# III. RESERVOIR REGULATION



The reservoir system in the Northwest is made up of Federal, municipal, public, and privately owned dams and reservoirs. Regardless of ownership major projects are operated in accordance with the Pacific Northwest Coordinating Agreement. This agreement coordinates the seasonal operation of the system member's projects for the best use of their collective reservoir storage, and along with some of the other agreements that affect project operation, is briefly discussed in Chapter VI. In this chapter, however, the regulation of the system as a unit is described followed by the regulation of the operation of individual projects, and the effects upon key gages, in downstream order and chronologically from the beginning of the operational year.

The members of the coordinated system of reservoirs are listed in the Glossary in Appendix A. Daily project operations are shown on charts in Appendix D. Charts 5-30 show the storage and streamflow hydrographs from July 1, 1998 through September 30, 1999, for major storage projects, Charts 31-56 present the annual hydrographs for flood storage projects, hydrographs of the spring freshet are shown in Charts 57-79, Chart 80 shows The Dalles discharge hydrograph for regulated and unregulated conditions, Charts 81-84 are the Willamette Basin's control point hydrographs, Charts 85-88 are the reservoir hydrographs for Section 7 projects, and Charts 89-92 are summary hydrographs for the four key stations. Table 17 is the monthly rule curves and observed reservoir elevations for the major storage projects.

## A. SYSTEM OPERATION

The operating year began with the coordinated reservoir system officially filling to 99.1% of storage capacity on July 31, 1998. As a result, first year firm energy load carrying capability (FELCC) was adopted for the 1998-99 operating year.

This year's observed peak flow at The Dalles was 379.3 kcfs on June 4 with a corresponding unregulated peak of 712.3 kcfs on June 20. Last year's observed peak was 570.7 kcfs.

## B. PROJECT OPERATION

The operation of the individual projects is discussed in downstream order, beginning at the headwaters of the Columbia River. Operation of each project is generally discussed chronologically beginning in the summer or early fall of the preceding water year. Exceptions will be noted by including the calendar year. The locations of these projects are shown on the maps in Chapter I, pages 3 through 6.

### 1. Mica Project

Kinbasket Lake was formed by the construction of Mica Dam near the Big Bend on the upper Columbia River in east-central British Columbia. The project was constructed as part of the Columbia River Treaty between the United States and Canada and is owned by BC Hydro and Power Authority (BCH or BC Hydro) and is operated primarily for power and flood control. This year's operation is graphically shown on Chart 5 and Chart 57.

The end of September 98 lake elevation at Mica was 2457.19 ft. Discharges averaged about 30.0 kcfs in October, 22.0k cfs in November and about 26.0 kcfs in December. Over November and December, the

reservoir drafted by 25 ft to 2417.8 ft by year's end. At that time the BC Hydro Non-Treaty Storage was about 384 ksfd, or 34% of full, with Treaty storage at 2313.3 ksfd (4.6 maf), or 65% of full.

In early January and February 1999, the inflows averaged about 4.0 kcfs, gradually increasing in March to an average of about 5.0 kcfs, and in April to 9.0 kcfs before the start of the spring freshet in May. Mica powerhouse discharges for January and February averaged around 21.0 kcfs and 15.0 kcfs, respectively, and the generation from Mica continued to decrease over the winter. The reservoir drafted by 32 ft during the period to 2398.1 ft by February 28 with Treaty Storage at 1083.6 ksfd and Mica Treaty overrun of 130.7 ksfd on that date. The BC Hydro NTSA was at 595.4 ksfd at the end of February. During March and April, the Mica Reservoir was drafted by 24 ft and reached its lowest level for the 1998-99 year of 2373.5 ft on April 20, 12.9 ft lower than the low level in the previous year. Mica Treaty storage was drafted to zero maf on May 2 with a Mica flex overrun of about 269 ksfd.

In March and April, the Mica turbine discharges averaged 23.0 kcfs and 18.0 kcfs, respectively, reducing to an average of about 8.0 kcfs in May and 1.0 kcfs in June. The corresponding plant generation was 54% and 43%, respectively of plant capacity. With the start of the spring freshet in May, Mica discharges remained low until July, and the reservoir refilled by 52 ft to 2426.0 ft at the end of June. At the end of May, the Mica Treaty underrun had increased to 391 ksfd. The Mica Treaty discharge was 10.0 kcfs for the months of May, June and July, allowing Treaty storage to refill to 3369.5 ksfd (6.7 maf; 95% of full) by July 31. Local inflows peaked in May, June and July averaging about 22.0 kcfs, 56.0 kcfs, and 63.0 cfs, respectively. Actual Mica discharges during July averaged 7.0 kcfs, resulting in a Mica Treaty underrun of 43 ksfd and a reservoir level of 2461.4 ft by end of July. The corresponding plant generation was about 17% of plant capacity in July. The August inflows averaged about 55.0 kcfs but started to recede and at month end, were about 47.0 kcfs. The Treaty storage reached full at 3529.2 ksfd on August 10 with the reservoir at 2469.4 ft, 5.6 ft below full pool. The reservoir elevation at end of August and September was 2474.6 ft (0.4 ft from full pool) and 2466.21 ft.

The peak daily inflow was 99.96 kcfs on June 19, with a corresponding outflow of 0.86 kcfs. Maximum daily outflow was 40.70 kcfs on August 25. The January-July runoff was 9,836 kaf or 101% of normal. The April-September runoff was 13,628 kaf, 107% of normal.

### 2. Revelstoke Project

The Revelstoke project, located in southeastern British Columbia on the Columbia River between Mica Dam and Arrow Lakes, is owned by BC Hydro and is operated primarily for power generation. This year's operation is graphically shown on Chart 6.

During this operating year the Revelstoke project was basically operated as a run-of-river plant, maintaining the reservoir within 4.9 ft of its normal full pool level of 1880.0 ft. During the snowmelt freshet, June through August, the reservoir level was operated as low as 1875.1 ft to allow control of high local inflows.

### 3. Keenleyside Project (Arrow Reservoir)

The Arrow Lakes are two tandem natural lakes on the Columbia River in southeastern British Columbia whose surface elevations are controlled by Keenleyside Dam, which is owned and operated by BC Hydro and Power Authority. At normal operating elevations the land area between the lakes is flooded, creating a single lake. This project was constructed as part of the Columbia River Treaty between the United States and Canada for flood control and downstream power generation. It has no on-site hydropower facilities. This year's operation is graphically shown on Chart 7 and Chart 58.

Arrow Reservoir was at 1433.2 ft on 30 September 1998, 1.0 ft higher than the previous year and the Arrow Treaty storage was 6.3 maf or 88% full. Project discharges averaged 29.0 kcfs in October and 31.0 kcfs in November. The discharge increased to an average of 40.0 kcfs in December. Total inflows were 53.7 kcfs in August, 40.60 kcfs in September dropping to 31.7 kcfs by the year-end, substantially lower than the previous year when the 1 in 200 year high rainfall event in October resulted in higher inflows late in the fall. The Arrow Reservoir drafted to 1430.8 ft by December 31, 1998, with the Treaty storage at 2910 ksfd (5.7 maf) or 81% of full.

In late December, BC Hydro requested that Arrow outflows be selectively reduced below TSR levels requests to keep river levels at acceptable and maintainable levels during the whitefish spawning and emergence period from December 20 to January 25. To achieve the January level of flows, BC Hydro exercised an option to store up to 340 ksfd under the Whitefish Provisional Draft Agreement over the first 16 days of January. Subsequently, outflows from Arrow fluctuated around 45.0 kcfs at Keenleyside, increasing in February to 90.0 kcfs, and then reducing to about 400 kcfs in March. The outflows from Arrow further reduced to 20.0 kcfs on March 25 and continued at that level through April to meet objectives for rainbow trout spawning. In exchange for the rainbow trout protection flows in the spring, the United States had the option, under the Non-Power Uses agreement signed in December, to store up to 1.0 maf in Arrow for Flow Augmentation objectives. Because of the unusually high volume runoff forecast, the U.S. Entity did not need to exercise this option. Arrow Reservoir continued to draft during the January to March period as local inflows averaged approximately 30.0 kcfs.

In this operating year, the Columbia River Treaty Operating Committee agreed to use the 'Arrow Local Method' for determining the Mica and Arrow Variable Refill Curves between January and June. Compared to the Total Method, the Arrow Local Method recognizes Mica outflows in excess of those from operating Mica to the Variable Refill Curve (VRC) when computing Arrow's VRC, and on average, results in lower VRC's at Arrow during January through April. In both cases, the Arrow reservoir is targeted to be full on1 July 31. The Arrow Local Agreement was signed in December with the expectation that power benefits realized in excess of those expected by the Total Method would be shared equally between BPA and BC Hydro. Multi-year TSR studies have indicated that the expected power benefits occur during average-to-low water conditions, and as this operating year was an above average water year, there were no power benefits realized this year.

Arrow Reservoir reached its lowest level for the year at 1383.9 ft on March 25 and the Arrow Treaty storage account reached its minimum at 180 ksfd (0.35 maf) or 5% of full on March 24. During April and early May, the Arrow discharge was maintained at about 20.0 kcfs in an attempt to meet the objective that rainbow trout would not spawn at higher river levels. Arrow discharge on May 12 was set at 30.0 kcfs and reduced further to 15.0 kcfs during the last week of June when the backwater effects of higher Kootenay River flows provided adequate river levels for rainbow protection at Norns Creek Fan, a prime spawning location for rainbow trout. Arrow discharge over the first week of July was reduced by about 20.0 kcfs below TSR to reduce spill at Grand Coulee generating station in the U.S. In exchange, BPA agreed to open an additional 50 ksfd of Non-Treaty space above the 130 ksfd space required under the Recallable Account Agreement, by the end of July.

The Arrow fisheries operations were conducted under the terms of two Operating Committee agreements, "Operation of Treaty Storage for Enhancement of Mountain Whitefish Spawning for the period of 8 September 1998 through 31 July1999" and "Operation of Treaty Storage for Nonpower Uses for 1 January through 31 July 1999". These agreements enabled the Arrow project flows to be adjusted to reduce impacts to whitefish and trout redds. With the low discharge in April and May, and the start of the spring freshet with high inflows in May, the Arrow Reservoir rose to 1395.5 ft by April 30, 1408.6 ft by May 31, and 1434.5 ft by June 30. Arrow reservoir levels remained below the Treaty flood control curves throughout the operating year.

The Arrow discharge was increased substantially in July as Arrow Treaty storage neared full and the reservoir reached its highest level, 1443.8 ft, on July 30. The Arrow discharge peaked at 94.3 kcfs on August 11, approximately one week later than the previous year. The Arrow Treaty storage content continued to fill and reached full (7.1 maf) on 31 July. Because of the unusually high July-August inflows, the Libby-Arrow storage exchange agreement used in prior operating years was not needed this year. Arrow Treaty content was full at the end of the August, but the actual reservoir operation drafted to 1437.8 ft through the use of Mica/Arrow flexibility.

The Arrow Lakes Power Company project at Keenleyside received official 'leave to commence' for the start of construction on March 20 while the preliminary preparation began in February, and full construction started on March 15. During the week of September 13, forms for the draft tubes for the generating units were

under construction. Arrow elevation at the end of September was 1432.31 ft.

The peak daily inflow was 120.0 kcfs on June 18, with a corresponding outflow of 21.87 kcfs, the unregulated peak inflow was 215.2 kcfs on June 18, and the maximum daily outflow was 94.28 kcfs on August 11. The January-July runoff was 22,286 kaf or 106% of normal and the April-September runoff was 28,139 kaf, or 110% of normal.

**4. Libby Project (Lake Koocanusa)**

Lake Koocanusa and Libby Dam, on the Kootenai River in northwest Montana, were constructed as part of the Columbia River Treaty with Canada and are operated by the Corps of Engineers for power, flood control, and recreational benefits. The lake extends northward from the dam near the town of Libby, 60 river miles to the international border and another 30 miles (at full pool) into British Columbia. This year's operation is graphically shown on Chart 8 and Chart 59.

Outflow from Libby averaged 7.0 kcfs and 5.8 kcfs in October and November, respectively. From December 1 through 18 daily load shaping occurred on weekdays and weekend flows were held steady at 10.0 kcfs. By December 20 the Pacific Northwest was experiencing a cold snap, and, to meet regional load, Libby outflow was increased to full powerhouse capacity on December 21, where it remained for three days. Outflow was reduced slightly over the Holiday weekend, since the cold snap had diminished. From December 28 through 31 Libby outflow averaged approximately 21.0 kcfs as the project was used to meet load. The monthly average outflow in December was 19.1 kcfs and the end of December elevation at Lake Koocanusa was 2405.6 ft, 5.4 ft below the normal December 31 flood control level of 2411 ft.

The water supply forecasts at Libby in January through March generally increased with time. In January the April through August forecast was 6.63 maf, or 104.0% of normal. In February and March the forecasts were 108.6% and 111.2% of normal, respectively. In April and May the forecasts dropped again and were 109.1% and 105.6%, respectively. The end of month flood control targets at the end of each month were: January, 2375.7 ft; February, 2333.8 ft; March, 2310.9 ft; and April, 2339.8 ft.

In January outflows ranged between 21.5 kcfs and 26.0 kcfs between January 1 and 17. Starting on January 18 flows were reduced gradually to 6.0 cfs to provide Idaho Department of Fish and Game a chance to monitor burbot movement below Libby. Flows were increased again on January 25. The end of January lake level was 2373.9 ft, or within 1.8 ft of the flood control target. The February average outflow was 21.1 kcfs, and the end of month lake level was 2334.14 ft, within 0.3 ft of the flood control target. Between March 1 and 8 there were four units available and these units were run at full load, approximately 16.4 kcfs. Between March 9 and 11 the outflow was reduced to 4.0 cfs to target the April 15 95% confidence of refill curve near the level of 2326 ft. However, the March and April average inflow was less than 4.0 kcfs, and Libby was below the April 15 95% confidence of refill curve as expected. The end of March elevation was 2323.46 ft, or 12.6 ft above the end of March target flood control elevation. The April average outflow was 4.0 kcfs, and the end of month elevation was 2338.56 ft, within 1.2 ft of the flood control target. Flows were held at 4.0 kcfs through May in preparation for the sturgeon pulse request from USFWS. The end of May lake level was 2386.56 ft.

Outflows were maintained at 4.0 kcfs through June 13 at which time the sturgeon pulse was requested by USFWS. This pulse was much later than normal because of low water temperatures at Bonners Ferry. The Libby outflow was 25.0 kcfs June 15 through 18. After the pulse, incubation flows were held at 30.0 kcfs measured at Bonners Ferry for 18 days. Outflows from Libby ranged from 16.8 to 25.0 kcfs to provide the incubation flows downstream. Lake Koocanusa was at 2432.94 ft on June 30, and these higher flows ended on July 5 when Libby outflows were gradually ramped down to 8.0 kcfs by July 10. Libby outflows of 8.0 kcfs were held for the majority of July and Lake Koocanusa filled to an end of month elevation of 2456.94 ft, within 2.1 ft from full.

Libby inflows in August were considerable at 151% of normal, the third highest for the period 1928-1988. Outflows ranged from 8.0 to 22.6 kcfs to keep the project from filling and spilling. A peak reservoir elevation was reached on August 9, 2458.97 ft, essentially a full pool. A 1999 Libby/Arrow storage exchange agreement

was not entered into. Due to the abundance of water in the Columbia Basin system the resulting end of month elevation in August was 2455.63 ft, 3.37 ft from full and 16.63 ft above the 1995 Biological Opinion interim draft limit of elevation 2439.0 ft.

For the majority of September, outflows were held steady at 12.0 cfs as the project began a slow draft to the December 31 flood control level of 2411.0 ft. Outflows were reduced to 10.0 kcfs on September 16 for transmission line testing, and releases were brought back to 12.0 kcfs for the remainder of the month. Lake Koocanusa ended the month of September at elevation 2449.12 ft, 9.88 ft from full.

The peak daily inflow was 66.4 kcfs on June 19, with a corresponding outflow of 16.8 kcfs and the maximum daily outflow was 25.0 kcfs in June 16 and July 4 and 5. The January-July runoff was 6946 kaf or 109% of normal and the April-September runoff was 7556 kaf, 112% of normal.

### 5. Kootenai River at Bonners Ferry

The Kootenai River at Bonners Ferry, Idaho, a major control point for the flood control operation of Libby Dam, is located 82 miles downstream of Libby Dam. Its stages are affected by both river flow and by backwater from Kootenay Lake. This year's operation is graphically shown on Chart 60.

The peak regulated stage was 60.6 ft on June 18 at which time Libby was releasing 22.2 kcfs. The unregulated peak stage would have been 72.9 ft, well above the 66.5 ft bankfull stage. The January-July unregulated runoff was 9781 kaf, 111% of normal, while the April-September unregulated runoff was 9937 kaf or 111% of normal.

### 6. Duncan Project

Duncan Dam and Lake on the Duncan River, a tributary to Kootenay Lake in southeastern British Columbia, was constructed as part of the Columbia River Treaty between the United States and Canada. The project is owned and operated by BC Hydro and, although it has no on-site power-generating facilities, it is operated for downstream power generation and for flood control. This year's operation is graphically shown on Chart 9 and Chart 61.

The Duncan reservoir level was 1877.9 ft on September 30, 1998. The project discharge averaged 9.0 kcfs in October, 6.0 kcfs in November, and less than 1.0 kcfs in December. Duncan Reservoir level was at 1830.7 ft (30% of full) on December 31. The Duncan reservoir remained at or below the flood control curve throughout the operating year.

During January, the Duncan discharge was increased to about 7.0 kcfs. The reservoir was drafted throughout February to mid-March and reached its lowest level for the year at 1794.4 ft (0.4 ft above empty) on March 21. Duncan discharge was reduced to minimum, 100 cfs, on May 25 and remained at that level during most of June to allow refill of the reservoir. The reservoir reached 1814.7 ft by May 31 and n 1860.3 ft by June 30. Duncan remained on minimum discharge until July 20 and increased thereafter to slow the rate of reservoir refill. The reservoir reached full pool elevation of 1892.0 ft on August 3, and exceeded it slightly on a number of days in August. Duncan passed inflows for the remainder of August and through to the first week in September to maintain the reservoir near full pool. On September 7 Duncan discharge was increased above inflows to start drafting the reservoir and keep the level of Kootenay Lake near the IJC limit. By the end of September, the lake was at 1884.24 ft.

The peak daily inflow was 20.8 kcfs on June 18 with a corresponding outflow of 120 cfs and the maximum daily outflow was 13.2 kcfs on August 7 and 9. The observed January-July volume runoff was 1910 kaf, or 105% of normal and the April-September runoff volume was 2563 kaf or 114%.

### 7. Kootenay Lake

Kootenay Lake is a large natural lake on the Kootenay River in southeastern British Columbia which has most of its inflow regulated by Libby and Duncan dams. The seasonal regulation of the lake level is governed by rules established by the International Joint Commission (IJC) as agreed upon by the United States and Canada. Outflow from the lake is discharged through a series of instream powerhouses and/or diverted to the

offstream Kootenay Canal Plant before it joins the Columbia River below Brilliant Dam near Castlegar, British Columbia. Although Corra Linn Dam, the project immediately downstream from the lake, controls the lake level, a constriction in the river channel at Grohman Narrows, between the lake and the dam, limits the maximum project outflow both during periods of high flows and when the lake approaches its minimum level. This year's project operation is graphically shown on Chart 10 and Chart 62.

The level of Kootenay Lake at Queens Bay was 1743.8 ft on September 30, 1998. During October and November, the reservoir level was kept high by passing inflow, with year-end level of 1743.5 ft on December 31. The reservoir did not reach the maximum IJC level of 1745.32 ft between January 1 and 7. Beginning in January, the Kootenay Lake level rose initially and then reduced to 1743.5 ft by month end. Then the reservoir discharges were kept slightly above the inflows during February-March to stay below the IJC limits. The reservoir level at the end of March was 1739.5 ft. The reservoir reached a minimum level of 1738.4 ft on April 17, rising quickly thereafter with the commencement of the spring freshet. The inflows peaked on June 17 at 112.0 kcfs. Kootenay Lake discharges were then also increased, and the outflows from Duncan reduced to minimum, to reduce the Kootenay reservoir level rise in the summer months. Kootenay Lake discharges peaked on June 25 at 71.8 kcfs.

Kootenay Lake reached its peak level for the year at 1750.2 ft on June 26, about three weeks later than the previous year. Then the reservoir level gradually started to recede due to receding runoff in late June and in July, and due to reduced Libby discharges in July. Kootenay Lake drafted in these months with the lowest summer reservoir level of 1745.0 ft occurring on August 31. Discharge from Kootenay Lake averaged 50.0 kcfs in July and 38.0 kcfs in August. The Nelson gage level remained above the IJC summer level of 1743.32 ft as of September 16. During August, increased outflows from Libby and Duncan served the strong market demand and caused the reservoir to draft gradually. This, combined with operational adjustments, allowed the reservoir level to maintain operating space in September, to accommodate unit outages at Kootenay projects in the fall.

### 8. Columbia River at Birchbank

The Columbia River at Birchbank, British Columbia, includes the effects of regulation of all the Columbia River Treaty Projects. Its flow is regulated by the use of storage in Kinbasket, Arrow, Koocanusa, Duncan, and Kootenay Lakes, the first four being the Treaty Projects. This is the portion of the Grand Coulee inflow contributed by the Columbia and Kootenay rivers. The Flathead/Pend Oreille River enters the Columbia River downstream of the Birchbank gage. This year's operation is graphically shown on Chart 63.

The observed daily peak discharge at Birchbank was 158.8 kcfs on August 11 and the unregulated peak flow was 273.2 kcfs on June 23. Bankfull and flood discharge is 225 kcfs. The unregulated January-July runoff was 44,057 kaf, or 113% of normal. The unregulated April-September runoff at Birchbank was 51,487 kaf, or 118% of normal.

### 9. Hungry Horse Project

Hungry Horse, a Section 7 Project on the South Fork Flathead River near Kalispell, Montana, is owned and operated by the Bureau of Reclamation for flood control, power, recreation, and fisheries. This year's operation is graphically shown on Chart 11 and Chart 64.

The 1998 summer was fairly dry so Hungry Horse was drafted to 3540.0 ft by August 31 then continued to draft throughout the fall, to meet the 3,500 cfs minimum flow requirement at Columbia Falls, reaching 3535.8 ft on October 1. After a dry fall, the runoff volume forecast increased considerably in January and the reservoir had to be drafted further for flood control, reaching its lowest level on April 16, 1999 at 3482.9 ft, 77 ft from full. Hungry Horse was pre-drafted in late March and early April, so that releases could be reduced in April for maintenance in the tailbay. Early April was chosen as the time to do maintenance since that is when inflows are lower so the project would not refill too quickly and high releases are not yet needed to meet ESA requirements. The project was then refilled to its May 1 flood control point. During the refill period releases were not provided through the outlet works so the total dissolved gas standard would not be exceeded.

To increase storage space the flashboards, which were added to the spillway the previous summer, were left in place. The reservoir reached its maximum elevation of 3560.61 ft on July 26. The peak observed inflow of 26.4 kcfs occurred on May 26, and the maximum outflow was 8.3 kcfs on March 3. Due to an above normal snowpack and a late runoff, flows on the Columbia River at McNary were high throughout the summer. Releases for BiOp operations did not start until early August, and the full 20-foot draft was not needed from Hungry Horse to meet the summer flow targets at McNary. Due to the high late runoff, flow targets at McNary were met on a weekly basis all but the last week of August when the target was missed by about 2.0 kcfs. The reservoir was drafted to 3554.0 ft by August 31, and by September 30 the pool was at 3544.8 ft. A kokanee spawning flow of at least 3500 cfs was provided at Columbia Falls for the entire year.

The peak inflow of 26.0 kcfs occurred on May 26 and the maximum outflow was 5.2 kcfs on May 6.

**10. Flathead R at Columbia Falls**

Discharges on the Flathead River at Columbia Falls gage record the combined flows of the North, Middle and South forks of the Flathead River. The flows on the North and Middle forks are uncontrolled and those of the South Fork are regulated by Hungry Horse Dam. This year's operation is graphically shown on Chart 65.

This year's peak stage of 43.3 kcfs, on May 26 at the time Hungry Horse outflow was 2.88 kcfs. The unregulated peak was 62.1 kcfs on May 26. Flood stage at Columbia Falls is 14.0 ft and major flooding does not occur until 16.0 ft. The January - July volume runoff for the tributary basins above Columbia Falls was 102% of normal.

**11. Kerr Project (Flathead Lake)**

Flathead Lake is a natural lake, the level of which is controlled by Kerr Dam which is owned by Montana Power Company and is licensed to be operated for power, flood control, and recreation. Spring refill of Flathead Lake is coordinated with the Corps of Engineers' Reservoir Control Center to control flooding of the agricultural lowlands between Kalispell and Flathead Lake. This area is prone to flooding if the lake reaches its full level, 2893.0 ft, coincident with the river flow being above 45 kcfs. This year's operation is shown on Chart 12 and Chart 66.

After the 1998 runoff, Flathead Lake was maintained in its top foot, 2892.0-2893.0 ft through September 14. Then the lake was then gradually drafted throughout the autumn and winter months for power and flood control, reaching its minimum level for the winter, 2883.43 ft on September 22, 1998. The lake also reached a low elevation of 2883.60 ft on March 1, 1999. On April 15 the lake level was at 2884.31 ft. Per the Memorandum of Understanding Agreement (date 1962, revised 1965) between the Corps and Montana Power, Kerr will endeavor to reach 2883.0 ft on April 15 for flood control. It goes on to say there is a natural channel restriction at the outlet of the lake which reduces the outflows at low lake levels and this elevation might not be attained every year. Inflows below Kerr were 90% of normal in April and 77% of normal in May. The Corps coordinates with Montana Power to refill Kerr in a controller manner during the spring freshet. On May 12, Kerr outflows were reduced to 12.0 kcfs to initiate refill. On May 15, per their FERC license, Montana Power increased flows to 12.7 kcfs which is a minimum flow requirement for May 16 to June 30 per their FERC license issued in July 1985. The lake reached 2889.62 ft on Memorial Day (May 31) and was within 0.5 ft of full on June 20. The project operated in its top half foot (2882.5 ft – 2283.0 ft) from July through September.

The peak seasonal inflow was 48.3 kcfs on May 27 and the maximum discharge was 34.6 kcfs on June 27. Average monthly discharges were 12.8, 22.7, and 16.0 kcfs for May, June, and July, respectively. The unregulated peak inflow would have been 69.3 kcfs kcfs on May 27. The unregulated January-July runoff into Flathead Lake was 7380 kaf, 96% of normal and the unregulated April-September runoff was 6702 kaf, 97% of normal.

**12. Albeni Falls Project (Lake Pend Oreille)**

Lake Pend Oreille is a natural lake, whose outflow and lake level are controlled by constrictions in the outlet channel and by Albeni Falls Dam, a Corps project that is operated for flood control, power, and

recreation. The dam is located 29 miles downstream of Lake Pend Oreille on the Pend Oreille River. Although the dam controls the lake level, the river channel between the lake and the dam limits the project outflow during both high flow periods and when the lake is near its minimum level. Inflow to Albeni Falls Dam is affected by the regulation of upstream impoundments, namely Hungry Horse and Flathead Lake (Kerr Dam) on a seasonal basis, and by two Washington Water Power projects, Noxon Rapids and Cabinet Gorge, on a daily basis. This year's operation is graphically shown on Chart 13 and Chart 67.

The annual autumn drawdown of Pend Oreille Lake began immediately after Labor Day 1998, and the lake was drafted to 2060.0 ft on October 1. The lake continued drafting in October and November, with the discharge averaging 17.0 kcfs in October and 18.8 kcfs in November. At the end of October and November, the lake levels were 2055.8 ft and 2055.4 ft, respectively. This was the third year of a three year fish habitat study to test the effects of higher winter lake levels on kokanee salmon spawning and overall population recruitment in Lake Pend Oreille. The theory is that there are cleaner gravels at higher elevations which are more conducive to spawning and population recruitment. Normally, 2051.0 ft is the minimum winter elevation but during this test, the minimum level was raised to 2055.0 ft. The study is a Fish and Wildlife measure adopted by the Northwest Power Planning Council and conducted by the Idaho Department of Fish and Game. The minimum level of 2055.0 ft was established for the January through March period. The maximum flood control rule curve elevations for January, February and March were 2060.0 ft, 2060.0 ft and 2056.0 ft, respectively. The project stayed at or below these levels through March. The lake was slowly filled because of cool weather, and concerns for late springtime flooding. Pend Oreille Lake reached 0.5 ft of full on June 22. A peak observed inflow of 90.9 kcfs was reached on June 21. Unregulated peak inflows crested at 102.5 kcfs on June 25. Project discharges averaged 41.9 and 65.5 kcfs in May and June, respectively. Peak discharges were 75.8 kcfs on June 1. The lake was maintained in its summer operating range, 2062.0-2062.5 ft, from June 22 through September.

The unregulated January-July runoff was 16.8 maf, 100 % of normal, while the April-September runoff was 14.3 maf, or 100% of normal.

### 13. Grand Coulee Project

Grand Coulee Dam and Franklin D. Roosevelt (FDR) Lake are owned by the Bureau of Reclamation and operated for flood control (under Section 7 of the 1944 Flood Control Act), power, irrigation, recreation, fisheries, and navigation. The project includes Banks Lake, an irrigation/pumped storage reservoir. This year's operation is graphically shown on Chart 14 and Chart 68.

On October 1, 1998, FDR Lake was at 1284.9 ft, was drafted to 1273.0 ft by December 24, and then refilled to 1278.7 ft by the first of January. The reservoir was then drafted to reach its May 1 flood control level of 1220.0 ft. Due to a late runoff FDR was held at this level for an additional two weeks, then drafted to 1213.4 ft at the request of the TMT to provide flows for fish emergence in the Hanford Reach. The reservoir reached its low level of the year at 1213.4 ft on May 19 then refilled to 1289.5 ft by July 12. The reservoir was able to remain near full throughout the summer due to high summer inflows, but was drafted slightly in August for recreation, because the pool was too high and provided only limited beaches for boaters. The maximum daily outflow for the year was 184.8 kcfs on August 12.

The seasonal *spring* flow objective (260 kcfs April 20-June 30) at McNary was met on a seasonal basis, with April 18-June 30 average flow of 300 kcfs, and was met on a weekly basis for all but the week of May 9, when the average was about 256 kcfs. At this time FDR was at its minimum elevation, and snowmelt runoff was low. This delayed runoff led to the decision, at the request of the TMT, to draft FDR below its minimum flood control level to meet flow targets. The *summer* seasonal flow objective (200 kcfs July-August) at McNary was met on a seasonal basis, with July-August seasonal flow averaging 228 kcfs. The summer objective was met on a weekly basis all but the last week in August when the weekly average was 198 kcfs at McNary. Releases were provided to the extent possible for ESA operations for July and August following the official weekly forecasts and flow recommendations established through the TMT process. The lowest level reached at FDR reservoir for ESA operations was 1283.8 ft on September 23. The reservoir refilled to 1286 ft

by September 30.

**14. Mid-Columbia PUD Projects**

Five run-of-river projects located on the mid-Columbia River in central Washington are operated by three separate Public Utility Districts (PUD's) primarily for power, flood control, fishery, and recreation. The five projects, in downstream order, are Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids and the three Public Utility Districts are those of Douglas, Chelan, and Grant counties. Although the projects are operated by these PUD's, 14 utilities, in addition to the three PUD's, split ownership of the generation output of these plants. Article 34 of the Federal Energy Regulatory Commission licenses for these projects states that some flood control space be provided, as instructed by the Corps, to replace lost valley storage under certain flood potential conditions but was not required this year. The operation of these projects is summarized in the flow of the Columbia River at Priest Rapids, Washington as shown on Chart 89.

Numerous special operations occurred at these projects to assist in the downstream passage of juvenile anadromous fish during this year's outmigration, including FERC-required spill. Other assistance included a coordinated effort during autumn to carried out operations at Priest Rapids to encourage fish to spawn at lower levels in the Vernita Bar area and from mid-October to late November (the primary spawning period), daytime flows were held as low as possible in an attempt to reduce the subsequent minimum flow necessary to protect redds until emergence of fry in early spring. The protection level was established at 60.0 kcfs. Special flow operations were also required of Priest Rapids Dam in March, September and October for Navy nuclear reactor compartment offloadings at Hanford, Washington. This is described in paragraph 34, Chief Joseph, McNary, The Dalles, and Bonneville Projects.

The unregulated peak flow at Priest Rapids was 457.0 kcfs on June 23 , and the observed peak was 228.7 kcfs on July 14.

**15. Yakima Project**

The five storage reservoirs in the Yakima Basin in eastern Washington were operated by Reclamation for irrigation, fish and wildlife enhancement, flood control, power generation, recreation, and dam safety concerns. This year's operation is graphically shown on Chart 31 and Chart 32.

The Yakima reservoirs were operated to enhance both fish spawning conditions during September to mid-October 1998 and incubation/rearing levels mid-October through December. The bypassing of reservoir inflows to maintain flood space requirements or power rights supported incubation/rearing level flows for the rest of the season. Incubation/rearing releases from reservoirs included 6.9 kaf from Keechelus, 5.4 kaf from Cle Elum, and 0.6 kaf from Rimrock. These below normal incubation/rearing releases were due to the above-normal carryover from last summer which required early bypassing of storage inflow to maintain flood control space. The system reached maximum storage for the year on July 12, 1998 at 1,046,204 af, and was placed on storage control on July 29. From mid-July the runoff in the Yakima River Basin continued to be above normal until the end of irrigation season, due to the cooler then normal temperatures in the Yakima Basin which delayed snowmelt approximately three to four weeks later than the normal runoff pattern. All entitlement water users received a full water supply during the irrigation season (March 15 to October 22). The project storage on September 30 was 646.6 kaf, 176% of normal. Based on the Total Water Supply Available (TWSA), during July 1 to October 31, the Yakima Basin was managed to provide target flows of 600 cfs for Yakima River gage near Parker, and 600 cfs for Yakima River near Prosser. These flows were provided for by law in TITLE XII -- YAKIMA RIVER BASIN WATER ENHANCEMENT PROJECT, Section 1205.

The Yakima reservoirs were operated to enhance both fish spawning conditions in early October 1998 and incubation/rearing levels from mid-October through March. The bypassing of reservoir inflows to maintain flood space requirements or power rights supported incubation/rearing level flows for the rest of the season. Incubation/rearing releases from reservoirs included 2.0 kaf from Keechelus, 44.3 kaf from Cle Elum, and 17.7 kaf from Rimrock. The below normal incubation/rearing releases from Keechelus were due to safety of dam concerns which required early bypassing of storage inflow to maintain monitoring elevations on the

reservoir and to control the refill rate.

Both fish spawning enhancements, "Mini-Flip-Flop" and "Flip-Flop," operations were executed in the Yakima Basin. The "Mini-Flip-Flop" operation required increasing outflows from Kachess Reservoir and decreasing outflows from Keechelus Reservoir to supply the demands in the Easton Reach of the upper Yakima River. This provided low spawning flows in the Yakima River above Lake Easton. The incubation/rearing level flows required during the winter were then supported by releases from Keechelus Reservoir. The "Mini-Flip-Flop" operation was implemented during the week of August 25-31. The Yakima River to Naches River "Flip-Flop" operation, executed for the 19th consecutive year, involved drawing storage from Keechelus, Kachess, and Cle Elum Reservoirs to meet all Yakima River diversions in June, July, August and the first few days of September. During these months Rimrock and Bumping reservoirs were used only to meet the Naches and Tieton River diversions. In September, when low stages of river flows were required in the Yakima River from Easton to the mouth of the Teanaway River, the Yakima River reservoirs were set to meet only the spawning flow levels. Also, up to 200 cfs was routed around that reach via the Kittitas Canal at Wasteway 1146. The Yakima system below the confluence of the Naches River, as well as the Naches and Tieton diversions, were met with releases from Tieton and Bumping reservoirs. These flows were provided for spring Chinook salmon under a 1980 court order. The "flip-flop" operation was implemented during the period of September 1-8 to provide a longer, environmentally friendly ramp-down of flows in the upper Yakima River.

Spawning flows were set at 100 cfs at Yakima River near Crystal Springs, 300 cfs in Yakima River below Easton Dam, and 300 cfs in the Cle Elum River below the reservoir. Due to the fisheries spawning cycle throughout the Yakima River Basin, incubation/rearing flow levels were established the last week of October1999, providing for 300 cfs at Yakima River below Easton Dam, and 300 cfs in the Cle Elum River below the reservoir.

The natural runoff for the water year at the Yakima River at Parker was 4.36 maf, about 129% with the peak daily unregulated flow of 27.5 kcfs occurring on May 25. Some bypassing of reservoir inflow was necessary from April through June, to maintain flood control space based on forecast runoff.

Total water year precipitation (total as recorded at five reservoir sites) was 280.41 inches, 121.7% (50.05 inches) above normal. The Yakima basin snow-pack was above normal, averaging 156% during the seven-month snow season, December through June.

**16. Jackson - Palisades Project**

Active storage in the Snake River Basin above Heise, Idaho, includes 847 kaf in Jackson Lake and 1,200 kaf in Palisades Reservoir (a Section 7 project) for a combined total of 2,047 kaf. The system is operated as a multipurpose unit for flood control, irrigation, recreation, fish and wildlife, and power production. Discharge measurements from Jackson Lake are gaged at the Snake River at Moran, Wyoming, and from Palisades Reservoir at the Snake River near Irwin, Idaho. Flood regulation curves are designed to maintain flows at Heise at or below 20.0 kcfs. This years operation is shown graphically on Chart 33, Chart 34, Chart 69, and Chart 70.

After the above normal runoff contents in Jackson Lake and Palisades reservoirs were 1,524 kaf on October 1, 1998. Storage increased slightly through the winter until flood control rule curves dictated that flood control space be evacuated. Flood control releases from Jackson Lake Dam began in mid March and were gradually increased to 2,000 cfs in early April, then to 3,000 cfs on May 7. This release was maintained until late May when it was gradually increased to 6,500 cfs by the second week in June. Starting June 26 the release was rapidly decreased to 2300 cfs. Maximum reservoir elevation for the year was 6,768.81 ft on July 20, and maximum reservoir content was 842.2 kaf.

Flood control releases to make space in Palisades Reservoir began late January and increased to 5,700 cfs by February 7. The release was lowered to 3,800 cfs during March 8-9 to accommodate Bureau of Land Management removal of a sandbar at Conant boat ramp. Starting March 10 the release was gradually increased, reaching11,000 cfs by March 15. In mid April releases were cut to 8,800 cfs and remained at that level until early May. As the runoff season progressed, the release steadily increased to 20,500 cfs by June 24,

then, with the snowmelt discharge in recession, decreased to 12,000 cfs by June 30. Releases reached the peak of 20,515 cfs on June 24. Palisades Reservoir maximum level was 5619.29 ft, 1,188,360 af, on July 16. Maximum combined content of the two reservoirs was 2.03 maf on July 17. September 30 content was 1.57 maf, 333 kaf above normal.

The October through July volume runoff above the Snake River near Heise, Idaho, gage was 5.61 maf, 120% of normal while the April through July runoff was 109%. Snow accumulation on the watershed above Palisades Dam peaked at 113% of normal on April 1. The unregulated peak flow at the Heise Gage was 38.9 kcfs on May 30, and the peak regulated flow was 20.9 kcfs on June 24. Flood regulation curves are designed to maintain flows at Heise at or below 20 kcfs, with flood level flows at 24.5 kcfs.

### 17. Ririe Project

Ririe Reservoir is a Section 7 project on Willow Creek in eastern Idaho that is owned and operated by the Bureau of Reclamation for the joint uses of irrigation, flood control, recreation, and fish and wildlife. Its active capacity of 90.5 kaf includes exclusive flood control space of 10.0 kaf. This year's operation is graphically shown on Chart 35.

The October through June runoff into the reservoir was 115.4 kaf, 115% of normal. The peak daily inflow was 1,630 cfs on April 30 and the maximum release was 902 cfs on May 6. The maximum content was 81.3 kaf on June 3 and the storage at the end of the water year was 61,359 af.

### 18. American Falls Project

American Falls Dam is a Section 7 project on the Snake River near Pocatello, Idaho, that has an active capacity of 1673 kaf and is operated primarily for irrigation, power, and flood control. During the irrigation season American Falls Reservoir is operated to meet irrigation needs in the Snake Basin downstream from the dam. The streamgage on the Snake River near Shelley, approximately 73 miles upstream from the dam, is the control point for flood regulation in American Falls Reservoir and for irrigation releases from upstream reservoirs. Milner Dam, located 74.0 river miles below American Falls, serves as a headworks for irrigation diversion in the middle Snake River plain. In normal years only minimum flows pass Milner with the remainder of the flow diverted for irrigation. This year's operation is graphically shown on Chart 36, Chart 37, Chart 38, and Chart 71.

American Falls releases were reduced to 3.5 kcfs in early October and remained there until mid-November when they were gradually increased to 8 kcfs by December 3. Flows remained at approximately 8 kcfs until the middle of March, except the release was lowered to 4 kcfs December 29 to accommodate Banbury pipeline inspection near Hagerman, and again when flows were lowered to 7 kcfs March 9 for USGS spring flow measurements below Milner Dam. Starting March 18 flows were increased to 15 kcfs by April 6 and was held at that level until April 16 for maintenance work in the stilling basin. American Falls release was again reduced from 15 kcfs on April 19 to 9 kcfs on April 28 to accommodate repairs to Banbury pipeline. Starting April 30 the release was steadily increased, reaching 25 kcfs on May 24. From May 26 to June 1 the release was reduced to 18.5 kcfs to allow repairs at the Banbury pipeline to be completed. After June 1 the release was steadily increased to 27.9 kcfs by June 13, then dropped rapidly to 13 kcfs by July 2. During the months of July, August and September the release declined at a fairly constant rate reaching 7.3 kcfs by the end of September. Maximum storage during the year was 1,694,652 af on June 12. Reservoir contents on September 30 was 704,507 af, 203,000 af above normal.

Approximately 206 kaf of water was provided from the Upper Snake reservoirs for salmon flow augmentation during 1999.

### 19. Little Wood Project

Little Wood Reservoir has an active capacity of 30,000 af. Although it was originally constructed by Little Wood Irrigation District for exclusive irrigation use, it has been designated as a Section 7 project since enlargement by the Bureau of Reclamation and is now operated also for flood control. The Little Wood River

at Carey gage, approximately 3 miles downstream from the dam, is the control point for reservoir operations. This year's operation is graphically shown on Chart 39.

Flood control space was evacuated and maintained starting in early February and continued through mid April during which time the discharge varied but averaged about 300 cfs. The reservoir started filling in mid April, filling on June 12 and remaining full until June 27. Maximum reservoir content was 30,142 af on June 14 and the storage at the end of September was 5,935 af, 143 af above normal.

The October through July runoff into the reservoir was 143,910 af, 106 percent of normal. Maximum mean daily inflow was 1,025 cfs on April 20 and peak mean daily discharge at the Carey gage was 790 cfs on June 19.

### 20. Owyhee Project

Owyhee Reservoir has an active capacity of 715 kaf and, although it was constructed by Reclamation as a single-purpose irrigation reservoir, it can provide significant incidental flood protection along the lower Owyhee River and along the Snake River from Nyssa, Oregon, to Weiser, Idaho. Most of the largest floods from this basin result from winter rains on snowpack over frozen ground. This year's operation is graphically shown on Chart 40.

The runoff this year was near normal with a December-June runoff volume of 651 kaf, 89% of normal. The peak mean daily inflow was 7,913 cfs on March 27 and the peak daily outflow was 2,561 cfs on April 20. The reservoir reached a maximum content of 730 kaf on May 7. The Owyhee net inflow for the period of June through September was 113% of normal.

### 21. Boise Project

The Boise Project, Arrowrock Division, is a three-reservoir system including Anderson Ranch, Arrowrock, and Lucky Peak reservoirs with a combined total active storage capacity of 974 kaf. Anderson Ranch and Arrowrock, Section 7 projects, are operated by Reclamation while Lucky Peak is a Corps project that is regulated in close cooperation with the two upstream projects. A powerhouse was retrofitted to Lucky Peak by Seattle City Light. This system is operated as a multipurpose unit for flood control, fish and wildlife, power production, recreation, and irrigation. The Boise River at Glenwood Bridge gage is the control point for the flood control operation of the system. This year's operation is graphically shown on Chart 41 and Chart 72.

The release from Anderson Ranch Reservoir was maintained at the dam's minimum release, 300 cfs, from the end of irrigation season until mid February then, until early June, releases varied from powerplant capacity of 1,700 cfs to flood control releases of 2,700 cfs. In mid June release from Anderson Ranch Reservoir reached a seasonal maximum of about 4,000 cfs.

The release from Lucky Peak Reservoir was reduced to 240 cfs at the end of the irrigation season in mid-October and maintained there until mid December. From then until mid February, releases were held between 150 and 170 cfs. Flood control releases were initiated in mid February with releases ramping to a maximum of 7,500 cfs in early March. Releases were maintained between 6,500 and 7,500 cfs until late April, then reduced to about 4,600 cfs by early May. The 4,600 cfs flow was maintained until early June then increased to 6.5 kcfs and ramped back down to fill the reservoir and match irrigation flows by the end of June. System storage at the end of September was 488 kaf, 69 kaf above average. Approximately 41 kaf of water was released from Boise River reservoirs between early July and late August for salmon flow augmentation.

Seasonal runoff in the Boise Basin for the period of April 1 through July 31 was 1,718 kaf, 122% of normal. The peak flow of the Boise River at the Glenwood Bridge gage was 6,460 cfs on March 21. Flood level discharge (compare to stage) at the Glenwood station is 7,000 cfs.

### 22. Malheur Project

Beulah (Agency Valley Dam) 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 of these Section 7 reservoirs are operated for multipurpose benefits and have a combined active capacity of 281 kaf.

The Malheur River is similar to the Owyhee River in that the major floods are usually caused by rain on frozen and snow-covered ground. The Malheur River at the Vale, Oregon, streamgage is the control point for flood control operation of the reservoirs, with the primary goal of limiting flows to 8000 cfs. This year's operation is graphically shown on Chart 43, Chart 44, and Chart 45.

The Malheur Basin experienced an above normal water supply this year. December through June runoff at Warmsprings Reservoir was 115% of normal and inflow on the North Fork at Beulah Reservoir was 144%. Warmsprings Reservoir reached a maximum storage volume of 191 kaf on June 5 and ended the year with 90 kaf. The peak daily inflow was 1164 cfs and the peak outflow was 1103 cfs.

Beulah Reservoir filled and reached a maximum storage content of 61 kaf on May 27. The end-of-year carryover storage in Beulah was 23 kaf.

Bully Creek Reservoir filled to its capacity of 30 kaf on April 21, and the end-of-year carryover storage volume was 15 kaf.

Approximately 18 kaf of water was provided this year, through natural flow rights, from the Malheur basin for salmon flow augmentation.

### 23. Payette Project

The Payette River reservoir storage system includes Cascade and Deadwood reservoirs which have a combined total active storage capacity of 815 kaf. These reservoirs were originally constructed by Reclamation for irrigation and power purposes, but now are also operated informally for incidental flood control. The control point for flood control operation of these projects is the Payette River near Horseshoe Bend streamgage at river mile 60.8. A second key streamgage is the Payette River near Emmett at river mile 38.4. Approximately 65% of the drainage basin above Horseshoe Bend is unregulated. This year's operation is shown on Chart 42 and Chart 73.

Cascade Reservoir filled on June 26 and was maintained at full pool through July 2. Releases were maintained near 1,500 cfs during July and August, then gradually decreased after Labor Day 1998 and to 900 cfs by the end of the water year.

Deadwood Reservoir filled on June 19, and remained full until July 17 followed by releases that ranged from 600 to 900 cfs through August, and then were reduced to the winter minimum of 50 cfs by September 4.

A total of 160 kaf of water was obligated for release for salmon flow augmentation from Payette basin reservoirs this year, about 95 kaf of which was released between mid-July and the end of August, with the remaining 65 kaf released from Idaho Power Company's Brownlee Reservoir on the Snake River. This "shaped" portion will be paid back to Idaho Power by releases from Cascade Reservoir later in November and December.

This year's runoff in the Payette Basin was above normal with the April through July volume, measured at Horseshoe Bend, was 2,126 kaf, 130% of normal, at Cascade Reservoir the runoff volume for the same period was 704 kaf, 136%, and at Deadwood Reservoir the corresponding runoff volume was 151 kaf, 112%. Peak daily inflow to Cascade Reservoir was 8,700 cfs on May 29, and peak inflow to Deadwood Reservoir was 2,230 cfs on May 29.

The peak flow of the Payette River at Horseshoe Bend was 12,970 cfs on June 18, with an unregulated peak of 22,550 cfs on May 29. The peak flow of the Payette River near Emmett was 12,180 cfs on May 30 where the flood stage flow is 16,000 cfs.

### 24. Snake R at Weiser

Snake River at Weiser flows are highly regulated by upstream irrigation diversions and reservoir storage operations previously discussed in this chapter. These operations normally results in a fairly smooth hydrograph at Weiser. This year's operation is graphically shown on Chart 46 and Chart 74.

### 25. Powder Project

Phillips Lake is formed by Mason Dam on the Powder River in eastern Oregon, is owned by Reclamation,

and is operated by the Baker Valley Irrigation District as a multipurpose project with 17 kaf for exclusive flood control, 21 kaf for joint use, and 52.5 kaf for active conservation use, for a total active capacity of 90.5 kaf. The control point for flood control regulation is the Powder River at Baker City streamgage, which should be controlled to 500 cfs, if possible. This year's operation is graphically shown on Chart 88.

The Powder River basin had an above normal runoff year with April through July runoff of 82 kaf, 155% of normal. Phillips Reservoir reached a maximum storage volume of 80,211 af on June 20.

The peak flow of the Powder River at Baker City was 430 cfs on March 26, and the unregulated peak flow was 1,090 cfs on April 19.

**26. Brownlee Project**

The Brownlee, Oxbow, and Hells Canyon dam complex is owned and operated by Idaho Power Company (IPC). These tandem projects on the Snake River on the border between Oregon and Idaho are operated in accordance with a single license issued by the Federal Energy Regulatory Commission (FERC) which requires operation for flood control and navigation, in addition to power. Specifically, this license requires that Brownlee, the only one of the three projects with significant storage, provide a minimum of 500 kaf of flood control space by March 1 in years of normal or greater forecast water supply at Brownlee and The Dalles. The license does, however, have a provision for a partial waiver of this requirement in dry years or for increased space in wet years. The license also requires adequate navigation depths be maintained below Hells Canyon Dam. Spring refill of Brownlee is coordinated with the Corps of Engineers Reservoir Control Center for flood control. This year's operation is graphically shown on Chart 15 and Chart 75.

At the beginning of the Water Year, Brownlee reservoir was at 2020.0 ft. The project was drafted to 2049.0 ft at the request of TMT for Lower Granite flow augmentation. This drafted 237 kaf from Brownlee, plus shaped an estimated 139 kaf of the USBR's 427 kaf delivery by August 4. Between August 4 and the end of September Brownlee was drafted to 2020.0 ft for power operations. (In addition, TMT had requested the project not refill in September). The lake was drafted to 2004.3 ft by October 18 to create space in the reservoir so a portion of the inflow could be stored while discharge from Hells Canyon could be maintained between 9.5 and 12 kcfs to encourage fall chinook salmon to spawn at a low levels in the downstream channel during the late October through December 9 time frame. The goal was to fill the lake near the end of the spawning operation. This goal was met, as by December 7 the pool had filled to 2076.3 ft (2077 ft is full). The Hells Canyon discharges were then maintained above 12.5 kcfs until fry emergence in the spring. In November, the Corps sent IPC a new procedure for determining the annual draft of Brownlee for flood control that delivers the same level of flood control and provides a smoother real-time operation than the current procedure and in December IPC sent the Corps a letter approving the new procedure. This new procedure was submitted in the PNCA Data Submittal for use in WY 2000.

The February water supply forecast for Brownlee for the April-July period was 102% of normal. Based on this forecast and the forecast at The Dalles the Corps notified IPC that 400 kaf of flood control space (2044.5 ft) be available at Brownlee by February 28, 500 kaf of flood control storage space be available (2034.6 ft) by March 31 and 600 kaf of flood control space be available (2024.1 ft) by April 30. Because of the low volume forecast in the Columbia basin, the Corps also notified IPC that Brownlee's entire March 31 flood control requirement could be shifted to Grand Coulee and that a lesser amount could be shifted by April 15. The Corps notified IPC if shift was elected, Brownlee's space requirement still had to be met by April 30. The April final volume forecast increased over the January forecast and required a flood space requirement of 975 kaf (1976.0 ft) by April 30. By that date the reservoir was drafted to 1990.5 ft. The Corps allowed Brownlee to pass inflow (rather than draft) the last 11 days of April because it appeared the May volume forecast was going to decrease dramatically and allow a much smaller flood control draft. The May final volume forecast indeed decreased dramatically and required a "lookback" end of April storage of 700 kaf (2012.8 ft). On May 6, NMFS called the Corps concerning dissolved gas below Hells Canyon because of spill saying that for the next couple of weeks there would be a lot of emerging fall Chinook salmon below Hells Canyon and that there was no current TDG data (IPC had dissolved gas meters in place but data was not

accessible). From last year's extrapolations, they thought there was about 125% TDG. They requested Hells Canyon Dam be reduced from 40 to 35 kcfs and requested Dworshak releases be increased in order to meet weekly average target flow of 100 kcfs at Lower Granite. This flow reduction at Brownlee/Hells Canyon resulted in initiation of its fill. IPC had initially wanted to fill to 2069.0 ft by midnight June 9 for conductive trout spawning conditions. A spill gate broke on May 26 and prevented the planned refill. The project filled to within 1-foot of full (2076.0 ft) on June 24. On July 8, Lower Granite flows dropped below target salmon flows (55 kcfs) and the Salmon Managers requested Brownlee start drafting to maintain the target flows. IPC agreed to draft, but at a rate no more than 1-foot per day (for recreation) until the 237 kaf fish augmentation volume required per the Biological Opinion was delivered (draft to 2059.0 ft). The project was further drafted to 2049.0 ft on August 4 which completed delivery Upper Snake pass-through water.

The regulated peak inflow was 49.61 kcfs on June 7 , the unregulated peak inflow was 114.88 kcfs on June 4, and the maximum daily outflow was 50.53 kcfs on April 22. The April-July observed Brownlee inflow was 8050 kaf, or 139 % of normal.

**27. Dworshak Project**

Dworshak Lake and Dam are located on the North Fork Clearwater River near Orofino in west central Idaho. This headwater project was constructed and is operated by the Corps of Engineers for power, flood control, fishery, navigation, and recreation. This year's operation is graphically shown on Charts 16 and 76.

Dworshak was drafted to 1520.32 ft for salmon flow augmentation by the end of August 1998. The project released minimum outflow of about 1.3 kcfs between September 1 and January 6. The end of December the lake level was 1533.0 ft, well below the Upper Rule Curve level of 1558.0 ft. Outflows were increased on January 7 in response to the volume forecast. The project released full load (about 10 kcfs) between January 19 and March 3. On March 4, flow was increased to about 14 kcfs (including about 4 kcfs spill) which was continued until April 3, when outflows were reduced to 10 kcfs to transition the project forebay to minimum pool. Dworshak reached minimum pool (1445.0 ft) on April 15. The April final volume forecast was 140.8% of normal and the May final volume forecast was 120.8%. In May, Dworshak was drafted to try to achieve target flows of 100 kcfs at Lower Granite during a cold and dry period, drafting the project 3.35 ft between May 9 and 19. This brought a flood of telephone calls from offices of the governor of Idaho and the two Idaho senators. On May 17, Lower Granite flows were still below 100 kcfs but the Dworshak flows were gradually decreased to 1.3 kcfs (minimum flow) by May 19 to start refill of the project. Temperatures and precipitation increased and by May 22, Lower Granite flows were again above 100 kcfs. The project filled from 1451.9 ft on May 19 to 1593.4 ft on July 15 (1600.0 ft is full pool). The Salmon Managers requested Dworshak start augmenting Lower Granite flows when flows dropped below the target of 54.5 kcfs. Dworshak flows were increased gradually starting on July 15 to gradually introduce 50°F water downstream. Dworshak has a water temperature control system which is used to keep Lower Granite forebay water temperatures below 70°F. However, the Dworshak water temperature must also be warm enough so not to adversely affect juvenile fish downstream at the National Hatchery since cold water retards growth of these fish. Between July 19 and 30, outflows were adjusted so total dissolved gas was at 110% which were provided by flows between 12.6 and 14.0 kcfs. On July 31, EPA issued a dissolved gas waiver (Nez Perce asked EPA to issue it to the Salmon Managers) to temporarily increase the TDG limit to as high as 120%. Project outflows were gradually decreased over the month per the Salmon Managers, and reached 8 kcfs on August 30. As flows gradually decreased, the Dworshak operators were required to continuously refine the outflow water temperature by raising and lowering selector gates on the units. On August 31, the Salmon Managers requested water temperature by increased to 50°F because the downstream hatchery was having trouble with fish growth with such cold water. The project drafted to 1526.6 ft by the end of August. Throughout the entire month of September, Dworshak was on minimum flow (1.3-1.5 kcfs) as it was targeting its end of December Upper Rule Curve elevation of 1558.0 ft.

The peak daily inflow was 31.0 kcfs on May 26, while outflow at that time was 1.4 kcfs. The peak daily outflow was 19.1 kcfs which was maintained until August 4. The January-July runoff volume was 4240 kaf,

120% of normal, while the April-July runoff was 3186 kaf, or 118 %.

**28. Clearwater River at Spalding**

The streamgage on the Clearwater River at Spalding in west-central Idaho measures the portion of the inflow to Lower Granite Dam that originates in the Clearwater River Basin. It is also used as a flood control point in the operation of Dworshak Dam. This year's operation is graphically shown on Chart 77.

The observed peak flow at Spalding this year was 53.04 kcfs on May 26 at which time Dworshak was releasing 1.2 kcfs. The unregulated peak flow during the flood season was 85.25 kcfs on May 26, well below the flow at flood stage of 111,600 cfs.

**29. Lower Snake Projects**

Lower Granite, Little Goose, Lower Monumental, and Ice Harbor are run-of-river projects on the lower portion of the Snake River in southeastern Washington. Lower Granite and Little Goose have 5-foot forebay operating ranges, and Lower Monumental and Ice Harbor have 3-foot ranges. All four projects are operated by the Corps of Engineers for navigation, hydropower, fishery, and recreation. This year's operation is graphically shown on Chart 78 and Chart 90.

During the summer of 1998 the projects had been operating at (MOP) to improve conditions for juvenile fish migration. Lower Monumental and Little Goose projects returned to their normal operating ranges on August 31, 1998. They were operated at minimum operating pool (MOP) between August 31 – October 23 as a soft constraint per TMT request. This soft constraint was requested because the Salmon Managers felt adult fish passage into the Snake River was beginning to increase at the end of August, but they still felt juvenile passage was the dominant passage. The Salmon Managers typically request Ice Harbor, Little Goose, and Lower Monumental projects refill about September 1 to submerge fish ladder entrances at upstream projects and facilitate adult fish passage. The MOP operation typically starts in early April. The theory of the MOP operation is to lower the pools to facilitate faster downstream juvenile fish passage. Lower Granite was not refilled until November 13, 1998. There is no project immediately upstream of Lower Granite and therefore no need to refill at an early date to facilitate adult passage. Ice Harbor was not refilled on August 31 like Lower Monumental and Little Goose because a contractor was working below the dam. Space in the pool was reserved to store water in the event of an emergency to allow the contractor to vacate his work area. The contractor completed his work February 5 and the pool was returned to normal operating range at that time.

Starting on April 3, all projects were drafted to MOP or MOP + 1-foot for juvenile fish migration, as required by the Biological Opinion. Required night time spill was initiated at Lower Granite, Little Goose, and Lower Monumental on April 2 and continued through June 20. Required around the clock spill was initiated at Ice Harbor on April 3 and terminated August 31 (lasted longer than the other Lower Snake projects because Ice Harbor does not have fish collection system). Spill was maintained at the 120% TDG cap level and were adjusted based on actual data. Spill adjustments were made for fish barge traffic at Lower Monumental and Lower Granite when requested by towboat personnel to aid in safe navigation. Fish transportation by truck was initiated on March 27 at Lower Granite and on April 3 at Little Goose and Lower Monumental. Barging at these three Snake River projects began on April 8 and ended on June 25 at which time transport mode reverted back to trucking. Trucking ended October 31 at Lower Monumental, November 4 at Little Goose and November 10 at Lower Granite. Fish bypass systems were used until December 16.

The regulated peak flow into Lower Granite was 189.0 kcfs on May 27 and the unregulated peak was 270.94 kcfs on May 31. The April-July unregulated runoff to Lower Granite was 25,776 kaf, or 119% of normal.

**30. Mill Creek Project**

Mill Creek Dam and Bennington Lake, east of Walla Walla, Washington, is an off-stream Corps of Engineers project with an active storage capacity of 8,200 af. It provides storage space for both flood control

for Walla Walla, by storing flows diverted from Mill Creek, and for recreation. Its annual operation is graphically shown on Chart 47.

Although there were no flood control operations at Mill Creek this year, Bennington Lake began filling for recreation use on March 8, 1999, and reached its conservation pool elevation of 1205 ft on March 16, 1999. It remained near 1205 ft until June 15 when inflows dropped to a level that was not sufficient to keep the reservoir full. Seepage and evaporation losses caused draw down of Bennington Lake to elevation 1193.7 ft by September 30, 1999.

**31. Willow Creek Project**

Willow Creek Dam at river mile 52.4, together with the City of Heppner Flood Warning System, constitutes the Corps of Engineers flood protection provided for the urban reach of Willow Creek through the city and immediately north of Heppner in north-central Oregon. The dam is a 154 ft high roller-compacted concrete structure with an ungated spillway. The 14,091 af of storage space below the ungated spillway crest, 2113.5 ft, is allocated to flood control, irrigation, and minimum flow maintenance. The lake is held at 2063.0 ft in the winter and 2076.5 ft in the summer to provide for flood control. This year's operation is graphically shown on Chart 48.

The reservoir was at 2,074.0 ft by October 15, the result of summer augmentation flows drew the reservoir down 2.5 ft. The reservoir was lowered to the winter flood control pool elevation of 2,063.0 ft by increasing the minimum flow of 3 cfs the 20 cfs needed to lower the pool by December 1. The flood control season was mild with the largest daily mean inflow, about 80 cfs, occurring in late March. The largest discharge from the project was 70 cfs. Filling the reservoir to the summer recreation level began in March and is scheduled to end on May 20. The last flow recession lasted from about mid-May through mid-July when the minimum flow of 3 cfs was maintained. From mid-May through mid-July the project discharge is maintained at 1 cfs in excess of inflow to satisfy downstream water rights with a margin for measurement error. According to rainfall records drought conditions prevailed in June, July and September. Water in the reservoir sparked a number of complaints from local downstream residents wanting release of water from the lake in excess of water rights. Denying these requests permitted maintained the minimum release of 3 cfs when inflow nearly dried up. This drew the lake down over 4.5 ft, 2 ft more than last year.

**32. John Day Project**

Lake Umatilla was formed by the construction of John Day Dam on the Columbia River. The project, which straddles the Oregon-Washington border, is operated by the Corps primarily for power, flood control, and navigation. The lake has approximately 500 kaf of active storage in its full operating range, 257.0-268.0 ft. Historically, the Corps generally operated the lake in the elevation range 260.0-265.0 ft from November through the spring runoff. Following the spring runoff, and continuing until mid-October, the lake was normally operated in its top three feet, 265.0-268.0 ft. However, in recent years the lake has been operated at lower levels in accordance with the Endangered Species Act in an attempt to improve juvenile spring/chinook salmon passage through the reservoir. From April 20-September 30 there is a 1.5-foot operating range while the normal operating range during this period is 262.5-264.0 ft. The lower elevation limit is adjusted to meet irrigation needs. Between September 30 and April 20 there is a 2.5-foot operating range of 262.5-265.0 ft. In addition, at any time during the year the lake can be operated 257.0- 268.0 ft for flood control. This year's operation is graphically shown on Chart 17.

While there were no flood control operations at John Day this year, there were special operations set up for several different parties. This included special operations for goose hunting (early October through mid January) and goose nesting (March 10-June 1). The requested operation for hunting was to operate in the top foot of the operating range on Mondays, Wednesdays, weekends and holidays. The requested operation for nesting was to operate in the top foot of the range at least once every four days for 6 to 8 daylight hours. There were also special operations set up involving specified turbine operations, flow, tailwater and forebay ranges for fish and dissolved gas research. Between April 20 and September 30 the forebay was operated in a 1.5-foot

operating range per the Biological Opinion. The range started out 262.5.0-264.0 ft and subsequently was raised to 263.5-265.0 ft for the irrigators from August 3 to September 30.

Spill for juvenile fish passage occurred at John Day between during the spring and summer. Spill levels were set in accordance with the Corps' Fish Passage Plan for 1999. See Section G., Fishery Operations for additional information

**33. Upper Deschutes Project**

This multiple-reservoir system is composed of six reservoirs: Prineville and Ochoco reservoirs (both Section 7 projects) on the Crooked River (a mid Deschutes Basin tributary) and Crane Prairie, Wickiup, Crescent Lake, and Haystack reservoirs on the upper Deschutes River. Including Haystack, which is an offstream re-regulating reservoir, the combined total active storage capacity is 559 kaf. This year's operation is graphically shown on Chart 49 and Chart 50.

Crescent Lake storage at the beginning of the water year was 60.5 kaf, peaked at 85.9 kaf on July 14, which is essentially full. Carryover storage at the end of the year was 77 kaf. The maximum combined Wickiup and Crane Prairie storage of 237 kaf was reached on April 12, drafting to a combined storage of 160 kaf at the end of the water year.

Prineville Reservoir entered the water year with a carryover of 102 kaf (106% of normal). Winter flood control space was maintained by releasing a stream-resource maintenance flow typically ranging from 80 cfs to 400 cfs until early March, when higher flood control releases became necessary. Peak storage of 151.3 kaf, 99% of active capacity, was reached on June 4, the maximum inflow was approximately 3560 cfs on March 26, and the maximum release was 2940 cfs on March 27. The reservoir had a storage of 102 kaf (107% of normal) at the end of September.

Ochoco Reservoir entered the water year with a carryover of 24.5 kaf. The outlets were closed following 1998 irrigation season and all inflow was stored until early December, when flood control releases were initiated. Discharges were progressively increased to 140 cfs through late February, and ranged up to 350 cfs during March to mid April to maintain flood control space. Heavy snowpack in the Ochoco Basin prompted a conservative operation which provided more reservoir space than called for under the rule curves. Very cool spring and early summer temperatures resulted in a slow, drawn out snowmelt, with inflows staying in the low to moderate range.

The peak inflow for the year was 600 cfs on March 21, and outflow peaked at 362 cfs on April 1. The reservoir did not refill completely, reaching a maximum content of 34.4 kaf (77% of capacity) on May 29. Irrigation demand drafted the reservoir during the summer to 13.8 kaf by the end of September.

**34. Chief Joseph, McNary, The Dalles, and Bonneville Projects**

These run-of-river projects are operated by the Corps for hydropower, navigation, irrigation, recreation, and fisheries. Chief Joseph is located on the mid-Columbia River in central Washington while McNary, The Dalles, and Bonneville are on the lower Columbia River, straddling the Oregon-Washington border. Several special operations occur each year at these projects to meet special operational requirements for power production, navigation, recreation, fishery, and construction activities. This year's operation is graphically shown on Chart 80 and Chart 91.

McNary Dam had BiOp flow requirements that varied throughout the spring and summer (see Section G., Fishery Operations). Fish were bypassed during the spring and barging started on June 24 and ended July 22, when the transportation mode was switched back to trucking, which lasted until about December 16. The fish bypass operated until December 16.

Also continuing at McNary this year was the offloading of three decommissioned defueled submarine reactor compartments by the Puget Sound Naval Shipyard at the Hanford Reservation. Two shipments were made in August and one shipment was made in September. For the first time, decommissioned defueled cruiser reactor compartments were offloaded and buried at the Hanford Reservation. There were six cruiser shipments this year, two each in March, September and October. These cruiser reactor compartments are a different

configuration and are slightly larger than submarine reactor and require a longer offloading period than the submarine compartments. The offloading operations of these reactors required special operation of the water level behind McNary Dam and Chief Joseph and Priest Rapids Dam discharges to allow barge docking and nuclear reactor compartment unloading at the Port of Benton slip. The duration of the special operations was about 50 hours for a submarine compartment and 53 hours for a cruiser compartment. Portland General Electric shipped and offloaded a Trojan reactor vessel package in August which required an operation similar to the Navy's submarine shipments.

There were also, special operations at McNary for national level competitive boat races, construction work, waterfowl nesting, and waterfowl hunting occurred throughout the year. At times, these requests conflicted with each other, requiring special coordination.

Special operations at Bonneville included high forebay for Treaty gill net fishing, low forebay for construction work, high forebay for cross-channel swim, low tailwater for lock repair work and juvenile bypass outfall construction and spill to assist Spring Creek Hatchery fish released in passing Bonneville Dam.

Spill for juvenile fish passage occurred at McNary, John Day, The Dalles, and Bonneville during the spring and summer. Spill levels were set in accordance with the Corps' Fish Passage Plan for 1999. See Section G, Fishery Operations for additional information.

The observed peak flow at The Dalles was 379.3 kcfs on June 4. The Dalles unregulated peak flow was712.3 kcfs, on June 20. The unregulated January-July runoff at The Dalles was 124.1 maf, or 117% of normal and the April-August unregulated runoff was 110.3 maf, or 118%.

### 35. Columbia River at Vancouver

The Columbia River Basin reservoir system did not need to be operated for flood control during the winter of 1998-99. This year's operation is graphically shown on Chart 79.

The observed peak stage at Vancouver, which was the result of an unusual spring rain/snowmelt, was 14.8 ft, 1.2 ft below flood stage, on December 31 and the spring observed peak stage at Vancouver was 12.7 ft on May 29, 3.3 ft below flood stage. The unregulated spring peak stage was 24.6 ft. Bankfull at Vancouver is 16.0 ft and a major flood is at a stage of 26.0 ft.

### 36. Willamette Basin Projects

There are 25 dams in the Willamette Valley of western Oregon, eleven of which are single-purpose, hydroelectric plants operated by public and private utilities and are not the focus of this report. Of the remaining projects the Corps operates 11 storage and two reregulating reservoirs and the Bureau of Reclamation operates one storage project, Scoggins Dam, which is a Section 7 project. The Federal projects are:

| **Hydroelectric** | | **Non-power** |
|---|---|---|
| **Storage** | **Re-regul'n** | **Storage only** |
| Hills Creek | Big Cliff | Fall Creek |
| Lookout Point | Dexter | Cottage Grove |
| Cougar | | Dorena |
| Green Peter | | Blue River |
| Foster | | Fern Ridge |
| Detroit | | Scoggins |

These projects are operated for flood control, hydropower (where applicable), irrigation, fishery habitat, and recreation. Since these federal projects are operated as a system to control the flow of the Willamette River, their operation will be discussed as a unit. This year's operation is graphically shown on Charts 18-28, Charts 81-84, and Chart 92.

**a. CORPS PROJECTS**. The Willamette reservoirs operated by the Corps were in the middle of their normal fall draft at the beginning of October 1998 with all projects approximately on their rule curve. On

November 21, a storm hit the Willamette Valley which the projects stored with Harrisburg the only downstream control point to reach bankfull. After the inflows peaked, the projects started evacuating the stored water.

Cottage Grove, Dorena and Foster were at minimum conservation pool on December 1, all other projects were still drafting, when another storm system arrived during the first week of December putting more water into storage in the reservoirs and pushed many streamflows to bankfull. By December 13, most projects were back at their rule curves. The exceptions being Hills Creek, Lookout Point, and Fern Ridge which required another week to reach their rule curves. On December 26, the projects were within 2% of the rule curve when the strongest storm of the season hit the Willamette on December 27, bringing as much as 5.1 inches of rain to some locations. All the projects were reduced to minimum outflows on December 28. In spite of this, many streams reached bankfull and flood stage. Goshen, Albany, Jefferson, and Salem all reached or exceeded flood stage during the event. During the peak, the Willamette projects were 33% full. All projects started drafting by December 30 and by January 13, all projects had evacuated the water stored, bringing the overall system flood control storage down from 33% to 1% full. Additional storm systems that arrived during the second and third week of January stored more water in the reservoirs and pushed many streamflows back to bankfull. Fern Ridge remained above its rule curve through the end of the month, while all other projects were back at their rule curves by the end of January. Overall, the Willamette received precipitation that was 120% of normal. This kept streamflows high and reservoir pools above the rule curve for the majority of January.

February marked the beginning of the spring refill in the Willamette. All projects except Fern Ridge began storing water according to the refill schedule. Fern Ridge continued to evacuate water throughout the month. Storm systems arrived throughout the month, resulting in a February precipitation total that was 186% of normal. High project inflows throughout the month helped the projects stay at or near the rule curve during February, which is the steepest part of the refill schedule. Streamflows remained within their banks during the month.

March began with high streamflows in the Willamette, caused by a storm in the final days of February. Many streams approached bankfull conditions but none reached or exceeded bankfull. All projects except Fern Ridge continued to refill in March. Fern Ridge spent the first part of March evacuating water, finally reaching its rule curve on March 11. Starting in mid-March, the power projects (Hills Creek, Lookout Point, Cougar, Green Peter, Detroit) remained 3-7 days behind their respective refill schedules. This was to provide additional flood control space given the years high snowpack (174% as of March 1). All projects filled to maximum conservation levels during May. Fern Ridge reservoir reached its summer level at the beginning of May while the remaining projects refilled in the middle of May. Above normal precipitation and snow pack persisted through May. All projects with a significant snow component were operated at or a foot below maximum conservation pool to account for the possibility of higher than normal inflows.

The summer augmentation plan was drafted and sent to interested State and Federal agencies in May. A meeting was held and the plan was presented to the agencies. The augmentation plan called for releases from the projects to be increased to meet downstream minimum flow requirements and target flows recommended by the Oregon Department of Fish and Wildlife. The following target minimum flows, in cfs, for the mainstem Willamette were adopted:

| Location | May | June | July | August | September |
|---|---|---|---|---|---|
| Albany | 6,000 | 4,500 | 4,500 | 5,000 | 5,000 |
| Salem | 15,000 | 12,500/8,500 | 6,000 | 6,000/6,500 | 7,000 |

The target minimum flows were met or exceeded in the May through September period. Fall drawdown at the projects was initiated after Labor Day.

**b. RECLAMATION'S TUALATIN PROJECT.** Henry Hagg Lake was formed by Scoggins Dam on Scoggins Creek, tributary to the Tualatin River near Forest Grove, Oregon. The reservoir has an active capacity of 53.64 kaf and is operated for flood control, irrigation, municipal supply, fish and wildlife,

recreation, and water quality. The inflow occurs mostly from winter rain storms. The year's operation was generally according to flood control regulations and is graphically shown on Chart 85.

Henry Hagg Lake storage at the beginning of the water year was 21.7 kaf, 41% of capacity and 83% of normal for the date. The reservoir was drafted farther during the fall to meet late season irrigation demand and provide water quality flows downstream on the Tualatin River, reaching its lowest storage for the year of 15.6 kaf on November 10. Storage began to accumulate when the discharge was reduced to the project minimums beginning in mid November. Storage accumulation reached the flood control rule curve by early December, when a high-water event forced storage above the curve. Significant releases to evacuate this storage were not possible due to downstream conditions until mid December, when outflows of up to 900 cfs were released to keep the Tualatin River and Dilley at or above its regulation goal of 16.5 ft. This flood space evacuation was nearly completed when another flood event occurred in late December, again forcing storage above the rule curve. Following this storm the reservoir once again drafted nearly to its rule curve in mid January when frequent rain events forced storage of inflows. Even with aggressive management of the remaining flood control space, the reservoir essentially filled by February 7. The typical operation involved reducing inflows to minimum while the Tualatin River peaked from runoff from uncontrolled areas, then 'backfilling' in behind the flow recession with releases from Scoggins to maintain the flow at Dilley below its earlier peak. Regulation above the 16.5-foot stage at Dilley was necessary, and typically ranged from 17.2 ft to 17.4 ft.

This operation was successful in allowing the reservoir to store all inflows during the peak of each flood episode. The reservoir briefly drafted below its rule curve by mid February before having to repeat its rule curve, which it quietly followed the rest of the spring, reaching its full pool level by May 1. The reservoir remained full until draft began in mid June, gradually lowering the contents to 15.9 kaf at the end of the water year. Volume inflow during the year was 150.1 kaf, 164% of normal and was the fifth year in a row with inflows greater than 120% of normal.

**37. Western Washington Projects**

**a. HOWARD A. HANSON DAM**. "Hanson" Dam, at mile 64.5 on the Green River, is a flood control and conservation storage project that provides fall and winter flood protection primarily for the lower Green-Duwamish River valley between the cities of Auburn and Seattle. In the spring, over 24 kaf are stored to augment late summer and fall low flows for fishery purposes. The City of Tacoma diverts an average daily discharge of 84 cfs for municipal and industrial water supply at its diversion dam and pipeline, 4.1 miles downstream from Hanson Dam. The year's operation is graphically shown on Chart 51.

The project began the water year with the pool at 1124.5 ft, 9.6 ft below the 98% rule curve and on November 24 reached the normal minimum flood control level of 1070.0 ft. This level provides a small pool for water quality control, yet the reservoir is essentially empty.

Water year precipitation was well above normal due to the influence of a moderately strong La Nina episode. The two-month period of November (18.62 inches) and December (19.36 inches) was the wettest on record for the basin. The snowpack was large, peaking in mid-April at 150% of normal. This abundant supply of water in the mountains provided flexibility for the spring refill.

There were four incidences where the project was operated for flood control during the year: two in November, one in both December and January. The most significant occurred on December 31 when the flood control pool reached its maximum for the winter at 1149.0 ft (32,077 af). For this event the project inflow peaked at 12,010 cfs and the streamflow at the Green River near Auburn streamgage peaked at 9,586 cfs (December 30), well below the authorized Auburn flow of 12,000 cfs, and coinciding with the year's largest project release of 7,094 cfs,.

In order to maintain the turbidity in the Hanson pool, the Corps periodically lowers the pool below 1070.0 ft to redistribute the material that accumulates in the reservoir. On January 14, the pool was lowered to elevation 1061.9 ft, permitting the Corps to maintain flows in excess of 2,000 cfs for more then three days to transport the sediment throughout the system. Subsequent inspections found no evidence of siltation on salmon

redds. The Tacoma Water Department, Federal, state and local agencies were informed of this operation.

Beginning in February the Corps, City of Tacoma Water Department, Muckleshoot Indian Tribe, and Federal and state resource agencies coordinated the project's annual spring refill operation, continuing a policy initiated in 1988. Due to this years's unusually large snowpack, weather forecasts associated with El Nino, and hydrologic predictions from historical streamflow analyses, a capture rate of 12% of inflow was established which began when refill started on March 20th when the reservoir level was at 1077.3 ft and reached its conservation pool level of 1141.0 ft on May 26. This year refill continued to 1147.0 ft to capture additional water to augment streamflows to improve juvenile rearing conditions and adult spawning conditions in early summer periods. The pool was held above 1141.0 ft until July 23 (a total of 58 days). No significant habitat impact was observed from holding the pool above the conservation level for such an extended period of time. During the Chinook spawning period the Corps captured a percentage of inflow in order to mimic the natural flows regime.

**b. MUD MOUNTAIN DAM** Mud Mountain Dam, at mile 29.7 on the White River, is a single-purpose, flood control project that is normally empty except during flood control operation, project maintenance, and occasional special regulation for downstream needs. The year's operation is graphically shown on Chart 52.

Water year precipitation was 112% of normal due to the climatic impact of a moderately strong La Nina. There were three incidences that required the regulations for flood control, two in November and one in December. The project pool started the year at 918.3 ft and reached a maximum level of 1073 ft on December 31, which is below the spillway crest of 1,215 ft. The maximum flow at the Puyallup gage control point was 21,990 cfs, slightly above the zero damage of approximately 20,000 cfs.

Special regulation of the project occurred on two occasions, both of which were to allow Puget Sound Energy to safely reconstruct their flashboard diversion structure downstream of Mud Mountain Dam. These regulations caused incidental short-term reservoir storage and streamflow fluctuations.

**c. WYNOOCHEE DAM** Wynoochee Dam, at river mile 51.8 on the Wynoochee River, provides flood control for the Wynoochee Valley, water supply for the City of Aberdeen's diversion at river mile 8.1, fishery enhancement, recreation, and irrigation benefits. On July 26, 1995, the project was transferred from the City of Aberdeen to the City of Tacoma. However, the Corps' role in the flood control operation of the project remains unchanged while Tacoma is responsible for all non-flood reservoir regulation duties. The year's operation was generally according to flood control regulations and is graphically shown on Chart 53.

The project began the year with a pool level of 753.6 ft, which is 22.5 ft below the flood control pool elevation of 776.1 ft. There were six flood events that caused the Corps to assume control of the project. The most significant was the storm event on November 16 which was a 100-year rain event with 21.57 inches in four days. The observed peak flow for the Wynoochee River near Black Creek gage, the control point, was 17,092 cfs on December 28,under the zero damage flow of approximately 18,000 cfs.

Refill of the lake to its summer conservation pool level of 800 ft began March 12 with the maximum elevation for the year of 799.84 ft on July 12.

**c. LAKE WASHINGTON SHIP CANAL & HIRAM M. CHITTENDEN LOCKS PROJECT** The Chittenden Locks project controls the level of both Lake Union and Lake Washington, and provides a navigation channel between these fresh water lakes and the saltwater Puget Sound. Project facilities include a large and small navigation locks, spillway gates, fish ladder, smolt slide, saltwater drain, and a special saltwater barrier at the upstream end of the large lock. The saltwater drain and barrier are designed to reduce and control saltwater intrusion into the fresh water lakes.

Lake Washington was operated within the normal 20.0 to 22.0 ft operating range the entire water year, beginning the year with the lake at 20.45 ft and gradually drafting to 20.0 ft by December 1 to provide shoreline protection against wind and wave action.

Special regulation occurred on several occasions including de-watered the large lock for general maintenance from November 23 to December 7. The smolt slide was in operation from early April to September 3. The fish ladder was closed from May 24 to 29 for general maintenance. From September 3 to 25 the locks performed a variety of operational changes to determine their effects on upstream salmon habitat.

Lake Washington reached the normal conservation pool of 21.85 ft on May 1, and continued to fill to 21.99 ft on June 26. Involuntary drawdown of the lake began on July 10, and as normal, the lake continued to draft to 20.75 ft on September 30.

**e. ROSS PROJECT** Ross Dam, at mile 105.2 on the Skagit River, is owned and operated by the City of Seattle, Department of Lighting (Seattle City Light). The FERC license for the dam states that evacuation of flood control storage must begin by October 1 and be completed by December 1 to provide storage of 120 kaf above 1592.1 ft. The storage space must remain available until at least March 15 of the following calendar year. The FERC license also gives the Corps limited authority to specify project regulation during a flood emergency. During a flood event, when the unregulated or natural flow in the Skagit River near the town of Concrete is forecast to exceed the major damage level of 90.0 kcfs, the Corps can specify operation of the project. Under this flood control operation, Seattle City Light is permitted to release full powerhouse capacity from Ross Dam provided the flow is regulated by the two downstream projects, Diablo and Gorge, to a maximum outflow of 5,000 cfs. The year's operation was generally according to flood control regulations and is graphically shown on Chart 54.

The pool began the water year at 1590 ft and by the end of the drawdown period on December 1 it was at 1573.0 ft, well below the flood control rule curve of 1592.1 ft, remaining below the curve the rest of the water year. None of the storms that moved through the Skagit River basin raised flood concerns and consequently at no time during the year did the Corps specify project regulation.

**f. UPPER BAKER PROJECT** Upper Baker Dam is located at mile 9.3 on the Baker River, a tributary of the Skagit River. The FERC license for this two dam hydroelectric project, owned and operated by Puget Sound Energy (PSE), requires Upper Baker Dam to provide 16 kaf of flood control storage space by November 1 for replacement of natural valley storage eliminated by the project. An additional 58 kaf of flood control storage must be provided by November 15 in accordance with congressional legislation and an agreement between PSE and the Federal Government for reimbursement of power losses due to operation of the additional storage for flood control. When necessary, flood control storage is managed by the Corps from November 1 through March 1each year. As with Ross Dam, the Corps can specify operation of Upper Baker Dam when the unregulated or natural flow in the Skagit River near the town of Concrete is forecast to exceed 90.0 kcfs. Under flood control operation, PSE is required to maintain a release of 5.0 kcfs from Upper Baker Dam. The year's operation was generally according to flood control regulations and is graphically shown on Chart 55.

At the beginning of the water year the pool was at 706.5 ft, which is below the November 15 target flood control level of 707.8 ft. On November 11, a fish barge got stuck in the spillway of Lower Baker Dam. To remove the barge, Upper Baker reduced outflows causing pool to temporarily rise above the flood control pool (707.8 ft). The pool dropped below the flood control pool on November 23 and remained below the curve for the remainder of the water year, because winter storms did not raise flood concerns.

**g. MOSSYROCK & MAYFIELD DAMS** Mossyrock and Mayfield dams are tandem projects on the Cowlitz River that are owned and operated by Tacoma City Light for hydroelectric power generation and flood control. Their FERC license gives the Corps limited authority to specify project regulation during a flood emergency. The flood control plan for Mossyrock is to provide a maximum of 360 kaf of flood control storage between 778.5-745.5 ft during December and January, with a gradual drawdown from full pool beginning October 1 and gradual refilling to full pool between February 1 and June 1. Storage space of 21 kaf assigned to Mayfield may be substituted at any time for an equal amount in Mossyrock. The year's operation was generally according to flood control regulations and is graphically shown on Chart 56.

The project was operated according to the authorized flood control rule curves during the flood season. The pool level was held between 10 ft and 25 ft below the rule curves between November and May. The most significant flood control operation occurred during November 1-5 when the inflow peaked at 45,000 cfs and the pool rose to 765.5 ft on November 5. The pool was then drafted back to below its flood control rule curve where it remained until spring refill began.

**h. SEDIMENT RETENTION STRUCTURE** The Sediment Retention Structure (SRS) is a Corps project on the North Fork Toutle River in southwestern Washington designed to trap Mount St. Helens volcanic sediment by slowing the river flow. The dam was designed with six rows of outlet pipes which allow the water to pass through the SRS and into the outlet channel. The rows of outlets are successively blocked and closed as the sediment deposited in the pool continues to increase.

The uppermost and final tier of outlet conduits, designed to pass inflow as the "pool" filled with sediment, were closed on April 21, 1998. In its nine years of operation nearly 70 million cubic yards (mcy) of volcanic sediment accumulated behind the Structure. The Toutle River now flows over the spillway as sediment continues to accumulate, to a maximum of 284 mcy, behind the 184-ft high structure. Other conduit-tiers were closed in 1991, 1993, 1994, 1995, and 1997.

**38. Oregon Coastal Projects**

Out of the 11 dams in the Rogue River Basin of southwestern Oregon, two are operated by the Corps, seven by Reclamation, and two by a private utility. Only the Corps projects, one of the Reclamation projects, and a county owned project are operated for flood control. The Corps reservoirs, Lost Creek and Applegate, with a combined active storage of 390 kaf, are operated for flood control, irrigation, fish and wildlife enhancement, municipal and industrial water supply, water quality, recreation and power (at Lost Creek only). Elk Creek Dam is a partially completed Corps project on Elk Creek, a tributary to the Rogue, five miles below Lost Creek. Reclamation's Emigrant Lake has 39 kaf of storage and is operated for flood control, irrigation, and recreation. Galesville Dam is owned by the Douglas County. The latter two projects are operated under Corps direction, when needed, for flood control.

**a. WILLIAM L. JESS DAM AND INTAKE (LOST CREEK LAKE AND DAM).** The lake level at the beginning of the year was being held at constant to meet the fishery goal of no augmentation from September 20 until the end of October (Chart 29).

November 1 is the beginning of the flood control season where the pool level is operated to 1,812 ft. The largest storm of the year occurred Thanksgiving Holiday week. Daily mean inflow nearly reached 8,000 cfs. Dam discharge was limited to a daily mean flow of 7,000 cfs. Though this flow posed no flood threat, the fishery agency representatives complained that more attenuation of the early season peak flow was not attempted. The by fishery Agency representatives believe that early season flows of this magnitude scour redds, negatively affecting salmonid egg and fry survival. There was another strong storm in the first week of December, then again after Christmas. Refill began in January and the process was helped along by a mid month storm. The snow pack continued to build and runoff stayed high. Another strong storm at the end of February along with a large snow pack forced a recognition that the potential for large snowmelt/runoff in the spring. It was decided to discontinue filling the reservoir in anticipation of the snowmelt/runoff event. Filling resumed on April 1 with the reservoir elevation about 15 ft below the Water Control Diagram. On April 1 it was reported by the NRCS that the heaviest snow core in 50 years had been measured at Crater Lake National Park headquarters. The snow pack did not melt as rapidly as prior experience indicated however there was less than normal rainfall and cloudy, cool weather remained through the Spring. In mid-May it was decided to again terminate filling because of the potential far warm Spring rainstorms on the remaining snow pack to cause late season high water. This judgement was confirmed at the annual public meetings for presentation of the summer water management plan. During the last of May it became apparent that the main snowmelt had occurred. It was decided to complete filling of the reservoir by June 20. The pool rose to highest level of elevation 1,870.2 ft on June 21when flow augmentation began. The water management plan called for a proportional drawdown of the reservoir until mid-August when fishery flows are specified in the range of 2,200 cfs until mid-September. Flows were reduced to pass inflow by September10 according to the water management plan. The elevation of the reservoir was at the flood control flow goal of no flow augmentation through the end of October. The water year was nearly 130% of normal; however, natural flows were only about 1,000 cfs distressing the jet boat tour operators. This natural flow of 1,000 cfs has an exceedence of 70% (*i.e.*, lower than normal). Flow was increased to 1,200 cfs until September 20. Coincidental to

increasing the discharge there was increased loads of dead water weeds loading up diversion intake screens as well as some of the highest measurements of *geosmin* in the water withdrawn for municipal water supply. The *geosmin* is what gives water its musty, dank, .river smell and flavor. There was a dramatic increase in taste and odor complaints received by Medford Water Commission by consumers. Lesson learned, wetter than normal winter and water year does not guarantee higher than normal base flow. Discharge water temperatures were lower than the target temperatures specified by the fishery Agencies for a number of reasons; Spring temperature targets have been raised to skim the warm surface temperature to preserve as much cooler water as possible for use during the fall. Spring was cloudier and cooler than normal, special reservoir operation for the record snow pack made the warm water layer inaccessible to the withdrawal ports. Temperatures were achieved only in the first half of July and from mid-August through the remainder of the water year. There was a special training session in July for the operations staff on the operation of the water temperature control (WTC) ports to include the ability to operate at partial port openings. Position indication equipment has been added to the WTC port bulkheads.

**b. APPLEGATE DAM.** The pool fell below the flood control level of 1,889.0 ft on November 1. The requested minimum fishery flow of 230 cfs was exceeded. The pool fell to 1,885.0 ft by mid-month by maintaining fishery flows during the low flow period. First fall storms caused an increase in the inflow and the pool elevation rose to the minimum flood control elevation by mid-month. The inflow rose to over 4,500 cfs then at the end of the month the largest flow of the winter came to over 7,200 cfs. Storms subsided until a single storm event in the last half of January. Reservoir filling began in February as scheduled. In February there were three storms then on March 1 there was another storm. These series of storms produced one of the largest snow packs in the records. It was decided to delay further filling for two weeks. An aerial reconnaissance was made of the Rogue Basin in April. Filling remained 10-15 ft behind schedule because of the flood threat posed by a record snow pack. Filling was once again halted in mid-May when the snow melt runoff increased the inflow. The snowmelt/runoff reached a peak flow of more than 2,000 cfs. When the snowmelt/runoff declined filling was resumed. Full pool at elevation 1,987.0 ft was reached on the June 15. Flow augmentation began on June 26 to maintain 500 cfs through the end of June. The third priority fishery goal is to maintain a steady summer low. Based on the forecast runoff it was decided to maintain a discharge of 400 cfs. On July 1 the discharge was reduced to 400 cfs. On September 20 the discharge was reduced slightly to 350 cfs which remained at that level until the end of the water year. Discharge temperatures were generally less than the target temperature because Spring weather was cloudy and cool but also the delayed filling placed the surface warm water layer out of reach of the water temperature control ports. Finally target temperatures were reached in the last third of June. Because of the flow augmentation schedule the lake level placed the warm water layer out of reach of the water temperature control (WTC) ports which resulted in an early cooling of the discharge. There was a special training session in July for the operations staff on the operation of the water temperature control ports to include the ability to operate more than one port per wetwell.

**c. ELK CREEK DAM.** The storage area behind the partially-completed Elk Creek Dam is dry except for involuntary storage during high water periods.

**d. GALESVILLE DAM.** The lake was operated according to its rule curve and its operations were in compliance with flood control regulations. The lake filled to the flood control curve in April. The year's operation is graphically shown on Chart 86.

The lake was operated according to the authorized water control diagram by filling between February 1 and May 1, in accordance with its flood control curves. No major storms occurred during the water year.

**e. EMIGRANT DAM**. The lake was operated by Reclamation in accordance with the authorized rule curve as graphically shown on Chart 87.

The lake was filled between January 1 and May 1, in accordance with the project rule curve. The maximum lake level for the year was 2226.7 ft, (maximum conservation pool level is 2241.0 ft and full pool is 2251.3 ft) and the maximum outflow for the year was 656 cfs.