FIRC	5119.0	5023.0	90.0	1.56					191	
PORTNEUF		1951	PORTNEUF		P.M.	IM			23.7							
AMERICAN FALLS	AMF	1927	SNAKE	714.0	USBR	IFPM	4354.5	4295.7	1700.0	56.10	3	13,500	100.0	88	6,430	REPLACEMENT DAM COMPLETE
MINADOKA		1906	SNAKE		USBR	IP	4245.0	4236.0	95.0	11.70	7	5,035	15.6		5,381	LAKE WALCOTT
OAKLEY	OKL	1913	GOOSE CREEK		OAKLEY	I	4799.0	4630.0	74.4	1.25					44	
TWIN FALLS		1912	SNAKE		USBR	IP	3519.4	3507.0	0.9	0.10	1	935	9.8	147	2,095	
WILSON LAKE		1909	OFF STREAM		N. SIDE	I			18.5	1.43						
MILNER LAKE	MIL	1932	SNAKE		USBR	I			22.0	3.02					1,707	
MURTAUGH		1905	DRY CREEK		T.F.	I			12.0							
SHOSHONE FALLS	SHOI	1908	SNAKE		USBR	IP	3362.0	3357.0	0.6	0.12	3	860	12.5	212	2,195	
SALMON R.		1911	SALMON FALLS CR.	46.0			5025.8		182.7						135	
CEDAR CREEK		1920	CEDAR CREEK		CEDAR	I			28.2	1.81					27	
1000 SPRINGS		1912	SNAKE (SPRINGS)	584.4	IDAHO	P	3061.9				3	560	7.8	182		
MUD LAKE	MUDI	1909	CAMAS CREEK		OWSLEY	I			60.0	6.60						
MACKAY	MAC	1918	BIG LOST		L. RIVER	IM	6066.5	6007.0	44.4	1.36					296	
UPPER SALMON B		1947	SNAKE	582.0	IDAHO	P	2878.2	2876.2	1.2	0.60	2	6,500	17.5	37	6,975	
UPPER SALMON A		1937	SNAKE	581.0	IDAHO	P	2841.3	2841.3			2	6,000	19.5	43		
LOWER SALMON		1949	SNAKE	572.9	IDAHO	P	2798.6	2791.0	5.5	0.83	4	16,000	68.8	60	7,947	

1/ Units 17 to 27, Under Construction. Schedules for completion in 1979.

JANUARY 1978
Figure 22
Sheet 2 of 5

PERTINENT DATA FOR SELECTED DAMS AND RESERVOIRS

DAM	CBTT IDENT	YEAR COMPLETION	LOCATION RIVER	LOCATION MILE	OWNER OR OPERATOR	FUNCTION	NORMAL MAX FOREBAY	NORMAL MIN FOREBAY	STORAGE (1000 AC FT) ACTIVE	STORAGE (1000 AC FT) TOP FT	INSTALLED GENERATION NO OF UNITS	INSTALLED GENERATION CAP IN CFS	INSTALLED GENERATION CAP IN MW	NORMAL MAX HEAD	AVE ANN DISCH (CFS)	REMARKS
						UPPER SNAKE RIVER										
LITTLE WOOD	WOD	1960	LITTLE WOOD	11.6	USBR	IF	5237.3	5127.4	30.0	0.57					135	
FISH CREEK			FISH CR. (WOOD)			I			13.5	0.56						
TWIN LAKES		1908	McKINNEY CR. (WOOD)		T.L.	IM			31.2	4.04						MORMAN RESERVOIR
MAGIC	MAG	1917	BIG WOOD	60.0	B. WOOD	IM	4935.0	4821.4	191.5	3.90					455	
UPPER MALAD		1948	MALAD	1.4	IDAHO	P	3011.9				1	800	8.0	124		
LOWER MALAD		1911	MALAD	0.2	IDAHO	P	2881.4				1	1,200	13.9	153		
BLISS		1949	SNAKE	560.0	IDAHO	P	2654.0	2644.0	2.2	0.25	3	15,000	75 NP	70	9,486	
MOUNTAIN HOME		1906	RATTLESNAKE CR.		MT. HOME	I			5.6	1.25						
C.J. STRIKE	CJS	1952	SNAKE	492.0	IDAHO	P	2455.0	2450.	39.7	7.40	3	13,800	88.	88	9,775	
SWAN FALLS	SWA	1900	SNAKE	456.0	IDAHO	P	2314.2	2310.0	6.8	0.89	10	8,000	12.0	24	9,744	RESERVOIR NOW USED FOR RECREATION
MOUNTAIN VIEW		1969	BLUE CREEK		D.V.R.	MR			8.3							BLUE LAKE
WILD HORSE			E.F. OWYHEE			I			71.7	2.93						
WISON RIVER			S.F. OWHEE			I			9.0	.83						
CHIMNEY CREEK			S.F. OWYHEE			I			9.0	0.54						
ANTELOPE			JACK CREEK		JORDAN	I			55.0							
OWYHEE	OWY	1938	OWYHEE	27.8	USBR	IF	2670.0	2367.5	715.0	13.90					1,604	
LITTLE CAMAS		1912	LITTLE CAMAS CR.	22.0		I			22.3							
ANDERSON RANCH	AND	1950	S. FK. BOISE	43.5	USBR	IFP	4196.0	4043.0	423.2	4.74	2	1,400	34.5	330	1,000	
ARROWROCK	ARK	1915	BOISE	74.0	USBR	IF	3216.0	2967.0	287.0	3.12					2,485	
LUCKY PEAK	LUC	1956	BOISE	63.8	CE	IF	3060.0	2905.0	278.0	2.85					2,560	
HUBBARD			OFF STREAM			I			7.5							
PLEASANT VALLEY		1925	BLACKS CREEK		PV				7.9	0.40						
LAKE LOWELL		1908	OFF STREAM		USBR	I	2530.5		169.0	9.84						
SILVER CREEK		1969	SILVER CREEK			I			5.7							MOON RESERVOIR
WARM SPRINGS	WAR	1919	M. FK. MALHEUR	108.0	USBR	CIFR	3406.0	3327.0	191.0	4.60					200	
AGENCY VALLEY	BEU	1935	N. FK. MALHEUR	15.0	USBR	CIFR	3340.0	3263.0	60.0	1.90					141	
BULLY CREEK	BUL	1963	BULLY CREEK	12.0	USBR	CIFR	2516.0	2456.6	30.0	0.95					34	
WILLOW CREEK #3		1911	MALHEUR		ORCHARDS	I			20.4							
GOOSE LAKE		1924	GOOSE CREEK		GOOSE	I			6.2							
PAYETTE LAKE			N. FK. PAYETTE			I			27.7	5.00						
LAKE FORK		1926	L. FK. PAYETTE	18.0	LAKE	I	5117.0	5101.0	17.0	1.50					147	
CASCADE	CSC	1948	N. FK. PAYETTE	39.9	USBR	IF	4828.0	4787.0	653.0	28.30					1,022	
DEADWOOD	DED	1931	DEADWOOD	24.4	USBR	I	5334.0	5203.0	162.0	3.00					235	
SAGE HEN		1938	SQUAW CREEK		SQUAW	IM			5.3							
BLACK CANYON	EMM	1925	PAYETTE	38.7	USBR	IP	2497.5	2478.5	19.4	1.09	2	1,540	10.0	94	3,658	
PADDOCK VALLEY		1950	LITTLE WILLOW CR.		L. WILLOW	I			32.0	1.50						
LOST VALLEY		1929	LOST		L. VALLEY	I			10.0	0.73						
C. BEN ROSS		1936	OFF STREAM		L. WEISER	I			7.6	0.35						
CRANE CREEK		1920	CRANE CREEK	12.5	CRANE	IP			60.0	3.30						
MANN CREEK	MAN	1967	MANN CREEK		USBR	CFIR	2889.0	2825.0	11.0	0.28						
						LOWER & MIDDLE SNAKE RIVER										
UNITY	UNY	1938	BURNT	63.6	USBR	I	3820.0	3775.0	25.2	0.93						
MASON	PHL	1968	POWDER	125.0	CE	CIFP	4071.0	3980.0	85.5	2.45					100	PHILLIPS LAKE
THIEF VALLEY	THE	1932	POWDER	70.0	USBR	I	3094.0		17.4	0.74					117	
BROWNLEE	BRN	1959	SNAKE	285.0	IDAHO	FPCR	2077.0	1976.0	980.3	13.84	4	23,000	450.0	272	16,530	
OXBOW	OXB	1961	SNAKE	273.0	IDAHO	P	1805.0	1800.0	5.0	0.99	4	25,000	220.0	120	16,530	
HELLS CANYON	HCD	1968	SNAKE	247.0	IDAHO	P	1688.0	1683.0	11.7	2.38	3	30,000	450.0	210	16,820	
WALLOWA LAKE		1929	WALLOWA LAKE		ADC	IR			37.5	1.29						WALLOWA LAKE
DWORSHAK	DWR	1971	N. FK. CLEARWATER	1.9	CE	FPR	1600.0	1445.0	2016.0	17.85	3	9,600	460.0	627	5,584	
LOWER GRANITE	LWG	1975	SNAKE	107.5	CE	PNR	738.0	733.0	53.0	10.70	3 1/	65,000	466.0	100	47,100	
LITTLE GOOSE	LGS	1970	SNAKE	70.3	CE	PNR	638.0	633.0	49.6	9.92	3 1/	65,000	466.0	98	47,230	LAKE BRYAN
LOWER MONUMENTAL	LMN	1969	SNAKE	41.6	CE	PNR	540.0	537.0	20.0	6.74	3	65,000	466.0	100	47,670	
ICE HARBOR	IHR	1961	SNAKE	9.7	CR	PNR	440.0	437.0	25.0	8.33	6	105,000	695.0	100	47,680	LAKE SACAJAWEA

1/ Units 4, 5 & 6 schedules on line Jan-June 1978

January 1978
Figure 22
Sheet 3 of 5

PERTINENT DATA FOR SELECTED DAMS AND RESERVOIRS

DAM	CBTT IDENT	YEAR COMPLETION	LOCATION RIVER	LOCATION MILE	OWNER OR OPERATOR	FUNCTION	NORMAL MAX FOREBAY	NORMAL MIN FOREBAY	STORAGE (1000 AC FT) ACTIVE	STORAGE (1000 AC FT) TOP FT	INSTALLED GENERATION NO OF UNITS	INSTALLED GENERATION CAP IN CFS	INSTALLED GENERATION CAP IN MW	NORMAL MAX HEAD	AVE ANN DISCH (CFS)	REMARKS
							LOWER COLUMBIA RIVER									
MILL CREEK	MLL	1942	MILL CREEK		CE	FR	1265.0	1195.0	8.1	0.23						
McNARY	MCN	1953	COLUMBIA	292.0	CE	PNRI	340.0	335.0	185.0	38.10	14	232,000	1127.0	75	169,800	LAKE WALLULA
McKAY	MCK	1927	McKAY CREEK		USBR	I	1322.0	1182.0	73.8	1.55						
COLD SPRINGS	CLS	1908	UMATILLA		USBR	I	621.5	560.0	50.0	3.93						
JOHN DAY	JDA	1968	COLUMBIA	215.6	CE	FPNRI	268.0	257.0	535.0	54.00	16	350,000	2484.0	105	172,400	LAKE UMATILLA
CRANE PRAIRIE	CRA	1940	DESCHUTES		USBR	I	4445.0	4424.0	55.3	4.94					236	
WICKIUP	WIC	1949	DESCHUTES		USBR	I	4336.5	4259.8	182.1	10.60					710	
CRESENT LAKE	CRE	1966	CRESENT CREEK		USBR	IR	4847.0	4823.4	86.0	3.93					49	
HATSTACK	HAY	1957	HAYSTACK CREEK		USBR	I	2848.5	2780.0	6.6	0.26						
WASCO	WAS	1959	CLEAR CREEK		USBR	I	3514.4	3488.0	11.9	0.56					15	
PRINEVILLE	PRV	1961	CROOKED	72.5	USBR	IFR	3234.8	3114.0	153.0	1.00					365	
OCHOCO	OCH	1950	OCHOCO	10.0	USBR	IR	3130.9	3048.1	47.0	1.00					47	
ROUNDBUTTE	ROU	1964	DESCHUTES	110.6	PGE	PR	1945.0	1860.0	274.3	3.99	3	13,200	330.0	365	4,115	LAKE BILLY CHINOOK
PELTON		1957	DESCHUTES	102.8	PGE	P	1580.0	1573.0	3.8	0.56	3	11,590	124.0	153	4,315	LAKE SIMTUSTUS
THE DALLES	TDA	1957	COLUMBIA	191.5	CE	PNR	160.0	155.5	53.0	10.50	22	375,000	2047.0	85	177,900	LAKE CELILO
POWERDALE		1923	HOOD	3.0	PP&L	P	291.6				1	485	5.5	210		
CONDIT		1913	WHITE SALMON	3.3	PP&L	P	295.0	282.0	1.1	0.01	2	1,250	14.5	179	1,128	
BONNEVILLE	BON	1937	COLUMBIA	146.1	CE	PNR	77.0	70.0	138.0	24.40	10	136,000	574.0	67	183,300	
BULL RUN #1	BUN	1928	BULL RUN	11.5	PORTLAND	M	1044.0		30.7						603	
BULL #2	RUN	1961	BULL RUN	6.5	PORTLAND	M	860.0		21.0							LAKE BEN MORROW
BULL RUN		1912	BULL RUN	4.7	PGE	P	655.0	648.0	0.9	0.16	4	1,120	22.0	326	659	
SWIFT	SWF	1958	LEWIS	47.9	PP&L	P	1000.0	878.0	447.0	4.62	3	9,350	268.0	396	2,919	
SWIFT #2		1958	LEWIS	44.2	COWLITZ	P	604.0	600.0	0.3	0.10	2	8,600	77.0	136	2,919	
YALE	YAL	1953	LEWIS	34.2	PP&L	P	490.0	430.0	189.6	3.77	2	8,000	132.0	250	3,940	
MERWIN	MER	1931	LEWIS	19.6	PP&L	P	239.6	165.0	244.0	3.92	4	11,000	145.0	187	4,825	LAKE MERWIN (FORMALLY ARIEL DAN)
PACKWOOD		1964	LAKE CREEK	5.3	WPPSS	P	2855.5	2850.5	3.6	0.46	1	300	31.5	1,812	100	PACKWOOD LAKE
MOSSYROCK	MOS	1968	COWLITZ	65.5	TACOMA	FPR	778.5	600.0	1397.0	11.63	2	14,507	384.0	347	5,108	RIFFE LAKE (FORMALLY) DAVISSON LAKE)
MAYFIELD	MAY	1963	COWLITZ	52.0	TACOMA	PR	425.0	415.0	21.4	2.20	3	10,150	133.0	182	6,148	
							WILLAMETTE RIVER									
HILLS CREEK	HCR	1962	M. FK. WILLAMETTE	47.8	CE	FPR	1543.0	1414.0	249.0	2.68	2	1,520	34.4	320	1,087	
LOOKOUT POINT	LOP	1955	M. FK. WILLAMETTE	21.3	CE	FPR	929.0	819.0	349.0	4.24	3	8,000	138.0	231	2,900	
DEXTER	DEX	1955	M. FK. WILLAMETTE	18.0	CE	PR	695.0	690.0	4.8	0.99	1	4,200	17.0	59	2,900	
FALL CREEK	FAL	1965	FALL CREEK	7.2	CE	FR	834.0	728.0	115.0	1.85					548	
COTTAGE GROVE	COT	1942	C. FK. WILLAMETTE	29.7	CE	FR	791.0	750.0	30.0	1.14					264	
DORENA	DOR	1949	ROW	7.5	CE	FR	835.0	770.5	71.0	1.87					708	
CARMAN	CRM	1962	McKENZIE	87.6	EUGENE	P	2605.0				2	3,400	101.6	513		POWER PLANT
SMITH	SMH	1963	SMITH	2.1	EUGENE	P	2605.0	2525.0	9.9	0.17					96	STORAGE FOR CARMAN POWER PLANT
TRAIL BRIDGE		1963	McKENZIE	81.9	EUGENE	P	2092.0	2045.0	2.2	0.07	1	1,900	11.4	82	1,009	
COUGAR	CGR	1964	S. FK. McKENZIE	4.4	CE	FPR	1699.0	1516.0	165.0	1.23	2	890	28.8	437	778	
BLUE RIVER	BLU	1968	BLUE	1.8	CE	FR	1357.0	1180.0	85.0	0.97					426	
LEABURG		1930	McKENZIE	38.8	EUGENE	P	742.0	740.0	0.1	0.07	2	2,500	14.8	89	4,323	
WALTERVILLE		1911	McKENZIE	28.5	EUGENE	P	607.0	601.0	0.3		1	2,575	9.4	54	4,461	
FERN RIDGE	FRN	1941	LONG TOM	25.6	CE	FR	373.6	353.5	110.0	9.04					512	
GREEN PETER	GPR	1967	M. FK. SANTIAM	5.5	CE	FPR	1015.0	887.0	333.0	3.59	2	4,000	92.0	310	2,141	
FOSTER	FOS	1968	SOUTH SANTIAM	37.7	CE	FPR	641.0	613.0	34.0	1.19	2	2,800	23.0	110	2,141	
DETROIT	DET	1953	NORTH SANTIAM	60.9	CE	FPR	1569.0	1425.0	340.0	3.45	2	4,400	115.0	360	1,567	
BIG CLIFF	BCL	1953	NORTH SANTIAM	58.1	CE	PR	1206.0	1193.0	3.0	0.14	1	3,000	21.0	96	2,524	
SCOGGINS	SCO	1975	SCOGGINS CREEK	4.8	USBR	FIRM	303.5	235.3	53.0	0.11					140	
T.W. SULLIVAN		1888	WILLAMETTE	26.6	PGE	P	52.0				13	5,750	15.0	40	30,640	
TIMOTHY LAKE	TMY	1956	CLACKAMAS		PGE	PR	3190.0	3125.0	61.7	1.43					123	STORAGE FOR POWER D/S
NORTH FORK	NFK	1958	CLACKAMAS		PGE	PR	665.0	646.0	6.0	0.35	2	5,455	54.0	135	2,691	LAKE HARRIET
OAKGROVE		1924	OAKGROVE FK.	5.1	PGE	P	1988.0	1958.0	0.4	0.03	2	820	49.0	880	477	
FARADAY		1907	CLACKAMAS	26.0	PGE	P	522.0	514.0	0.6	0.10	6	4,835	44.0	133	2,691	
RIVER MILL		1911	CLACKAMAS	23.3	PGE	P	388.8	381.0	0.5	0.11	5	4,510	23.0	81	2,691	

JANUARY 1978
Figure 22
Sheet 4 of 5

PERTINENT DATA FOR SELECTED DAMS AND RESERVOIRS

DAM	CBTT IDENT	YEAR COMPLETION	LOCATION RIVER	LOCATION MILE	OWNER OR OPERATOR	FUNCTION	NORMAL MAX FOREBAY	NORMAL MIN FOREBAY	STORAGE (1000 AC FT) ACTIVE	STORAGE (1000 AC FT) TOP FT	INSTALLED GENERATION NO OF UNITS	INSTALLED GENERATION CAP IN CFS	INSTALLED GENERATION CAP IN MW	NORMAL MAX HEAD	AVE ANN DISCH (CFS)	REMARKS
PUGET SOUND & COASTAL RIVERS																
LAKE WHATCOM		1937	WHATCOM CREEK		BELLINGHAM	M			26.4	5.00					—	
ROSS	ROS	1949	SKAGIT	105.2	SEATTLE	FPR	1602.5	1475.0	1052.0	11.85	4	16,000	446.0	397	3,377	
DIABLO	DIA	1929	SKAGIT	101.0	SEATTLE	P	1206.0	1186.0	16.8	0.91	4	7,130	159.0	330	4,093	
GORGE	GOR	1960	SKAGIT	96.6	SEATTLE	P	875.0	825.0	6.6	0.24	4	7,440	175.0	380	4,458	
UPPER BAKER	UBK	1959	BAKER	9.3	PUGET	FP	724.0	655.0	221.0	4.89	2	4,818	103.0	285	2,026	BAKER LAKE
LOWER BAKER	SHA	1927	BAKER	1.2	PUGET	P	438.6	355.0	142.0	2.22	1	3,717	71.3	263	2,593	LAKE SHANNON
GEORGE CULMBACK		1965	SULTON	16.5	PUD#1 SNO.	M	1360.0	1250.0	34.5						797	SPADA LAKE
LAKE CHAPLAIN			CHAPLAIN CREEK	0.5		M			13.4	0.44						
SNOQUALMIE #1		1898	SNOQUALMIE	40.0	PUGET	P	401.0		0.4		5	970	13.0	271	2,623	
SNOQUALMIE #2		1910	SNOQUALMIE	40.0	PUGET	P	401.0	396.5	0.4	0.11	2	1,530	31.0	287		
TOLT		1963	S. FK. TOLT		SEATTLE	M			57.8						200	
CEDAR FALLS		1914	CEDAR	29.0	SEATTLE	P	1550.0	1510.0	38.8	1.82	2	750	30.0	620	311	
HOWARD A. HANSON	HAH	1962	GREEN	64.5	CE	FA	1141.0	1040.0	28.0	1.73					1,074	
MUD MOUNTAIN	MMD	1948	WHITE	29.6	CE	F	1215.0	895.0	106.0	0.96					1,469	
LAKE TAPPS		1911	WHITE		PUGET	P	543.0	515.0	46.7	2.52	4	1,994	63.8	489		
ELECTRON		1904	PUYALLUP	42.0	PUGET	P	1538.0		54.0	0.01	4	440	26.4	874	534	
ALDER	ALD	1945	NISQUALLY	44.2	TACOMA	PR	1207.0	1114.0	179.7	3.33	2	2,549	52.0	272	1,405	LAKE ALDER
LA GRANDE		1912	NISQUALLY	42.0	TACOMA	P	935.0	910.0	1.0	0.05	5	2,095	65.0	423	1,405	
YELM		1930	NISQUALLY	26.2	CENTRALIA	P	318.0				1		9 NP	208	1,816	
CUSHMAN #1	CSH	1926	SKOKOMISH	11.8	TACOMA	PR	738.0	615.0	371.9	4.20	2	2,448	47.0	257	746	LAKE CUSHMAN
CUSHMAN #2		1930	SKOKOMISH	9.0	TACOMA	P	480.0	460.0	2.1	0.11	3	2,670	88.0	480	753	
GLINES CANYON		1927	ELWHA	10.0	CROWN Z	PM	588.3	559.3	21.8	0.44			17.4	192	1,510	LAKE MILLS
WYNOOCHEE	WYN	1974	WYNOOCHEE	51.8	CE	FCA	800.0	700.0	62.8	1.12					556	
LEMOLA	LEM	1954	UMPQUA	93.0	PP&L	P	4148.5	4095.0	12.7	0.44	1	500	28.0	752	424	
CLEARWATER #1		1953	CLEARWATER CREEK	9.0	PP&L	P	3863.0	3855.0			1	250	12.0	651	168	
CLEARWATER #2		1953	CLEARWATER CREEK	5.7	PP&L	P	3179.5	3169.0			1	460	26 NP	760	215	
LEMOLO #2		1956	NORTH UMPQUA	88.4	PP&L	P	3184.5	3173.0			1	655	35.0	729	583	
TOKETEE		1950	NORTH UMPQUA	75.3	PP&L	P	2430.0	2414.0	1.2	0.10	3	1,435	42.0	448	987	
FISH CREEK		1952	FISH CREEK	7.3	PP&L	P	3024.0	3014.0			1	172	12.0	1,034	191	
SLIDE CREEK		1951	NORTH UMPQUA	73.0	PP&L	P	603.0	600.0			1	1,500	17.0	169	1,092	
SODA SPRINGS		1952	NORTH UMPQUA	69.8	PP&L	P	1805.5	1779.0	0.6	0.03	1	1,550	11.5	114	1,237	
PROSPECT #2		1928	ROGUE	169.5	PP&L	P	2597.5	2594.0			2	840	36.0	607	804	
PROSPECT #3		1932	SO. FK. ROGUE	9.0	PP&L	P	2640.0				1	130	6.8	720	174	
LOST CREEK	LOS	1977	ROGUE	158.4	CE	FPR	1872.0	1751.0	315.0	3.40	2		49.0	323	1,821	
FISH LAKE		1923	N. FK. L. BUTTE CR.		USBR	I	4827.2	4790.0	8.0	0.42					37	
FOURMILE LAKE		1956	FOURMILE CREEK		USBR	I	6002.5		13.3	0.90					14	
AGATE		1966	ANTELOPE CREEK		ROGUE	I			5.4							
HYATT PRAIRIE	HYA	1922	KEENE CREEK		USBR	IP	5016.0		16.2	0.88					12	
HOWARD PRAIRIE	HPP	1960	GRIZZLE CREEK		USBR	CFIPR	4533.0		60.5	1.96					117	
GREEN SPRINGS		1960	EMIGRANT CR.	8.0	USBR	P	4403.0		0.3		1		18.4	1,984		
EMIGRANT LAKE	EML	1961	EMIGRANT CREEK	23.0	USBR	IF	2241.0	2131.5	39.0	0.81					31	

OWNER OR OPERATOR

ADC	ASSOCIATED DITCH CO.
ASH	ASHLEY IRRIGATION DISTRICT
B. FERRY	CITY OF BONNERS FERRY
B. WOOD	BIG WOOD CANAL CO.
B.C. HYDRO	B.C. HYDRO & POWER AUTHORITY
BIA	BUREAU OF INDIAN AFFAIRS
CE	CORPS OF ENGINEERS
CEDAR	CEDAR MESA CO.
CENTRALIA	CITY OF CENTRALIA
CHELAN	CHELAN COUNTY PUD NO. 1
COWLITZ	COWLITZ COUNTY PUD
CRANE	CRANE CREEK RESERVOIR CO.
D.V.R.	SHO-PAI TRIBE OF D.V.R.
DOUGLAS	DOUGLAS COUNTY PUD NO. 1
EUGENE	CITY OF EUGENE
GOOSE	GOOSE LAKE RESERVOIR CO.
GRANT	GRANT COUNTY PUD NO. 2
HAYDEN	HAYDEN LAKE WATER SHED IMPROVEMENT

OWNER OR OPERATOR

IDAHO	IDAHO POWER CO.
JORDAN	JORDAN VALLEY IRRIGATION CO.
L. RIVER	LOST RIVER IRRIGATION CO.
L. VALLEY	LOST VALLEY RESERVOIR CO.
L. WEISER	LITTLE WEISER RIVER IRRIGATION DISTRICT
L. WILLOW	LITTLE WILLOW CREEK IRRIGATION CO.
LAKE	LAKE IRRIGATION DISTRICT
MONTANA	MONTANA POWER CO.
MT. HOME	MOUNTAIN HOME IRRIGATION CO.
N. SIDE	NORTH SIDE CANAL CO.
N.V.R.	NILE VALLEY RANCH
OAKLEY	OAKLEY CANAL CO.
ORCHARDS	ORCHARDS WATER CO.
OWSLEY	OWSLEY CANAL CO.
P.M.	PORTNEUF-MARSH VALLEY CO.
P.S.	PERKINS & SCHRODER RANCH
P.V.	PLEASENT VALLEY IRRIGATION CO.
P.V.P.	PLEASANT VALLEY IRRIGATION & POWER CO.

OWNER OR OPERATOR

PEND	PEND OREILLE COUNTY PUD
PGE	PORTLAND GENERAL ELECTRIC CO.
PORTLAND	CITY OF PORTLAND
PP & L	PACIFIC POWER & LIGHT CO.
PSP & L	PUGET SOUND POWER & LIGHT CO.
PUD #1 SNO	SNOHOMISH COUNTY PUD & CITY OF EVERETT
ROGUE	ROGUE RIVER VALLEY IRRIGATION DISTRICT
S. MONT	STATE OF MONTANA
SEATTLE	CITY OF SEATTLE
SQUAW	SQUAW CREEK IRRIGATION CO.
T.F.	TWIN FALLS CANAL CO.
T.L.	TWIN LAKE RESERVOIR & IRRIGATION CO.
TACOMA	CITY OF TACOMA
UP & L	UTAH POWER & LIGHT CO.
USBR	U.S. BUREAU OF RECLAMATION
W. KOOTENAY	WEST KOOTENAY POWER & LIGHT
WPPSS	WASHINGTON PUBLIC POWER SUPPLLY SYSTEM
WWP	WASHINGTON WATER POWER CO.

PROJECT FUNCTION SYMBOLS

P	Hydropower at Site and/or Downstream
I	Irrigation
F	Flood Control
N	Navigation
M	Municipal and Industrial Water Supply
C	Fish and Wildlife Conservation
A	Pollution Abatement or Low Flow Augmentation
R	Recreation

MISCELLANEOUS SYMBOLS

UC	Under Construction
NP	Name Plate

JANUARY 1978
Figure 22
Sheet 5 of 5

B. Current Status of Construction at Major Projects

McNaughton Lake, the reservoir at Mica Dam project 85 miles north of Revelstoke, Canada, filled to normal maximum pool elevation in August 1976. The first three hydroelectric generators are in service and Unit 4 is expected in service during November 1977.

B.C. Hydro & Power Authority awarded the main civil contract to build the Seven Mile Dam on the Pend Oreille River upstream from the Waneta Dam project. The Contract was awarded 7 September, 1976 and first power is scheduled for early 1980.

The Third Powerhouse at Grand Coulee Dam is complete with the first three new units (G-19, 20 & 21) on line. These three units are each 600 MW. The first 700 MW units (G-22) is scheduled on line December 1977, with two additional 700 MW units (G-23 & G-24) scheduled at about six month intervals.

The modification of Chief Joseph project to provide an increase of 10 additional feet in normal maximum pool elevation is progressing with an estimated completion data of February 1980. Two of the new 95 MW units are in service and the third is expected in October 1977. All eleven additional units are scheduled for completion by May 1979.

Modification of the Original Rock Island Dam to provide for a 6.1 foot increase in forebay elevation requires the addition of a section to the bottom of each of the present gates; this work is scheduled for completion during January 1978. The upstream cofferdam area was intentionally flooded during September 22-26, 1977, and the removal of the upstream cofferdam is scheduled for October 1977. The first of the new bulb-type Nyerpic Turbine generators is scheduled in operation in February 1978.

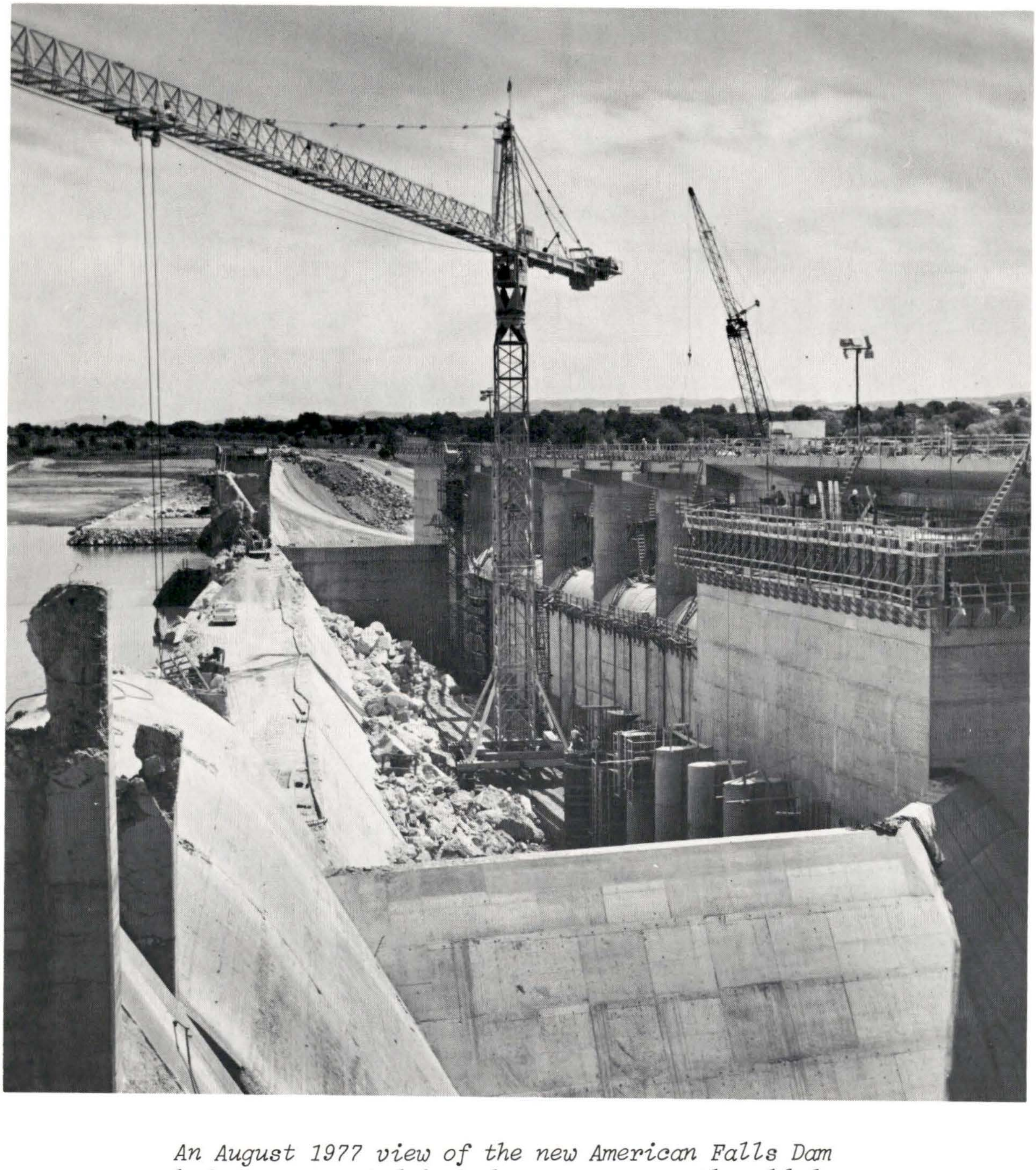
Three additional units are being installed in each of three lower Snake River projects. The Lower Granite units are expected in service between January 1978 - May 1978; Little Goose between February 1978 - June 1978 and Lower Monumental between February 1979 - April 1979.

The authorized fifth generator is being installed at Noxon Dam; the scheduled on-line date is November 1977.

Work continues on the seepage cut-off wall for the Bonneville second powerhouse. The contract for construction of the second powerhouse is expected to be awarded in May 1978. The first unit is estimated to be on line about May 1981.

Construction of the fifth unit (225 MW) of Brownlee Dam is scheduled to be completed by November 1979. The present powerhouse was extended to include the original diversion tunnel which will provide water to the new unit.

The new American Falls Dam is now nearing completion. Final blasting for breaching the old dam was completed on September 1, 1977. The American Falls Reservoir District, which represents the American Falls reservoir storage water users, was authorized to finance and construct the replacement dam and to contract with a nonfederal entity for the use of the water released from the dam for power generation. On September 10, the dam was transfered to the Bureau of Reclamation.



An August 1977 view of the new American Falls Dam being constructed just downstream from the old dam

X. GLOSSARY

STREAMFLOW - the rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

HISTORICAL STREAMFLOW - is synonymous with observed streamflow.

OBSERVED STREAMFLOW - is the amount of water that has been historically measured or otherwise determined to have occurred at a specified point in the stream system.

AVERAGE STREAMFLOW - the average rate of flow at a given point during a specified period.

MEDIAN STREAMFLOW - the rate of flow at a given point for which there are equal numbers of greater and lesser flow occurrences during a specified period.

ADJUSTED STREAMFLOW - observed streamflow adjusted to eliminate effects of specified controls.

REGULATED STREAMFLOW - the controlled rate of flow at a given point during a specified period resulting from an actual reservoir operation (observed streamflow), or a theoretical operation.

UNREGULATED STREAMFLOW - regulated streamflow adjusted to eliminate the effects of reservoir regulation, but reflecting the effects of natural storage in lakes and river channels.

BASEPOWER FLOW - observed streamflow adjusted to eliminate the effects of reservoirs, controlled lake regulation and actual Grand Coulee pumping and then further adjusted to a given level of irrigation development.

NATURAL STREAMFLOW - the rate of flow at a given point of an uncontrolled stream, or streamflow adjusted to eliminate the effects of all man made development.

DIVERSION DEMAND - the amount of water withdrawn from surface or groundwater sources.

RETURN FLOW - that portion of the diversion demand that is returned to the stream system and is available for further downstream use.

STREAMFLOW DEPLETION - that portion of diversion demand that is permanently removed from the stream system.

MODIFIED FLOW - the observed or historical flow which has been adjusted to a common level of development by correcting for the effects of diversion demand, return flow, and changes in contents of upstream reservoirs and lakes.

RESERVOIR STORAGE* CAPACITY - the volume of a reservoir available to store water.

RESERVOIR STORAGE - the volume of water in a reservoir at a given time.

ACTIVE STORAGE CAPACITY - the portion of the live storage capacity in which water normally will be stored or withdrawn for beneficial uses, in compliance with operating agreements or restrictions.

ACTIVE STORAGE - water occupying active storage capacity of a reservoir.

INACTIVE STORAGE CAPACITY - the portion of the live storage capacity from which water normally will not be withdrawn, in compliance with operating agreements or restrictions.

INACTIVE STORAGE - water occupying inactive storage capacity of a reservoir.

DEAD STORAGE CAPACITY - the volume of a reservoir which is below the invert of the lowest outlet and cannot be evacuated by gravity.

DEAD STORAGE - water occupying dead storage capacity of a reservoir.

LIVE STORAGE CAPACITY - the volume of a reservoir exclusive of dead and surcharge storage capacity.

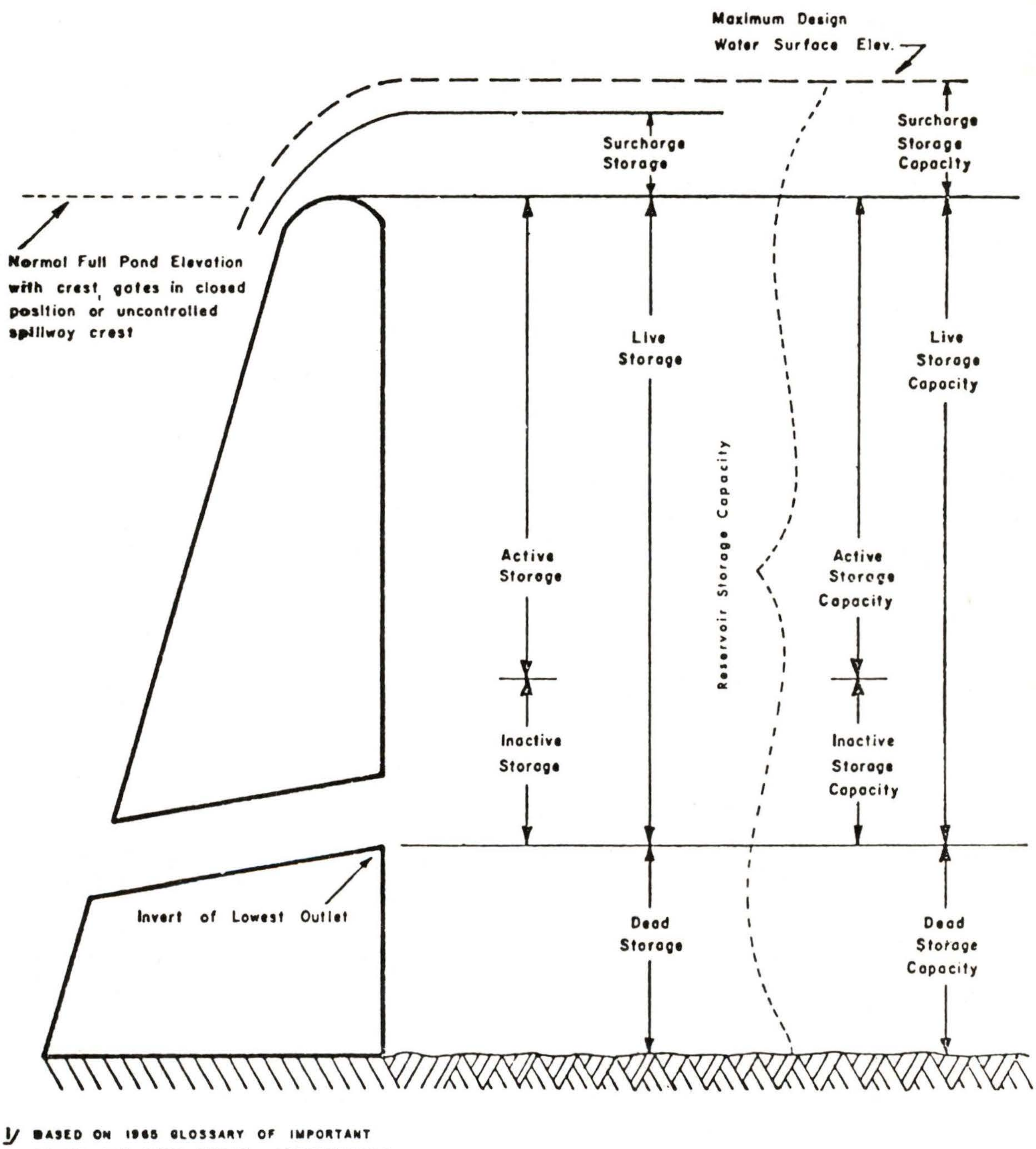
LIVE STORAGE - water occupying live storage capacity of a reservoir.

SURCHARGE STORAGE CAPACITY - the volume of a reservoir between the crest of an uncontrolled spillway, or the volume between the normal full pond elevation with the crest gates in the normal closed position, and the maximum water surface elevation for which the dam is designed.

SURCHARGE STORAGE - water occupying surcharge storage capacity of a reservoir.

*STORAGE is synonymous with CONTENTS and the terms RESERVOIR STORAGE and RESERVOIR CONTENTS are used interchangeably.

ILLUSTRATION OF RESERVOIR TERMS 1/



1/ BASED ON 1965 GLOSSARY OF IMPORTANT POWER AND RATE TERMS, ABBREVIATIONS, AND UNITS OF MEASUREMENT"

WATER MANAGEMENT SUBCOMMITTEE, COLUMBIA BASIN INTER-AGENCY COMMITTEE

FIGURE 23

CAPABILITY - the maximum load which a generator, turbine, transmission circuit, apparatus, station, or system can supply under specified conditions for a given time interval, without exceeding approved limits of temperature and stress.

CAPACITY - the load for which a generator, turbine, transformer, transmission circuit, apparatus, station, or system is rated. Capacity is also used synonymously with capability. NOTE: For definitions pertinent to the capacity of a reservoir to store water, see Reservoir Storage Capacity.

OVERLOAD CAPABILITY - the maximum load that a machine, apparatus, or device can carry for a specified period of time under specified conditions when operating beyond its normal rating but within the limits of the manufacturer's guarantee, or in the case of expiration of the guarantee, within safe limits as determined by the owner.

PEAKING CAPABILITY - maximum peak load that can be supplied by a generating unit, station, or system in a stated time period. It may be the maximum instantaneous load or the maximum average load over a designated interval of time.

INSTALLED CAPACITY - the total of the capacities as shown by the nameplates of similar kinds of apparatus such as generating units, turbines, synchronous condensers, transformers, or other equipment in a station or system.

ENERGY - that which does or is capable of doing work. It is measured in terms of the work it is capable of doing; electric energy is usually measured in kilowatt-hours.

POWER - the time rate of transferring energy. NOTE: The term is frequently used in a broad sense, as a commodity of capacity and energy, having only general association with classic or scientific meaning (see also "Electric Power").

ELECTRIC POWER - a term used in the electric power industry to mean inclusively power and energy.

GENERATION - the act or process of producing electric energy from other forms of energy; also the amount of electric energy so produced.

NET ENERGY FOR SYSTEM - the electric energy requirements of a system, including losses, defined as: (1) net generation of the system, plus (2) energy received from others, less (3) energy delivered to other systems for resale.

POTENTIAL HYDRO ENERGY - the aggregate energy capable of being developed over a specified period by practicable use of the available streamflow and river gradient.

INTERCHANGE ENERGY - electric energy received by one electric utility system usually in exchange for energy delivered to the other system at another time or place. Interchange energy is to be distinguished from a direct purchase or sale, although accumulated energy balances are sometimes settled for in cash.

PRIMARY ENERGY - hydroelectric energy which is available from continuous power.

SECONDARY ENERGY - all hydroelectric energy other than primary energy.

FIRMENERGY - electric energy which is intended to have assured availability to the customer to meet all or any agreed upon portion of his load requirements.

NONFIRM ENERGY - electric energy having limited or no assured availability.

CONTINUOUS POWER - hydroelectric power available from a plant on a continuous basis under the most adverse hydraulic conditions contemplated.

PRIME POWER - Same as continuous power.

INTERRUPTIBLE POWER - power made available under agreements which permit curtailment or cessation of delivery by the supplier.

FIRM POWER - power intended to have assured availability to the customer to meet all or any agreed upon portion of his load requirements.

NONFIRM POWER - power which does not have assured availability to the customer to meet his load requirements.

LOAD - the amount of electric power delivered at a given point.

BASE LOAD - the minimum load in a stated period of time.

CONNECTED LOAD - the sum of the ratings of the electric power consuming apparatus connected to the system, or part of the system, under consideration.

INTERRUPTIBLE LOAD - electric power load which may be curtailed at the supplier's discretion, or in accordance with a contractual agreement.

PEAK LOAD - the maximum load in a stated period.

OPERATING RULE CURVE - a curve, or family of curves, indicating how a reservoir is to be operated under specific conditions to obtain best best or predetermined results.

FLOOD CONTROL RULE CURVE - a curve or family of curves of reservoir contents with respect to time indicating space required to control flood flow. These curves are determined from analysis of magnitude, duration, and potential damage of flood flows throughout the year or for certain periods during the year.

CRITICAL RULE CURVE - a schedule or budget of seasonal reservoir drafts with respect to time as determined from analyses of estimated loads and calculated reservoirs based on critical flow water supply for the period. In the analyses, consideration is given first, to providing power so as to meet system firm loads; secondly, to economy of operation; and thirdly, to providing power to meet interruptible loads. The schedule or budget of reservoir draft may be shown as a plot of reservoir elevation with respect to time, energy producible from reservoir draft with respect to time or by other similar means.

In multiple-year critical periods there will be a Critical Rule Curve for each corresponding year of the critical period, the first year's curve being the highest in indicated storage energy, the second year's being the next highest, etc.

ENERGY CONTENT CURVE - indicates the end-of-month storage content which is the higher of the first year critical rule curve and of a value which would assure refill of a seasonal reservoir based on a specified historical volume of inflow for the whole or remaining portion of the refill period. The specified historical volume for most projects in the Columbia Basin is the second lowest of historical record. The year 1931 represents the second lowest historical January-July volume inflow for the system as measured at The Dalles, Oregon.

The curve is a guide to the use of storage water from each reservoir. It is used to define certain operating rights, obligations and limitations. The Energy Content Curve for each reservoir shall consist of a graphic, tabular or other representation of reservoir elevations at the end of specificed periods.

VARIABLE ENERGY CONTENT CURVE - determined for certain large reservoirs which do not have all storage drafted to normal bottom elevation by Energy Content Curves. The variable Energy Content Curves provide for drafts below the Energy Content Curve by the amount of forecasted volume inflow is in excess of total requirements for refill of the reservoir, minimum discharge requirements, non-power requirements for water at site and upstream and water required to refill upstream reservoirs. The inflow volume at each reservoir may be reduced by deducting the 95 percent confidence forecast error, power discharge requirement, non-power requirements upstream (if any), and water required for refill at upstream reservoirs.

The rights, obligations and limitations are the same as those defined by the Energy Content Curve.

X. ACKNOWLEDGMENTS

Mr. Fred A. "Fritz" Limpert retired in February 1977, after 34 years of Federal service. He was the Head of Bonneville Power Administration's Hydrology Section from 1961 until his retirement. Mr. Limpert was very active in work of both the CBIAC and the CRWMG, getting people to think with one accord and to cooperatively plan and coordinate on an interagency basis to eliminate duplication of services and research. He was active in the cooperative research on the acoustic velocity meter for streamflow measurements and the snow pillow and radioisotopic snow profiling gage for making snow measurements. Mr. Limpert was very much the catalyst in the promotion of the interagency aspect of the CROHMS and the automation of data collection and transmission.

Mr. Vail P. Schermerhorn retired from his post as Hydrologist in Charge of the National Weather Service River Forecast Center at Portland on July 2, 1977. Mr. Schermerhorn had been in charge of the local NWS-RFC for the past four years and was Principal Assistant for 23 years. He was instrumental in establishing the Columbia River Forecasting Service, a joint operation of the NWS, COE and BPA. The Columbia River Forecasting Service is the tri-agency unit that coordinates flow requirements for all agencies involved in the management of Columbia Basin water resources. Mr. Schermerhorn's leadership and expertise will be missed in the Columbia River Water Management Group meetings and the many other subcommittees he served.

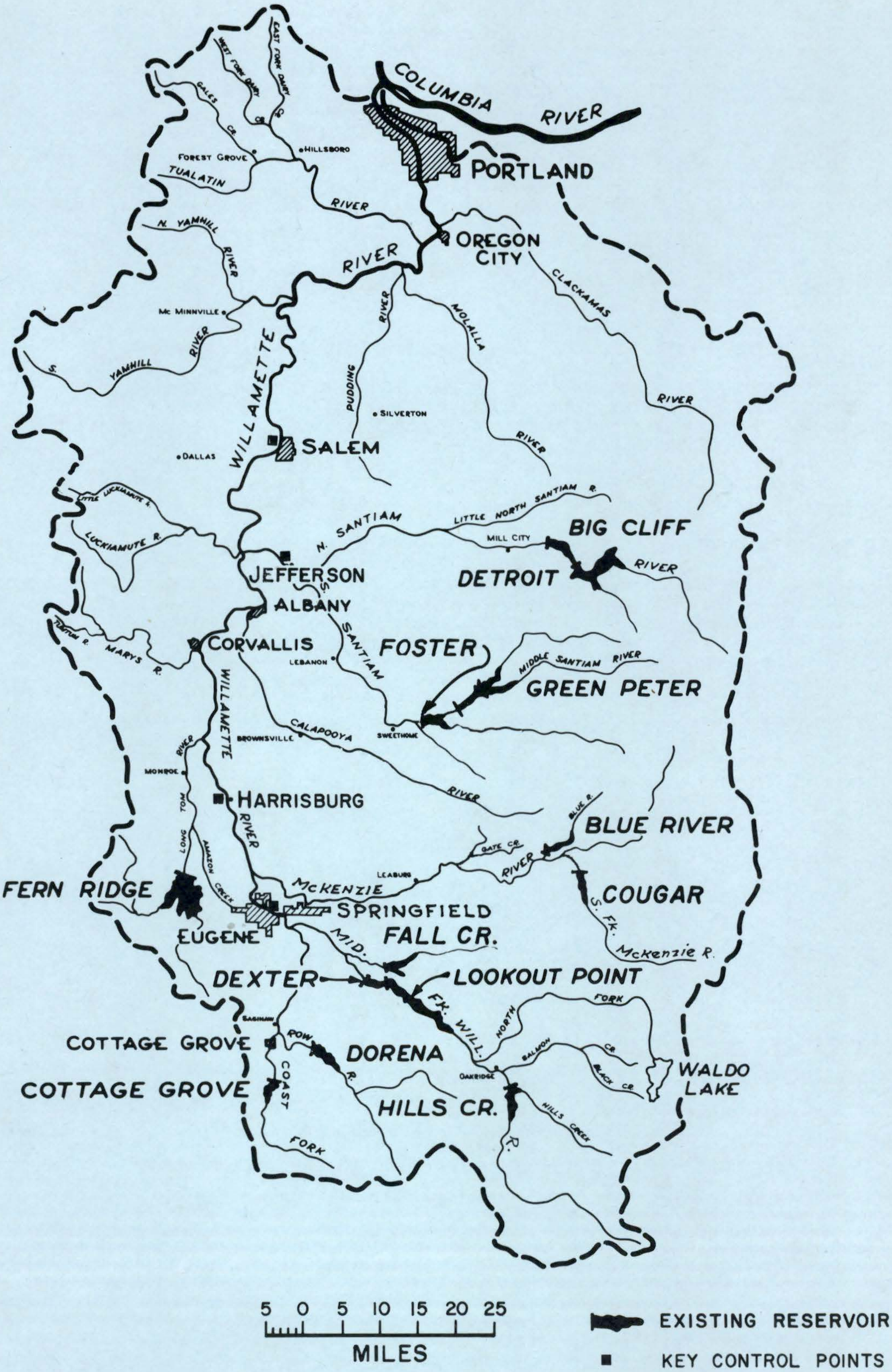
Dr. Fred Cleaver retired from Federal Government Service in December 1976. He had served on the Columbia River Water Management Group as the representative of the National Marine Fisheries Service since its formation in 1968. Fred has had a long association with Columbia River fishery matters, both as Federal and State Administrator. His expertise will be missed by the Group.

Mr. David M. Rockwood began his career with the Corps of Engineers in 1939, left for active duty with the Army Air Corps in 1942, and returned in 1946. "Dave" was secretary of the Water Management Subcommittee of the Columbia Basin Interagency Committee at its first meeting which was held in Portland, May 17, 1951. Dave has been actively involved with CBIAC and later with the CRWMG during the entire period May 1951 to December 1977, when he retired from the Federal Service. He served as Chairman of the CRWMG in 1974 and again in 1976. He has always been a firm supporter of interagency cooperation. His leadership and involvement in numerous committees and work groups of the CBIAC and the CRWMG has provided a significant contribution to the spirit of mutual understanding and cooperation among state, and federal agencies. His expertise in water management is widely recognized and his influence in fostering cooperation between water management agencies has provided benefits to the public that cannot be measured, yet are nonetheless tangible.

Mr. Nicholas A. Kallio, Chief of Northwest Resources Data Center, U. S. Geological Survey in Portland, retired December 31, 1977 after completing 32 years of federal service. "Nick" has been serving as the Geological Survey representative to CRWMG since 1970. During that time he has been an active member of several committees and work groups. He was particularly involved with interagency coordination of activities related to installation of automated telemetry at U.S.G.S. gaging stations for use by the Columbia River Operational Hydromet System. Nick was one of the first to draw attention to the need for studies of potential data errors in automated data collection systems. Subsequent studies eventually led to participation, by the N.W. Water Resources Data Center, in a national program of experimental streamflow data collection by earth orbiting satellites. The knowledge gained from these efforts will assist in the development of the CROHMS system. Nick's experience and willing assistance in the field of data collection has provided a lasting contribution to the CRWMG and many of the committees in which he served.

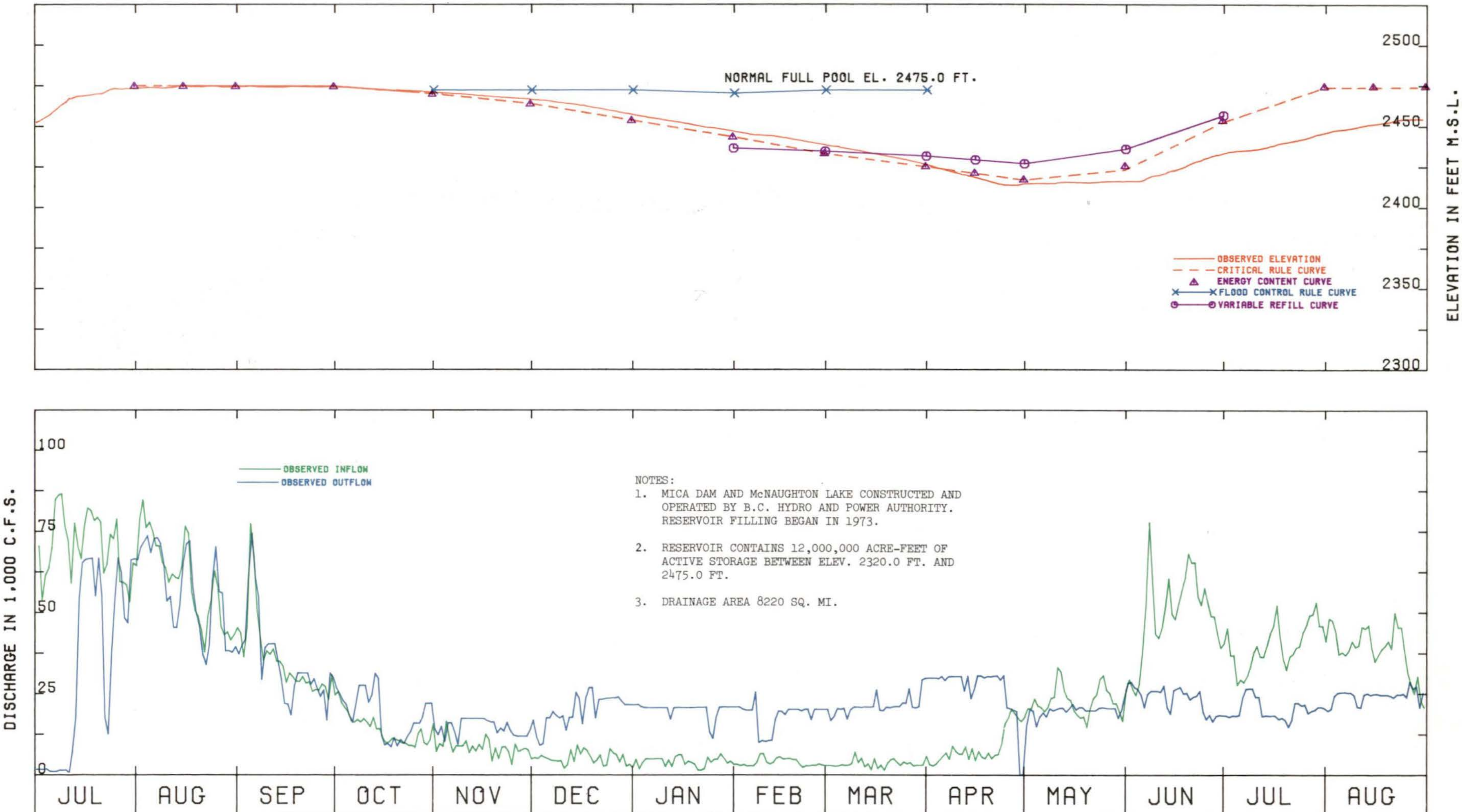
Left to Right

Vail Schermerhorn, Nick Kallio, Fritz Limpert, and Dave Rockwood
Dr. Cleaver was not available for picture



WILLAMETTE RIVER BASIN

CHART 2



COLUMBIA RIVER WATER MANAGEMENT GROUP

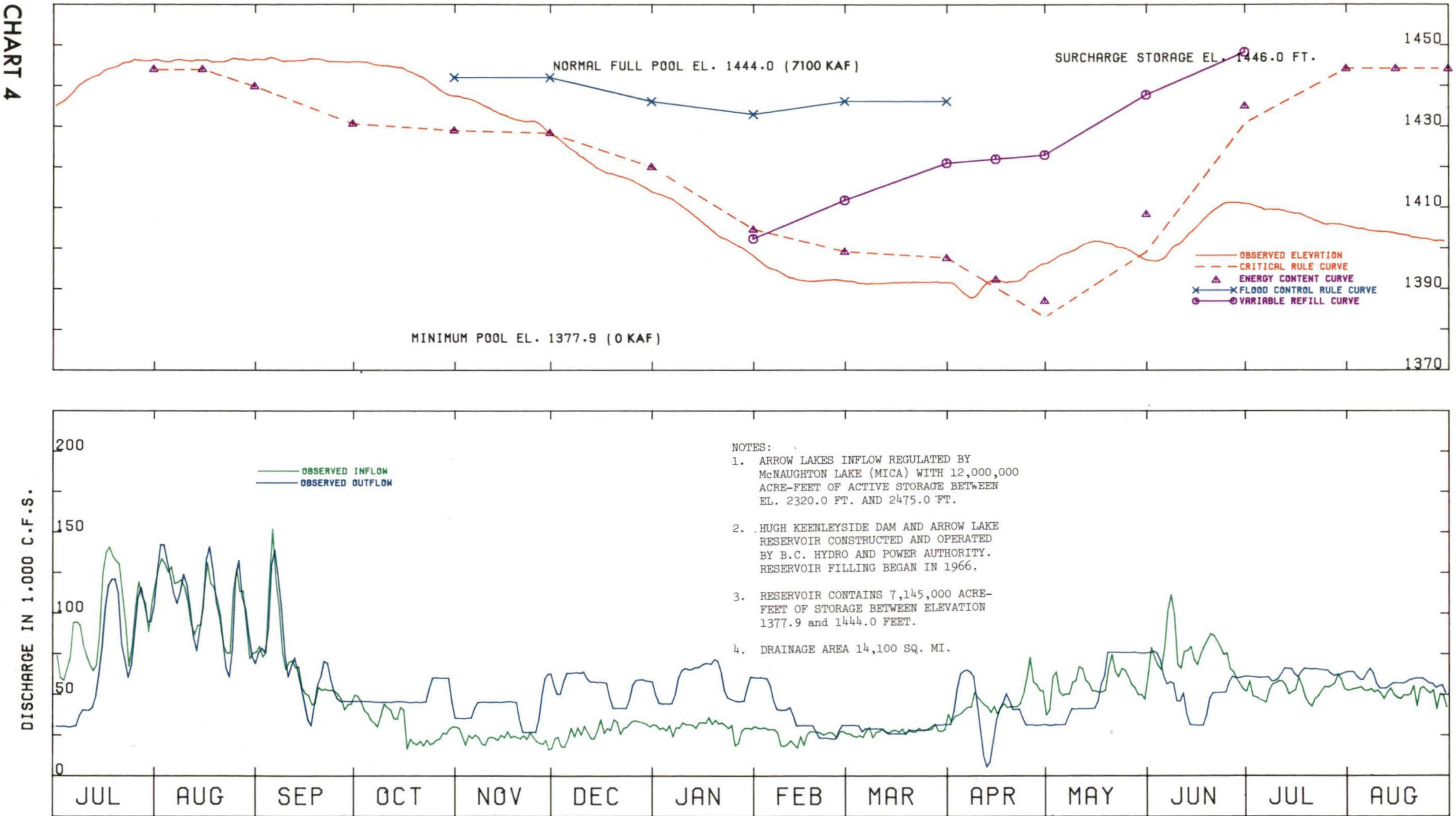
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

COLUMBIA RIVER AT MICA PROJECT, BRITISH COLUMBIA, CANADA

CHART 3

CHART 4

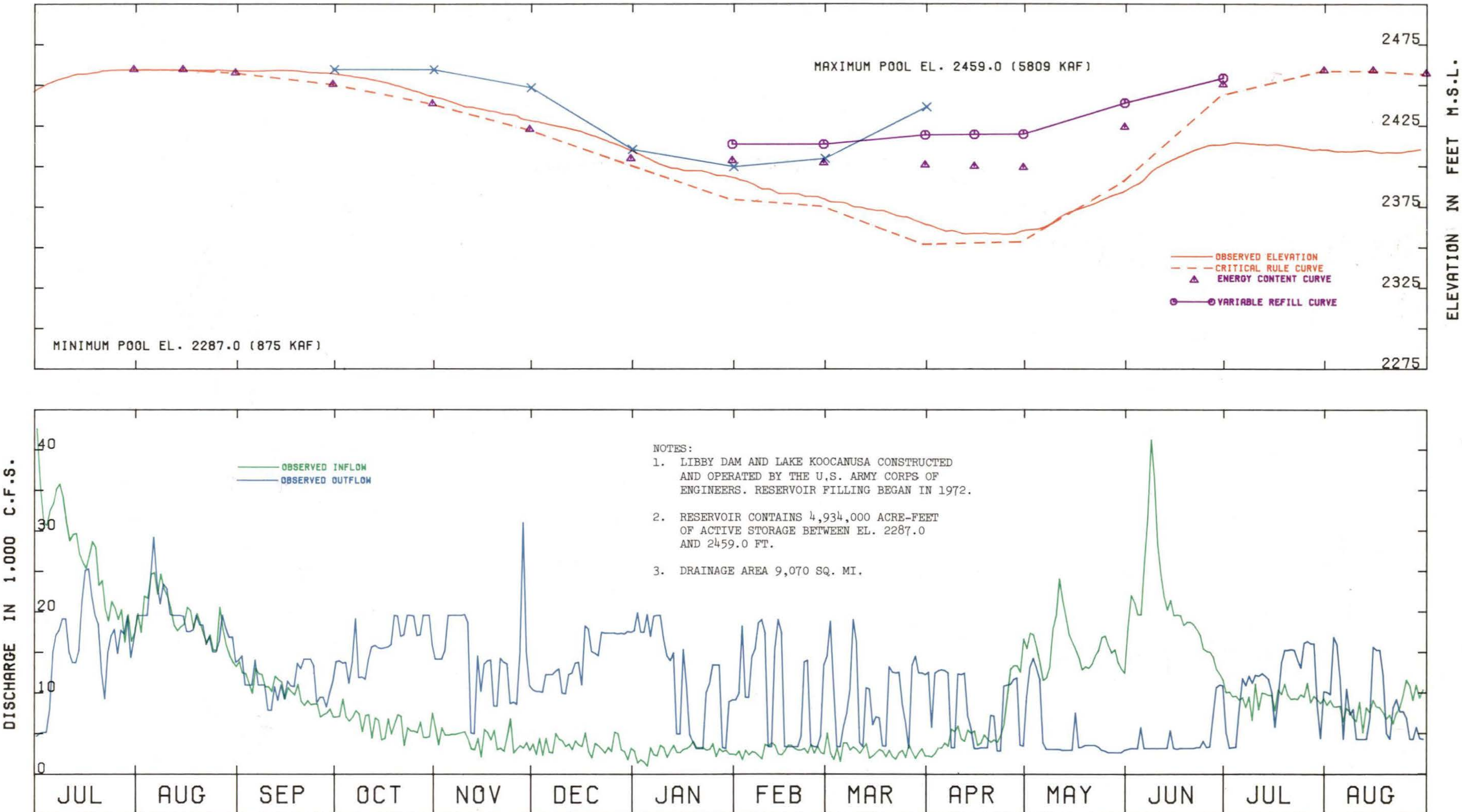


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

COLUMBIA RIVER AT ARROW PROJECT, BRITISH COLUMBIA, CANADA



NOTES:

1. LIBBY DAM AND LAKE KOOCANUSA CONSTRUCTED AND OPERATED BY THE U.S. ARMY CORPS OF ENGINEERS. RESERVOIR FILLING BEGAN IN 1972.
2. RESERVOIR CONTAINS 4,934,000 ACRE-FEET OF ACTIVE STORAGE BETWEEN EL. 2287.0 AND 2459.0 FT.
3. DRAINAGE AREA 9,070 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

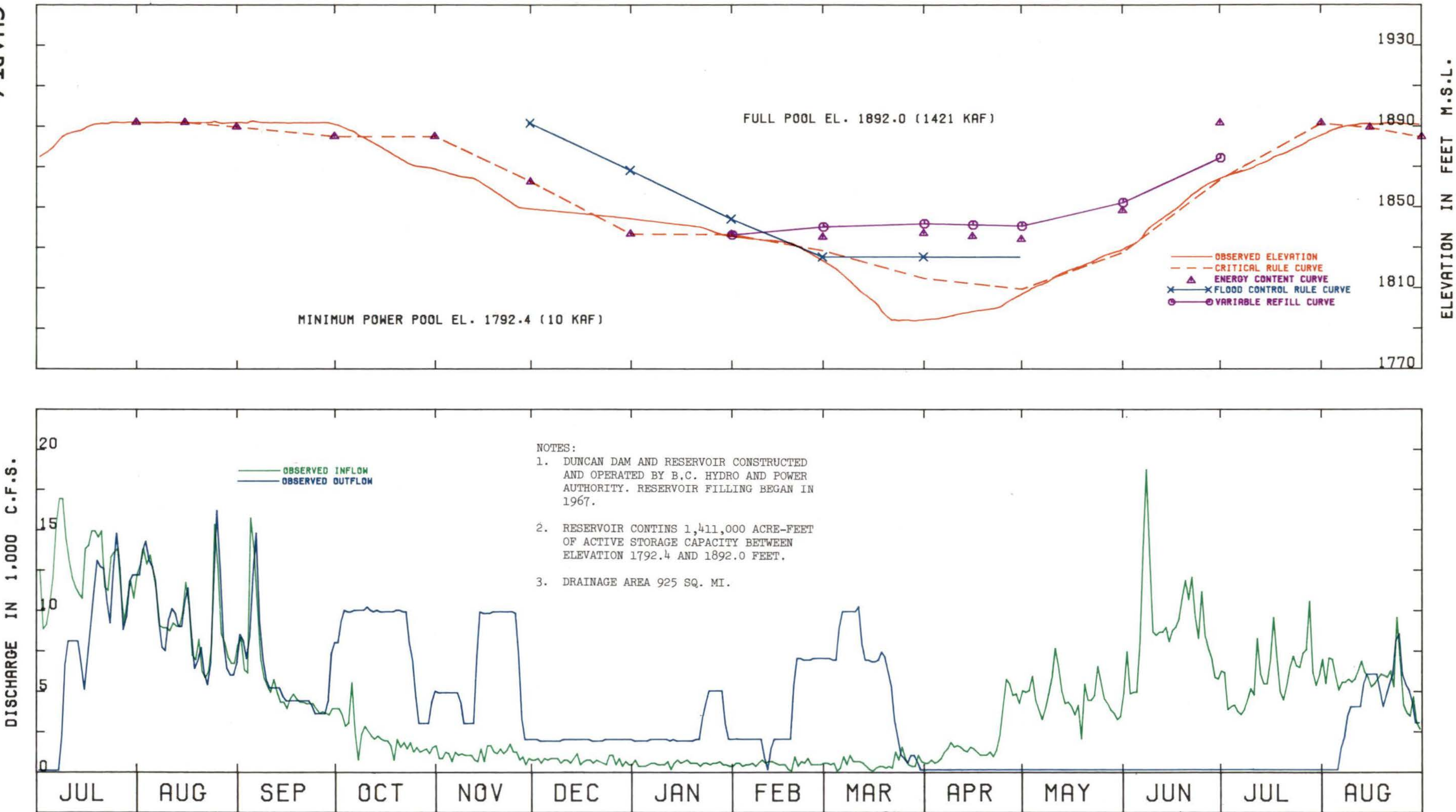
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

KOOTENAI RIVER AT LIBBY PROJECT, MONTANA

CHART 5

CHART 6



NOTES:

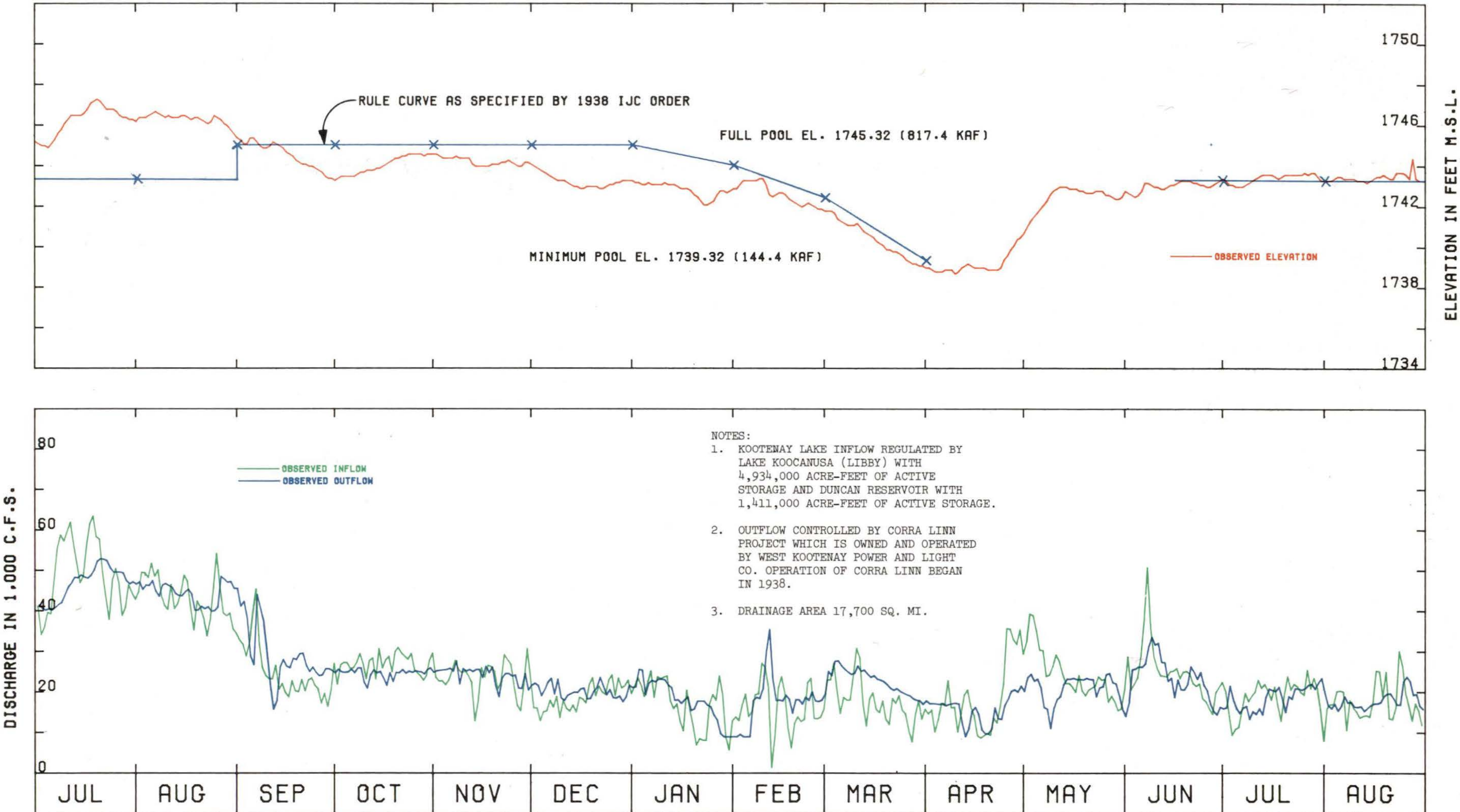
1. DUNCAN DAM AND RESERVOIR CONSTRUCTED AND OPERATED BY B.C. HYDRO AND POWER AUTHORITY. RESERVOIR FILLING BEGAN IN 1967.
2. RESERVOIR CONTINS 1,411,000 ACRE-FEET OF ACTIVE STORAGE CAPACITY BETWEEN ELEVATION 1792.4 AND 1892.0 FEET.
3. DRAINAGE AREA 925 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

DUNCAN RIVER AT DUNCAN PROJECT, BRITISH COLUMBIA, CANADA



NOTES:
1. KOOTENAY LAKE INFLOW REGULATED BY LAKE KOOCANUSA (LIBBY) WITH 4,934,000 ACRE-FEET OF ACTIVE STORAGE AND DUNCAN RESERVOIR WITH 1,411,000 ACRE-FEET OF ACTIVE STORAGE.
2. OUTFLOW CONTROLLED BY CORRA LINN PROJECT WHICH IS OWNED AND OPERATED BY WEST KOOTENAY POWER AND LIGHT CO. OPERATION OF CORRA LINN BEGAN IN 1938.
3. DRAINAGE AREA 17,700 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

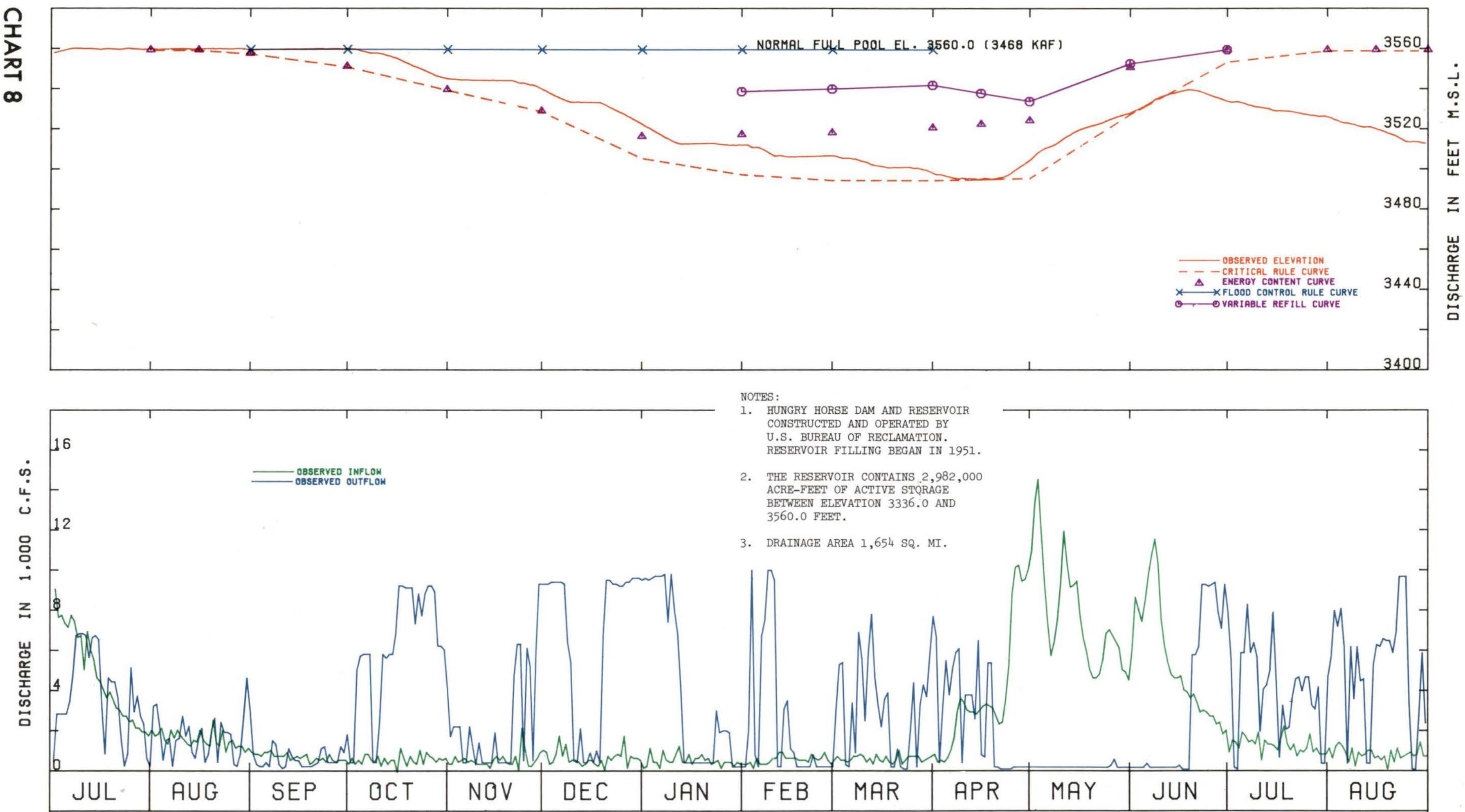
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

KOOTENAY RIVER AT KOOTENAY LAKE, BRITISH COLUMBIA, CANADA

CHART 7

CHART 8

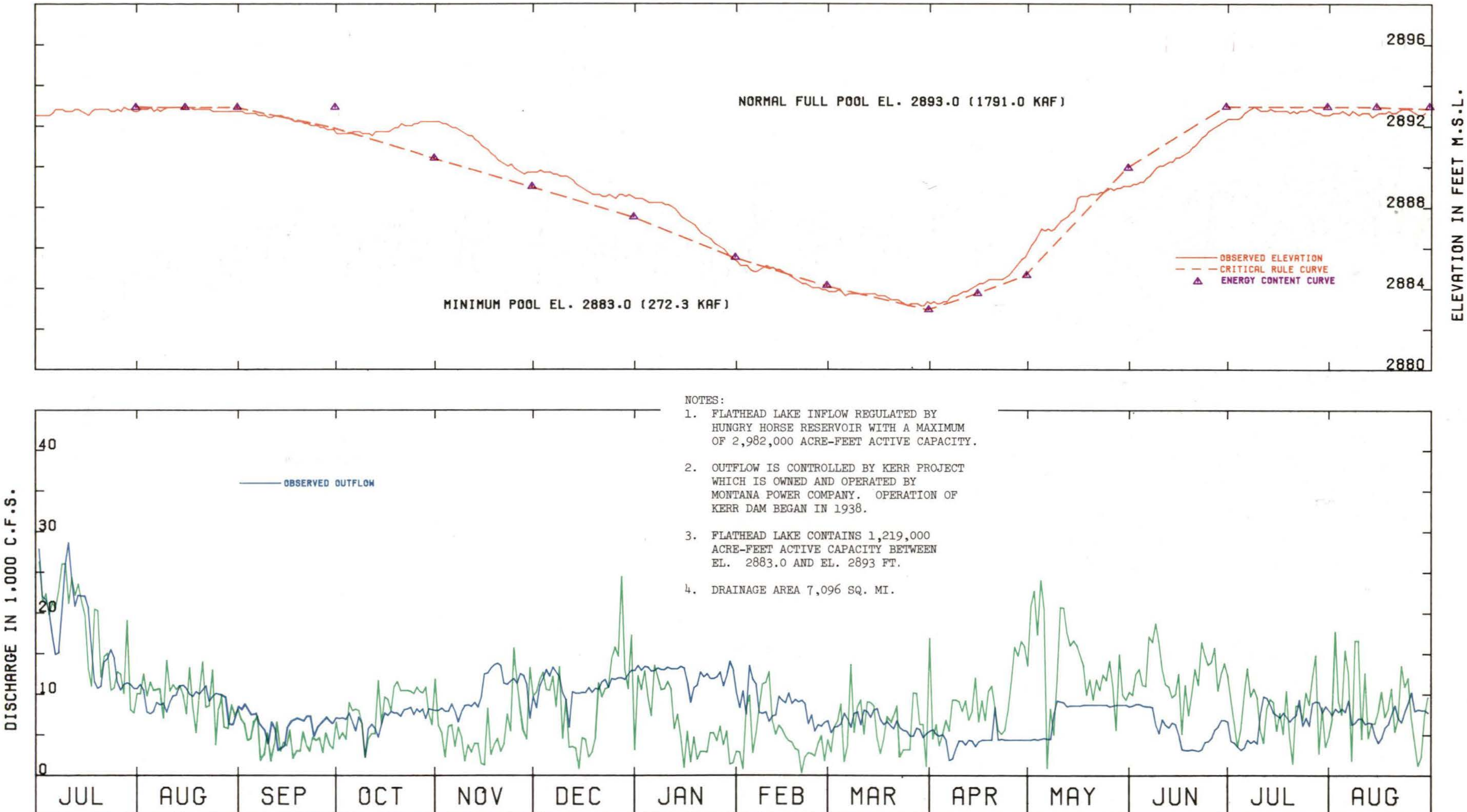


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

SOUTH FORK FLATHEAD RIVER AT HUNGRY HORSE PROJECT, MONTANA



COLUMBIA RIVER WATER MANAGEMENT GROUP

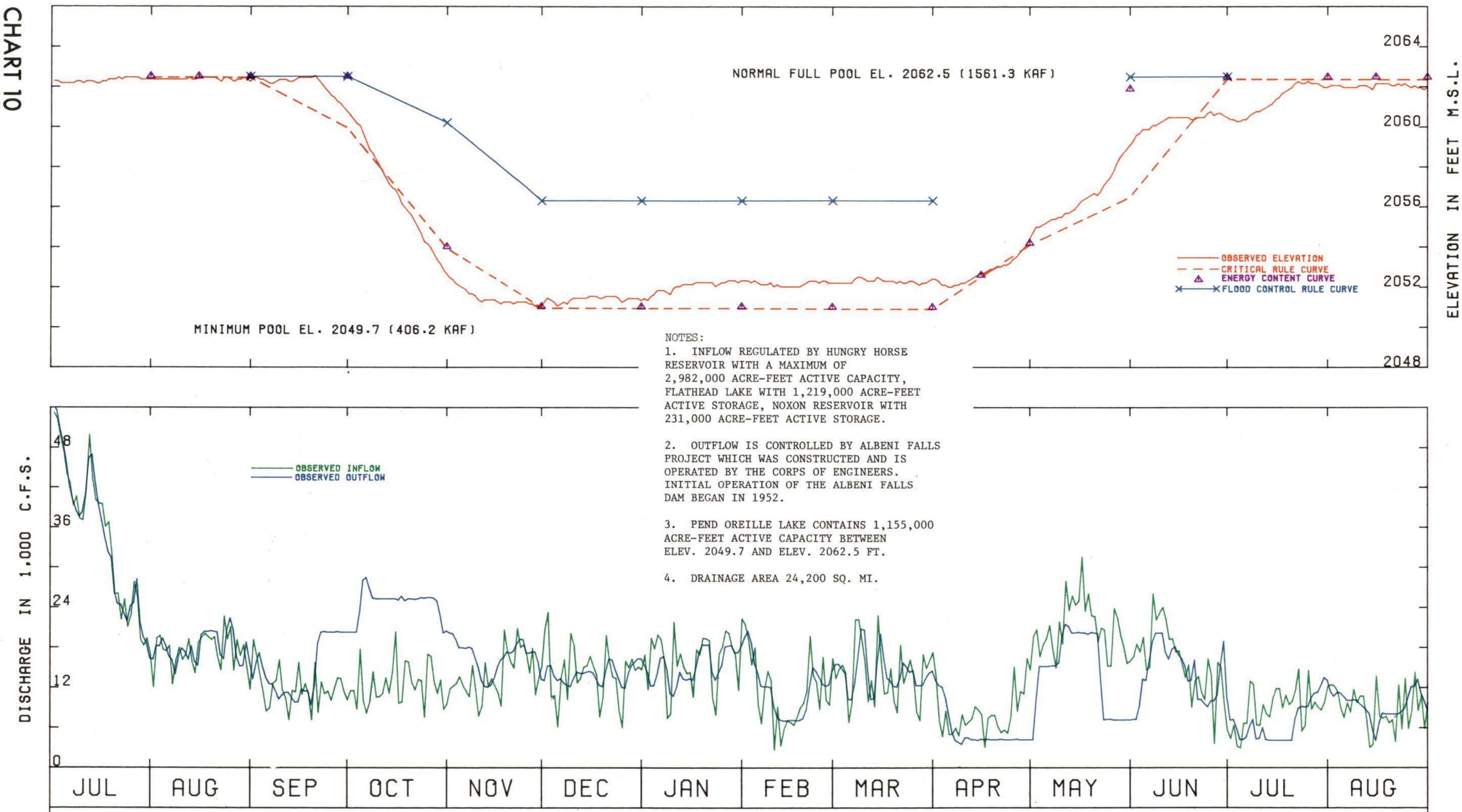
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

FLATHEAD RIVER AT FLATHEAD LAKE, MONTANA

CHART 9

CHART 10



NOTES:

1. INFLOW REGULATED BY HUNGRY HORSE RESERVOIR WITH A MAXIMUM OF 2,982,000 ACRE-FEET ACTIVE CAPACITY, FLATHEAD LAKE WITH 1,219,000 ACRE-FEET ACTIVE STORAGE, NOXON RESERVOIR WITH 231,000 ACRE-FEET ACTIVE STORAGE.

2. OUTFLOW IS CONTROLLED BY ALBENI FALLS PROJECT WHICH WAS CONSTRUCTED AND IS OPERATED BY THE CORPS OF ENGINEERS. INITIAL OPERATION OF THE ALBENI FALLS DAM BEGAN IN 1952.

3. PEND OREILLE LAKE CONTAINS 1,155,000 ACRE-FEET ACTIVE CAPACITY BETWEEN ELEV. 2049.7 AND ELEV. 2062.5 FT.

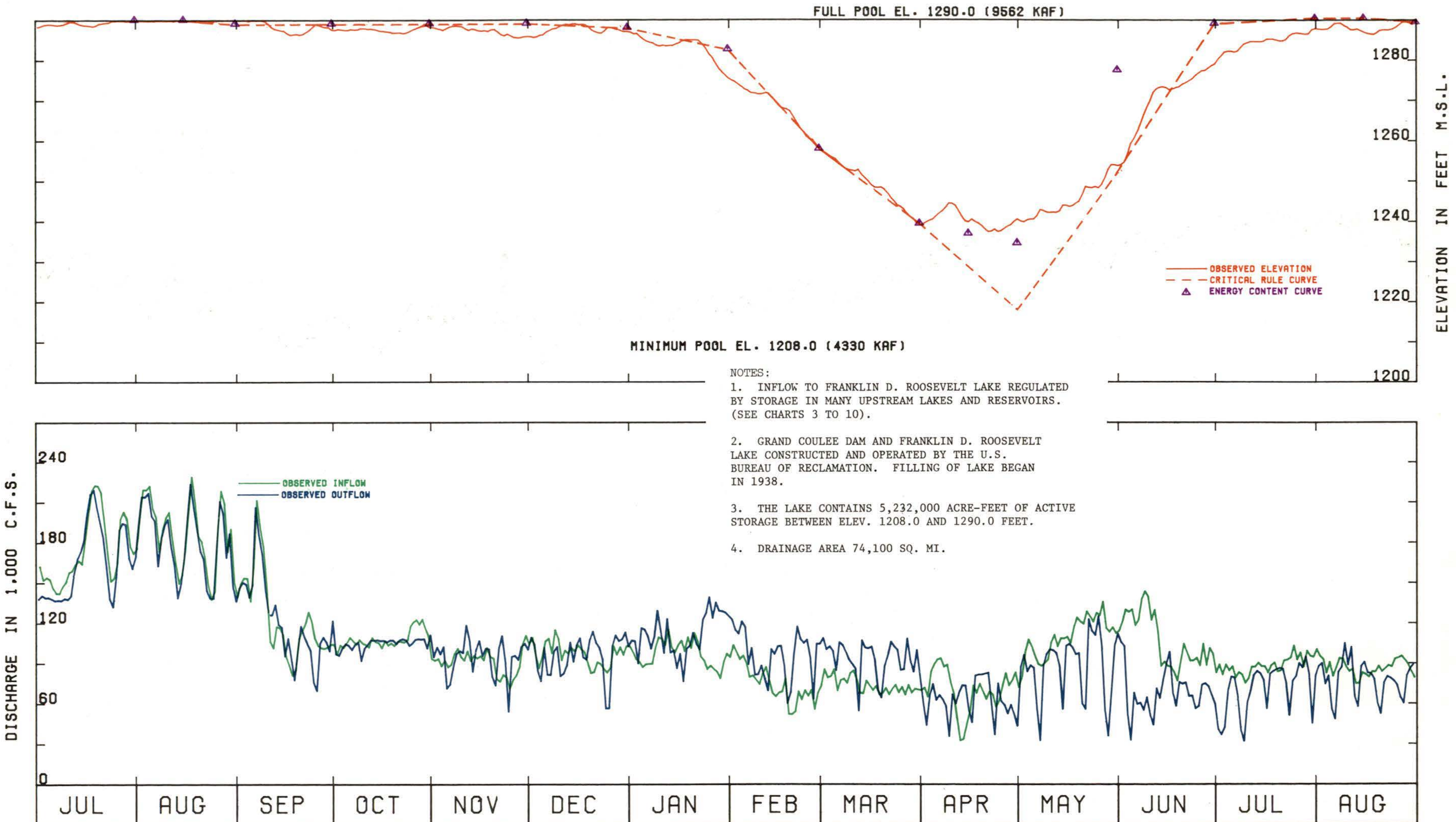
4. DRAINAGE AREA 24,200 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

PEND OREILLE RIVER AT PEND OREILLE LAKE, IDAHO



COLUMBIA RIVER WATER MANAGEMENT GROUP

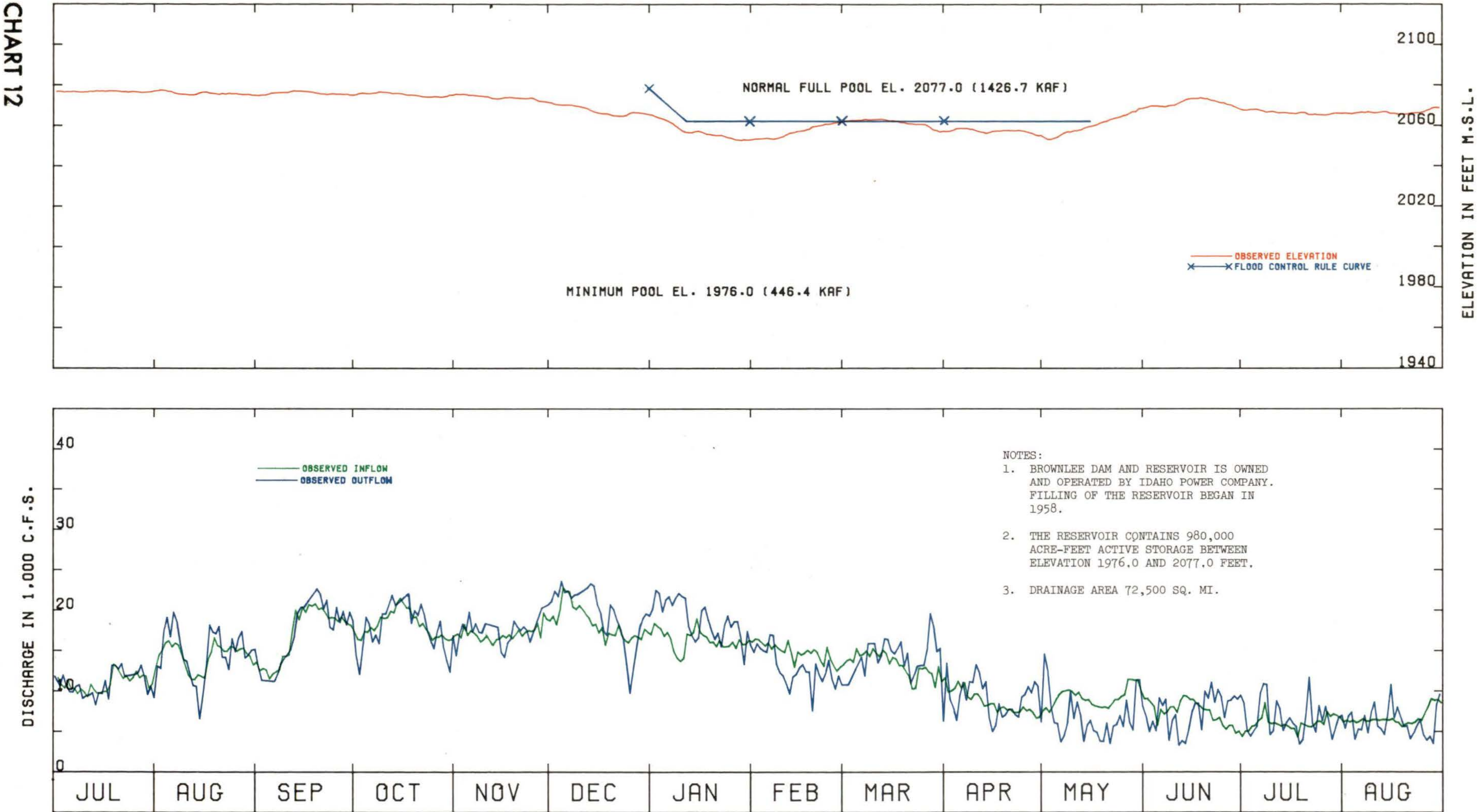
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

COLUMBIA RIVER AT GRAND COULEE PROJECT, WASHINGTON

CHART 11

CHART 12

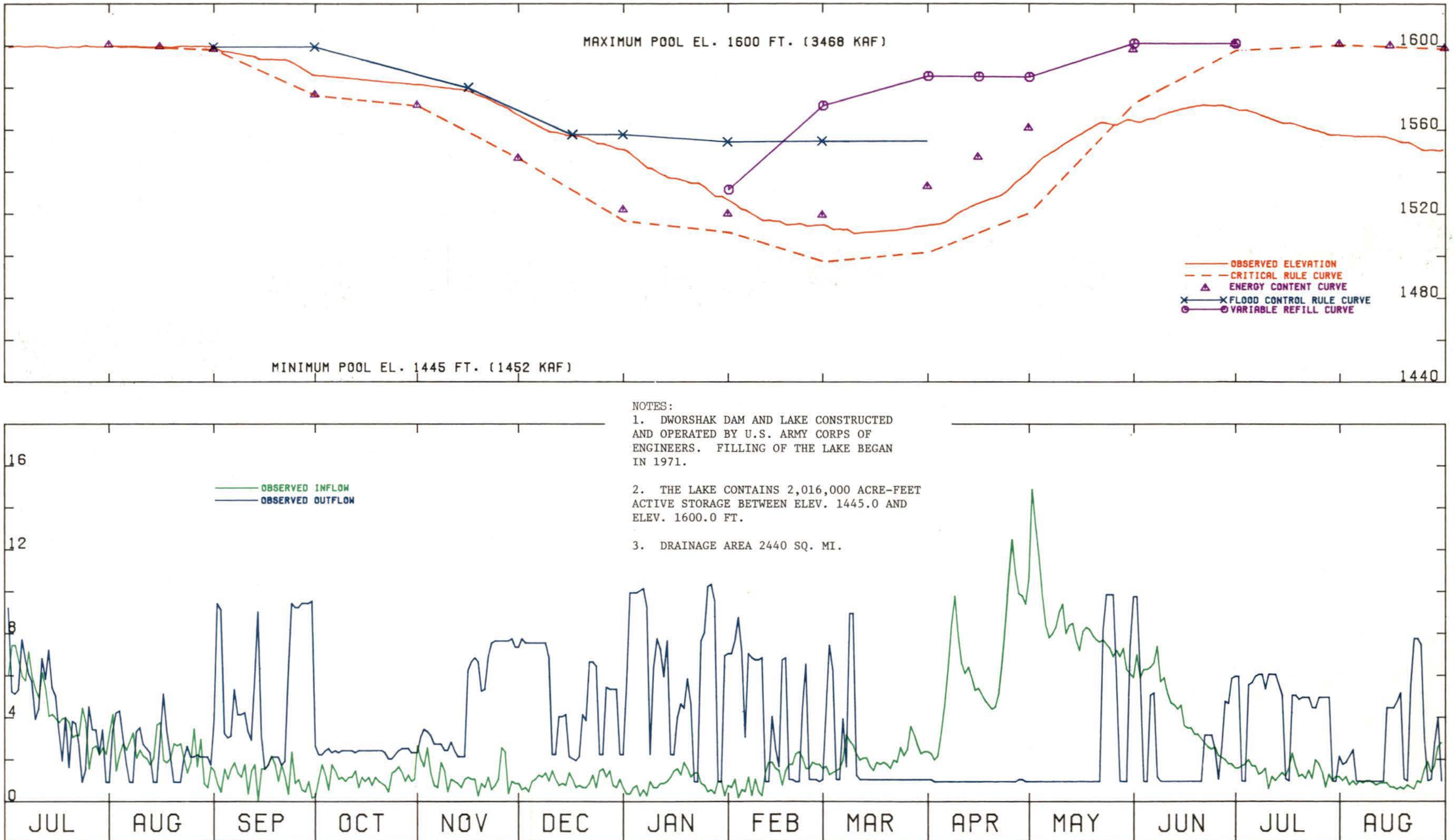


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

SNAKE RIVER AT BROWNLEE PROJECT, IDAHO - OREGON



COLUMBIA RIVER WATER MANAGEMENT GROUP

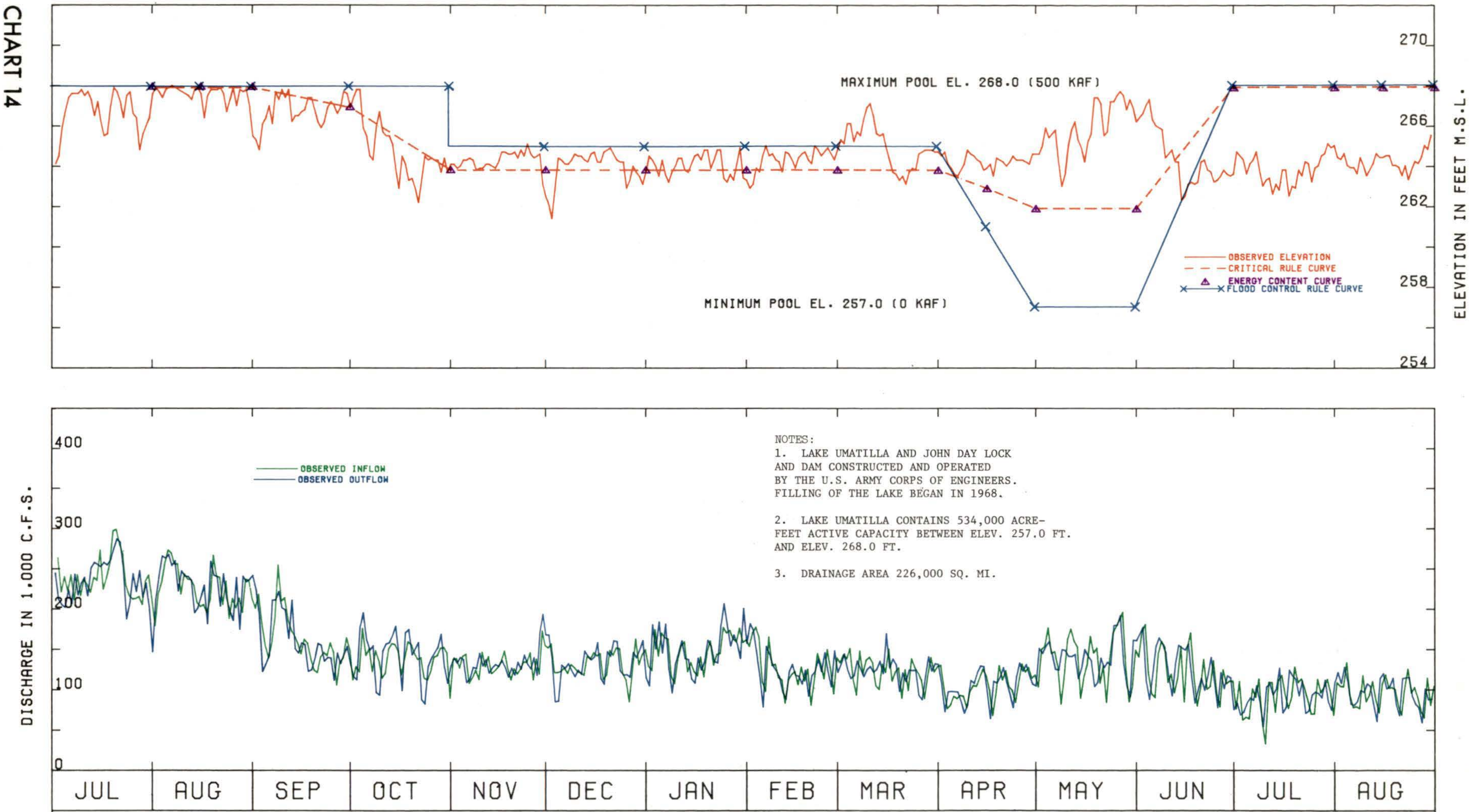
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

NORTH FORK CLEARWATER RIVER AT DWORSHAK PROJECT, IDAHO

CHART 13

CHART 14

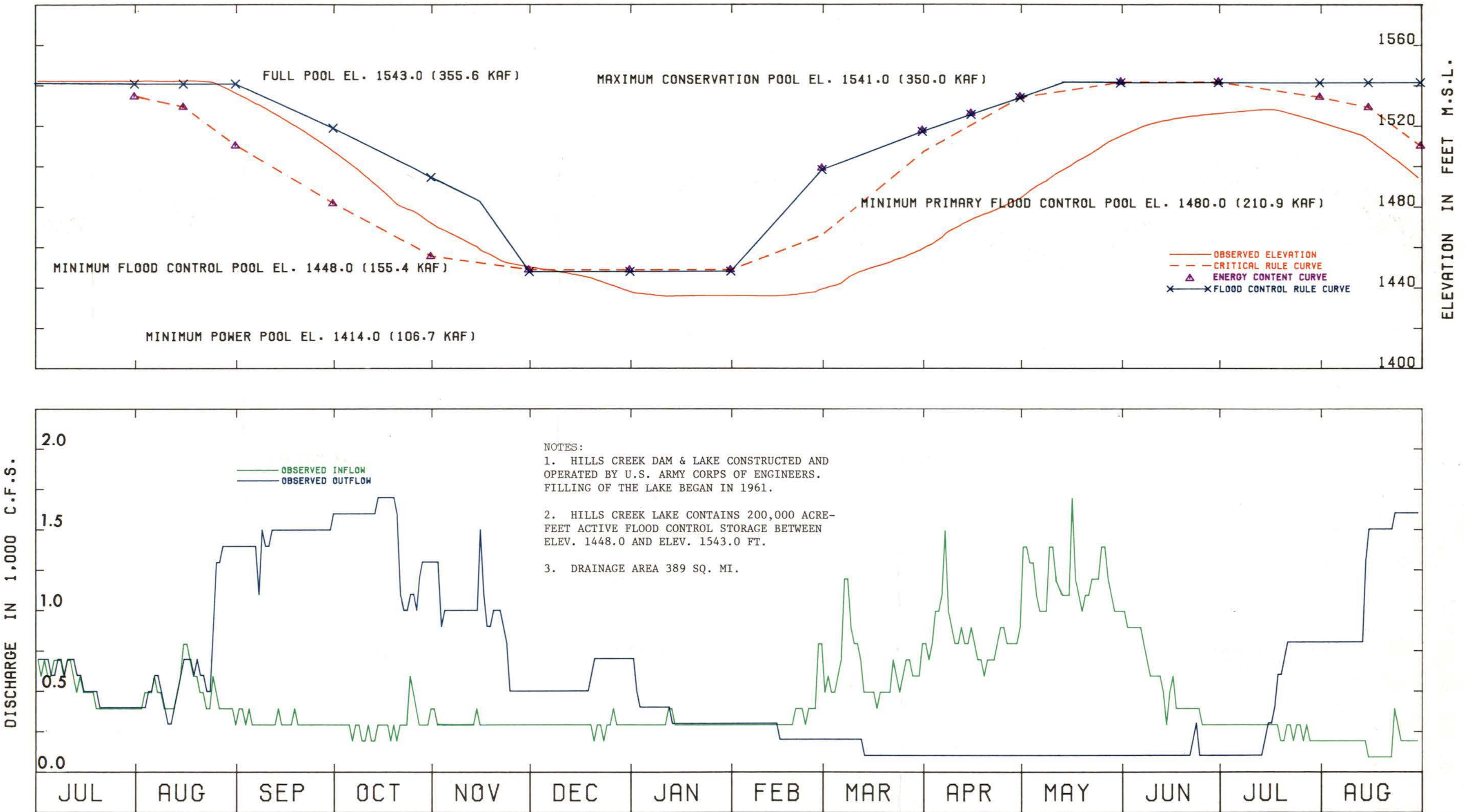


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

COLUMBIA RIVER AT JOHN DAY PROJECT, OREGON - WASHINGTON



NOTES:

1. HILLS CREEK DAM & LAKE CONSTRUCTED AND OPERATED BY U.S. ARMY CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1961.

2. HILLS CREEK LAKE CONTAINS 200,000 ACRE-FEET ACTIVE FLOOD CONTROL STORAGE BETWEEN ELEV. 1448.0 AND ELEV. 1543.0 FT.

3. DRAINAGE AREA 389 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

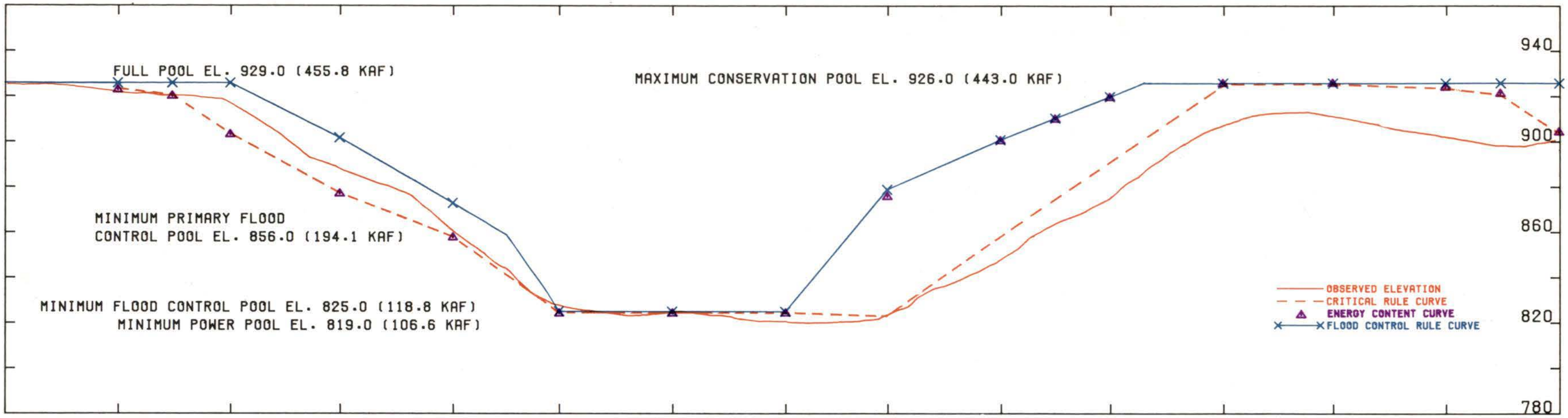
STORAGE AND STREAMFLOW HYDROGRAPHS

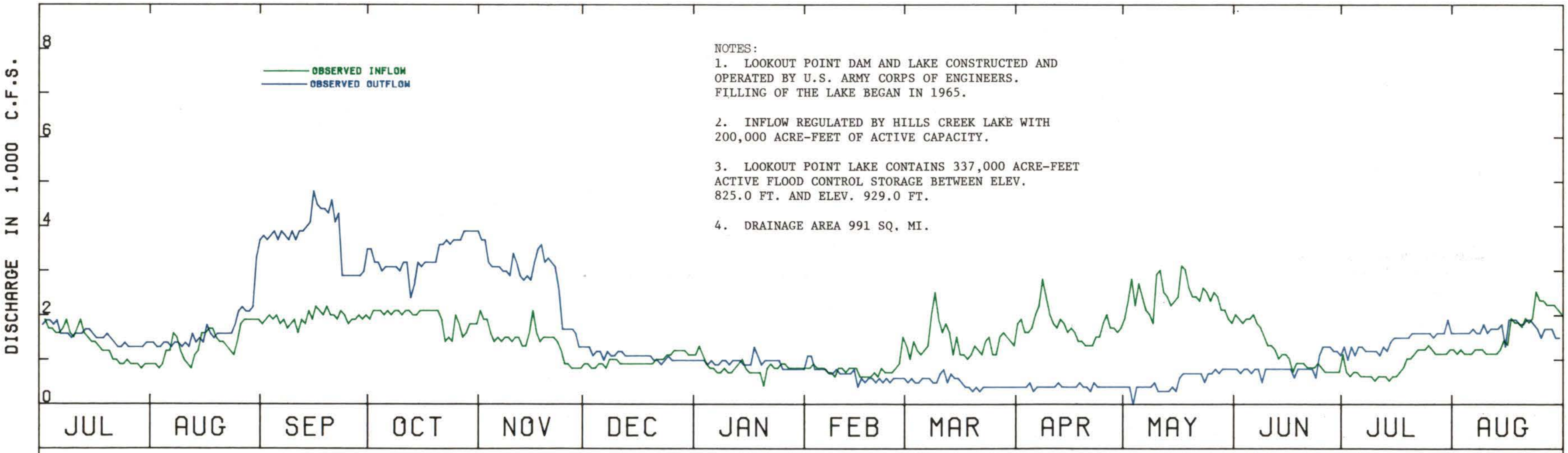
JULY 1976 - AUGUST 1977

MIDDLE FORK WILLAMETTE RIVER AT HILLS CREEK PROJECT, OREGON

CHART 15

CHART 16





NOTES:
1. LOOKOUT POINT DAM AND LAKE CONSTRUCTED AND OPERATED BY U.S. ARMY CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1965.

2. INFLOW REGULATED BY HILLS CREEK LAKE WITH 200,000 ACRE-FEET OF ACTIVE CAPACITY.

3. LOOKOUT POINT LAKE CONTAINS 337,000 ACRE-FEET ACTIVE FLOOD CONTROL STORAGE BETWEEN ELEV. 825.0 FT. AND ELEV. 929.0 FT.

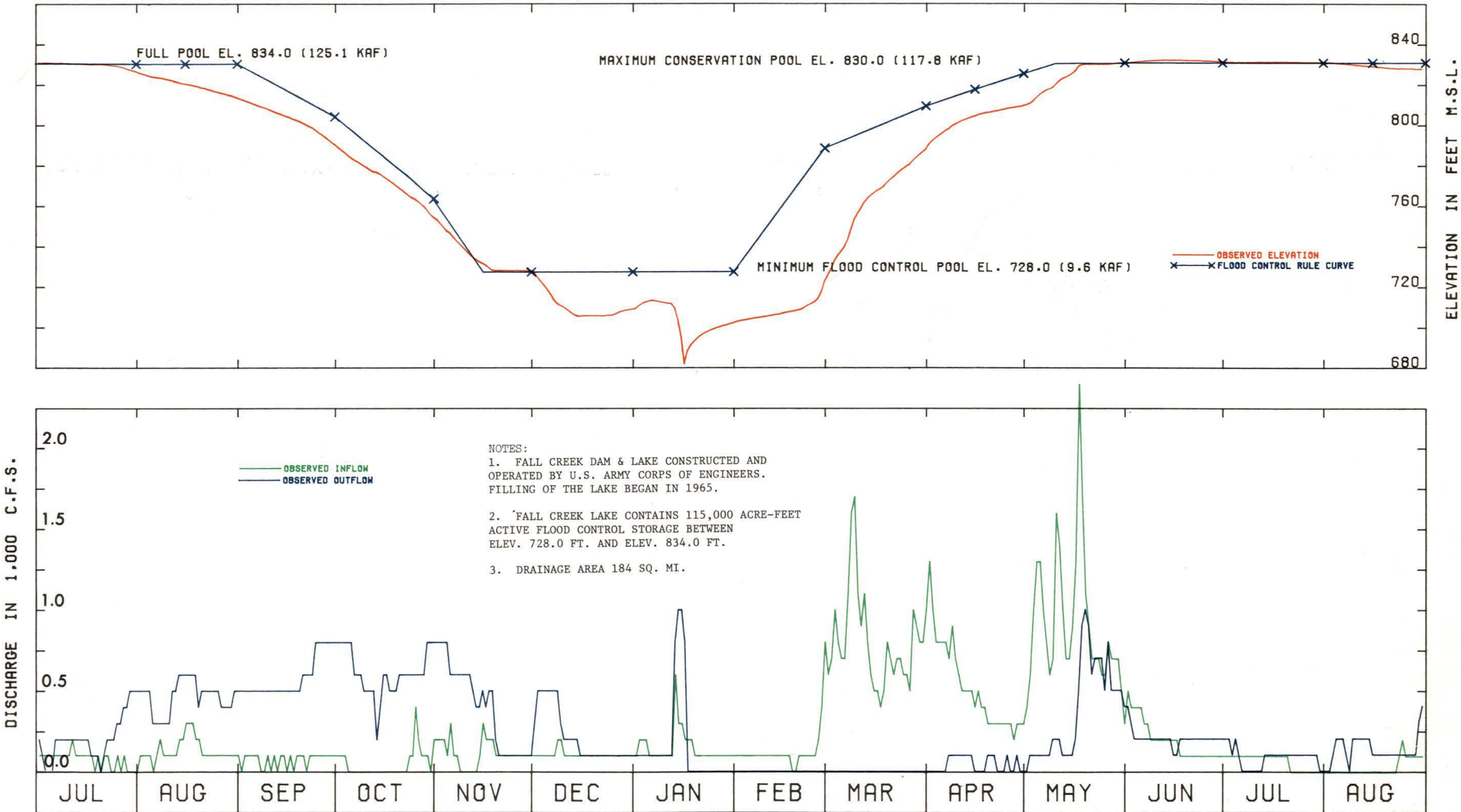
4. DRAINAGE AREA 991 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

MIDDLE FORK WILLAMETTE RIVER AT LOOKOUT POINT PROJECT, OREGON



NOTES:
1. FALL CREEK DAM & LAKE CONSTRUCTED AND OPERATED BY U.S. ARMY CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1965.

2. FALL CREEK LAKE CONTAINS 115,000 ACRE-FEET ACTIVE FLOOD CONTROL STORAGE BETWEEN ELEV. 728.0 FT. AND ELEV. 834.0 FT.

3. DRAINAGE AREA 184 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

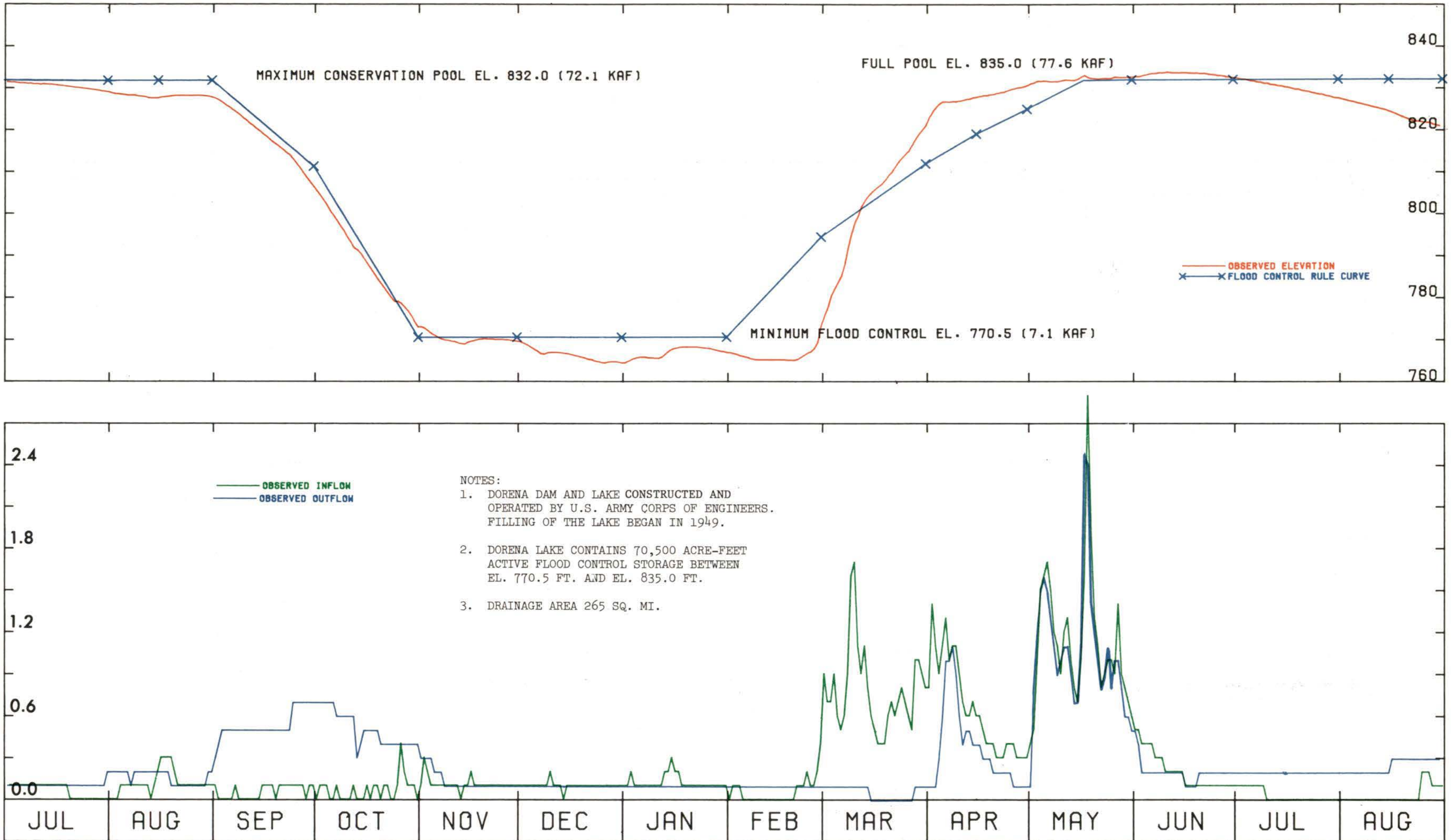
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

FALL CREEK AT FALL CREEK PROJECT, OREGON

CHART 17

CHART 18

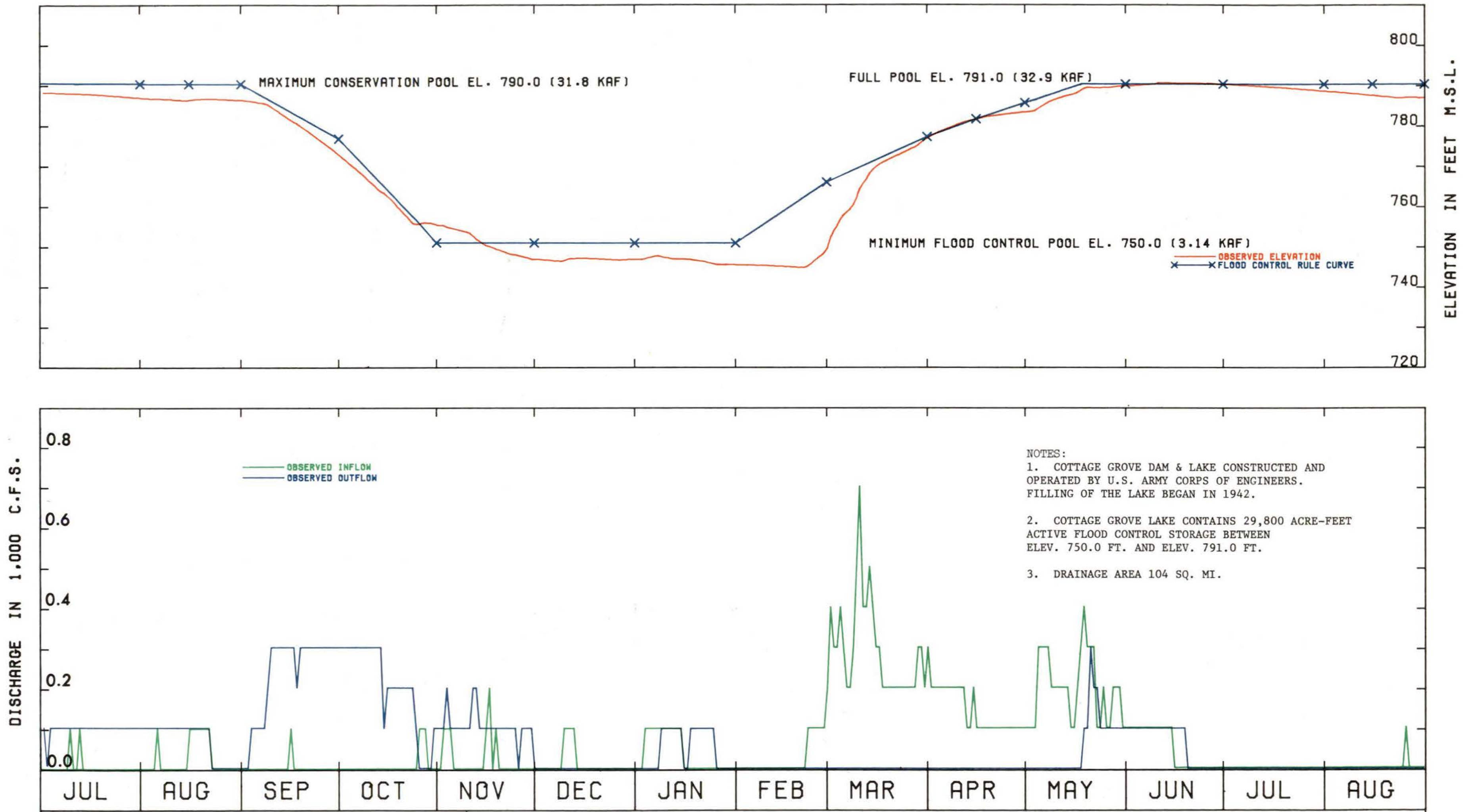


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

ROW RIVER AT DORENA PROJECT, OREGON



COLUMBIA RIVER WATER MANAGEMENT GROUP

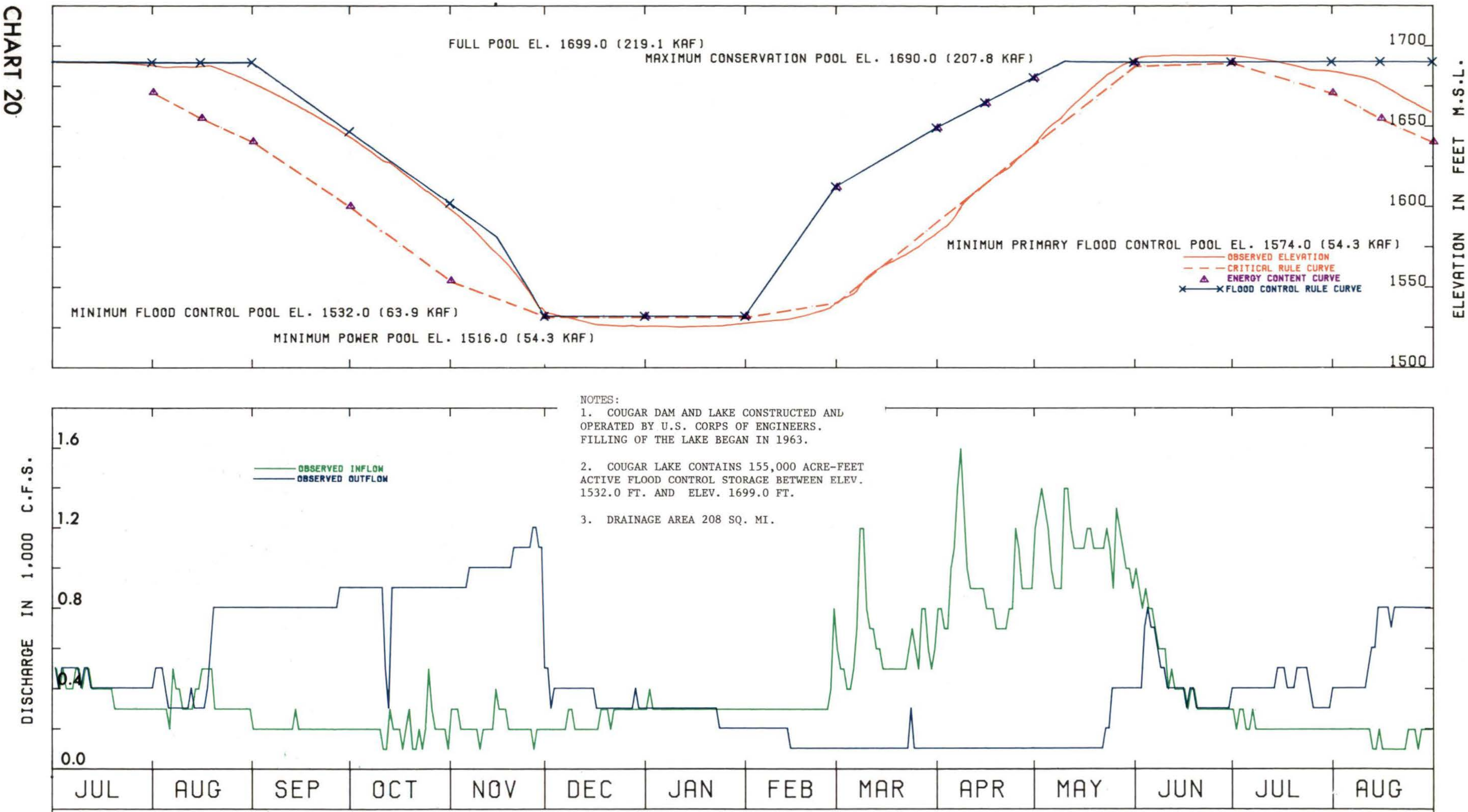
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

COAST FORK WILLAMETTE RIVER AT COTTAGE GROVE PROJECT, OREGON

CHART 19

CHART 20



NOTES:

1. COUGAR DAM AND LAKE CONSTRUCTED AND OPERATED BY U.S. CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1963.

2. COUGAR LAKE CONTAINS 155,000 ACRE-FEET ACTIVE FLOOD CONTROL STORAGE BETWEEN ELEV. 1532.0 FT. AND ELEV. 1699.0 FT.

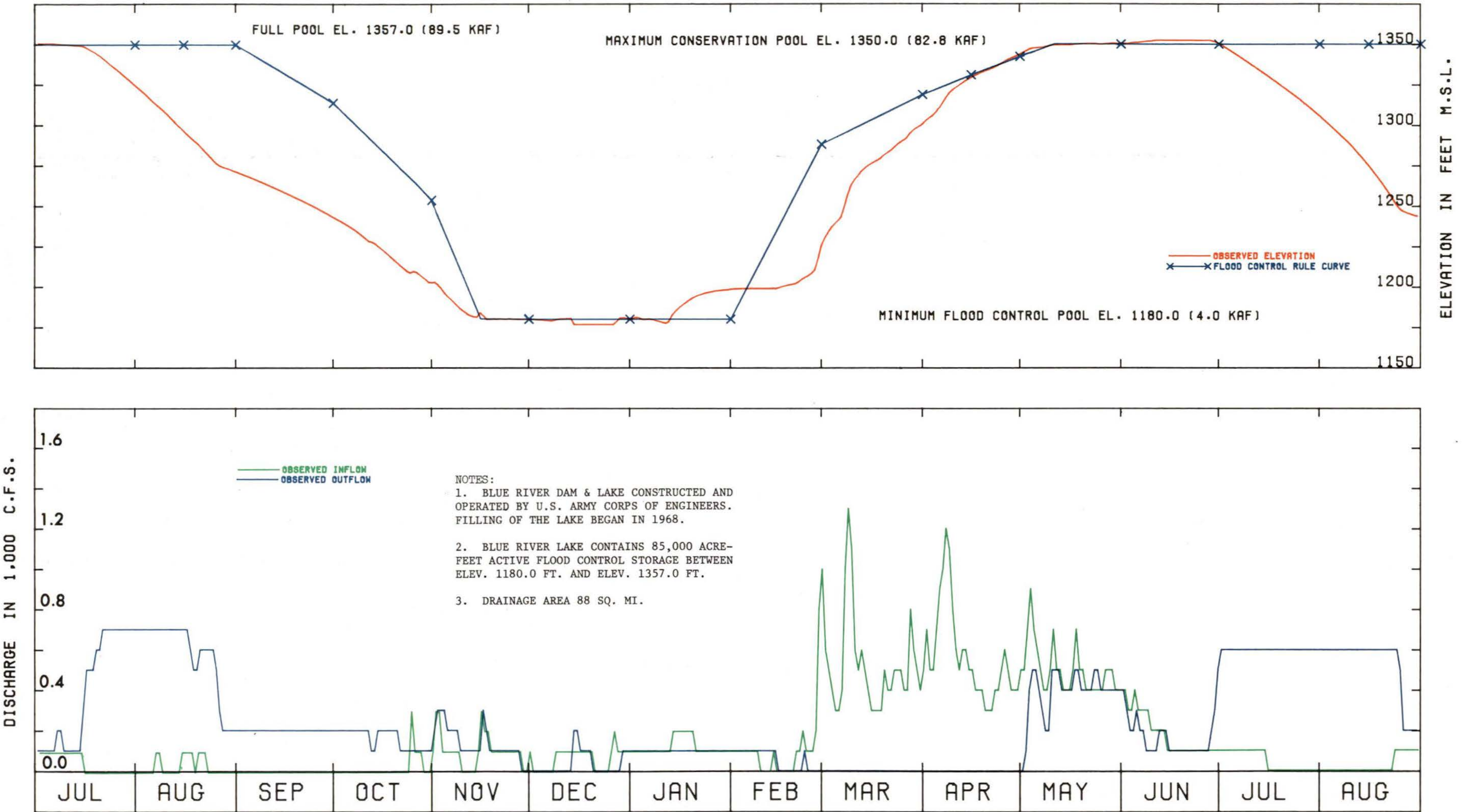
3. DRAINAGE AREA 208 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

SOUTH FORK MCKENZIE RIVER AT COUGAR PROJECT, OREGON



NOTES:

1. BLUE RIVER DAM & LAKE CONSTRUCTED AND OPERATED BY U.S. ARMY CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1968.

2. BLUE RIVER LAKE CONTAINS 85,000 ACRE-FEET ACTIVE FLOOD CONTROL STORAGE BETWEEN ELEV. 1180.0 FT. AND ELEV. 1357.0 FT.

3. DRAINAGE AREA 88 SQ. MI.

COLUMBIA RIVER WATER MANAGEMENT GROUP

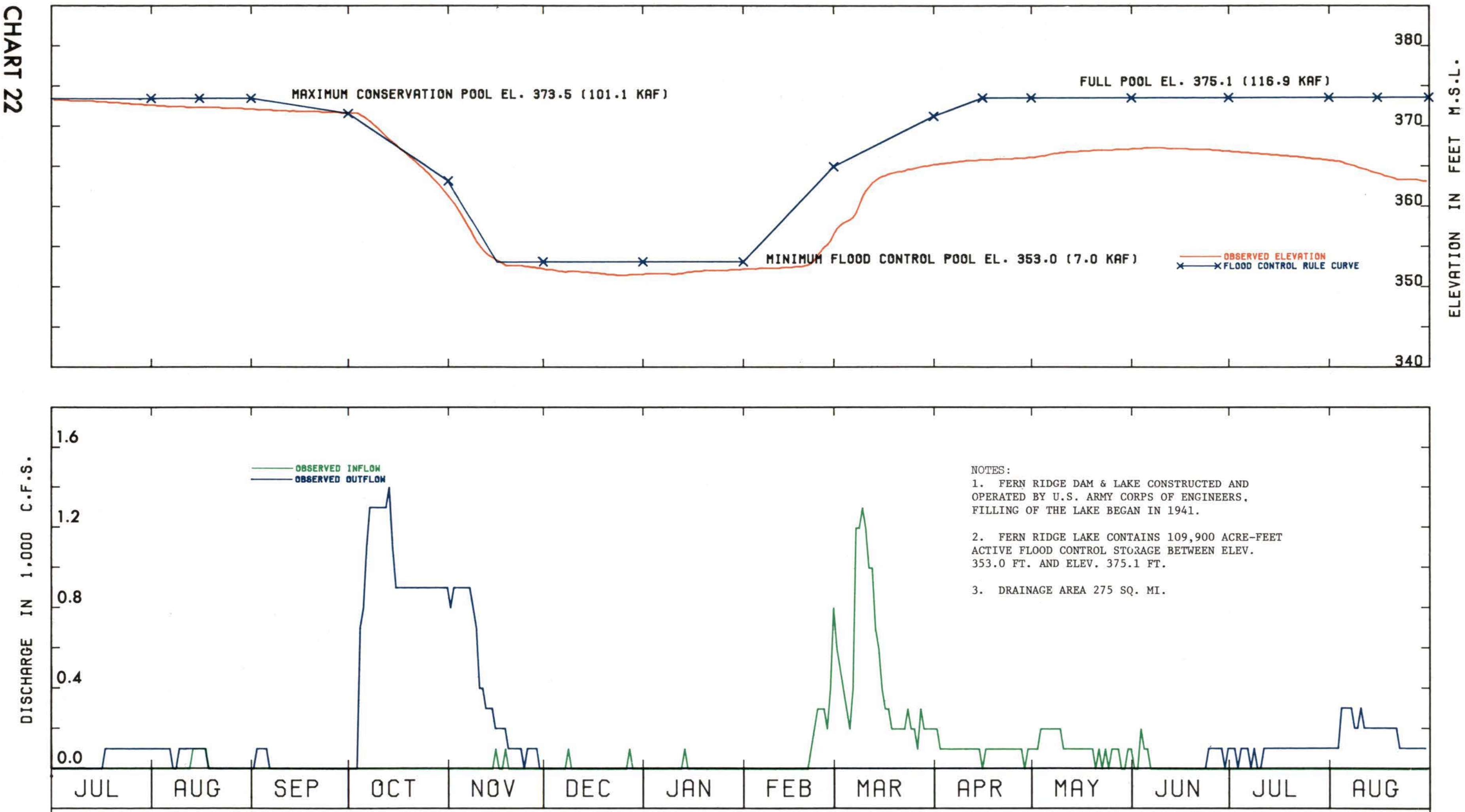
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

BLUE RIVER AT BLUE RIVER PROJECT, OREGON

CHART 21

CHART 22

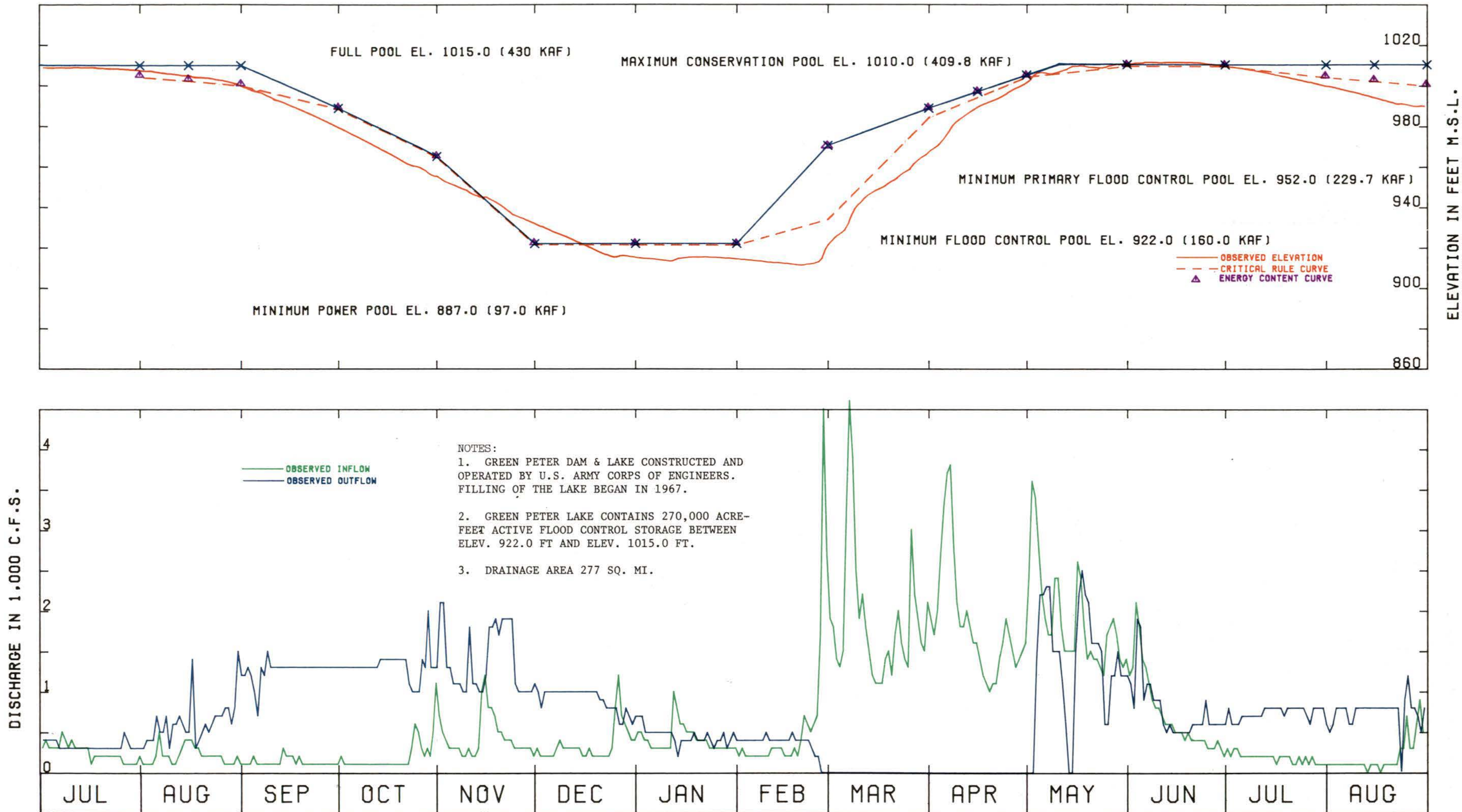


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

LONG TOM RIVER AT FERN RIDGE PROJECT, OREGON



COLUMBIA RIVER WATER MANAGEMENT GROUP

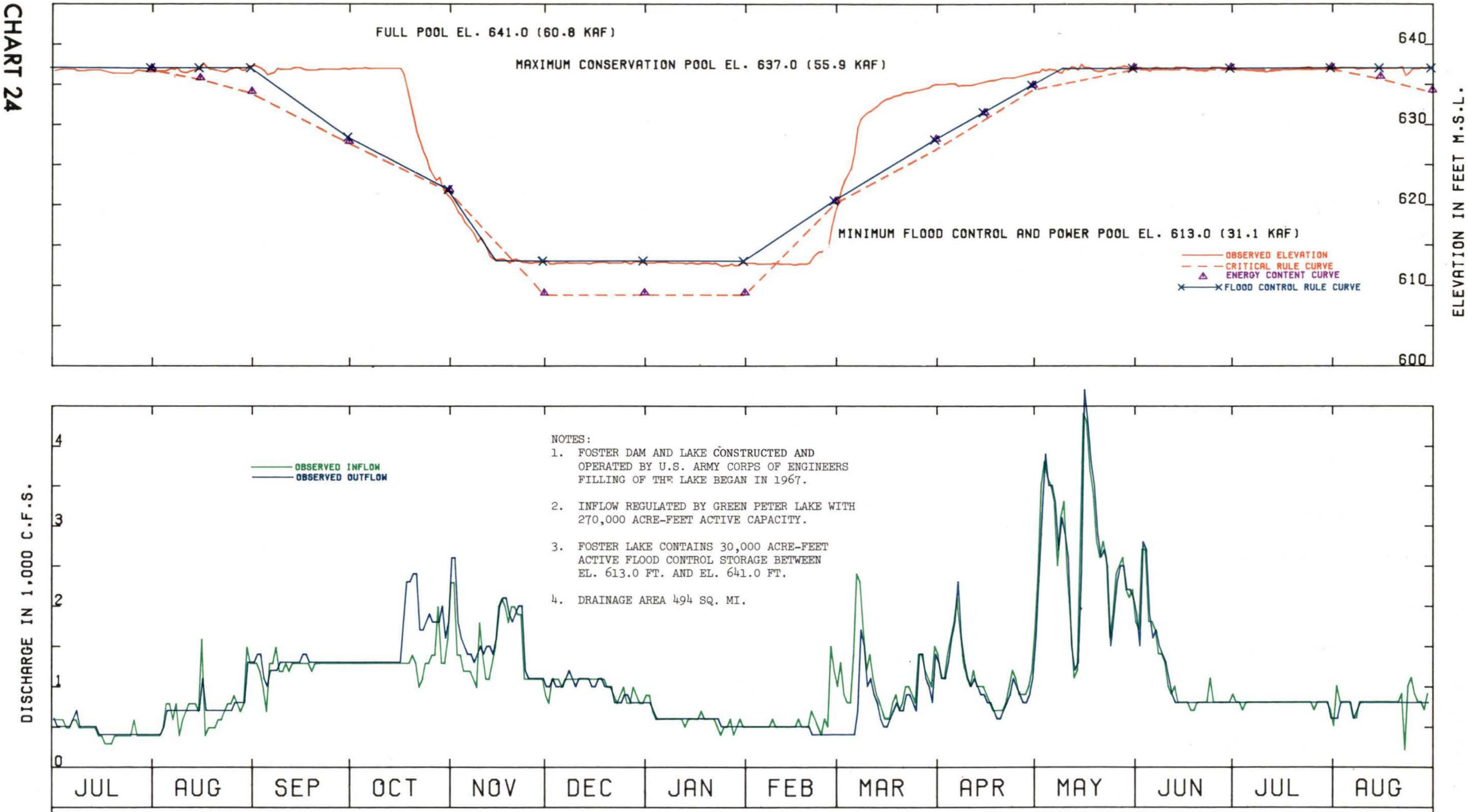
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

MIDDLE SANTIAM RIVER AT GREEN PETER PROJECT, OREGON

CHART 23

CHART 24

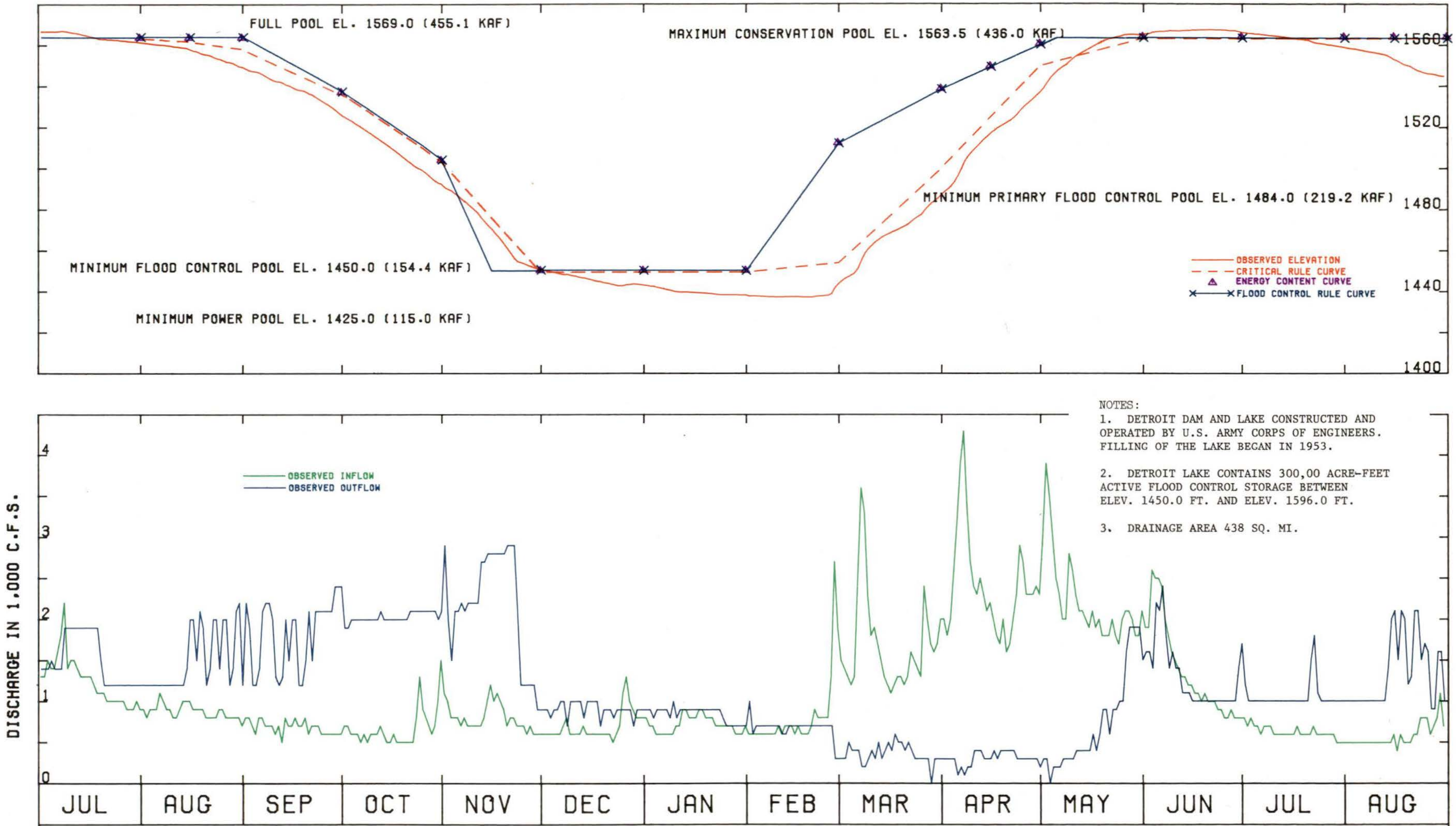


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

SOUTH SANTIAM RIVER AT FOSTER PROJECT, OREGON



COLUMBIA RIVER WATER MANAGEMENT GROUP

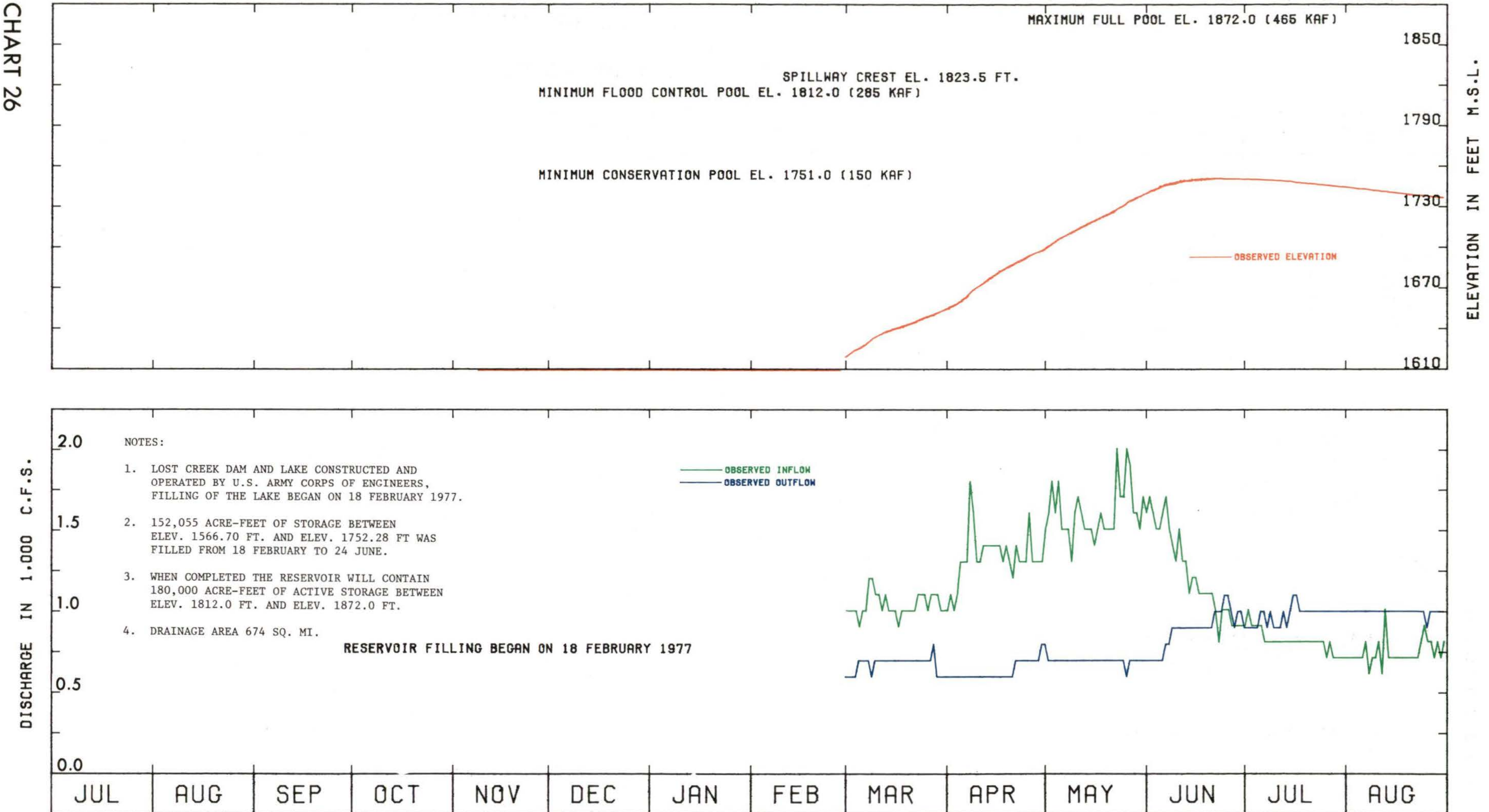
STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

NORTH SANTIAM RIVER AT DETROIT PROJECT, OREGON

CHART 25

CHART 26

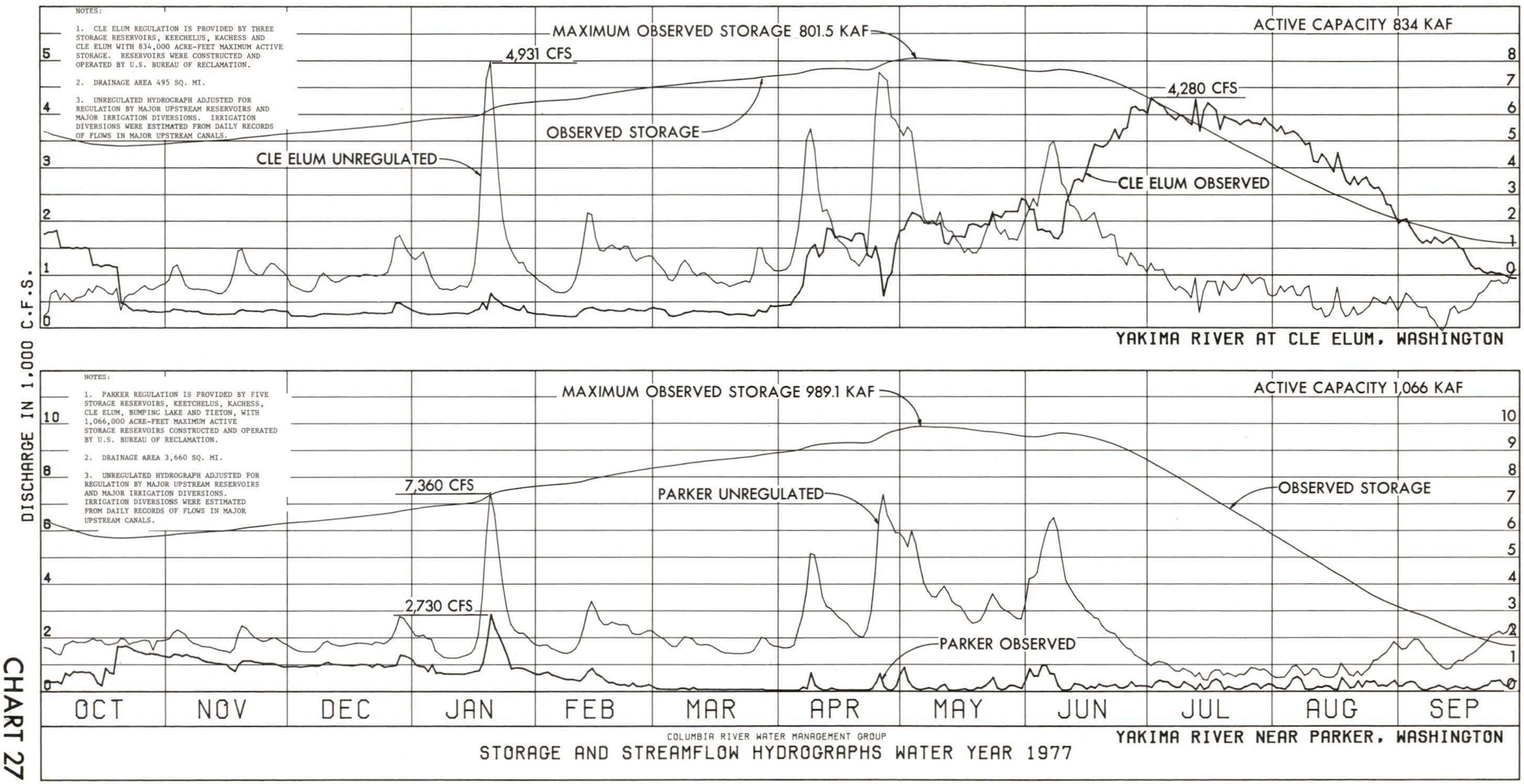


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS

JULY 1976 - AUGUST 1977

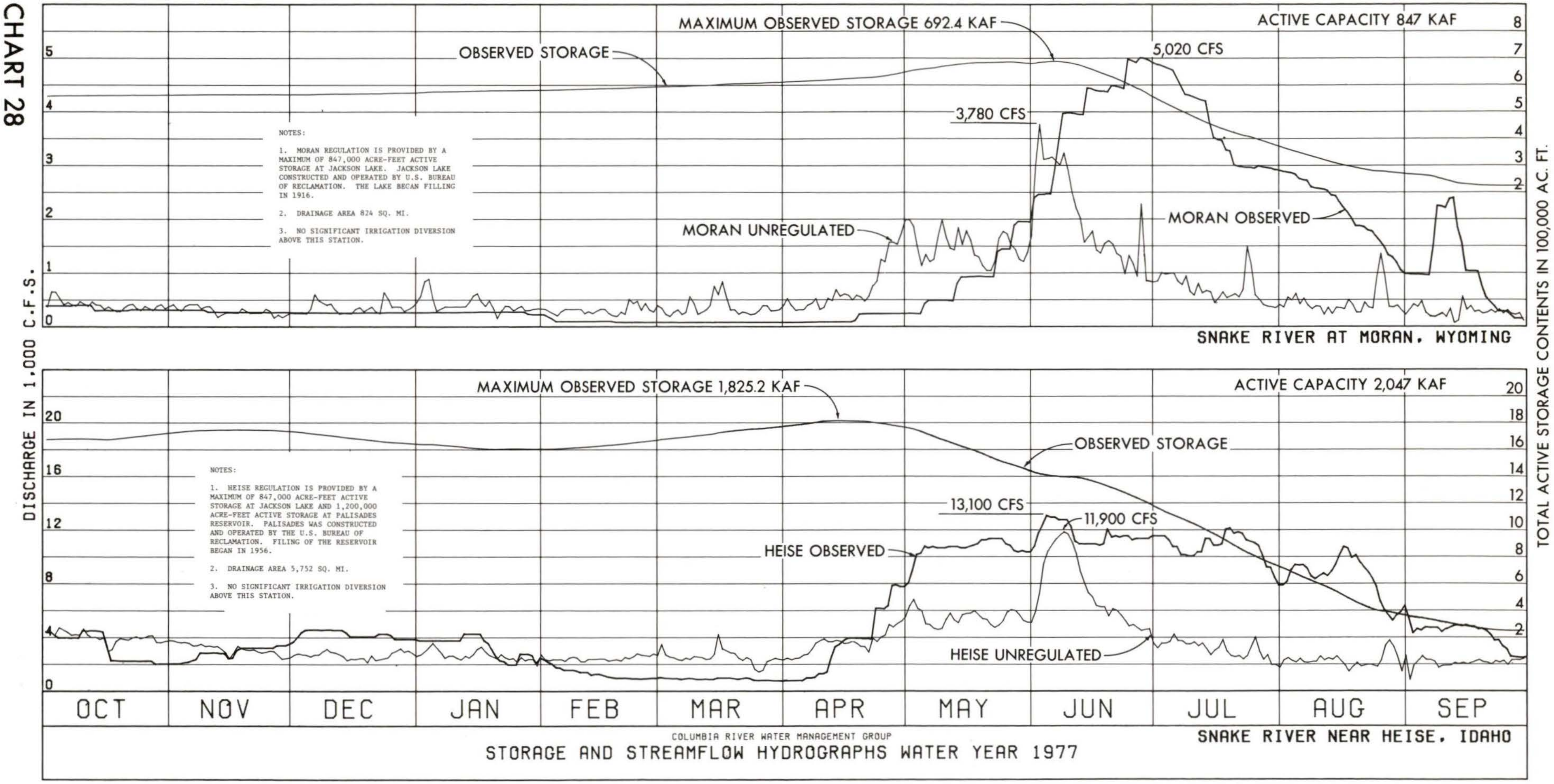
ROGUE RIVER AT LOST CREEK PROJECT, OREGON



NOTES:
1. CLE ELUM REGULATION IS PROVIDED BY THREE STORAGE RESERVOIRS, KEECHELUS, KACHESS AND CLE ELUM WITH 834,000 ACRE-FEET MAXIMUM ACTIVE STORAGE. RESERVOIRS WERE CONSTRUCTED AND OPERATED BY U.S. BUREAU OF RECLAMATION.
2. DRAINAGE AREA 495 SQ. MI.
3. UNREGULATED HYDROGRAPH ADJUSTED FOR REGULATION BY MAJOR UPSTREAM RESERVOIRS AND MAJOR IRRIGATION DIVERSIONS. IRRIGATION DIVERSIONS WERE ESTIMATED FROM DAILY RECORDS OF FLOWS IN MAJOR UPSTREAM CANALS.
MAXIMUM OBSERVED STORAGE 801.5 KAF
ACTIVE CAPACITY 834 KAF
4,931 CFS
4,280 CFS
OBSERVED STORAGE
CLE ELUM UNREGULATED
CLE ELUM OBSERVED
YAKIMA RIVER AT CLE ELUM, WASHINGTON
NOTES:
1. PARKER REGULATION IS PROVIDED BY FIVE STORAGE RESERVOIRS, KEETCHELUS, KACHESS, CLE ELUM, BUMPING LAKE AND TIETON, WITH 1,066,000 ACRE-FEET MAXIMUM ACTIVE STORAGE RESERVOIRS CONSTRUCTED AND OPERATED BY U.S. BUREAU OF RECLAMATION.
2. DRAINAGE AREA 3,660 SQ. MI.
3. UNREGULATED HYDROGRAPH ADJUSTED FOR REGULATION BY MAJOR UPSTREAM RESERVOIRS AND MAJOR IRRIGATION DIVERSIONS. IRRIGATION DIVERSIONS WERE ESTIMATED FROM DAILY RECORDS OF FLOWS IN MAJOR UPSTREAM CANALS.
MAXIMUM OBSERVED STORAGE 989.1 KAF
ACTIVE CAPACITY 1,066 KAF
7,360 CFS
2,730 CFS
PARKER UNREGULATED
OBSERVED STORAGE
PARKER OBSERVED
DISCHARGE IN 1,000 C.F.S.
TOTAL ACTIVE STORAGE CONTENTS IN 100,000 AC. FT.
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
YAKIMA RIVER NEAR PARKER, WASHINGTON
COLUMBIA RIVER WATER MANAGEMENT GROUP
STORAGE AND STREAMFLOW HYDROGRAPHS WATER YEAR 1977

CHART 27

CHART 28



STORAGE AND STREAMFLOW HYDROGRAPHS WATER YEAR 1977

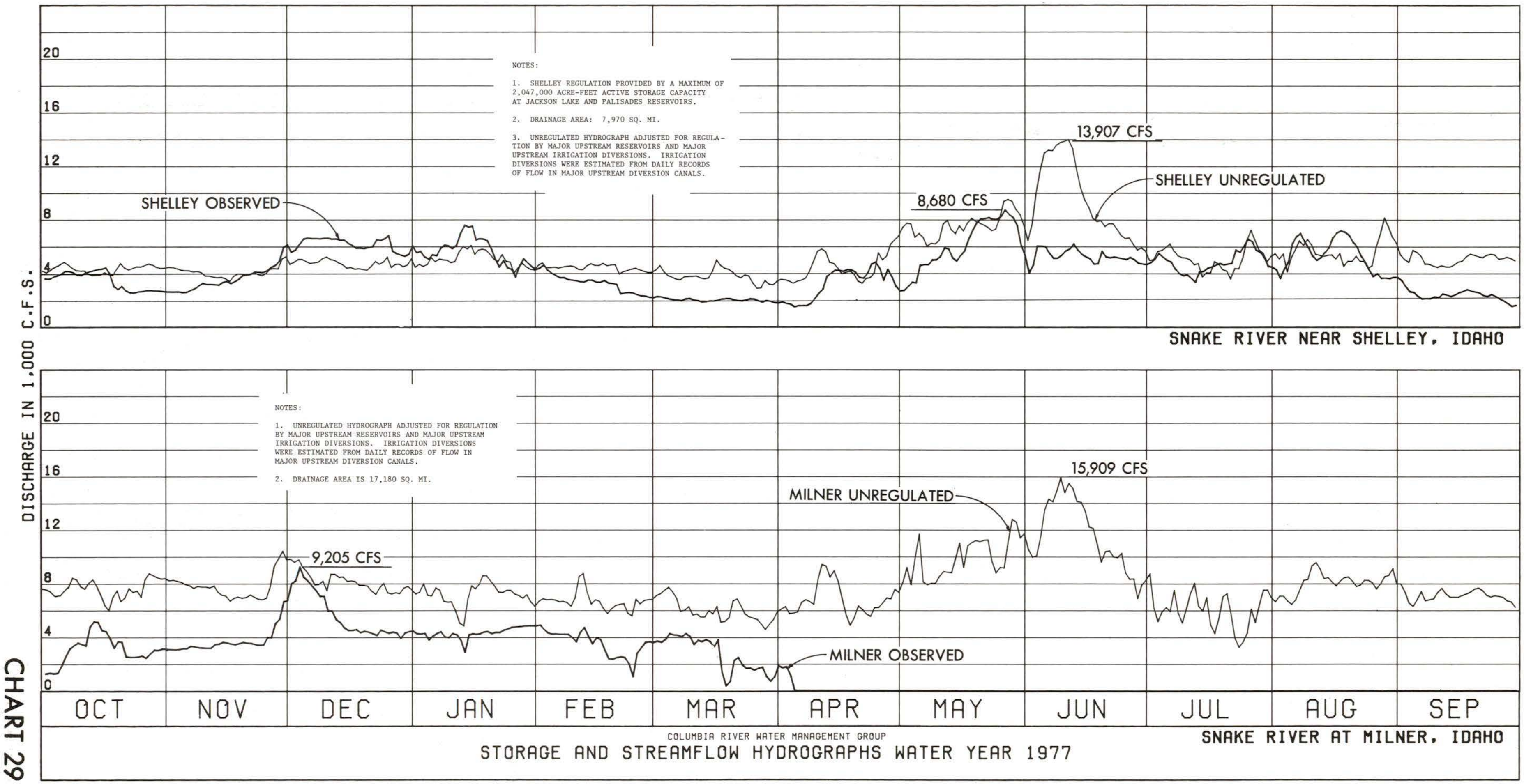
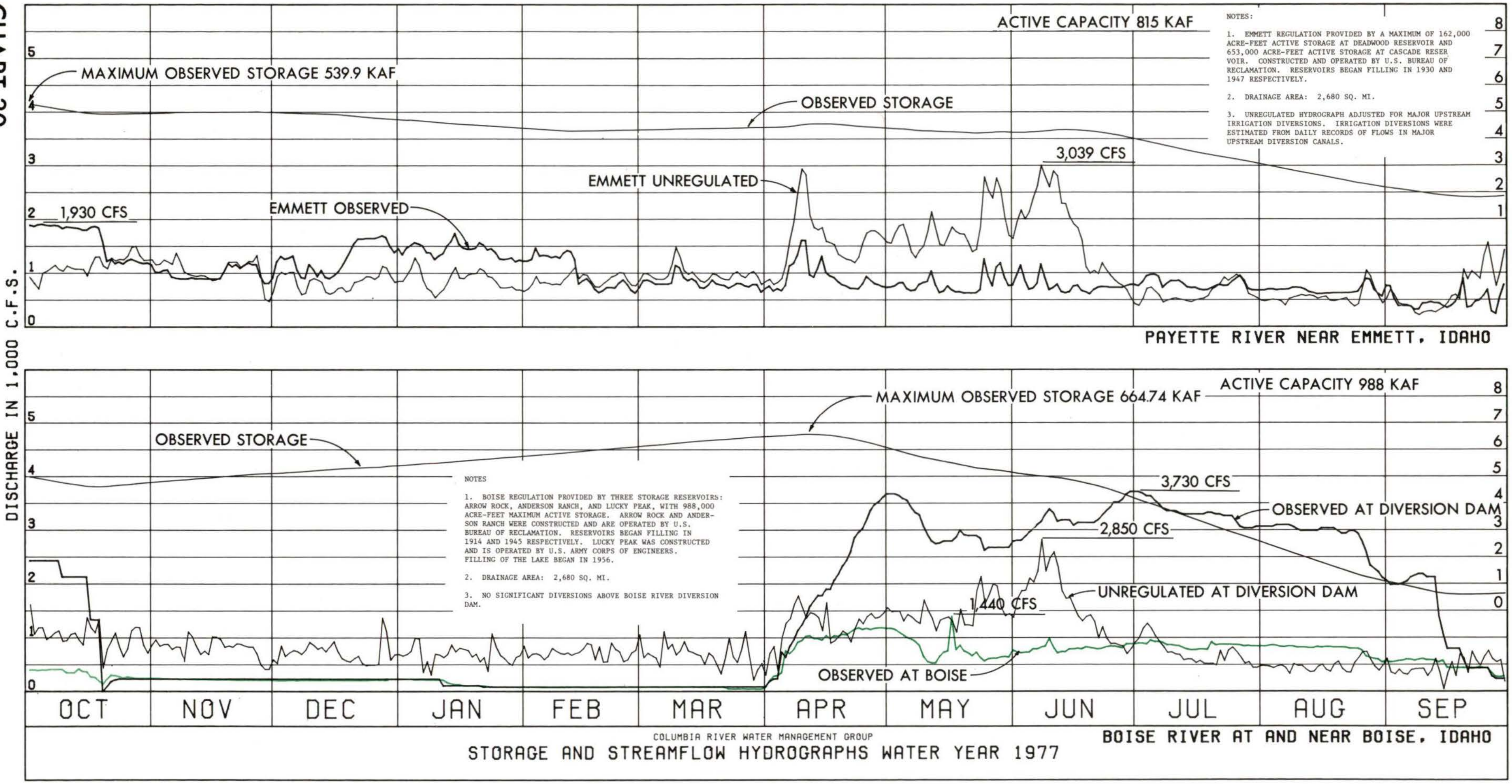
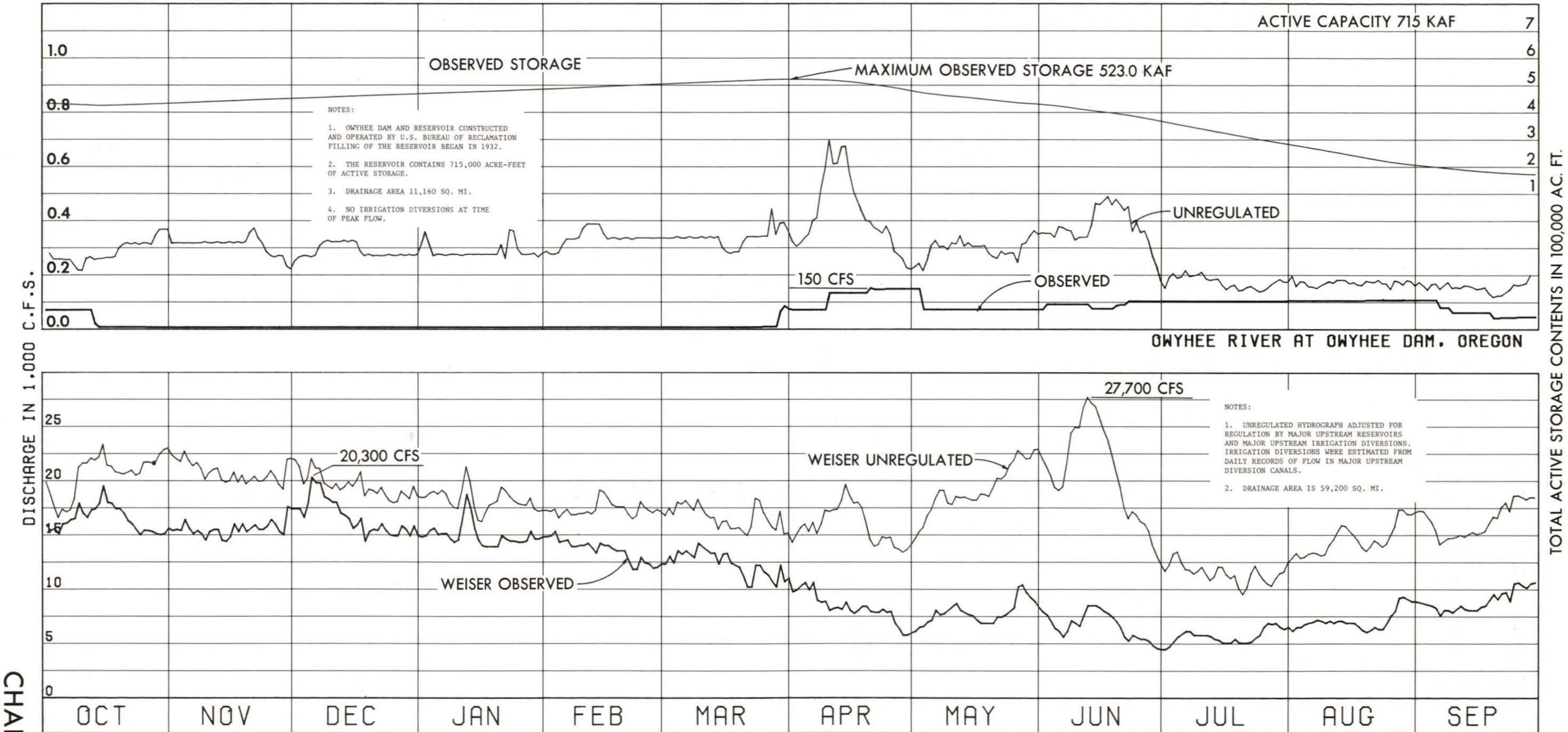

NOTES:
1. SHELLEY REGULATION PROVIDED BY A MAXIMUM OF 2,047,000 ACRE-FEET ACTIVE STORAGE CAPACITY AT JACKSON LAKE AND PALISADES RESERVOIRS.
2. DRAINAGE AREA: 7,970 SQ. MI.
3. UNREGULATED HYDROGRAPH ADJUSTED FOR REGULATION BY MAJOR UPSTREAM RESERVOIRS AND MAJOR UPSTREAM IRRIGATION DIVERSIONS. IRRIGATION DIVERSIONS WERE ESTIMATED FROM DAILY RECORDS OF FLOW IN MAJOR UPSTREAM DIVERSION CANALS.
13,907 CFS
SHELLEY UNREGULATED
8,680 CFS
SHELLEY OBSERVED
20
16
12
8
4
0
SNAKE RIVER NEAR SHELLEY, IDAHO
DISCHARGE IN 1,000 C.F.S.
NOTES:
1. UNREGULATED HYDROGRAPH ADJUSTED FOR REGULATION BY MAJOR UPSTREAM RESERVOIRS AND MAJOR UPSTREAM IRRIGATION DIVERSIONS. IRRIGATION DIVERSIONS WERE ESTIMATED FROM DAILY RECORDS OF FLOW IN MAJOR UPSTREAM DIVERSION CANALS.
2. DRAINAGE AREA IS 17,180 SQ. MI.
15,909 CFS
MILNER UNREGULATED
9,205 CFS
MILNER OBSERVED
20
16
12
8
4
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
COLUMBIA RIVER WATER MANAGEMENT GROUP
STORAGE AND STREAMFLOW HYDROGRAPHS WATER YEAR 1977
SNAKE RIVER AT MILNER, IDAHO

CHART 29

CHART 30



DISCHARGE IN 1,000 C.F.S.
TOTAL ACTIVE STORAGE CONTENTS IN 100,000 AC. FT.
ACTIVE CAPACITY 815 KAF
MAXIMUM OBSERVED STORAGE 539.9 KAF
OBSERVED STORAGE
3,039 CFS
EMMETT UNREGULATED
1,930 CFS
EMMETT OBSERVED
NOTES:
1. EMMETT REGULATION PROVIDED BY A MAXIMUM OF 162,000 ACRE-FEET ACTIVE STORAGE AT DEADWOOD RESERVOIR AND 653,000 ACRE-FEET ACTIVE STORAGE AT CASCADE RESER VOIR. CONSTRUCTED AND OPERATED BY U.S. BUREAU OF RECLAMATION. RESERVOIRS BEGAN FILLING IN 1930 AND 1947 RESPECTIVELY.
2. DRAINAGE AREA: 2,680 SQ. MI.
3. UNREGULATED HYDROGRAPH ADJUSTED FOR MAJOR UPSTREAM IRRIGATION DIVERSIONS. IRRIGATION DIVERSIONS WERE ESTIMATED FROM DAILY RECORDS OF FLOWS IN MAJOR UPSTREAM DIVERSION CANALS.
PAYETTE RIVER NEAR EMMETT, IDAHO
ACTIVE CAPACITY 988 KAF
MAXIMUM OBSERVED STORAGE 664.74 KAF
OBSERVED STORAGE
3,730 CFS
OBSERVED AT DIVERSION DAM
2,850 CFS
UNREGULATED AT DIVERSION DAM
1,440 CFS
OBSERVED AT BOISE
NOTES
1. BOISE REGULATION PROVIDED BY THREE STORAGE RESERVOIRS: ARROW ROCK, ANDERSON RANCH, AND LUCKY PEAK, WITH 988,000 ACRE-FEET MAXIMUM ACTIVE STORAGE. ARROW ROCK AND ANDER-SON RANCH WERE CONSTRUCTED AND ARE OPERATED BY U.S. BUREAU OF RECLAMATION. RESERVOIRS BEGAN FILLING IN 1914 AND 1945 RESPECTIVELY. LUCKY PEAK WAS CONSTRUCTED AND IS OPERATED BY U.S. ARMY CORPS OF ENGINEERS. FILLING OF THE LAKE BEGAN IN 1956.
2. DRAINAGE AREA: 2,680 SQ. MI.
3. NO SIGNIFICANT DIVERSIONS ABOVE BOISE RIVER DIVERSION DAM.
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
BOISE RIVER AT AND NEAR BOISE, IDAHO
COLUMBIA RIVER WATER MANAGEMENT GROUP
STORAGE AND STREAMFLOW HYDROGRAPHS WATER YEAR 1977

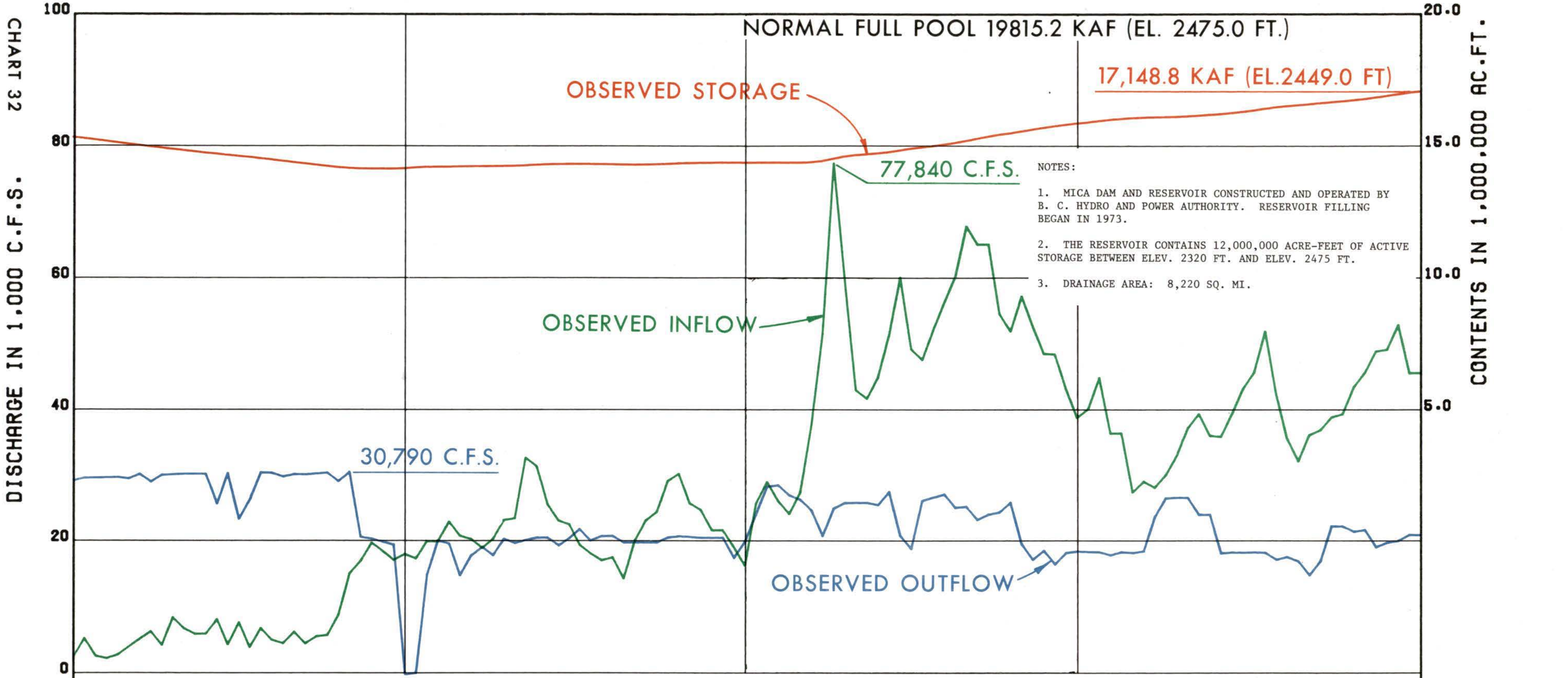


COLUMBIA RIVER WATER MANAGEMENT GROUP

STORAGE AND STREAMFLOW HYDROGRAPHS WATER YEAR 1977

SNAKE RIVER AT WEISER, IDAHO

CHART 31



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

COLUMBIA RIVER AT MICA PROJECT, BRITISH COLUMBIA, CANADA

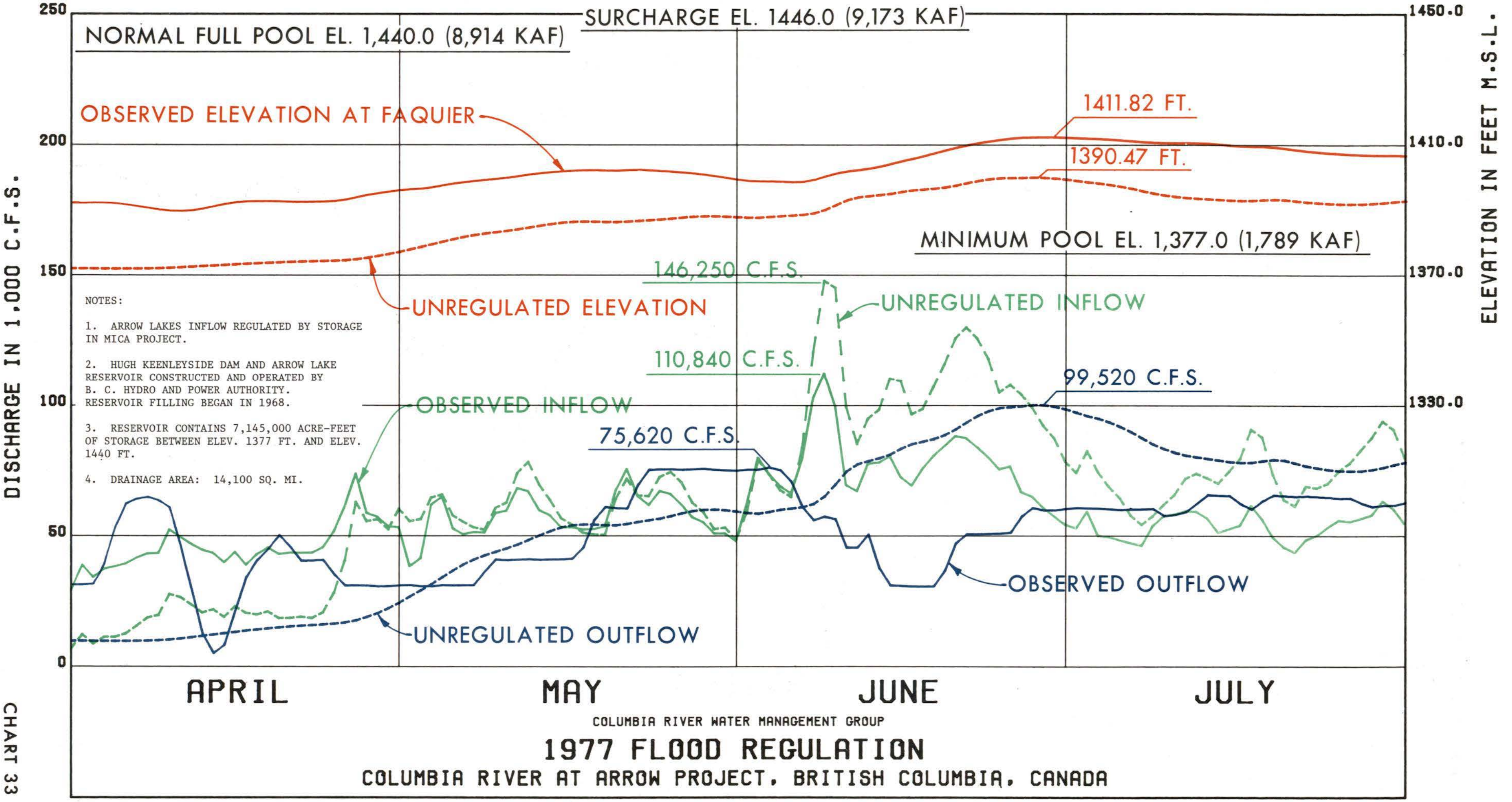

SURCHARGE EL. 1446.0 (9,173 KAF)
NORMAL FULL POOL EL. 1,440.0 (8,914 KAF)
OBSERVED ELEVATION AT FAQUIER
1411.82 FT.
1390.47 FT.
MINIMUM POOL EL. 1,377.0 (1,789 KAF)
146,250 C.F.S.
UNREGULATED ELEVATION
UNREGULATED INFLOW
110,840 C.F.S.
99,520 C.F.S.
OBSERVED INFLOW
75,620 C.F.S.
OBSERVED OUTFLOW
UNREGULATED OUTFLOW
NOTES:
1. ARROW LAKES INFLOW REGULATED BY STORAGE IN MICA PROJECT.
2. HUGH KEENLEYSIDE DAM AND ARROW LAKE RESERVOIR CONSTRUCTED AND OPERATED BY B. C. HYDRO AND POWER AUTHORITY. RESERVOIR FILLING BEGAN IN 1968.
3. RESERVOIR CONTAINS 7,145,000 ACRE-FEET OF STORAGE BETWEEN ELEV. 1377 FT. AND ELEV. 1440 FT.
4. DRAINAGE AREA: 14,100 SQ. MI.
DISCHARGE IN 1,000 C.F.S.
250
200
150
100
50
0
ELEVATION IN FEET M.S.L.
1450.0
1410.0
1370.0
1330.0
APRIL
MAY
JUNE
JULY
COLUMBIA RIVER WATER MANAGEMENT GROUP
1977 FLOOD REGULATION
COLUMBIA RIVER AT ARROW PROJECT, BRITISH COLUMBIA, CANADA

CHART 33

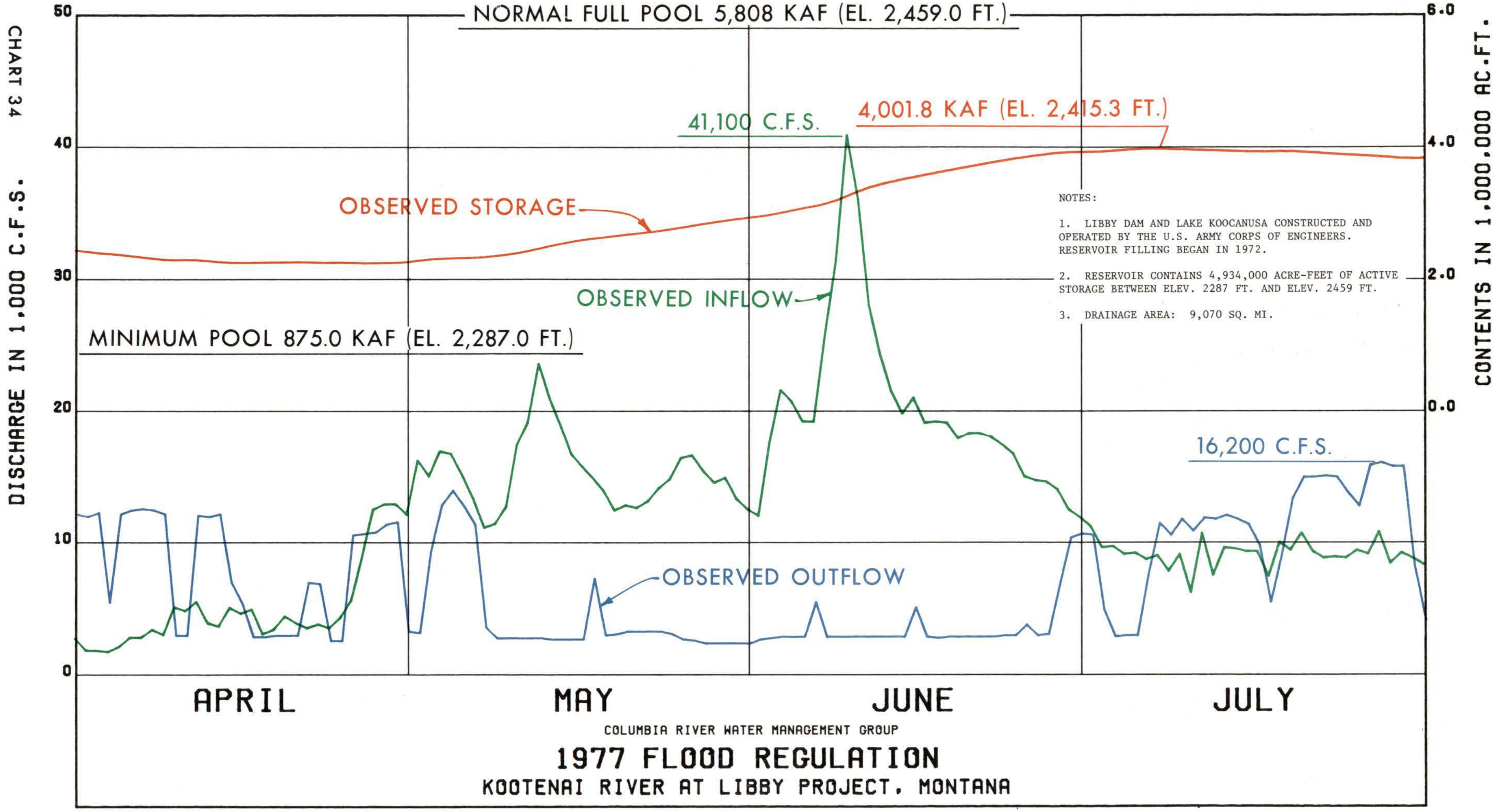
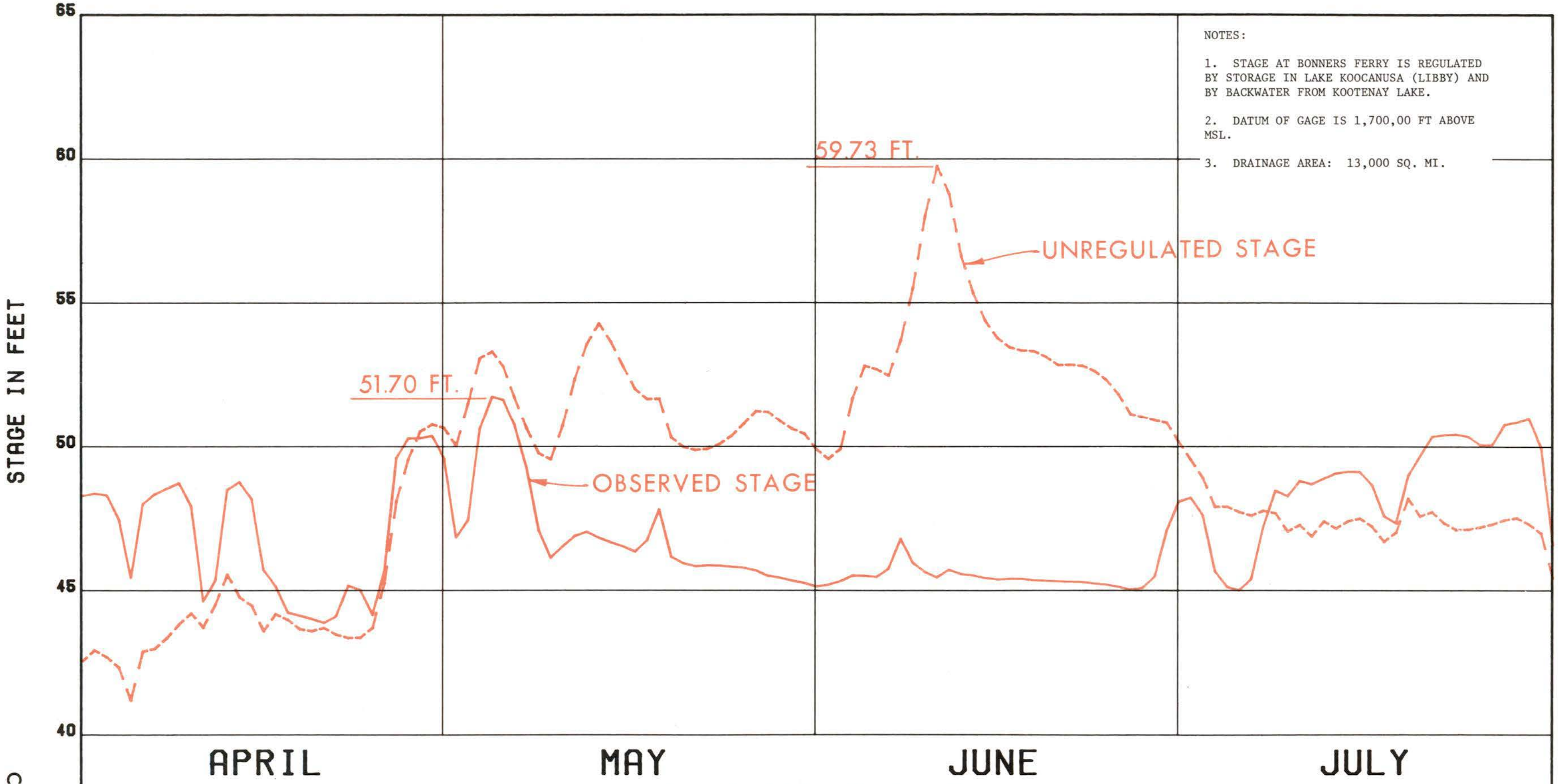


CHART 34
NORMAL FULL POOL 5,808 KAF (EL. 2,459.0 FT.)
41,100 C.F.S.
4,001.8 KAF (EL. 2,415.3 FT.)
OBSERVED STORAGE
NOTES:
1. LIBBY DAM AND LAKE KOOCANUSA CONSTRUCTED AND OPERATED BY THE U.S. ARMY CORPS OF ENGINEERS. RESERVOIR FILLING BEGAN IN 1972.
2. RESERVOIR CONTAINS 4,934,000 ACRE-FEET OF ACTIVE STORAGE BETWEEN ELEV. 2287 FT. AND ELEV. 2459 FT.
3. DRAINAGE AREA: 9,070 SQ. MI.
OBSERVED INFLOW
MINIMUM POOL 875.0 KAF (EL. 2,287.0 FT.)
16,200 C.F.S.
OBSERVED OUTFLOW
DISCHARGE IN 1,000 C.F.S.
CONTENTS IN 1,000,000 AC.FT.
50
40
30
20
10
0
6.0
4.0
2.0
0.0
APRIL
MAY
JUNE
JULY
COLUMBIA RIVER WATER MANAGEMENT GROUP
1977 FLOOD REGULATION
KOOTENAI RIVER AT LIBBY PROJECT, MONTANA

BANKFULL 70 FEET

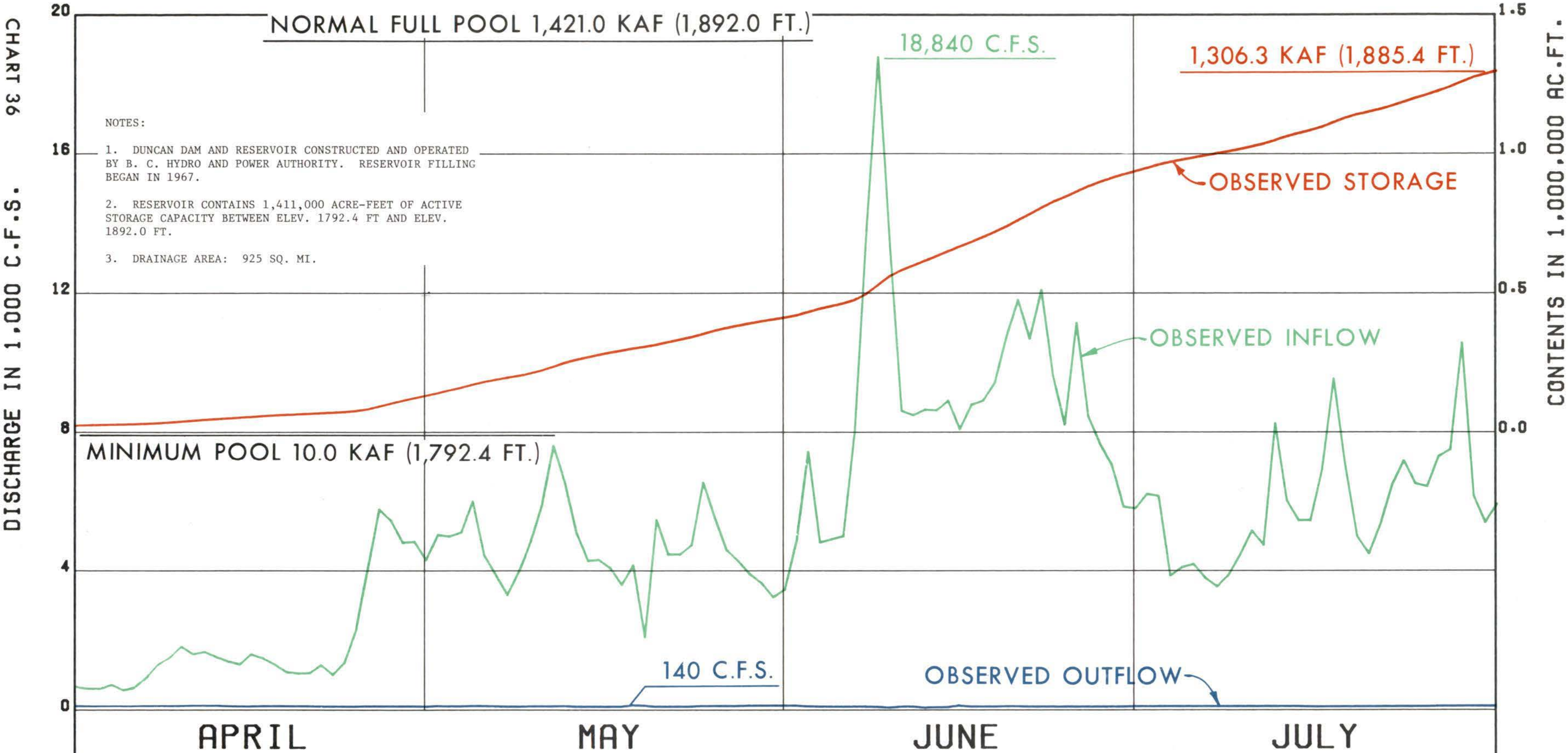


COLUMBIA RIVER WATER MANAGEMENT GROUP

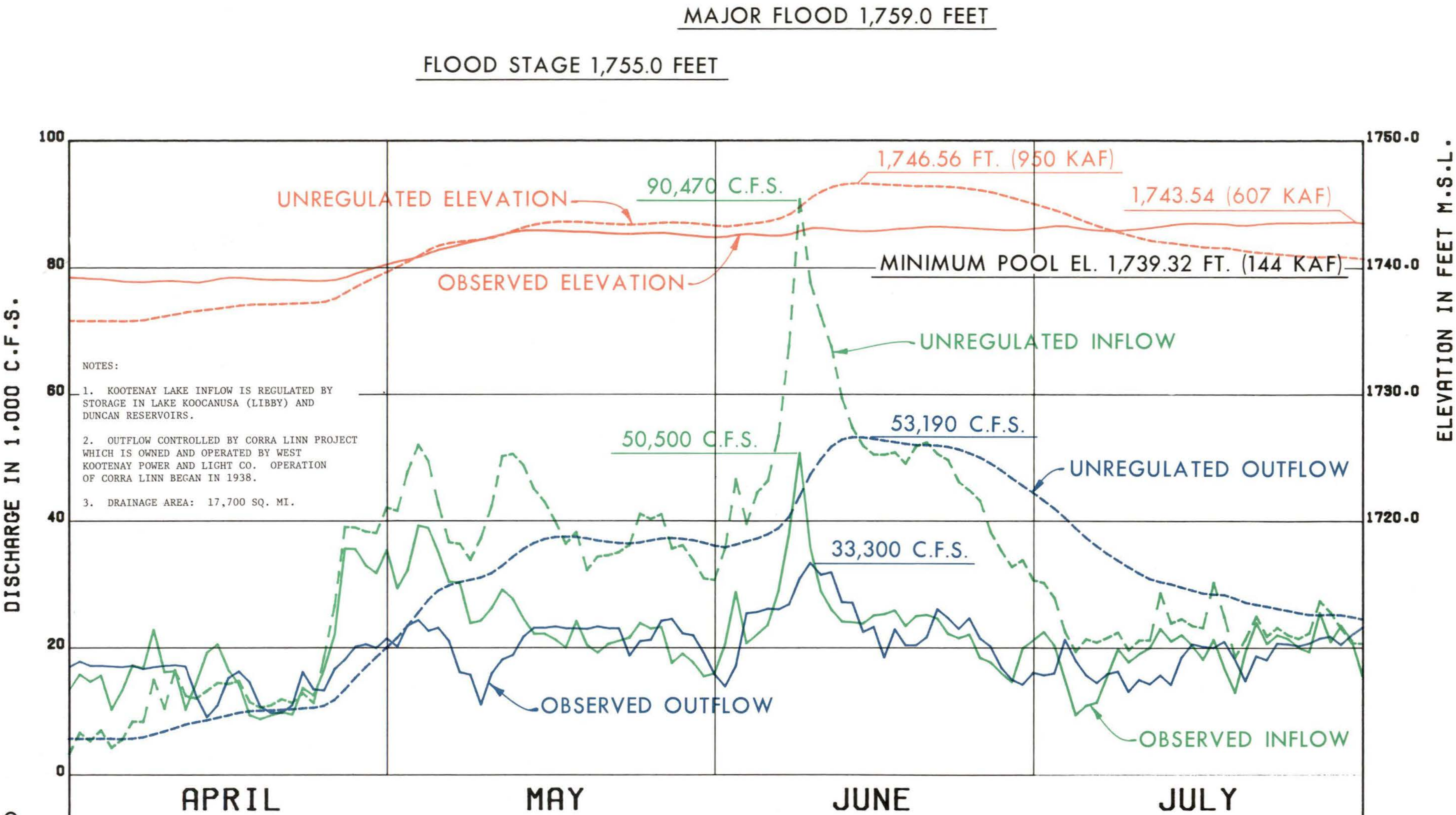
1977 FLOOD REGULATION

KOOTENAI RIVER AT BONNERS FERRY, IDAHO

CHART 35



COLUMBIA RIVER WATER MANAGEMENT GROUP
1977 FLOOD REGULATION
DUNCAN RIVER AT DUNCAN PROJECT, BRITISH COLUMBIA, CANADA

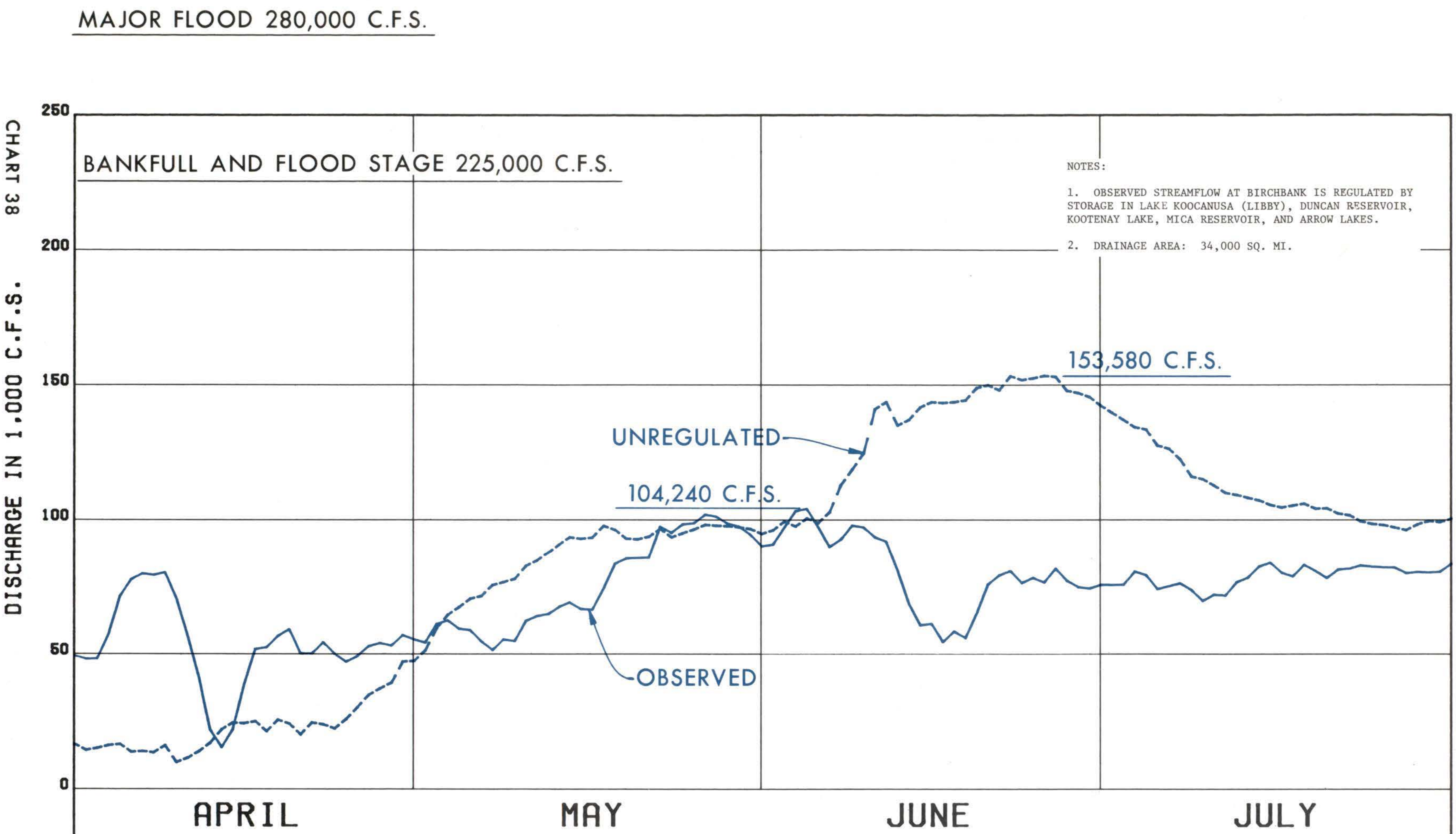


COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

KOOTENAY RIVER AT KOOTENAY LAKE, BRITISH COLUMBIA, CANADA

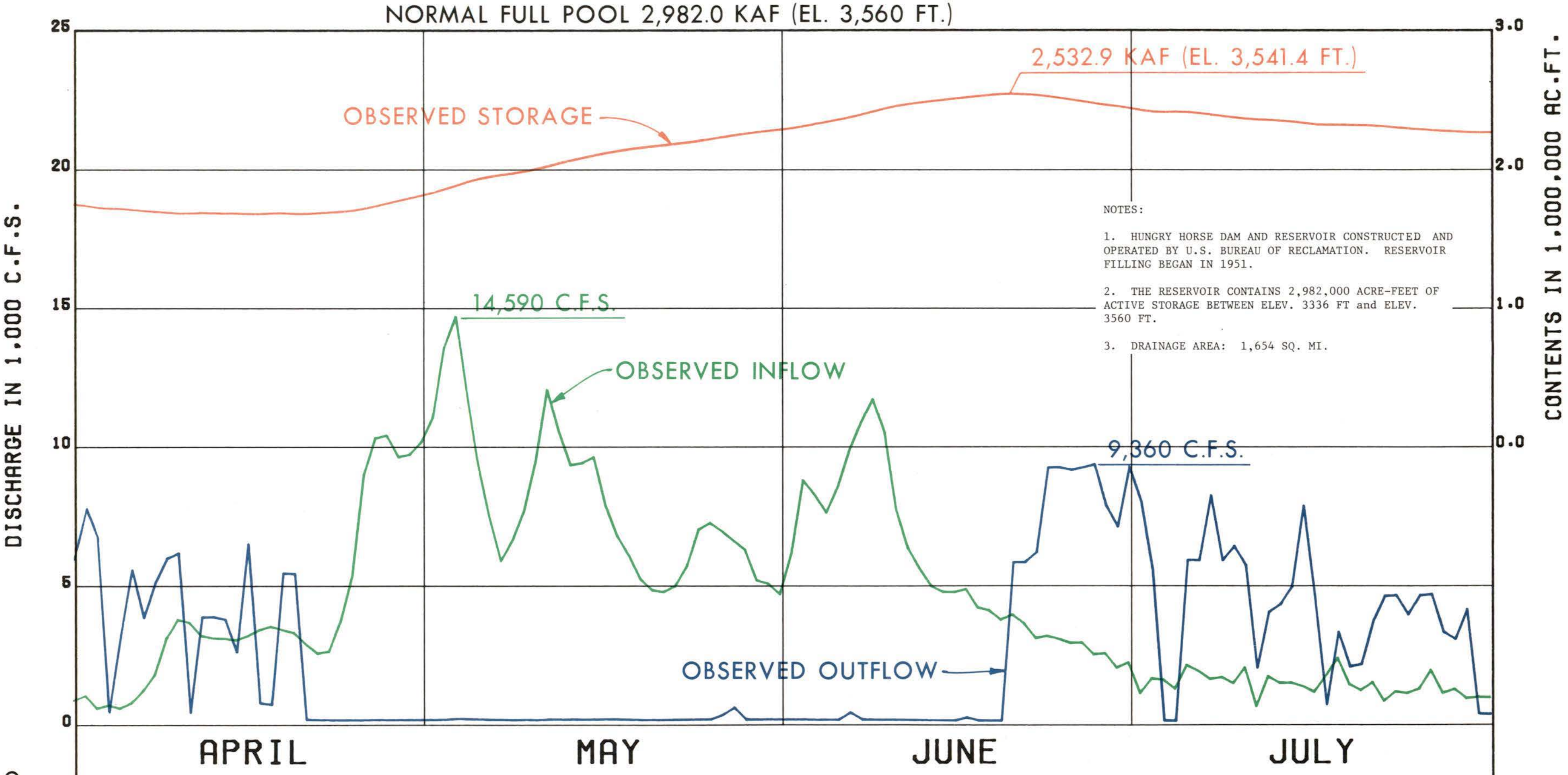
CHART 37



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

COLUMBIA RIVER AT BIRCHBANK, BRITISH COLUMBIA, CANADA

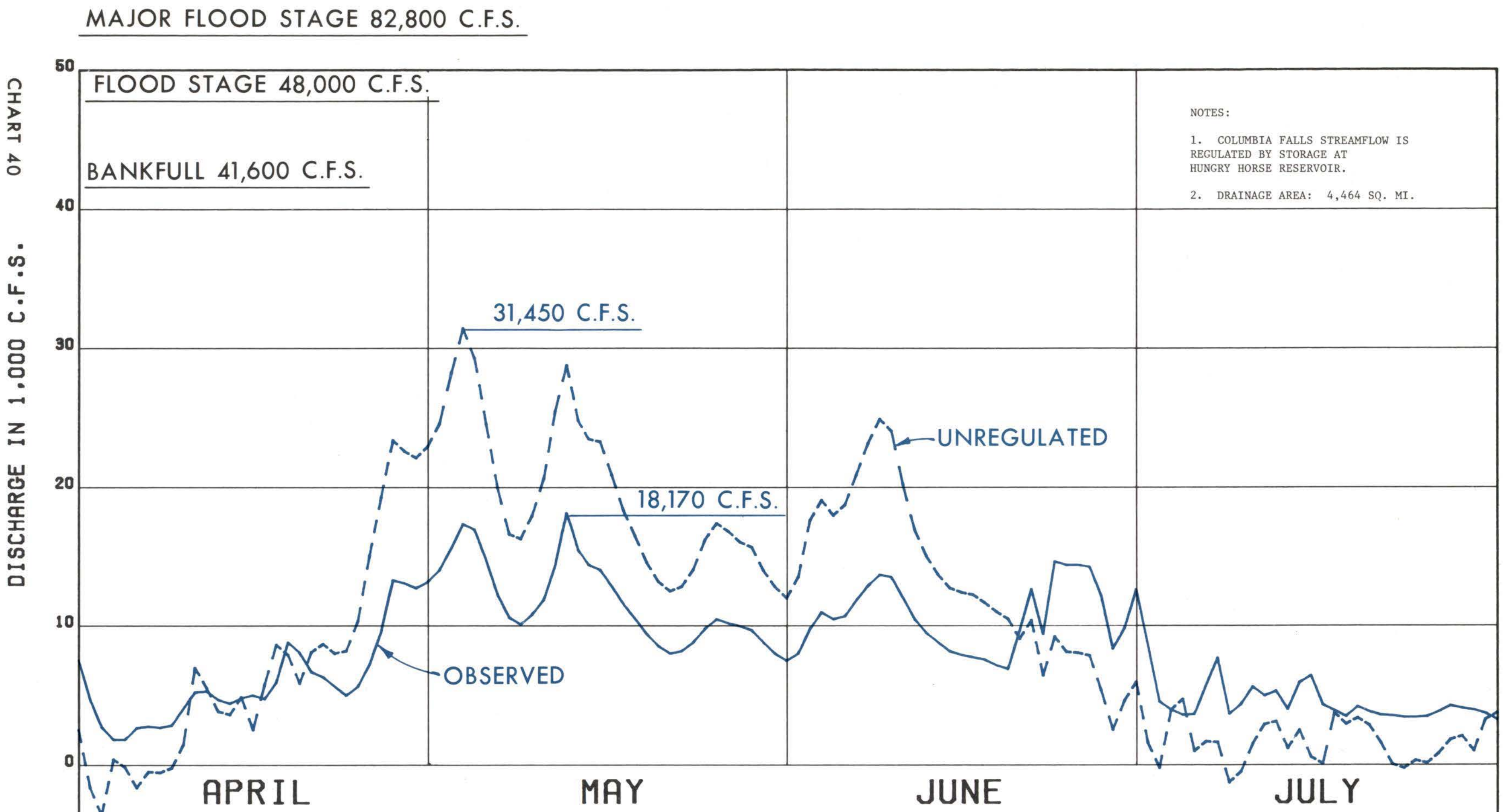


COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SOUTH FORK FLATHEAD RIVER AT HUNGRY HORSE, MONTANA

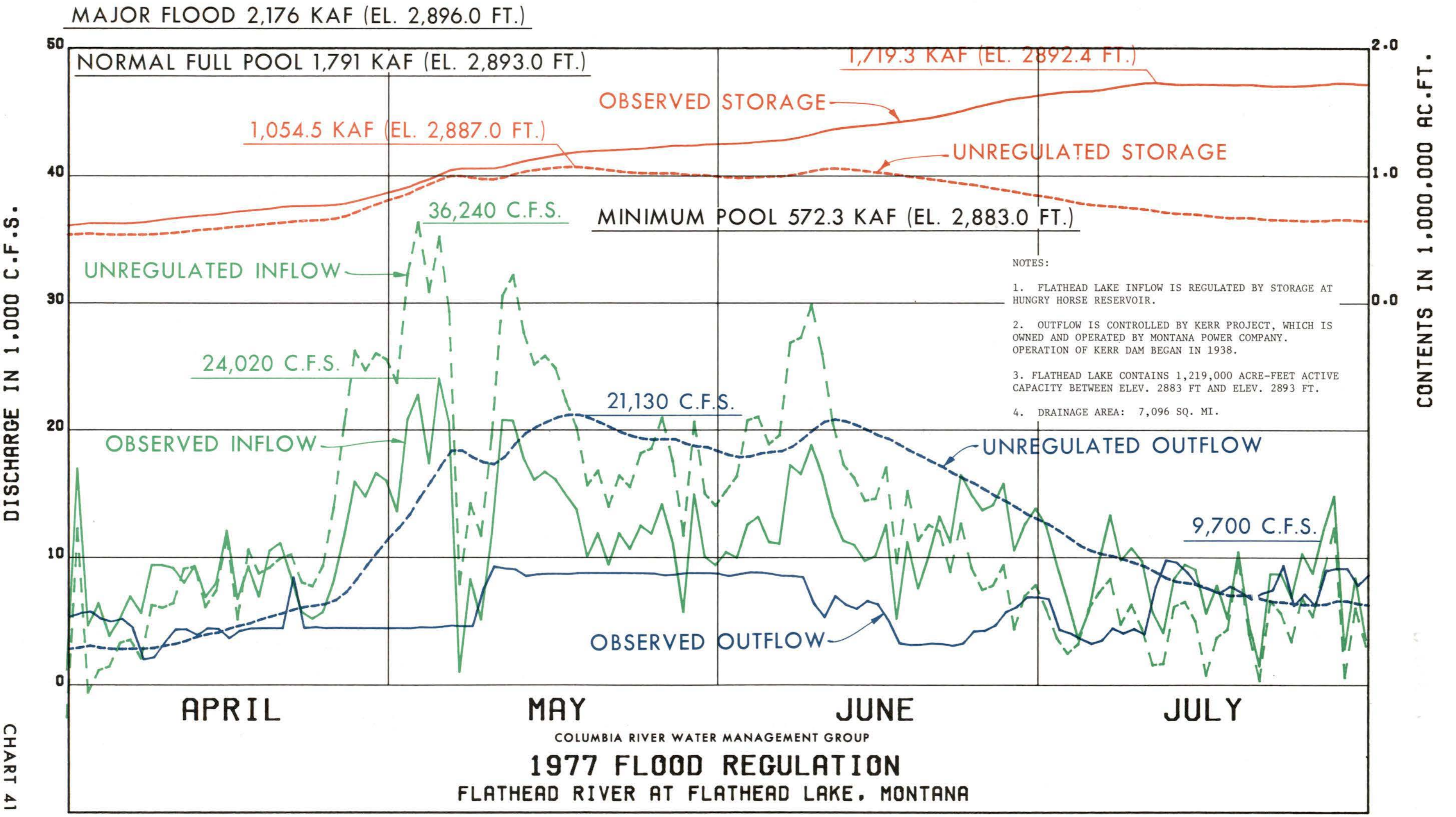
CHART 39



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

FLATHEAD RIVER AT COLUMBIA FALLS, MONTANA

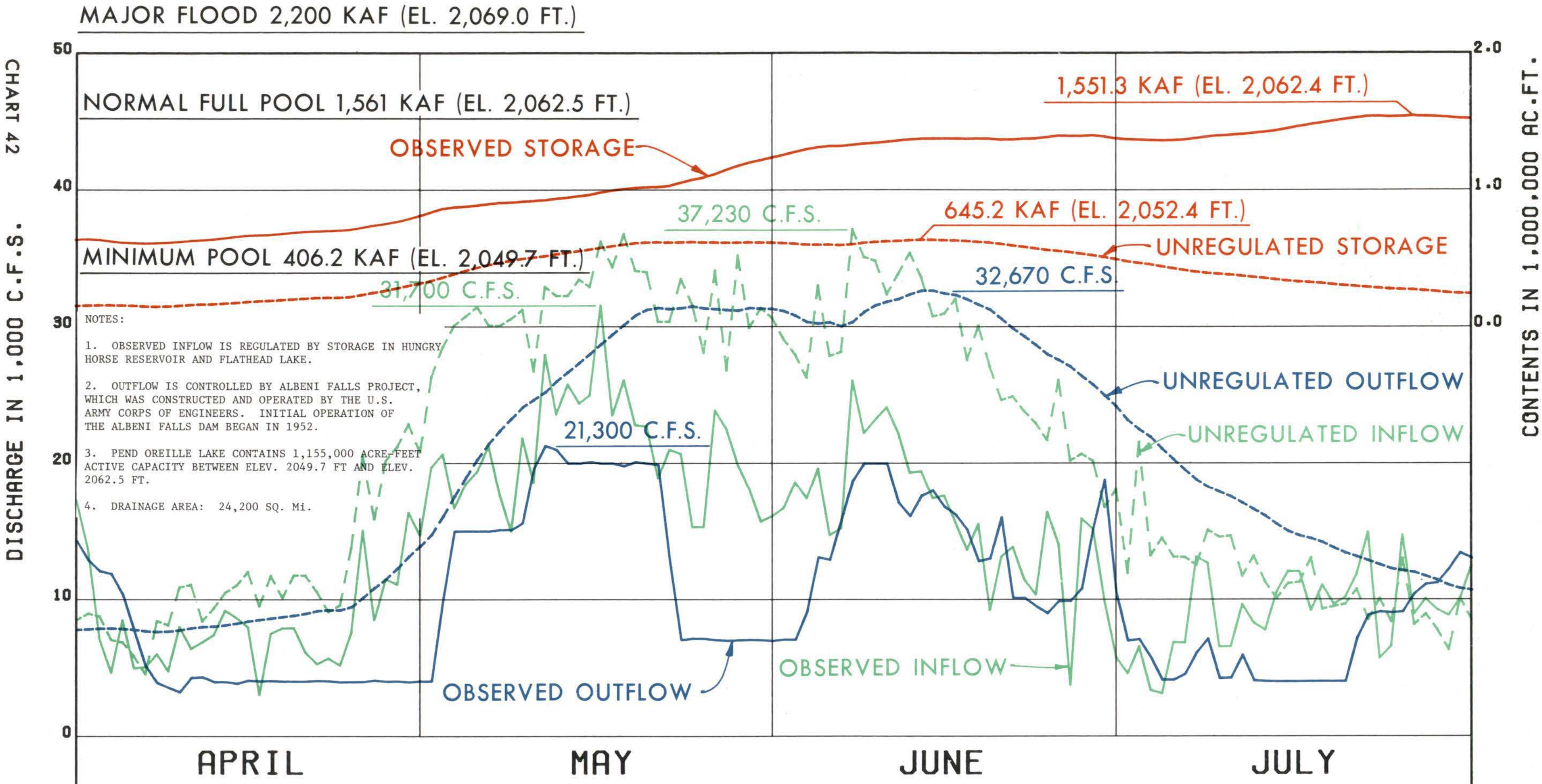


COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

FLATHEAD RIVER AT FLATHEAD LAKE, MONTANA

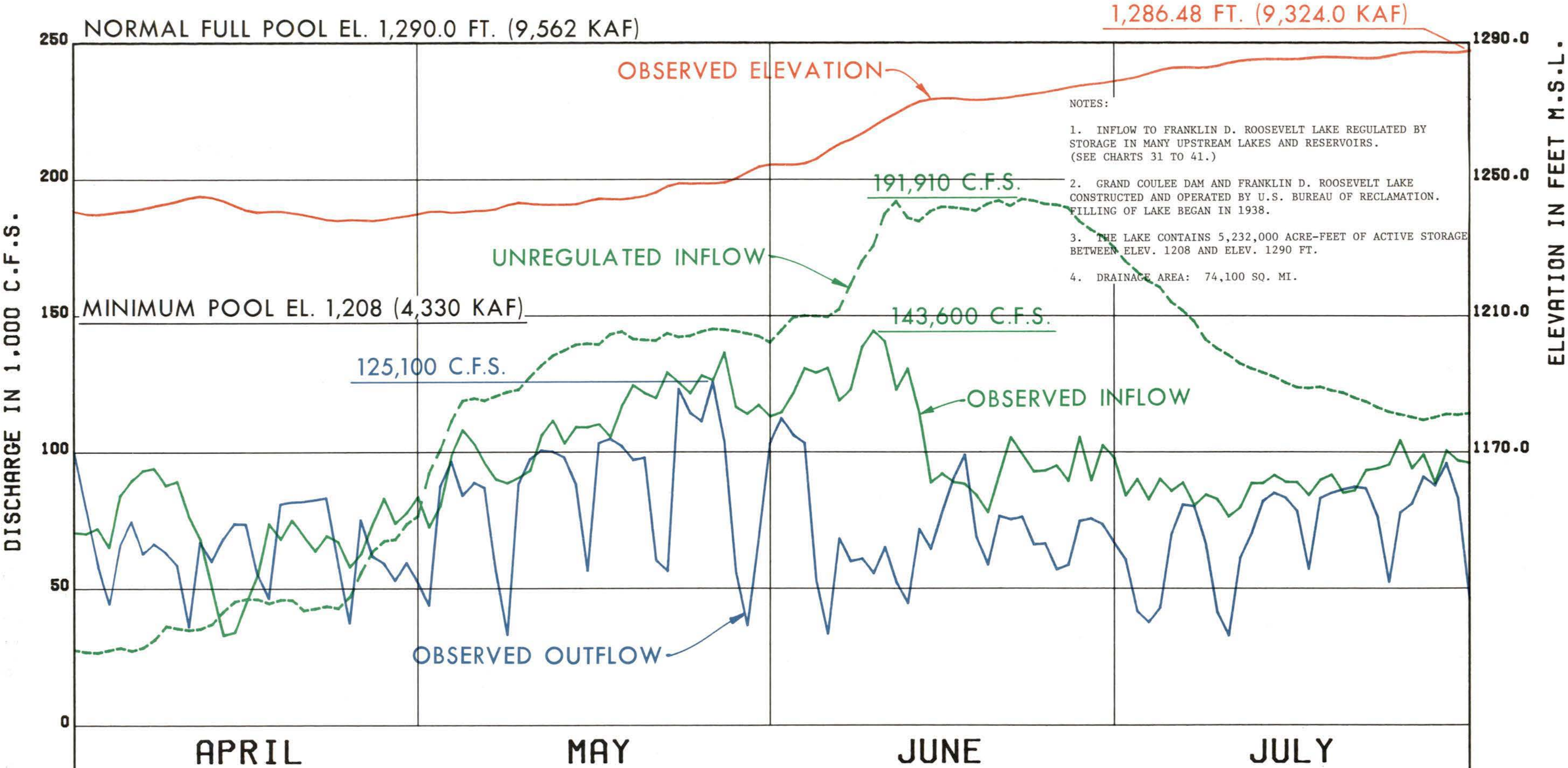
CHART 41



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

PEND OREILLE RIVER AT PEND OREILLE LAKE, IDAHO



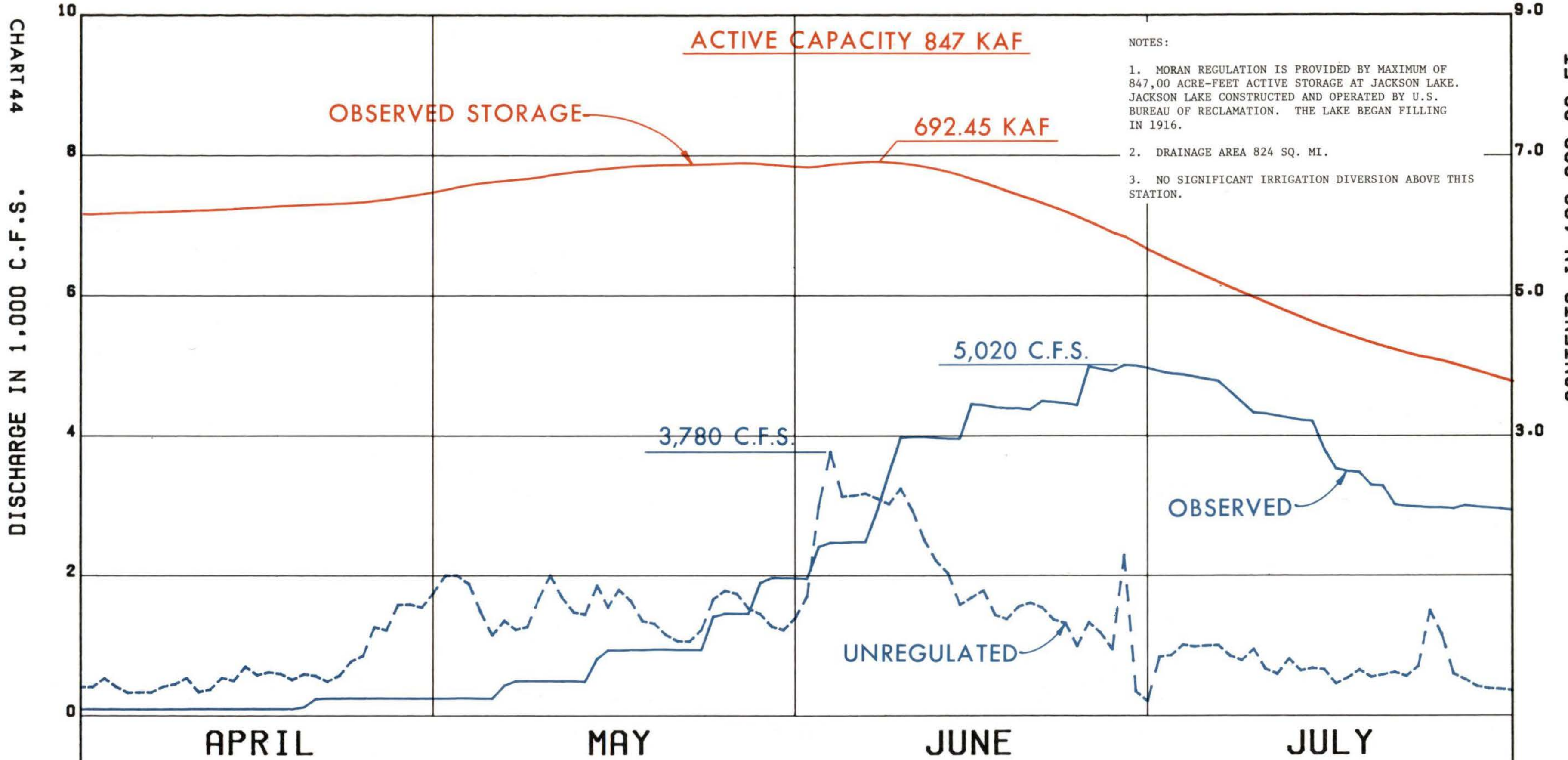
COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

COLUMBIA RIVER AT GRAND COULEE PROJECT, WASHINGTON

CHART 43

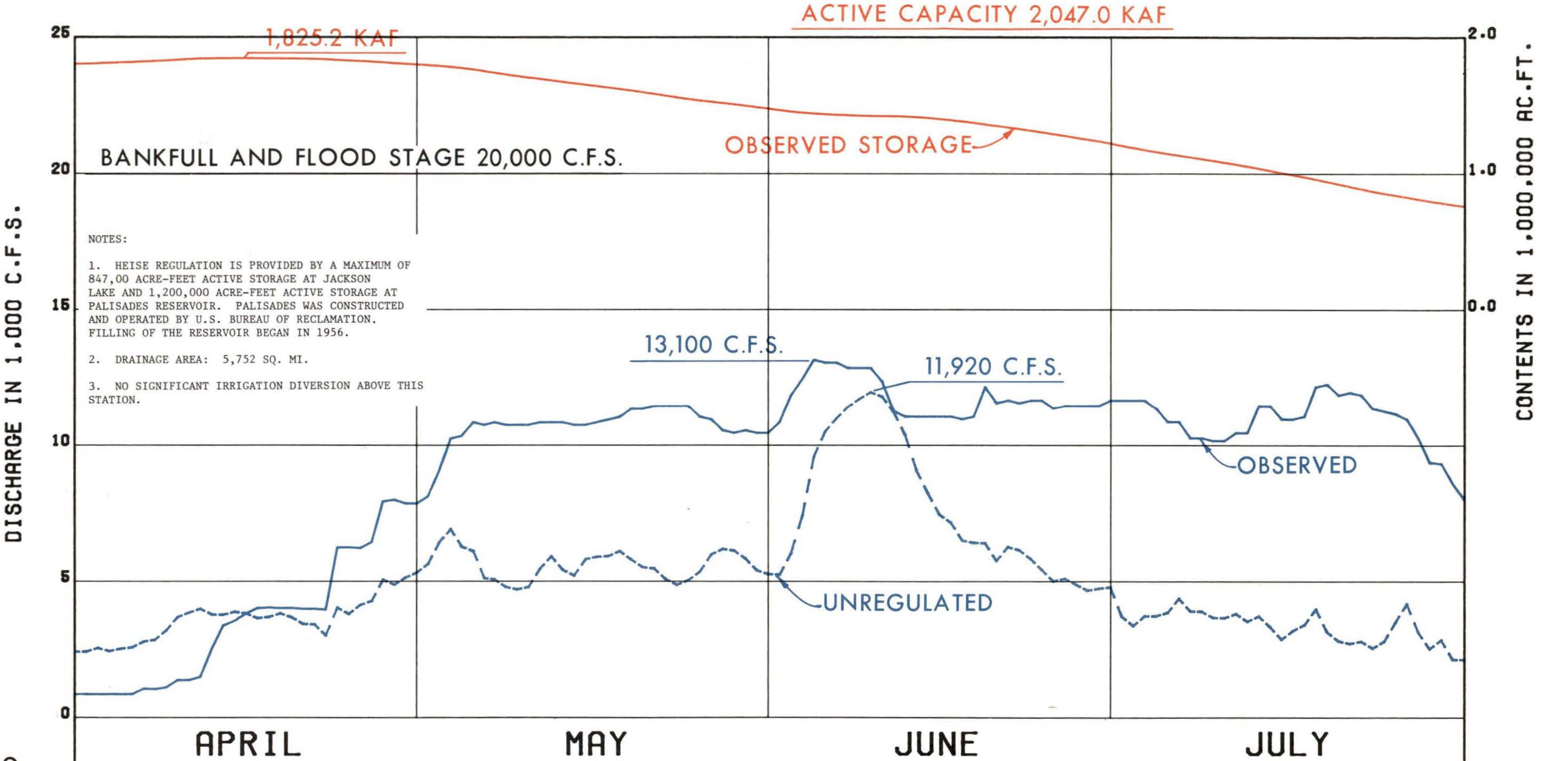
CHART44



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER AT JACKSON LAKE, WYOMING



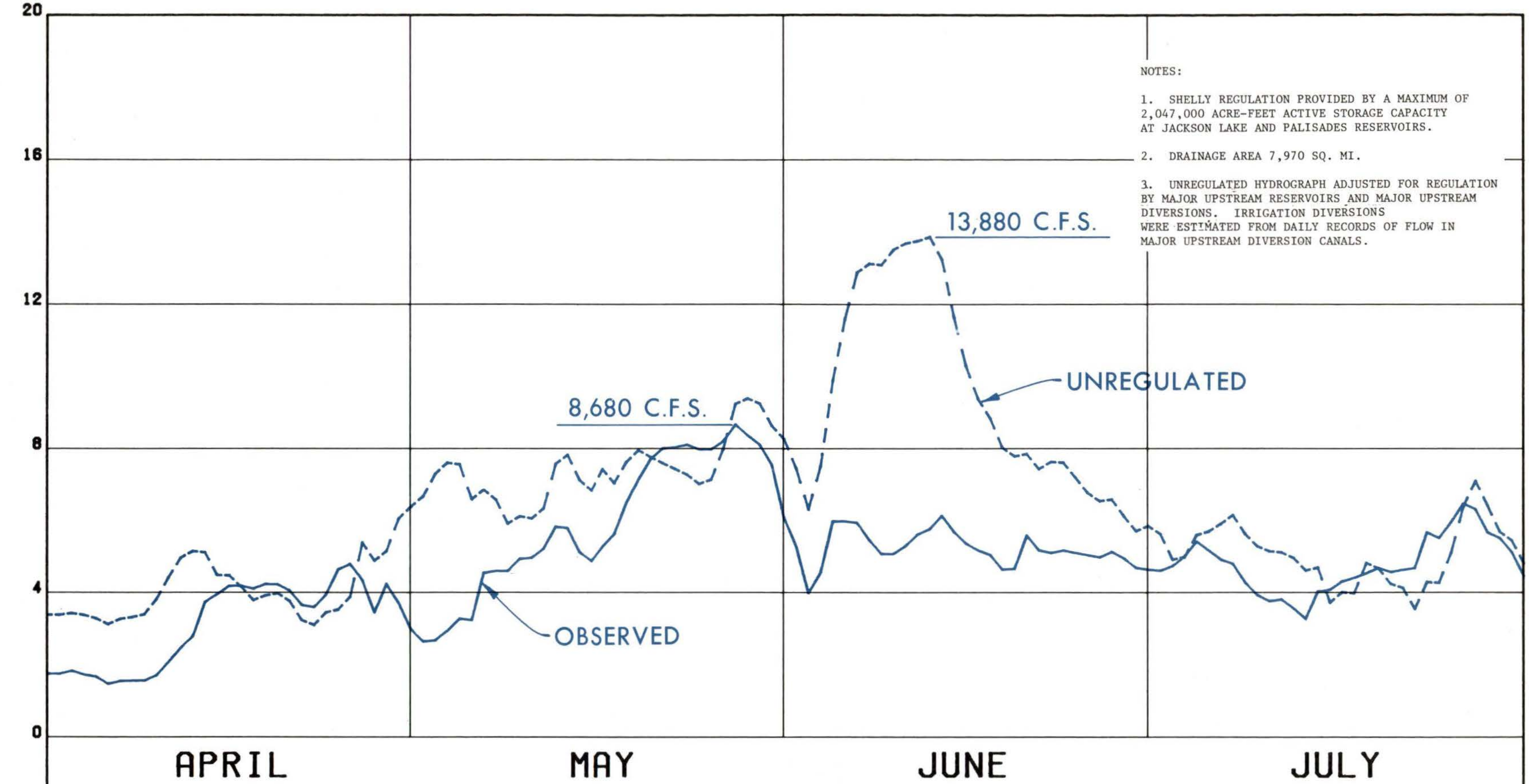
COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER NEAR HEISE, IDAHO

CHART 45

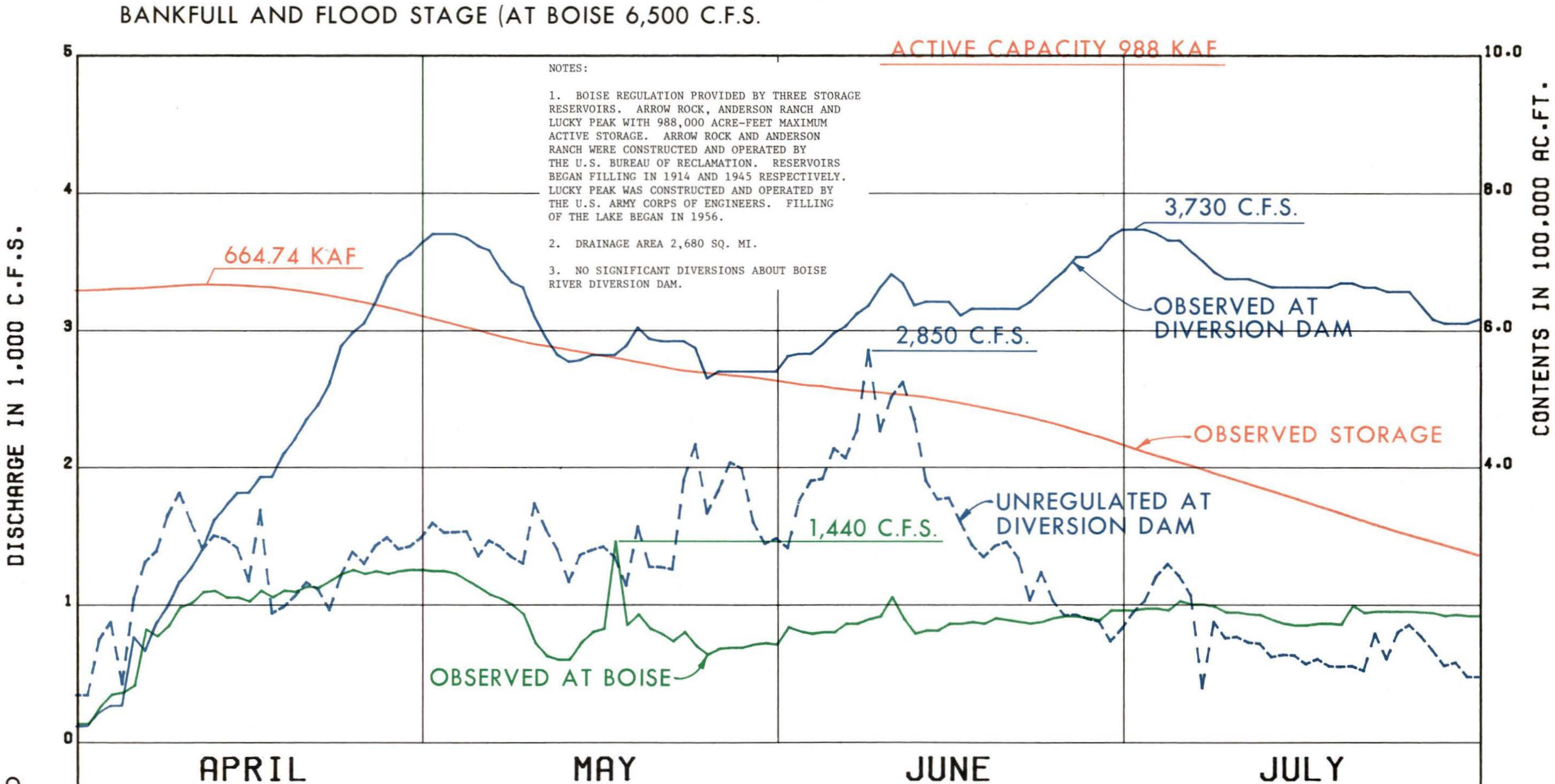
CHART 46



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER NEAR SHELLEY, IDAHO



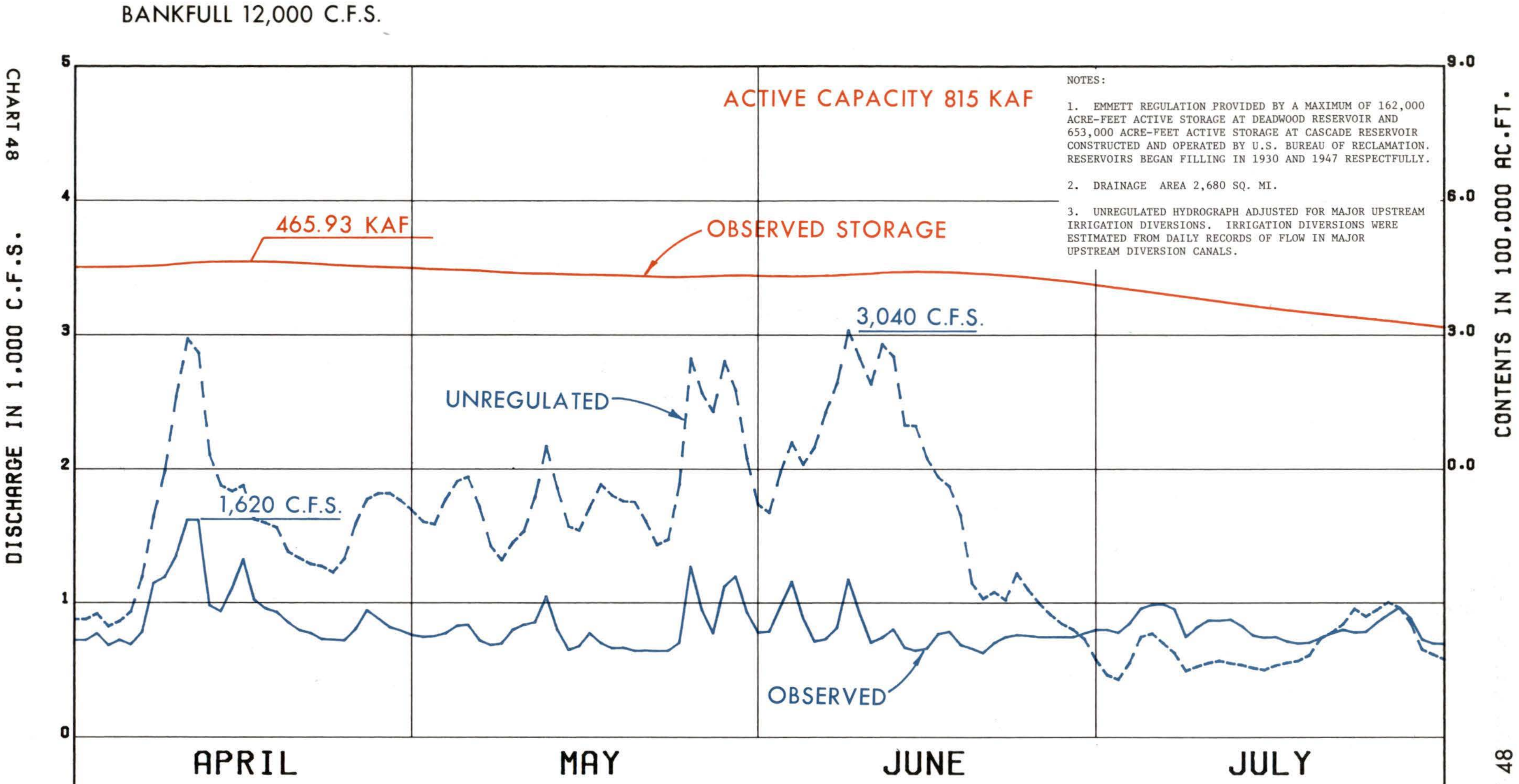
COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

BOISE RIVER AT AND NEAR BOISE, IDAHO

CHART 47

CHART 48

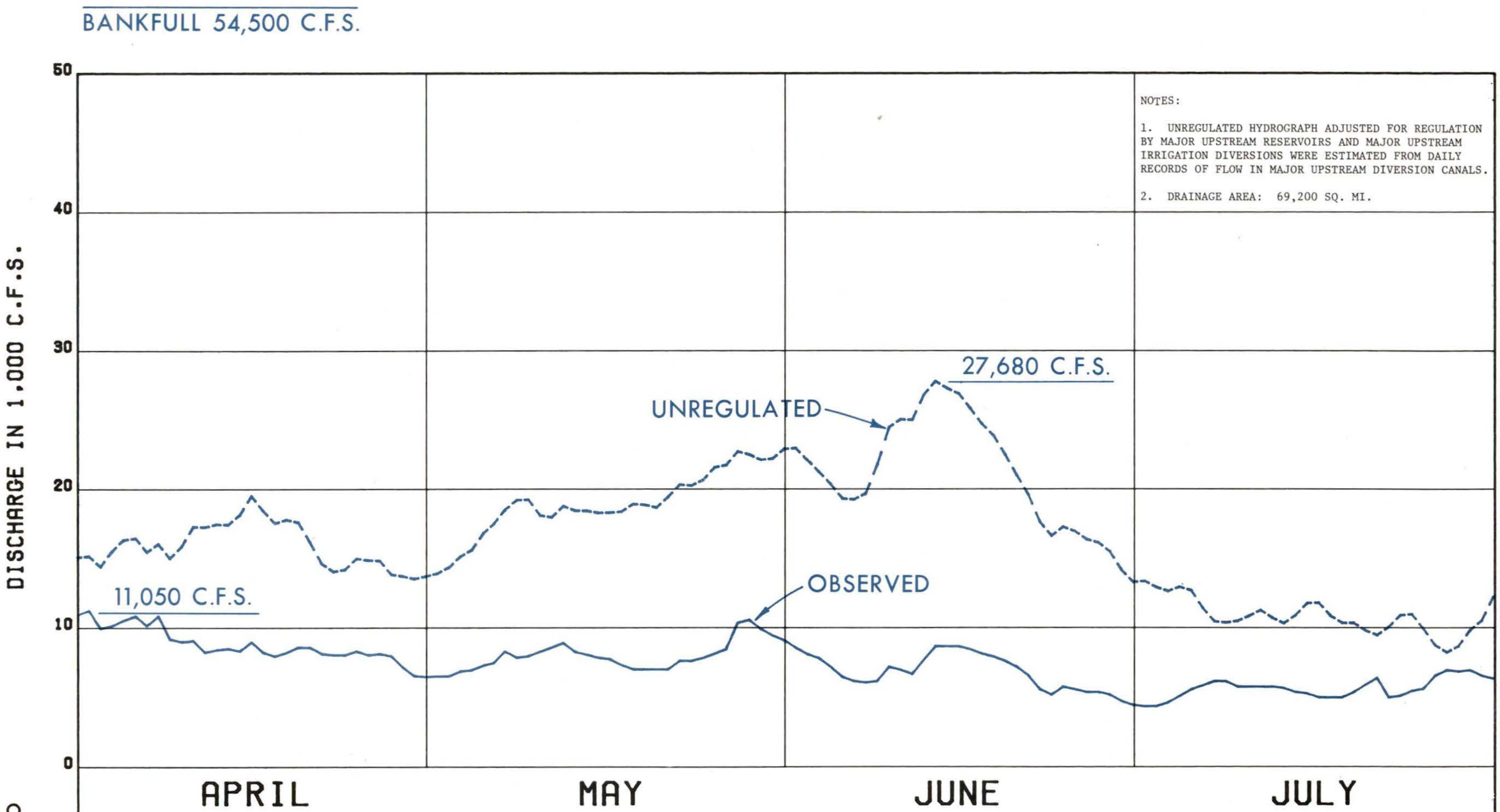


COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

PAYETTE RIVER NEAR EMMETT, IDAHO

CHART 48



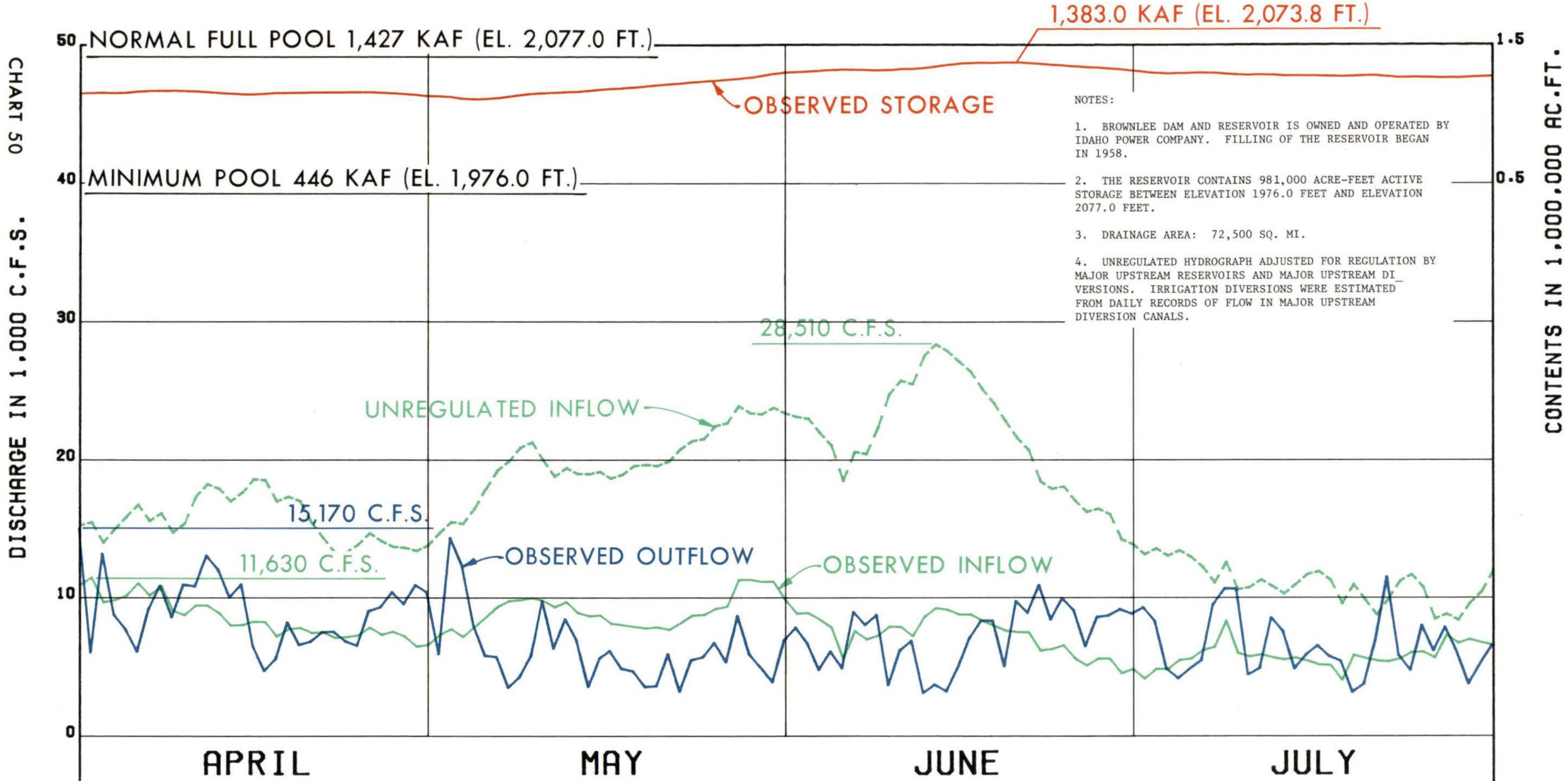
COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER AT WEISER, IDAHO

CHART 49

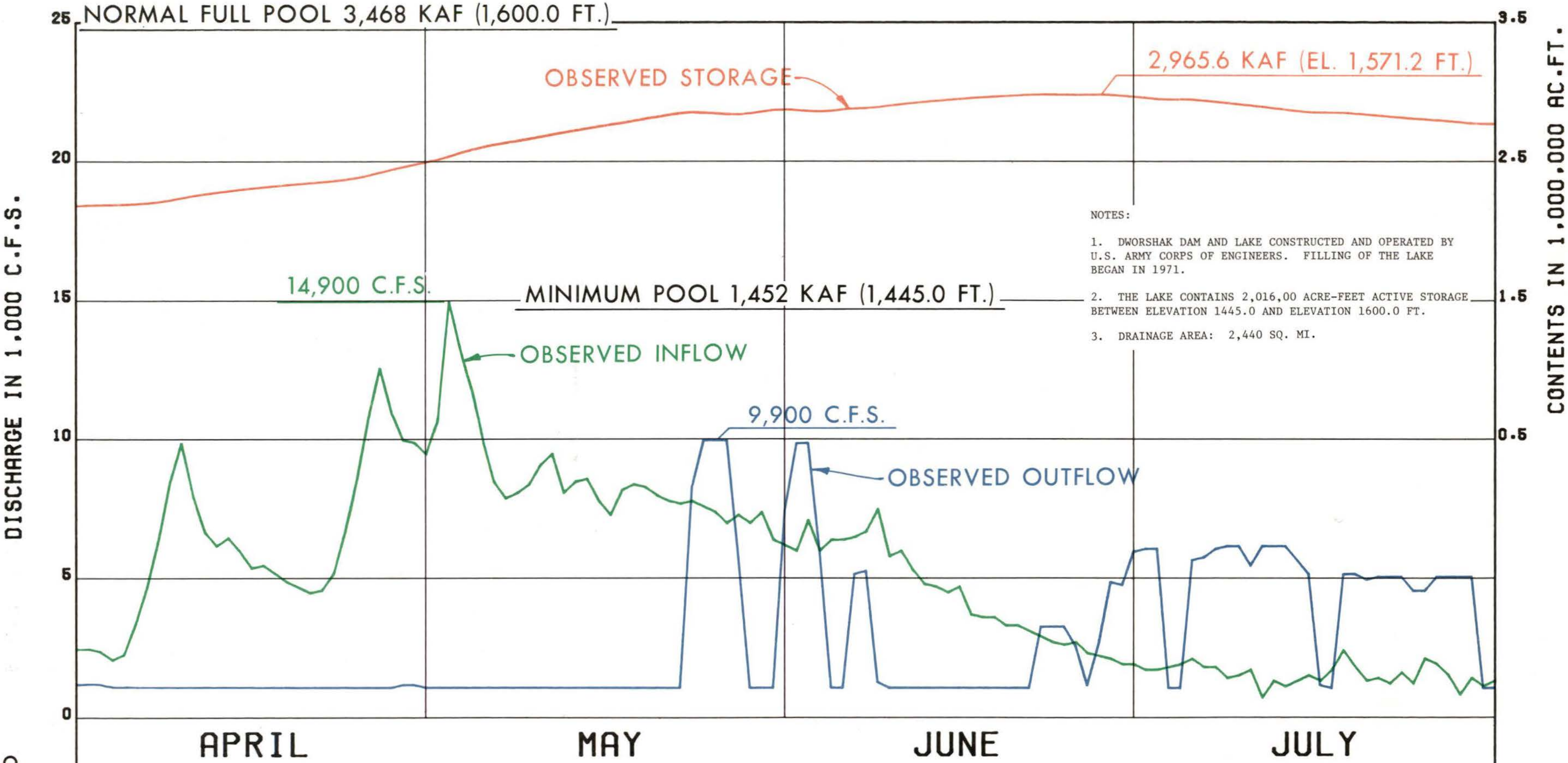
CHART 50



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER AT BROWNLEE PROJECT, IDAHO-OREGON



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

NORTH FORK CLEARWATER RIVER AT DWORSHAK PROJECT, IDAHO

CHART 51

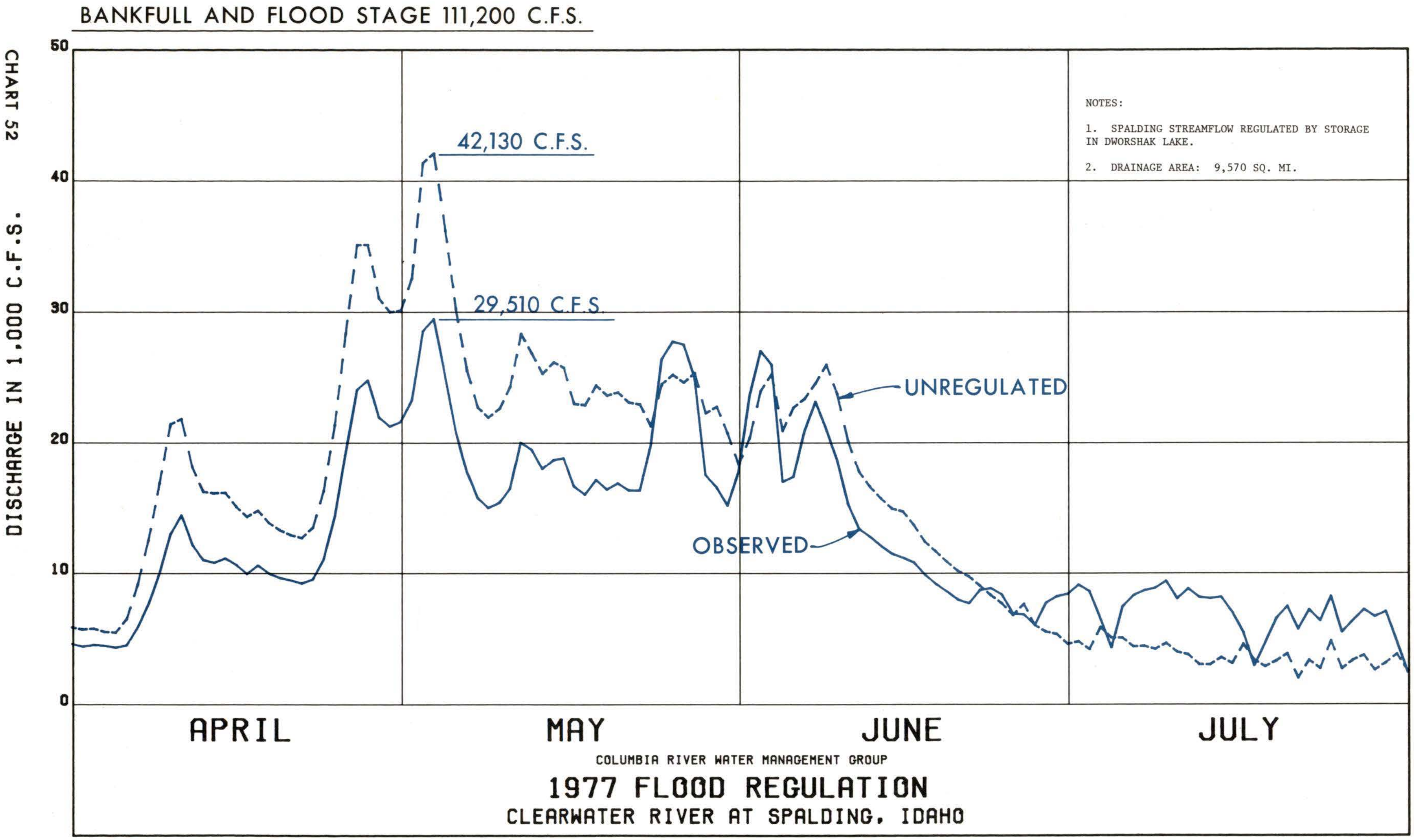
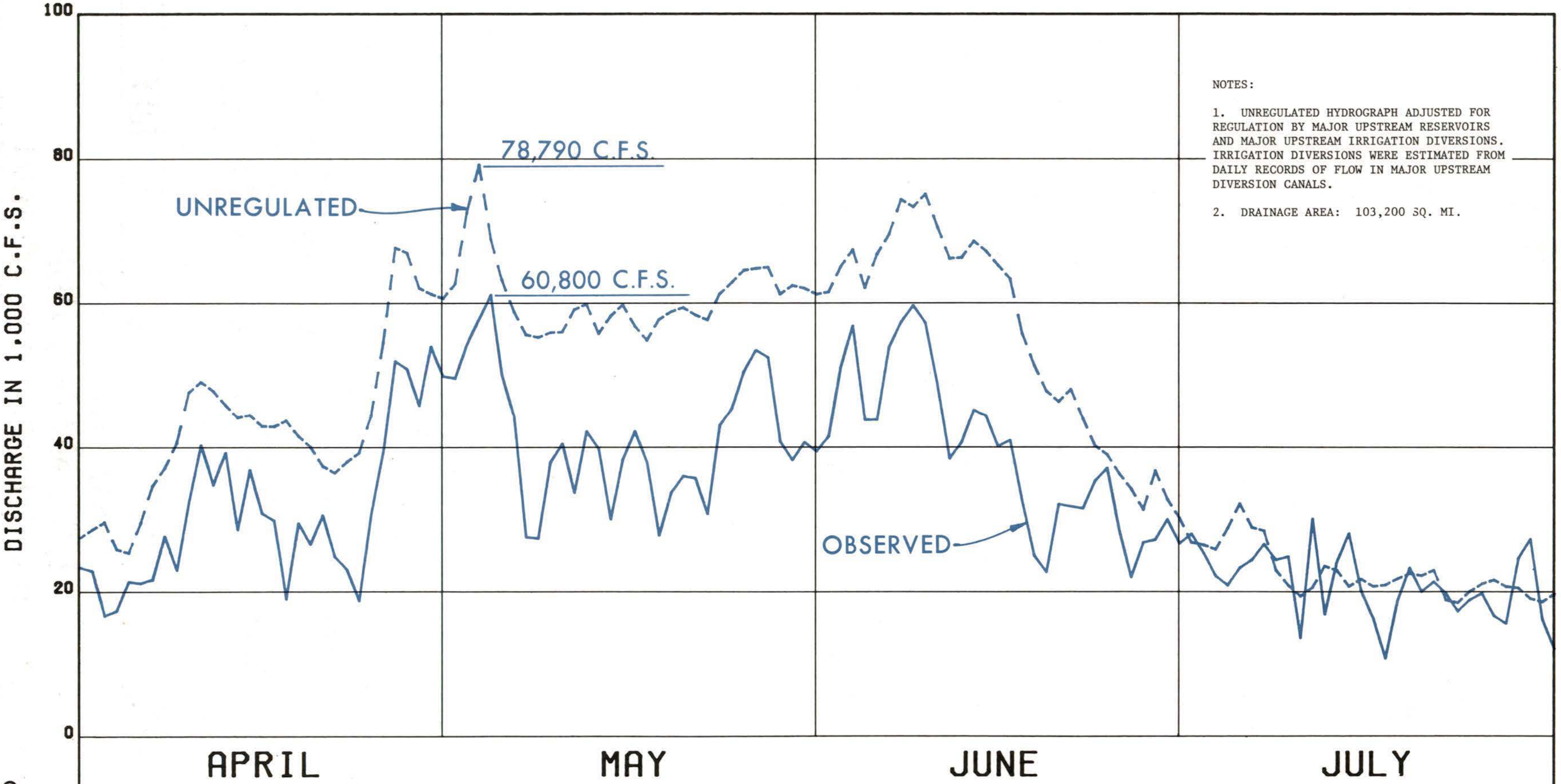


CHART 52
BANKFULL AND FLOOD STAGE 111,200 C.F.S.
DISCHARGE IN 1,000 C.F.S.
50
40
30
20
10
0
42,130 C.F.S.
29,510 C.F.S.
UNREGULATED
OBSERVED
NOTES:
1. SPALDING STREAMFLOW REGULATED BY STORAGE IN DWORSHAK LAKE.
2. DRAINAGE AREA: 9,570 SQ. MI.
APRIL
MAY
JUNE
JULY
COLUMBIA RIVER WATER MANAGEMENT GROUP
1977 FLOOD REGULATION
CLEARWATER RIVER AT SPALDING, IDAHO



COLUMBIA RIVER WATER MANAGEMENT GROUP

1977 FLOOD REGULATION

SNAKE RIVER BELOW LOWER GRANITE DAM, WASHINGTON

CHART 53

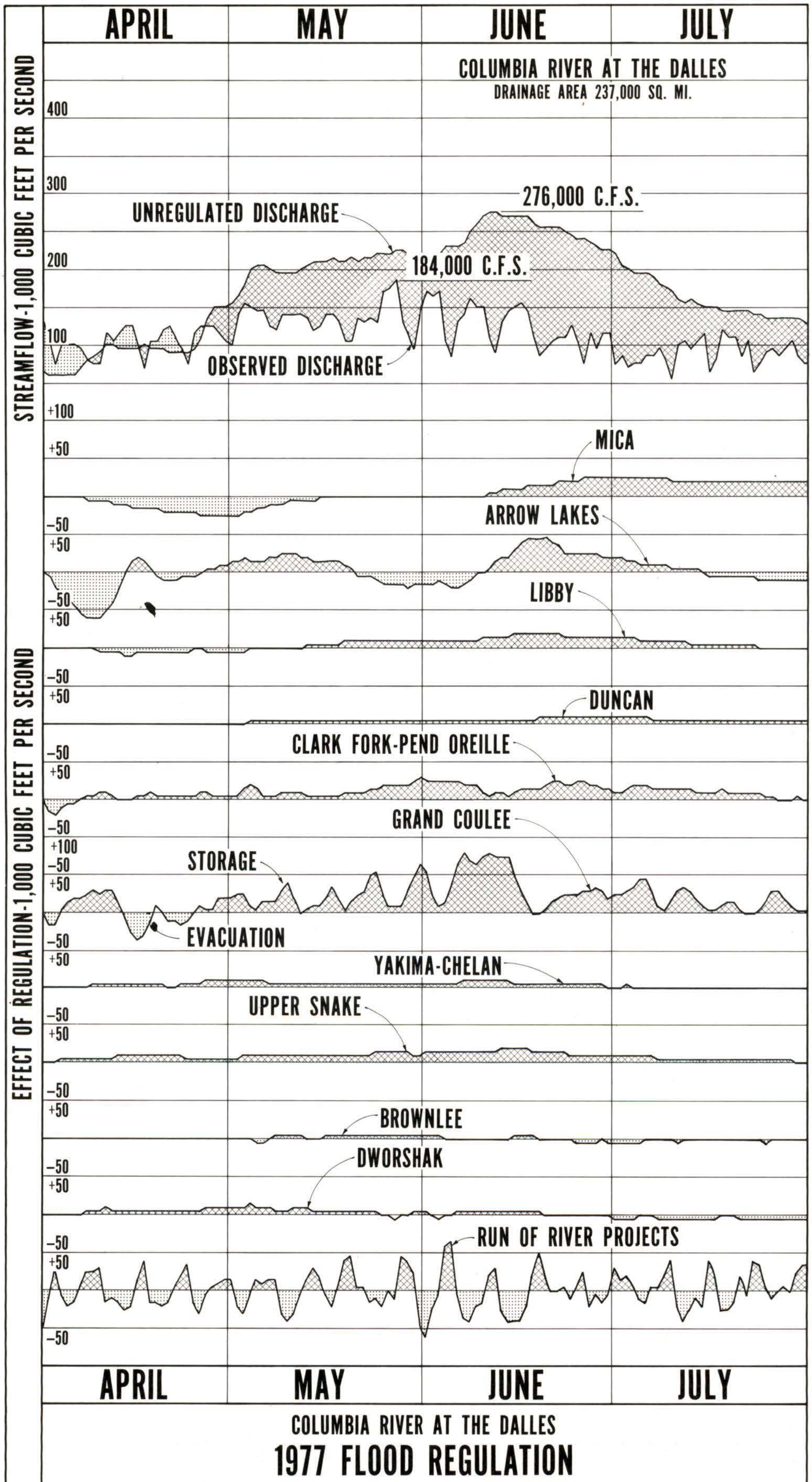
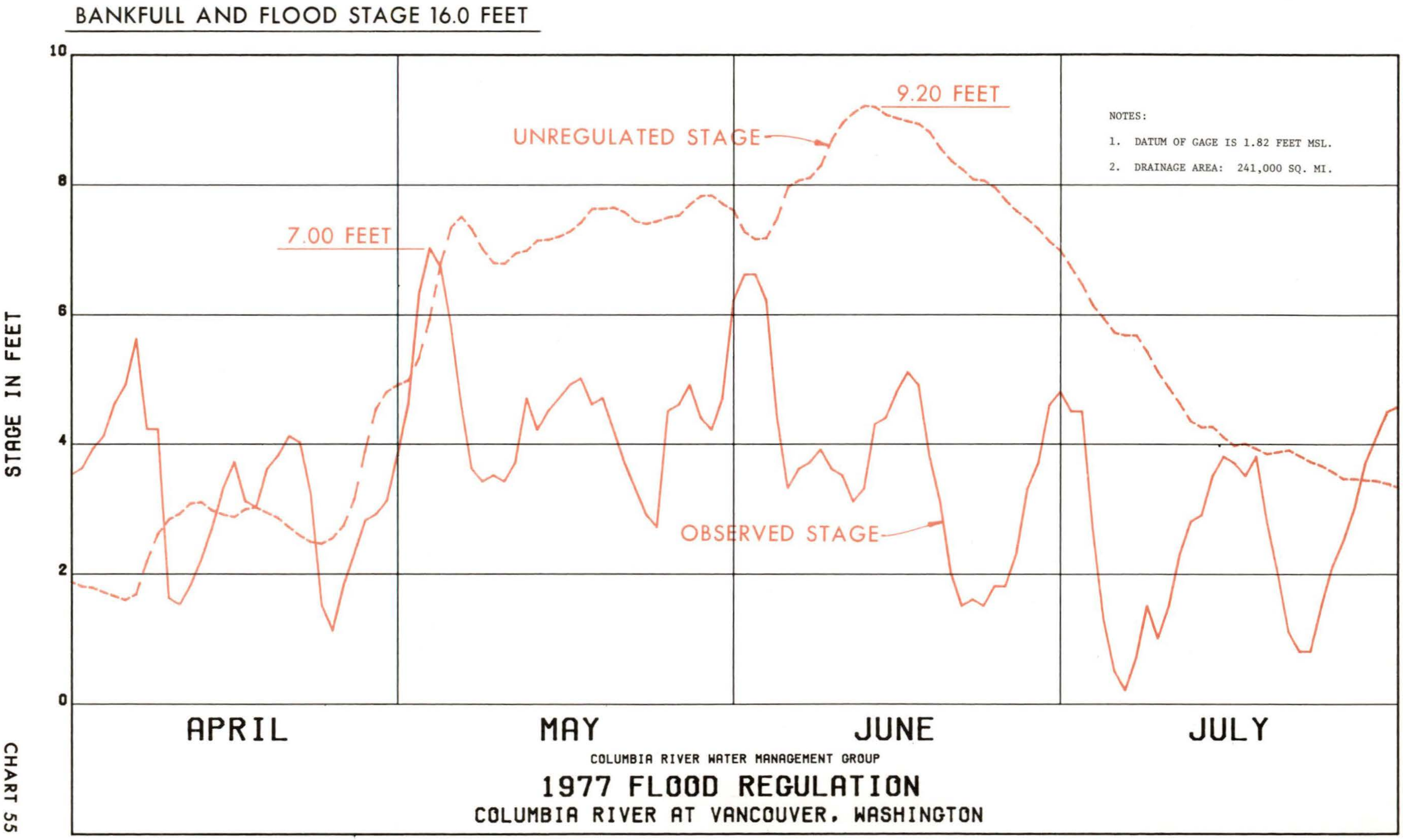
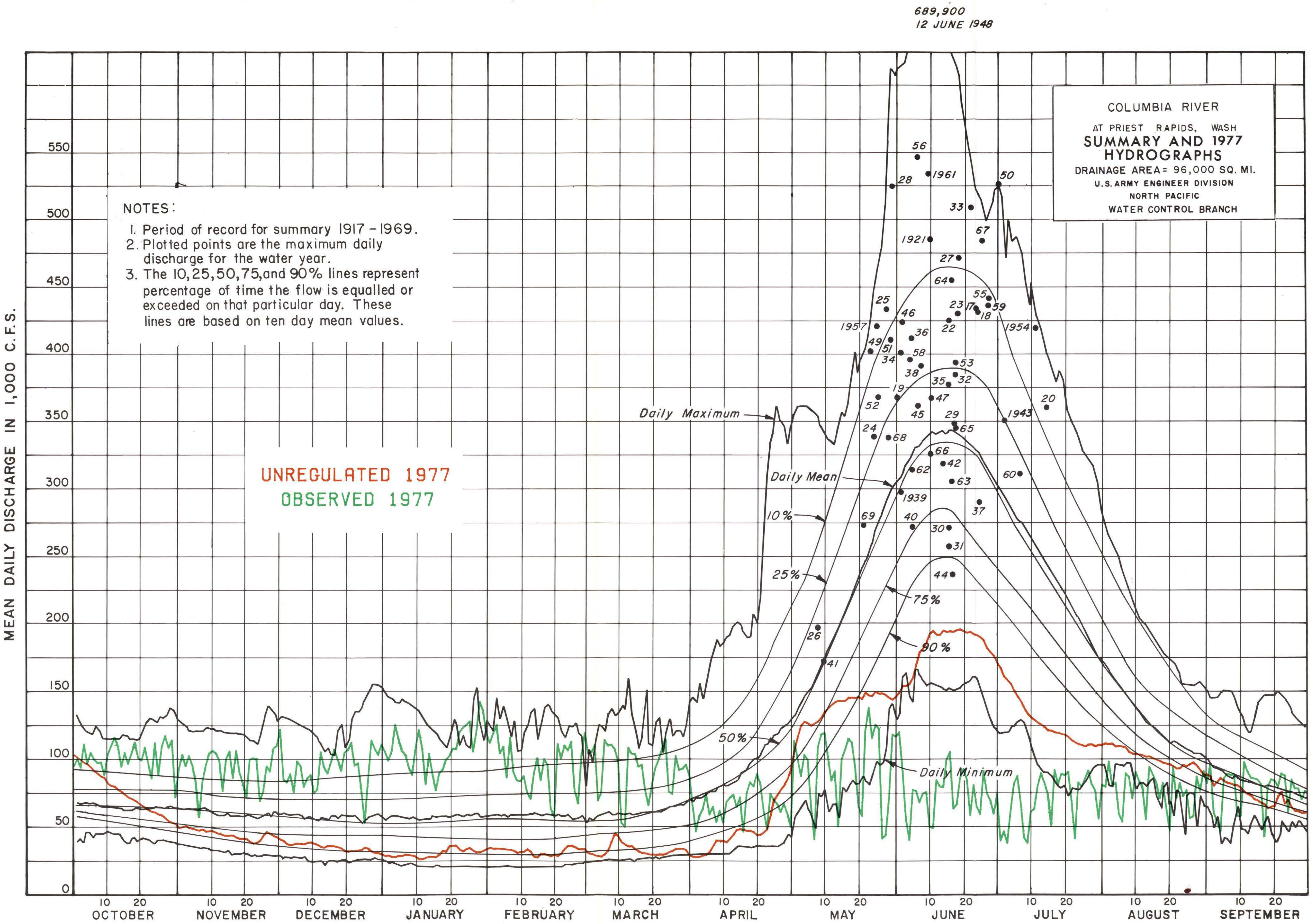

APRIL
MAY
JUNE
JULY
COLUMBIA RIVER AT THE DALLES
DRAINAGE AREA 237,000 SQ. MI.
STREAMFLOW-1,000 CUBIC FEET PER SECOND
400
300
200
100
276,000 C.F.S.
UNREGULATED DISCHARGE
184,000 C.F.S.
OBSERVED DISCHARGE
EFFECT OF REGULATION-1,000 CUBIC FEET PER SECOND
+100
+50
-50
MICA
ARROW LAKES
LIBBY
DUNCAN
CLARK FORK-PEND OREILLE
GRAND COULEE
STORAGE
EVACUATION
YAKIMA-CHELAN
UPPER SNAKE
BROWNLEE
DWORSHAK
RUN OF RIVER PROJECTS
APRIL
MAY
JUNE
JULY
COLUMBIA RIVER AT THE DALLES
1977 FLOOD REGULATION
U.S. ARMY CORPS OF ENGINEERS, NORTH PACIFIC DIVISION

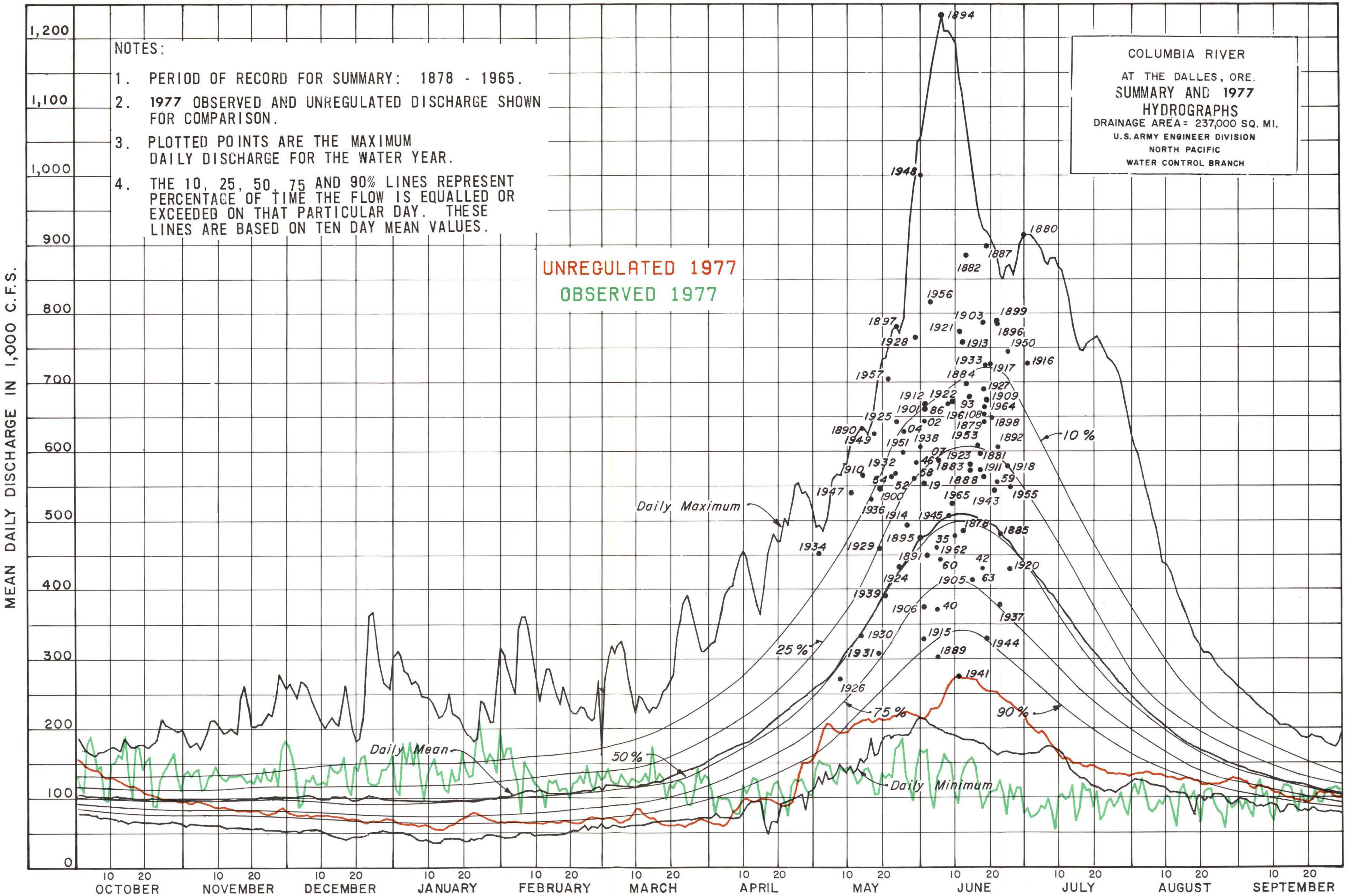
CHART 54


BANKFULL AND FLOOD STAGE 16.0 FEET
STAGE IN FEET
10
8
6
4
2
0
9.20 FEET
UNREGULATED STAGE
7.00 FEET
OBSERVED STAGE
NOTES:
1. DATUM OF GAGE IS 1.82 FEET MSL.
2. DRAINAGE AREA: 241,000 SQ. MI.
APRIL
MAY
JUNE
JULY
COLUMBIA RIVER WATER MANAGEMENT GROUP
1977 FLOOD REGULATION
COLUMBIA RIVER AT VANCOUVER, WASHINGTON



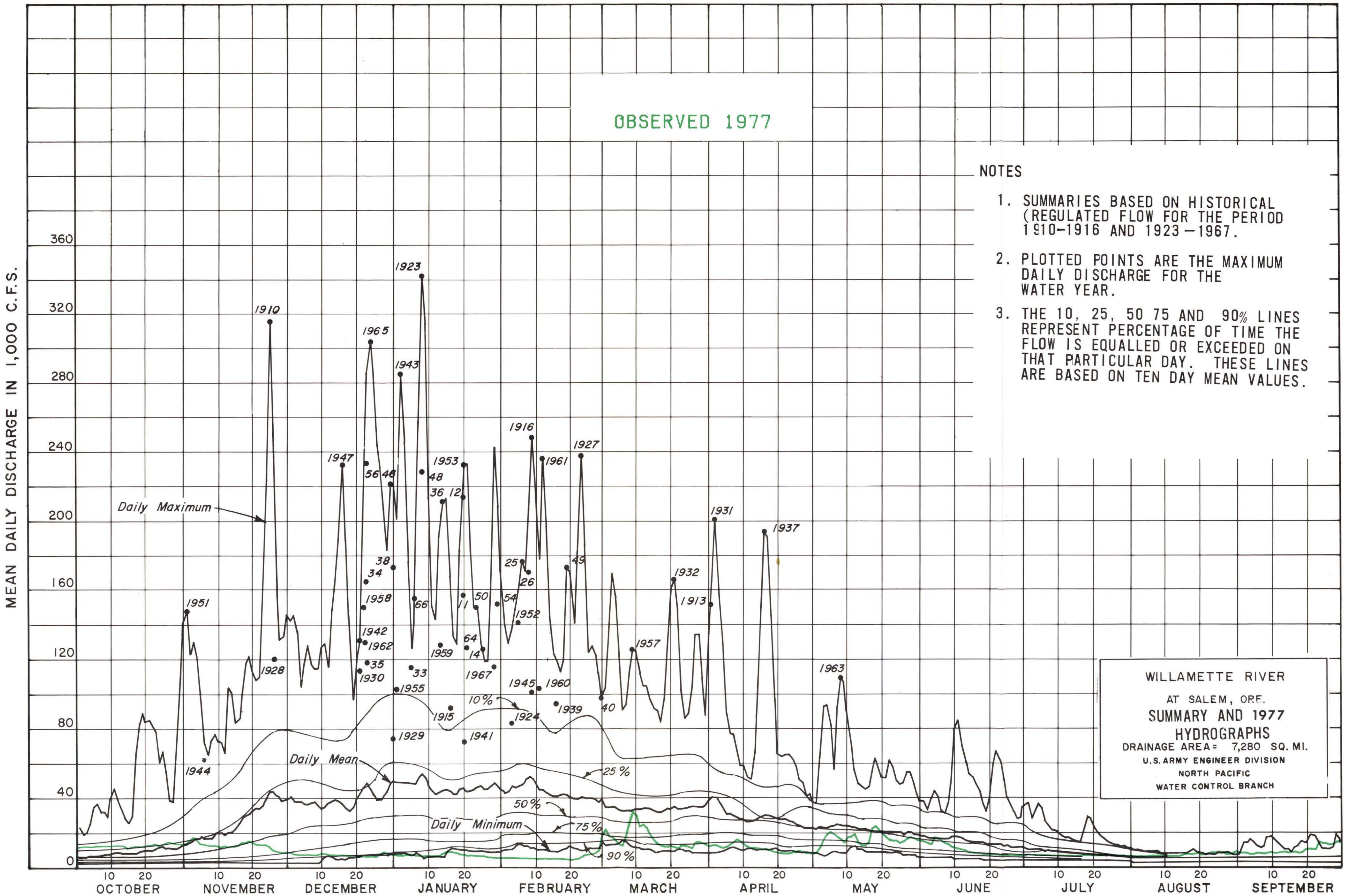
124645

CHART 56



141057

CHART 57



141910
CHART 58

COMPLETED REPORTS OF THE
WATER MANAGEMENT SUBCOMMITTEE
COLUMBIA BASIN INTER-AGENCY COMMITTEE
AND
COLUMBIA RIVER WATER MANAGEMENT GROUP

1. Snake River Streamflow Depletion--May, 1951.

* 2. Return Flow Study Columbia Basin Project Area--May 9, 1952.

* 3. Review of Procedures for Forecasting Inflow to Hungry Horse Reservoir, Montana--June, 1953.

* 4. Review of Procedures for Forecasting Seasonal Runoff of Boise River Above Diversion Dam, Idaho--January, 1954.

* 5. Recommended Reservoir Storage Adjustments to Seasonal Runoff Volume Forecasts in the Columbia River Basin--February, 1954.

* 6. Recommended Base Period for Comparing Runoff Forecasts and Related Hydrologic Data in the Columbia River Basin--July, 1954.

* 7. Review of Procedures for Forecasting Seasonal Runoff of Columbia River near The Dalles, Oregon--August, 1954.

* 8. Use of 30-Day Weather Outlook in Forecasting Runoff in the Columbia River Basin--January, 1955.

* 9. Relationship Between Peak Discharge and Volume Runoff of Columbia River near The Dalles, Oregon--June, 1955.

* 10. Report on Columbia River Flood Control Operations 1956 Flood.

11. Report on Determination of Historical Flows at Selected Power Sites Columbia River Basin--November 9, 1956.

12. Report of Streamflow Depletion Columbia River Basin--May, 1957.

13. Report on Modified Flows at Selected Power Sites Columbia River Basin--June, 1957.

* 14. Report on Columbia River Flood Control Operations 1957 Flood.

* 15. Report on Columbia River Flood Control Operations 1958 Flood.

* 16. Report on Columbia River Flood Control Operations 1959 Flood.

17. Extension of Modified Flows through 1958 Columbia River Basin June, 1960.

----

* Out of print.

COMPLETED REPORTS
(Continued)

* 18. Reports on Summary of Operations Columbia River 1960 Flood.

19. Extension of Historical Flows through 1958 Columbia River Basin--May, 1961.

* 20. Review of Procedures for Forecasting Inflow to Hungry Horse Reservoir, Montana--August, 1961.

* 21. Report on Summary of Operations Columbia River 1961 Flood.

22. Report on Summary of Operations Columbia River 1962 Flood.

* 23. Report on Summary of Operations Columbia River 1963 Flood.

* 24. Derivation of Procedure for Forecasting Inflow to Hungry Horse Reservoir, Montana--August, 1964.

* 25. Report on Summary of Operations Columbia River 1964 Flood.

26. Report on Summary of Operations Columbia River 1965 Flood.

27. Columbia River--Water Management--1966.

28. Columbia River--Water Management--1967.

29. Columbia River--Water Management--Water Year 1968.

30. Columbia River--Water Management--Water Year 1969.

31. Columbia River Water Management Report for Water Year 1970.

32. Columbia River Water Management Report for Water Year 1971.

33. Columbia River Water Management Report for Water Year 1972.

34. Columbia River Water Management Report for Water Year 1973.

35. Columbia River Water Management Report for Water Year 1974.

36. Columbia River Water Management Report for Water Year 1975.

37. Columbia River Water Management Report for Water Year 1976.

* Out of Print

COLUMBIA RIVER WATER MANAGEMENT GROUP

Representatives and Alternates

For Water Year 1977

Member Agency	Representative	Alternate
Bureau of Reclamation	H. R. Brush	Dan Yribar
Bonneville Power Administration	C. H. Watkins	John Dillard
Corps of Engineers	D. M. Rockwood	Gordon Green
National Weather Service	D. W. Kuehl	C. E. Orwig
U. S. Geological Survey	N. A. Kallio	S. F. Kapustka
EPA - Water Quality Office	W. E. Eldridge	
U.S. Forest Service	Jerry Swank	
Soil Conservation Service	Manes Barton	Authur G. Crook
Bureau of Land Management	Richard Banta	
Federal Power Commission	Bernard Smith	
U.S. Fish and Wildlife Service	Robert McVein	Robert Cleary
National Marine Fisheries Service	Dale Evans	John Hodges
Oregon Water Resources Department	C. L. Wheeler	W. N. Perry
Washington Department of Ecology	John F. Spencer	Kris Kauffman
Idaho Water Resources Board	A. C. Robertson	
Nevada State Engineer	R. D. Westergard	
Wyoming State Engineer	George Christopulos	
Dept. of Nat. Resources & Conservation (Montana)	Orrin Ferris	Richard Bondy

J. A. Anderson, Secretary
Corps of Engineers
P.O. Box 2870
Portland, Oregon 97208

C. H. Watkins, Chairman
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208