III. RESERVOIR REGULATION

The reservoir system in the Northwest is made up of Federal, municipal, public, and privately owned dams. Regardless of ownership major hydroelectric 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. This and some of the other agreements that affect project operation are 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 in downstream order and chronologically from the beginning of the operational year.

The members of the coordinated system of reservoirs are listed 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, 1996 through September 30, 1997, 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 other Section 7 projects, and Charts 89-92 are summary hydrographs for the four key stations. Table **19** 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 99.5% of storage capacity on July 31, 1996. As a result, first year firm energy load carrying capability (FELCC) was adopted for the 1997-98 operating year. Because of persistent high flows, the system generally operated to Operating Rule Curves (ORC) or flood control for the entire year. The system storage energy reached 99.1% of full on Jule 31, 1997, and the system adopted the first-year FELCC for the 1997-98 PNCA (Pacific Northwest Coordinating Agreement) Final Regulation study.

The January 1, 1997 water supply forecast was for The Dalles was 138.0 maf for the January-July period, or 130% of normal. Subsequent forecasts through April reflected an increasing trend, with the April forecast being 141% of normal. During April through July, above normal precipitation turned the forecasts upward with the June showing runoff forecast volumes of 159.0 maf, 150% of normal.

In April, the system was on the Energy Content Curve, with Grand Coulee, Libby, Hungry Horse, and Dworshak at or above their April 15 flood control elevations. During the April 7 - August 31 flow augmentation period, these projects were used to augment flows at Lower Granite and McNary. In accordance with the National Marine Fisheries Service's Biological Opinion, these projects were regulated in an attempt to meet Lower Granite suggested target flows that are listed in Chapter IV, Section G.

Daily flood control regulations were required during January at Libby, Grand Coulee, Dworshak and the Snake River projects. This year's observed peak flow at The Dalles was 570.7 kcfs on June 17 with a corresponding unregulated peak of 896.0 kcfs on June 15. The observed winter peak flow at The Dalles was 321.5 kcfs on January 5 with a corresponding unregulated peak of 398.0 kcfs on January 3. Last year's observed peak was 462.2 kcfs. The system reached 47% of its full energy capacity in the Actual Energy Regulation (AER) on July 31, 1997, resulting in first-year FELCC being adopted for the 1997-98 operating year. The observed refill was near 90% of capacity, providing some reservoir operating storage above the proportional draft level going into the new operating year.

Table 19

MONTHLY OBSERVED RESERVOIR ELEVATIONS AND RULE CURVES

	1996						1997						
PROJECT	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MA	APR 15	APR 30	MAY	JUN	JUL
MICA													
OBS	2475.4	2471.3	2462.1	2443.3	2427.3	2410.5	2402.5	2390.7	2384.2	2383.7	2406.4	2406.4	2448.1
MRC	2469.8	2469.8	2467.9	2467.9	2467.9	2466.0	2464.3	2462.4	2462.4	2462.4	2465.9	2467.3	2469.8
BECC	2469.8	2469.8	2469.7	2467.0	2460.1	2452.6	2442.7	2431.7	2426.1	2421.1	2425.3	2449.5	2469.8
CRC1	2469.8	2469.8	2459.8	2443.6	2427.0	2408.8	2396.5	2386.3	2382.3	2379.2	2387.4	2414.9	2444.0
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	2455.9	2459.2	2457.7	2451.5	2438.8	2426.7	2409.9	2393.8	2393.8	2393.8	2393.8	2393.8	2415.2
ARROW													
OBS	1437.6	1428.4	1421.9	1422.1	1418.1	1407.7	1343.8	1389.5	1393.7	1397.6	1419.8	1419.8	1437.5
MRC	1444.0	1444.0	1442.1	1442.1	1436.2	1434.1	1432.1	1429.8	1430.2	1431.0	1439.2	1444.0	1444.0
BECC	1441.1	1435.9	1431.5	1422.8	1421.6	1398.0	1390.1	1402.3	1403.2	1406.2	1418.7	1436.8	1444.0
CRC1	1441.1	1435.9	1431.5	1422.8	1421.6	1398.0	1384.2	1384.4	1387.6	1390.4	1401.4	1430.1	1442.1
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	1438.4	1437.6	1436.7	1428.6	1419.2	1407.4	1391.5	1381.4	1377.9	1378.7	1378.7	1390.1	1408.8
DUNCAN													
OBS	1892.1	1883.7	1880.6	1872.6	1857.4	1837.5	1808.9	1797.6	1799.9	1796.8	1834.5	1834.5	1879.7
MRC	1892.0	1892.0	1892.0	1892.0	1868.6	1853.0	1838.0	1838.0	1839.2	1841.3	1854.4	1873.7	1892.0
BECC	1890.8	1887.6	1877.5	1867.5	1852.2	1842.2	1835.8	1836.5	1837.7	1837.7	1854.7	1876.7	1892.0
CRC1	1890.8	1887.6	1877.5	1867.5	1852.2	1842.2	1814.2	1806.7	1796.5	1795.0	1818.8	1853.5	1876.4
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	1833.7	1843.4	1852.0	1856.0	1840.3	1829.0	1823.1	1806.8	1807.0	1796.9	1795.2	1823.2	1853.8
LIBBY													
OBS	2452.3	2448.7	2439.3	2425.2	2402.1	2370.3	2339.3	2339.7	2337.7	2343.8	2399.5	2442.1	2453.3
MRC	2459.0	2459.0	2459.0	2448.0	2411.0	2419.5	2427.9	2432.1	2433.1	2435.0	2443.9	2459.0	2459.0
BECC	2439.0	2432.4	2430.9	2428.4	2411.0	2406.9	2403.6	2400.5	2399.6	2399.5	2424.2	2449.9	2459.0
CRC1	2439.0	2432.4	2430.9	2428.4	2411.0	2406.9	2403.6	2400.3	2399.1	2397.2	2413.3	2416.0	2427.9
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	2442.4	2439.6	2428.6	2427.1	2412.4	2365.4	2330.9	2324.9	2316.4	2308.6	2301.2	2346.1	2375.9
HUNGRY HORSE													
OBS	3543.2	3537.7	3531.9	3528.4	3511.1	3488.8	3468.2	3449.1	3434.5	3442.0	3516.7	3553.4	3559.8
MRC	3560.0	3560.0	3555.7	3555.7	3555.7	3547.6	3540.0	3531.0	3526.7	3522.3	3544.1	3560.0	3560.0
BECC	3540.1	3535.1	3529.1	3522.7	3515.5	3507.3	3501.1	3498.2	3502.2	3508.2	3542.8	3556.9	3560.0
CRC1	3540.1	3535.1	3529.1	3522.7	3515.5	3507.3	3499.8	3491.0	3488.6	3494.0	3529.6	3552.7	3558.3
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	3470.6	3456.7	3429.2	3424.2	3419.0	3402.4	3390.2	3381.2	3358.1	3367.9	3358.1	3436.1	3449.8
KERR													
OBS	2892.8	2892.3	2891.9	2888.9	2887.6	2887.5	2885.9	2885.4	2885.7	2887.1	2891.5	2891.5	2892.8
MRC	2893.0	2893.0	2893.0	2893.0	2893.0	2893.0	2893.0	2893.0	2883.0	2890.0	2890.0	2893.0	2893.0
BECC	2893.0	2892.5	2892.8	2891.2	2888.1	2885.3	2883.5	2883.0	2883.0	2883.1	2890.0	2893.0	2893.0
CRC1	2893.0	2892.5	2892.8	2891.2	2888.1	2885.3	2883.5	2883.0	2883.0	2883.1	2890.0	2893.0	2893.0
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	2893.0	2893.0	2893.0	2891.9	2890.9	2889.6	2887.2	2885.0	2883.7	2883.3	2884.6	2890.0	2893.0
ALBENI FALLS													
OBS	2062.2	2060.2	2055.4	2055.3	2055.6	2055.6	2056.0	2055.3	2055.3	2057.6	2064.8	2061.8	2062.4
MRC	2062.5	2062.5	2060.0	2056.0	2056.0	2060.0	2060.0	2056.0	2056.0	2056.0	2062.5	2062.5	2062.5
BECC	2062.5	2060.0	2055.0	2055.0	2055.0	2055.0	2055.0	2055.0	2055.5	2056.0	2057.0	2062.5	2062.5
CRC1	2062.5	2060.0	2055.0	2055.0	2055.0	2055.0	2055.0	2055.0	2055.5	2056.0	2057.0	2062.5	2062.5
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	2062.0	2062.0	2060.0	2054.0	2051.0	2051.0	2051.0	2051.0	2051.0	2051.0	2054.0	2057.0	2062.0
GRAND COULEE													
OBS	1280.3	1281.7	1284.7	1284.8	1274.2	1263.0	1243.2	1288.7	1219.6	1210.9	1251.7	1284.1	1287.5
MRC	1290.0	1290.0	1290.0	1290.0	1290.0	1290.0	1288.7	1282.2	1281.0	1281.0	1288.2	1290.0	1290.0
BECC	1280.1	1285.0	1287.2	1286.0	1281.0	1287.4	1290.0	1283.1	1277.9	1280.1	1280.1	1280.1	1290.0
CRC1	1280.1	1285.0	1287.2	1286.0	1281.0	1287.4	1290.0	1283.1	1277.9	1280.1	1280.1	1280.1	1280.1
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	1288.1	1288.1	1288.1	1288.1	1290.0	1287.2	1283.6	1270.8	1247.2	1248.6	1248.1	1255.0	1285.2
DWORSHAK													
OBS	1535.6	1519.5	1520.0	1523.2	1531.4	1519.4	1488.6	1466.4	1448.2	1455.2	1556.6	1598.6	1563.7
MRC	1600.0	1587.7	1581.9	1568.9	1558.2	1555.5	1558.2	1570.2	1581.2	1571.3	1592.9	1600.0	1600.0
BECC	1517.8	1515.3	1512.1	1508.7	1506.6	1502.4	1499.5	1508.6	1530.3	1545.5	1591.4	1599.8	1600.0
CRC1	1517.8	1515.3	1512.1	1508.7	1506.6	1502.4	1499.5	1502.2	1511.3	1520.1	1541.0	1530.7	1520.1
CRC2	There is no CRC2 because the 1995-96 Final Regulation was a one year critical period.												
CRC3	1563.7	1563.1	1562.4	1563.3	1565.3	1558.2	1559.8	1562.2	1576.7	1589.0	1582.8	1586.5	1596.1

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 is 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 Charts 5 and 57.

The Mica reservoir (Kinbasket Lake) surface elevation on July 31, 1996 was 2470.4 ft, 4.6 ft below full pool level. The reservoir continued to fill in August, reaching its peak elevation for the year, 2475.4 ft, on September 1 and remained above 2460.0 ft until early November. Mica Treaty storage, expressed in volume and not reservoir level, was 6.657 maf (3356 ksfd or 95% of full) on July 31, 1996. Mica Treaty storage continued to refill during August, reaching a maximum of 7.00 maf (3529 ksfd or 100% of full) on August 12. Actual Mica discharges were fairly high throughout the summer, and the Mica Treaty flex reached 829 kaf (418 ksfd) on August 31. Mica powerhouse discharges during November and December averaged about 37 kcfs and 29 kcfs, respectively, as the reservoir drafted to 2427.2 ft by December 31 at which time Treaty storage was 4.25 maf (2142.7 ksfd).

In January, the inflows decreased to 1.0 kcfs or less and then gradually increased between February and mid-April before the start of spring freshet, Non-Treaty Storage reached 75% of the full amount. Mica powerhouse discharges for January averaged around 26.4 kcfs which continued to decrease over the winter season. The reservoir drafted to 2401.1 ft by February 28, with Treaty Storage at 2.00 maf (1007.1 ksfd) and Mica Treaty flex at 647 kaf (326 ksfd) on that date. The BC Hydro NTSA (non-Treaty storage allocation) remained unchanged at 1688 kaf (851 ksfd) in February and March. Mica Reservoir continued to draft during March and April, reaching its lowest level for the year at 2383.6 ft on April 25, which was 21 ft lower than the previous year's low. Mica Treaty Storage reached a minimum of 0.11 maf (or 56 ksfd), on April 30 with Mica flex storage reaching 50 kaf (25 ksfd).

Powerhouse discharge in April was about 15 kcfs, dropping to an average of about 3 to 3.5 kcfs in May and June when the corresponding plant generation was less than 10% of plant capacity. With the start of the spring freshet in early May, Mica discharges were reduced and the reservoir refilled quickly. At the end of May, the Mica Treaty flex storage had been increased to 165 maf (83 ksfd). Treaty discharge was 10 kcfs for May and June, allowing Treaty storage to refill to 6.62 maf (3336.9 ksfd or 94% of full) by July 31. Local inflows were the highest in June and July averaging about 66 kcfs and 59 kcfs respectively. Actual Mica discharges during July averaged 20 kcfs, resulting in the Mica Treaty flex storage of 59 kaf (29 ksfd) by the end of July as the reservoir refilled to 2471.1 ft. The powerhouse discharge increased to 21 kcfs with plant generation at about 45% of plant capacity in July.

The reservoir level remained within a foot of full pool between August 8 and 19 before receding. Treaty storage reached its maximum allowed volume at 7.00 maf (3529 ksfd) on August 12. The inflows decreased to less than 30 kcfs by mid-September.

The peak daily inflow was 95.44 kcfs on June 17, with a corresponding outflow of 3.5 kcfs, the maximum daily outflow was 38.79 kcfs on July 24.

2. Revelstoke Project

The Revelstoke project, located 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 4.8 ft of its normal full pool level of 1880.0 ft. During the spring freshet, June through August, the reservoir level was operated as low as 1875.4 ft to allow control of high local inflows.

3. Keenleyside Project (Arrow Reservoir)

Keenleyside Dam was constructed as part of the Columbia River Treaty between the United States and Canada and is owned and operated by BC Hydro for flood control and downstream power generation; it has no on-site hydropower facilities. The reservoir controlled by Keenleyside Dam consists of two tandem natural lakes, Upper and Lower Arrow Lakes, on the Columbia River in southeastern British Columbia. During normal operation, the land area between the lakes is flooded, creating a single lake. This year's operation is graphically shown on Charts 7 and 58.

Arrow Lakes reached a maximum level on July 10, 1996, 1442.6 ft and then drafted slightly to 1442.4 ft by July 3 at which time the Arrow Treaty storage account was full at 7.10 maf. Then it was drafted slowly to

1428.4 ft by the end of September followed by discharges averaging 55 kcfs in October, 50 kcfs in November, and 45 kcfs in December, drafting the reservoir to 1418.1 ft by December 31, when the Arrow Treaty storage at 4.9 maf (2447 ksfd, or 68% of full).

In early January, BC Hydro requested that Arrow outflows be selectively reduced below Treaty requests to keep river levels at acceptable and maintainable levels during whitefish spawning and later emergence. BPA agreed to this under terms of the Non-Power Uses Agreement and so the treaty requests were reduced with a total of 400 kaf (202 ksfd) held back. This storage was later returned and the Canadian Treaty Storage returned to the Treaty Storage Regulation (TSR) levels. Arrow Lakes continued to draft during the January-March period when the local inflows ranged between 5.0 to 5.8 kcfs.

Arrow Reservoir reached its lowest level for the year, 1389.5 ft, on March 31, at the same time Arrow Treaty Storage reached its minimum at 0.78 maf (392 ksfd or 11% of full). During April, Arrow discharge was kept between 15-20 kcfs in an attempt to insure that rainbow trout would not spawn high on the river banks that might be out of the water if river flows decrease. Several trout redds, which were de-watered, were kept wetted for a limited time using a pump and sprinkler system. From April through June, Arrow was operated under the terms of two Operating Committee agreements: ***Operation of Treaty Storage for Enhancement of Whitefish Spawning for January 1 through April 30, 1997***, and ***Operation of Treaty Storage for Enhancement of Trout Spawning for March 1 through July 31, 1997***. These agreements allowed the Arrow project flows to be maintained and avoid dewatering rainbow trout redds. With the low discharge throughout April and most of May, and start of spring freshet in mid-May when high inflows occurred, the Arrow Reservoir level rose to 1397.6 ft by April 30 and to 1419.8 ft by May 31 and continued to fill in June due to higher inflows. With the start of the spring freshet, increasing discharges from the Kootenay River created a backwater effect on the Norns Creek Fan, a prime spawning location for rainbow trout. Discharge from Arrow was held at 20 kcfs for the first three weeks of May and gradually increased throughout June, raising the pool to 1437.4 ft by June 30. Except for a few days near the end of June, Arrow Lake slightly exceeded the Treaty flood control curve levels during June and early July.

Arrow discharge was increased substantially in July as Arrow Treaty Storage neared full and the reservoir reached its highest level for the year, 1444.1 ft on July 31, slightly above full pool elevation of 1444.0 ft. The Arrow discharge peaked for the summer at 94.6 kcfs on July 17 and the Arrow Treaty storage content continued to fill and reached full (7.1 maf) on July 31. With the increased project discharges in late July and August, Arrow Lakes drafted to approximately 1439.0 ft by the end of August. To minimize spill at the Canadian Kootenay River plants and maintain Lake Koocanusa (Libby Reservoir) water levels in Canada for resident fish and recreation, the Canadian and US Entities agreed to a Libby-Arrow water transfer (swap) for late summer. Under the agreement, Libby release was reduced by a total of 377 kaf (190 ksfd) through August and instead, an equal amount of water was released from Arrow. This water, effectively stored in Libby, will be returned to Arrow in the October to December period as part of the agreement.

The peak daily inflow was 121.5 kcfs on July 9, with a corresponding outflow of 60.0 kcfs while the unregulated peak inflow was 214.5 kcfs on May 31 and the maximum daily outflow was 94.6 kcfs on July 18.

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 from the dam near 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 Charts 8 and 59.

Lake Koocanusa started the operating year full, at 2459.0 ft, 2.4 higher than last year. The first 12 days of August saw Libby releasing 24 kcfs which was then reduced to 12-14 kcfs for the remainder of the month because of high water difficulties near Bonners Ferry. Libby did not release its full BiOp volume allocation due to the Arrow Libby swap of nearly 377 kaf (190 ksfd), which was delivered from Arrow Lakes instead. September outflows were 8-12 kcfs for an on-going Montana Fish, Wildlife & Parks fishery study. The observed pool level on September 30 was 2448.7 ft, while the assured energy refill (AER) level was 2432.3 ft. During October, Libby was used for weekly load shaping: weekend (Thursdays through Sundays) flows were 8 kcfs and the weekday flows were 14.5 kcfs. By October 21 weekly load following stopped and the project released 14.5 kcfs for nearly the rest of the month drafting the reservoir nine feet to 2439.26 ft on October 31. Libby operated for power, fish monitoring studies, and flood control in November and was drafted about 14 feet and then maintained full load (20 kcfs on four units, one unit was out of service due to a forced outage) for the whole month of December. The exception was for four days over the Christmas holiday when power loads were down and a fish monitoring study was conducted requiring 4 kcfs. The project was drafted to 2402.13 ft by the end of

December, which is 8.87 ft below the Upper Rule Curve, to try to eliminate possible spill in January to get down to anticipated low flood control elevations.

On January 1 and February 1, the runoff volume forecasts required the project was operated for flood control by using all four available units at their maximum capacity for both months. On March 1 the runoff volume forecast was reduced so outflows in March were reduced from 18 kcfs to 7 kcfs weekly average. Between March 17-21 and April 1-10, flat flows of 4.0 kcfs and 6.0 kcfs, respectively, were maintained to meet flood control/refill needs as well as accommodate the State of Idaho's request to facilitate rainbow trout spawning. Project releases in April and May of 8.7 kcfs and 13 kcfs, respectively, considered flood control needs as well as temporary refill to provide higher flows for both sturgeon in June and salmon in August.

The US Fish and Wildlife Service requested three flow pulsing operations, up to full powerhouse capacity, to enhance sturgeon spawning above Bonners Ferry where the hard river bottom is more conducive to sturgeon egg survival. These pulses were requested to take place when the water temperature at Bonners Ferry reached 10°C, 12°C, and 14°C. The first pulse was sent on June 5-19 and the second pulse on June 24-28. The third pulse was not sent due to fear of filling/spilling the reservoir in June. However, heavy June rain caused several "natural pulses" for the sturgeon.

Throughout July the temperature and rainfall remained below normal, resulting in the water supply forecast under estimating the actual runoff. By July 16 the outflow was ramped down to 10 kcfs causing the reservoir to rise to near 2453 ft (6 ft from full) by the end of the month. Libby continued this discharge until the Libby/Arrow swap (see Chapter IV, Section H) was initiated on August 13 when the outflow was increased to 14.5 kcfs with a total of 377 kaf (190 ksfd) swapped (stored in Libby while an equal amount was released from Arrow). The maximum reservoir level reached was 2454.82 ft on August 12 and by the end of August it was 2450.12 ft, less than 10 ft from full. September outflows were weekly shaped for power production: higher flows during the week and lower flows during the weekend. This weekly operation, in lieu of daily shaped flows, was to help improve the general health of the river. The pool on September 30 was 2447.38 ft while the proportional draft point (PDP) level was 2441.3 ft.

The peak daily inflow during the water year was 80.3 kcfs on June 2, with a corresponding outflow of 12.0 kcfs. Maximum daily outflow was 28.0 kcfs on several days in June.

5. <u>Kootenai River at Bonners Ferry</u>

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 1764.4 ft on May 17 while Libby was releasing 4.0 kcfs and the unregulated peak stage would have been 1779.9 ft, well above the 1766.5 ft bankfull stage.

6. <u>Duncan Project</u>

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 Charts 9 and 61.

Duncan Reservoir level was 1882.2 ft (slightly above full) on July 31, 1996 and passed inflow during August; then during September its discharged was increased to an average of 5.5 kcfs to maintain both the Kootenay Lake levels and outflows. Project discharge was reduced to an average of 3.5 kcfs in October and remained at that level for most of November and decreasing to 2 kcfs in first half of December. Higher discharges between mid-December and February were necessary to again support Kootenay Lake levels and flows. Duncan Reservoir was at 1857.4 ft (58% of full) on December 31. These operations contributed to Duncan reservoir levels remaining at or below the flood control curve in this operating year. During January, project discharge increased to about 6 kcfs which continued the reservoir drafting throughout February and into mid-March to meet Kootenay Lake IJC levels. Duncan reservoir exceeded its Treaty flood control curve slightly near the end of February and then continued to draft another 6 ft below the flood control curve between March and May 1. The reservoir reached its lowest level for the year at 1796.6 ft (2.2 ft above empty) on May 1 when project discharge was reduced to minimum, 100 cfs, to begin refilling the reservoir. The reservoir reached 1834.4 ft on May 31 and 1879.7 ft on June 30. Duncan remained on minimum discharge until July 4 when discharge was increased to slow the rate of reservoir refill. Duncan Reservoir reached 1892.0 ft, full pool, on July 15 and exceeded it by 0.1 ft on July 30. Duncan passed inflow during August to maintain the reservoir near full pool and on September 1 discharge was increased to start drafting the reservoir and to fill Kootenay Lake.

The peak daily inflow was 23.8 kcfs on July 8 with a corresponding outflow of 7.0 cfs and the maximum daily outflow was 14.1 kcfs on July 17.

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 operation is graphically shown on Charts 10 and 62.

The level of Kootenay Lake at Queens Bay was 1746.4 ft on July 31, 1996, while the level at Nelson, BC, was below the summer IJC operating level of 1743.32 ft. Discharges were adjusted to pass inflow during August through December then, beginning in January and continuing to mid-March, Kootenay Lake was drafted to avoid violating the IJC order, lowering the lake level to a low of 1739.7 ft on March 19. The lake then started to fill with the local inflows into Kootenay Lake peaking on March 23 at 53.9 kcfs. At this time the discharge was about 26 kcfs causing the lake exceeded the IJC level by up to one foot between March 20 and April 1. This was not a Treaty violation, however because the exceedence was due to extraordinarily high natural inflow conditions which are allowable under the 1938 IJC Order on Kootenay Lake. The outflow from Duncan was reduced to its minimum to lower the Kootenay Lake level to the IJC limit. The lake remained below the IJC levels for the remainder of the water year.

Mainstem inflows to Kootenay Lake increased starting mid-April filling the lake to its peak level for the year, 1752.9 ft, on June 12 where it remained until June 16, before starting to draft. With receding runoff in late June and reduced Libby discharge in July, Kootenay Lake drafted. The Nelson gage dropped below the IJC summer level of 1743.32 ft on August 12 after which lake discharges were adjusted to keep the Nelson gage below the IJC level until the end of August, reaching its lowest level for the year, 1743.6 ft, on September 1. During September, due to late occurrences of heavy rainfall, lake discharges were adjusted to gradually refill the reservoir and on September 30, the lake was at 1744.42 ft.

There was a change this year in methodology for calculating the IJC levels. The past interpretation had been that the regulated inflows (equal to or less than the natural flows) into Kootenay Lake should be used for the calculation of the IJC level. An interpretation on the IJC order was requested from the Board of Control by the US Army Corps of Engineers. The Board ruled that the natural (unregulated) flows are to be used in the calculation.

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. This is the portion of the Grand Coulee inflow contributed by the Columbia and Kootenay rivers. The Flathead/Pend Oreille River enters the Columbia downstream of the Birchbank gage. This year's operation is graphically shown on Chart 63.

The unregulated daily peak flow at Birchbank was 313.96 kcfs on June 18 and the observed peak was 160.24 kcfs on July 16. Thus, the Treaty storage reduced the Columbia discharge well below the 225 kcfs level of discharge for bankfull and flood stage.

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 Charts 11 and 64.

On October 1, 1996, the lake was at 3537.9 ft after its peak of 3560.69 ft on July 31, drafting for downstream fish migration. The reservoir began mandatory drafting in October with a target level (BECC) of 3515.0 ft by January 1. Because of early snow accumulation, reservoir releases were increased to between 6000 cfs and 8000 cfs on December 10 to provide a constant winter drawdown schedule. By April 20 the reservoir had been pre-drafted 130 ft to 3430.51 ft, the May 1 flood control target. At this time releases were reduced for about six weeks to put in place a protective relaying system between the units and new transformers. Due to the high potential for flooding the spillway flashboards were removed. During the refill period releases were not provided through the outlet works so the total dissolved gas standard would not be exceeded. The reservoir inflow increased quickly after May 1 filling the reservoir to its maximum of 3559.82 ft on July 31. Releases were provided for ESA operations during August, following the official TMT weekly forecasts. The reservoir was drafted 20 ft to 3540.00 ft by September 22 and by September 30 the reservoir drafted to 3537.50 ft. A kokanee spawning flow of at least 3500 cfs was provided at Columbia Falls throughout the entire year.

The peak inflow of 41.9 kcfs occurred on May 17 and the maximum outflow was 12.7 kcfs on June 22.

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.

Greater than normal rainfall in June triggered snowmelt which resulted in the year's peak stage of 15.5 ft, or 59.9 kcfs, on May 17 at the time Hungry Horse outflow was 300 cfs. The unregulated peak was 101.6 kcfs on the same day.

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 graphically shown on Charts 12 and 66.

In late October Flathead Lake began a gradual draft from near full pool, which lasted throughout the autumn and winter months, for power production and spring flood control, reaching its minimum level for the year, 2884.81 ft on March 20. Refilling was slow until late April when inflows began increasing rapidly. The heavy rains of mid-May caused concern about overfilling the lake which greatly increased project discharges during late May and part of June.

The observed lake gage at Somers crested at 2893.0 ft on July 11 (unregulated 2895.6 ft on June 7 - a reduction of 2.6 ft), and the project outflow near Polson peaked at 52.2 kcfs on June 15 (unregulated 74.8 kcfs on June 7).

The peak seasonal inflow was 59.9 kcfs on May 16, the unregulated peak inflow was 101.6 kcfs on May 17, and the peak lake level was 2892.99 ft on August 11.

12. Albeni Falls Project (Pend Oreille Lake)

Pend Oreille Lake 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 Pend Oreille Lake 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 Charts 13 and 67.

The annual autumn drawdown of Pend Oreille Lake began immediately after Labor Day, drafting to 2060.0 ft on October 3. The lake continued drafting with discharge averaging 18.9 kcfs in October and 17.3 kcfs in November. This was the second year of a three year fish habitat study to test if cleaner gravels at higher lake levels are more conducive to spawning of kokanee salmon in Lake Pend Oreille. Normally, 2051.0 ft is the minimum winter lake elevation but in this study, the minimum elevation was 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. At the end of October and November, the lake was at 2055.4 ft and 2055.3 ft, respectively. The minimum level, 2055.0 ft, was established for January through March. 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. In April, the project reached 2057.57 ft, which exceeded its maximum flood control rule curve by 1.57 ft. The project continued to fill during the spring runoff in May and June even though on April 21 the project went to free flow (no generation, all spill), which continued through June 24, to get a maximum amount of water out of the lake (the generating units can only operate if there is at least 8 ft of head). Project discharges averaged 42.5 kcfs, 100.7 kcfs, and 116.2 kcfs in April, May, and June, respectively. By June 24 the project had drafted to 2061.96 ft, 0.04 ft below its maximum flood control rule curve. Between June 24 and September 7 the lake was maintained between 2062.0 ft and 2062.5 ft.

The observed lake inflow peaked at 152.7 kcfs (unregulated 170.8 kcfs on May 31), the lake gage at Hope crested at 2065.7 ft on June 4 (unregulated 2068.3 ft on June 8 - a reduction of 2.6 ft), and the project outflow peaked at 138.2 kcfs on June 5 (unregulated 159.4 kcfs on June 8).

13. Grand Coulee Project

Grand Coulee is 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. This year's operation is graphically shown on Charts 14 and 68.

Because of high runoff volume forecasts this winter he operational objective for the Columbia River was to provide enough flood control space and still meet the Biological Opinion (BiOp) flows. The early runoff allowed target flows to be met until late August. Releases were made in July and August to meet Endangered Species Act (ESA) target flow requirements of 260 kcfs for April 20-June 30 and 200 kcfs for July 1-August 31 with Grand Coulee drafting to 1280.0 ft.

On October 1, Grand Coulee Reservoir, Franklin D Roosevelt (FDR) Lake was at 1282.5 ft and was operated above 1270.0 ft through late January. The lake was drafted for flood control to its low for the year at 1208.6 ft on May 4. The reservoir refilled to 1289.9 ft by July 20. FDR continued operations of flow augmentation, normal water budget, and ESA requirements until the end of August. The lowest level reached for operations was 1279.8 ft on August 30. The reservoir filled to 1285.0 ft on September 30 and the maximum daily outflow was 295 kcfs on June 22.

14. <u>Mid-Columbia PUD Projects</u>

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 the 1997 outmigration, including FERC-required spill. These include: during autumn, a coordinated effort was carried out to operate Priest Rapids to encourage fish to spawn at lower levels in the Vernita Bar area; 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 65.0 kcfs.

The unregulated peak flow at Priest Rapids was 599 kcfs on June 6, and the observed peak was 414.9 kcfs on June 12.

15. <u>Yakima Project</u>

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, and recreation. This year's operation is graphically shown on Charts 31 and 32.

Yakima Project flood control operations started in mid-February, with the bypassing of inflow to maintain flood control space from the reservoir system, and continued into early July. The heavy runoff held Yakima River at Parker flows at or above 10.0 kcfs from mid-March to mid-June, but caused no major flooding in the Yakima River System. Yakima Project successfully maintained a balance between the very high runoff forecast, maximum flood control space and maximizing storage in July for irrigation and carryover storage.

The system reached maximum storage for the year on July 6 at 1,068 kaf, and was placed on storage control on July 21. Bumping Reservoir was allowed to surcharge and pass flow over the spillway for instream outflows while repair work was completed on the outlet tunnel and channel. From mid-July until the end of irrigation season the runoff in the Yakima River Basin continued to be above normal. All entitlement water users received a full water supply, but due to the above normal rainfall the water users required only 82% (2.15 maf) of entitlement water to meet their needs. The Project storage on September 30 was 585.0 kaf, 159% of normal.

With the excellent total water supply available, the Yakima Basin was regulated to provide target flows of 600 cfs for Yakima River at Parker, and 600 cfs for Yakima River at Prosser. These flows are required by law in "TITLE XII -- YAKIMA RIVER BASIN WATER ENHANCEMENT PROJECT", Section 1205.

The Yakima reservoirs were operated to enhance both fish spawning conditions during September to mid-October and incubation/rearing conditions from mid-October through March 23. 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 9.6 kaf from Keechelus, 40.4 kaf from Cle Elum, 0.9 kaf from Bumping Lake and 4.5 kaf from Rimrock.

Both fish spawning enhancements,"Mini-Flip-Flop" and "Flip-Flop" operations were executed in the Yakima River 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 for 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 25-29.

The Yakima River to Naches River, "Flip-Flop" operation was executed for the 17th consecutive year. It 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 400 cfs was routed around that reach via the Kittitas Canal. 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, under a 1980 court order, for spring Chinook salmon. The "flip-flop" operation, implemented during the period September 2-10, provided a longer more environmentally friendly ramping down of flow levels in the upper Yakima River.

Spawning flows were set at 60 cfs on the Yakima River near Crystal Springs, 200 cfs on the Yakima River below Easton Dam, and 200 cfs on the Cle Elum River below the reservoir. Due to the high carryover in reservoir storage and well above normal October inflows, which at this time required the bypass of inflows through the reservoir system, incubation/rearing flow levels have not been established at this time.

16. Jackson - Palisades Project

Active storage in the Jackson/Palisades System includes 847 kaf in Jackson Lake and 1.20 maf in Palisades Reservoir, a Section 7 project, for a combined total of 2.047 maf. This system was operated as a multipurpose unit for flood control, irrigation, recreation, fish and wildlife, and power production. Discharge from Jackson Lake is measured on the Snake River at Moran, Wyoming, and discharge from Palisades Reservoir is measured on the Snake River near Irwin, Idaho. This year's operation is shown on Charts 33, 34, 69, and 70.

Flood control releases of 1500 cfs from Jackson Lake Dam began in early February and were gradually increased in mid-March from 1,500 cfs to 3,500 cfs on March 22. This release was held until Jackson Lake Reservoir reached a maximum flood control space of 427.0 kaf on May 5 (27.0 kaf above the maximum space called for by rule curves). In early June, Jackson Lake filled rapidly reaching a maximum content of 874, kaf on June 11 and resulting in the maximum release of 11.7 kcfs on June 12. On June 7 Jackson Lake filled into 1.06 ft of surcharge as outflows were gradually decreased to 7,000 cfs until June 28, when Jackson Lake came out of surcharge. In the Jackson area, flood control levies had to be repaired and reinforced during the peak of the runoff to prevent breaches in the levies.

Flood control releases to make space in Palisades Reservoir began in mid-January, reached 13.0 kcfs on February 28 where they remained until April 8 when they were reduced to 9.0 kcfs. The reduced outflow was required as the reservoir approached empty to prevent the formation of a dangerous vortex near the intake structure. As freshet inflow increased, releases were increased to 17.0 kcfs by May 7. During the rest of May releases were adjusted to keep the Snake River near Shelley at or near flood stage. During the last week in May and the first two weeks in June above normal rainfall added to the rapidly melting snow, raising the Palisades inflow to its peak of 58.5 kcfs. As the reservoir approached its maximum capacity in the second week in June Palisades outflows were increased quickly to its peak for the year of 40,290 cfs on June 20. This was the highest release since closure of Palisades Dam in 1957 and greatly exceeded the previous record of 25.3 kcfs in June 1974. Palisades Reservoir filled on June 13 and by June 20, 0.9 ft of surcharge was used to limit the peak outflow. Widespread flooding occurred downstream of Palisades Dam as the levies breached near the towns of Roberts and Menan, resulting in their evacuation. Damages included water inside of homes, loss of farm crops, some farm land destroyed, and major structural damage to bridges and canal diversion facilities. By July 1 releases were reduced to 22.0 kcfs.

After the above normal runoff in 1996, contents in Jackson Lake and Palisades reservoirs totaled 1,543 kaf on October 1. Storage increased steadily through the first half of the winter until flood control rule curves dictated that flood control space be evacuated. Drafting began on January 10 and freshet storage began on May 6. Maximum system content was 2,079 kaf on June 20 and the September 30 content was 1,746 kaf, 523 kaf above normal.

The unregulated peak flow at the Heise gage was 56.1 kcfs on June 6, and the observed peak flow was 40.3 kcfs on June 20. Flood regulation curves were designed to maintain flows at Heise at or below 20.0 kcfs, and flood stage is 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 peak daily inflow was 2,307 cfs on April 29 and the maximum release was 1,670 cfs on May 8th. The maximum active reservoir content was 83.1 kaf on May

18, 2,537 af into the exclusive flood control space. Storage at the end of the water year was 62.4 kaf, 78% of capacity.

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 1,673,000 af 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 American Falls Dam. The Snake River near Shelley gage, 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 Charts 36 - 38, and 71.

Project releases in the fall gradually decreased throughout October reaching 2.0 kcfs by the end of the month. The release was reduced to 1.0 kcfs on November 13 and remained there until December 4 when outflow was gradually increased, eventually reaching 20.0 kcfs on February 25. Above normal precipitation fell in November, December, and January requiring drafting for flood control space in American Falls Reservoir. Project outflow was maintained at 20.0 kcfs until April 11, which provided 606 kaf of flood control space, then releases were gradually decreased to 14,500 cfs by April 22. Heavy snowmelt runoff from the Henrys Fork during May combined with large releases from Palisades Dam and low irrigation demand caused American Falls Reservoir to fill rapidly, reaching full capacity on June 3 while releasing 24.0 kcfs. Inflows continued to rise as heavy rainfall persisted in the basin, and flood flows were released from Palisades Dam, until American Falls Dam was releasing the maximum mean daily discharge for the year of 46.0 kcfs on June 24, the highest measured flow since 1918. After the flood peak passed, releases were cut rapidly until the second week in July when they equaled normal irrigation deliveries.

Maximum storage at American Falls during the year was 1,705.7 kaf on June 19 while the reservoir contents on September 30 was 956.7 kaf, 434.0 kaf above normal.

19. Little Wood Project

Although it was originally constructed by Little Wood Irrigation District for exclusive irrigation use, the Little Wood Dam and Reservoir, on the Little Wood River in central Idaho, has been designated as a Section 7 project since its enlargement by the Bureau of Reclamation, to an active capacity of 30.0 kaf, is now operated also for flood control. The Little Wood River at Carey streamgage, approximately 3 miles downstream from the dam, is the control point for reservoir operations. This year's operation is graphically shown on Chart 39.

The reservoir filled gradually from mid November in response to heavy rains and was followed by the extraordinarily heavy New Year's Day rainfall that produced the annual peak flow of 1.30 kcfs and raised the pool to 90% of capacity. Flood control space was evacuated following the peak and through the end of February with a discharge of 300 cfs and was maintained in March and most of April by passing inflow. The reservoir started filling from the spring freshet in mid-April, filled by May 30, and remaining full until June 30. Maximum reservoir content was 30,495 af on June 5 and the storage at the end of September was 9,760 af, 3,300 af above normal.

Maximum mean daily springtime inflow was 1,271 cfs on April 21 and peak mean daily discharge at the Carey gage was 916 cfs on June 11.

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 to Weiser. 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 peak mean daily inflow was 31,590 cfs on January 3 and the peak daily outflow was 4,154 cfs on February 7. The spring peak inflow was 9,740 kcfs on March 21. The reservoir reached a maximum content of 722 kaf on May 16 and the storage at the end of September was 432 kaf, 121% of normal.

21. Boise Project

The Boise Project, Arrowrock Division, is a three-reservoir system composed of 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 projects that are upstream. 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 streamgage is the control point for the flood control operation of the system. This year's operation is graphically shown on Charts 41 and 72.

Releases from Anderson Ranch Reservoir were maintained at 600 cfs through October and reduced to the winter minimum release of 300 cfs on November 4 and held at that level until December 26 when they were increased to 600 cfs. In mid January the release was increased to 1,600 cfs and further increased later in the month reaching a total discharge of 3,000 cfs by January 28. The Anderson Ranch release was maintained at 3,000 cfs until mid April when it was reduced to 2,600 cfs and in mid May it was increased to 3,000 cfs and held at that rate until early June. As the reservoir filled the release was gradually increased, reaching a maximum discharge of 5,586 cfs on June 13. The release was subsequently reduced to 1,600 cfs by July 7 and maintained at that rate until August 6 when the release was reduced to 600 cfs, the summer minimum release rate, and was maintained at that rate through the balance of the water year.

The flow of the Boise River below Lucky Peak Reservoir was set at 240 cfs at the end of the irrigation season, and maintained at that level until flood control releases were initiated on December 26. Extremely heavy rains and warm temperatures prevailed in the Boise Basin from mid-December through early January resulting in extremely high runoff on January 1 and 2. The mean daily inflow into the Boise River reservoirs on January 2 exceeded 24,000 cfs with the estimated instantaneous peak inflow of approximately 29,000 cfs. The reservoir system contained the runoff and prevented severe flooding along the Boise River. On January 10 the release from Lucky Peak Reservoir was increased to 6,500 cfs, the flood control target flow and then, due to continued heavy precipitation and record level runoff forecasts, the release was increased to 7,000 cfs, flood stage, on January 31. The flow of the Boise River at Glenwood Bridge was maintained at or near flood stage from then until early May while the maximum release from Lucky Peak Reservoir was 9,766 cfs on April 20. (The difference between Lucky Peak releases and flow at the Glenwood Bridge gaging station is diverted for irrigation, primarily by the New York Canal, upstream of Boise.) The spring freshet peak daily inflow was approximately 22.0 kcfs on May 17, with an outflow of 8.0 kcfs. Flood control releases continued until June 29 when the freshet was over. The flow of the Boise River was maintained at or below flood stage throughout the runoff period and the reservoir system was filled to 99.1% of capacity by early July. Between mid-July and late August 40 kaf was released from Boise River reservoirs for salmon flow augmentation.

Content in the three reservoir system on September 30 was 564 kaf, 134% of normal.

22. <u>Malheur Project</u>

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 8,000 cfs. This year's operation is graphically shown on Charts 43, 44, and 45.

Flood control operations in the Malheur Basin prevented serious flooding during the January 2 flood event. The downstream flow briefly exceeded 8,000 cfs with reports of some minor flooding of low-lying farmland between Vale and Ontario, Oregon. Without the reservoirs, the estimated instantaneous flow would have been in the 16,000 cfs range.

Warm Springs Reservoir reached a maximum storage volume of 188 kaf on May 19 and drafting to 89 kaf by the end of water year. End of year carryover storage in Beulah Reservoir was 23 kaf. Bully Creek Reservoir reached a maximum storage volume of 30 kaf on April 14 and ended the year with carryover storage volume of 11 kaf.

23. <u>Payette Project</u>

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 graphically shown on Charts 42 and 73.

From mid October through early December the release from Cascade Reservoir was maintained at the minimum release rate of 200 cfs, the natural flow water right of the Idaho Power Co powerplant at Cascade Reservoir. On December 5 project releases were increased to 1,000 cfs to draft the reservoir for snowmelt runoff flood control and were generally maintained between 1500 cfs and 3800 cfs until late June. On four occasions these flows were reduced to the minimum of 200 cfs to minimize downstream flows during extremely high runoff periods in early January, early February, in mid April, and in mid May. Severe flooding affected the Payette Basin in early January when daily inflow into

Cascade Reservoir peaked at 11,262 cfs on January 1. The peak flow of the Payette River near Emmett was estimated at about 33,000 cfs on January 2 (flood stage is 16,000 cfs at Emmett) with an unregulated peak flow on January 2 at Emmett of about 45,000 cfs. Water stored upstream at Cascade and Deadwood reservoirs and Payette Lake reduced the flood peak by about 12,000 cfs. No significant flooding occurred in the Payette basin except for the high flows of early January. Cascade Reservoir filled on July 1 and was maintained at full pool through July 11. As the reservoir began to draft in mid-July the release rate was set at 1,500 cfs to provide for delivery of water for irrigation and salmon flow augmentation. Releases gradually decreased after Labor Day, reaching 700 cfs by the end of the water year.

The release from Deadwood Reservoir was maintained at the winter minimum release rate of 50 cfs from the beginning of the water year until early December when flood control releases were initiated, increasing outflows to 100 cfs and subsequently increased to 200 cfs on December 11 but were mostly in the range of 300 to 800 cfs. Flood control releases continued until June 8 when the reservoir filled. As in the case of Cascade Reservoir, the Deadwood release was reduced to the 50 cfs minimum to minimize downstream flow during high runoff periods in early January, early February, and mid April and mid May with the maximum release for flood control evacuation, 1,280 cfs, occurred on February 18. The peak inflow into Deadwood Reservoir was 2,826 cfs on May 17. Subsequent to filling the maximum flow from Deadwood was 1,437 cfs on June 15.

A total of 155 kaf was obligated for release for salmon flow augmentation. About 109 kaf was released from Cascade and Deadwood reservoirs between mid-July and September 2. The remaining 46 kaf is to be released between late November and January 1998. Some of the water released from Cascade Reservoir for this purpose is water conveyed downstream from Payette Lake.

Carryover in Cascade Reservoir on September 30 was 507 kaf, 129% of normal while Deadwood Reservoir carried over 120 kaf, or 200% of normal.

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 Charts 46 and 74.

A major rain on snow event in late December and early January established the peak flow for the year. The computed unregulated peak flow at Weiser was 154.6 kcfs on January 2 and the observed peak was 81.8 kcfs on January 3, which is just shy of the record flow of 83.8 kcfs established in 1952, and third highest since record keeping began in 1910. (Peak flow in 1921 was also slightly higher.) Operation of the Boise, Payette, and Owyhee Projects were responsible for an approximate 50% flow reduction at the Weiser gage during the January flood. The spring freshet peak observed flow was 60.5 kcfs of June 17 and the unregulated peak was 122 kcfs on May 19.

25. Powder Project

Phillips Lake is formed by Mason Dam on the Powder River in eastern Oregon that 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 streamgage, which should be controlled to 500 cfs, if possible. This year's operation is graphically shown on Chart 88.

High flows in early January affected the basin as elsewhere in the region. The peak flow of the Powder River at Baker City was 554 cfs on January 1. Storage of high inflows in Phillips Reservoir substantially reduced downstream flooding as the peak mean daily inflow on January 1 was 1073 cfs with a release rate of only 11 cfs. Releases for snowmelt runoff from Phillips Reservoir were initiated on January 21 and continued through early July. The maximum release for flood control was in the range of 480 to 490 cfs and were maintained from May 17 through June 2.

Phillips Reservoir reached a maximum storage volume of 84.3 kaf on May 21, which was 93% of its total active capacity. The end of the year storage content in the reservoir was 47.1 kaf, 52% of its total active capacity.

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 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 Charts 15 and 75.

Brownlee began the water year at 2045.3 ft after a July-September draft to help meet NMFS target flows for juvenile fish migration at Lower Granite Dam. The lake was then drafted to 2032.5 ft by October 19 to create space in the reservoir so a portion of the inflow could be stored while discharge from Hells Canyon could be maintained near between 9.5 and 12 kcfs to encourage fall chinook salmon to spawn at a low levels in the down-stream channel between late October and December 9. The goal was that the lake be full near the end of the spawning operation. This goal was met, as by December 15 when the pool had filled to 2076.4 ft (2077.0 ft is full pool). The Hells Canyon discharge was then maintained above 12.5 kcfs until fry emergence in the spring. At the request of IPC the Corps, after consultation with NMFS, waived the navigation requirement of maintaining 13 kcfs at Lime Point, near Anatone, through April 15.

(During this period the New Year's peak inflow came at the time of this full pool. This was the peak flow, 81 kcfs for the year and was passed without any storing.)

Based on the forecast at Brownlee and The Dalles the Corps notified IPC that 750 kaf of flood control storage space was required at Brownlee (surface elevation of 1976.0 ft) by April 30. Throughout the forecast period, the flood storage requirement remained at 750 ft and by April 30 the reservoir was drafted to 1982.75 ft. The project continued to draft for flood control to a low of 1976.37 ft on May 2. Increasing inflows from the beginning of the spring runoff refilled Brownlee reservoir to 2076.44 ft on June 28.

The State of Idaho developed a plan (which was approved by the Technical Management Team) to start drafting Brownlee on July 24 to meet the 237 kaf augmentation volume required per the Biological Opinion (See Chapter IV, Section G). The outflow was about 20 kcfs in order to keep Oxbow from spilling (because of unit outage). This outflow was held constant from July 24 to September 14 when Brownlee releases were increased to about 30 kcfs for the last two weeks in September in order to make room for the large amount of upper Snake water that had runoff in the summer and was not used by irrigators. Brownlee was drafted to 2070.5 ft by July 31, to 2051.8 ft by August 31 and 2022.6 ft by September 30.

The regulated peak spring inflow was 63.3 kcfs on June 16 and the unregulated peak inflow was 133.5 kcfs on May 17. Maximum daily outflow was 65.6 kcfs on April 28.

27. Dworshak Project

Dworshak Lake and Dam are located on the North Fork Clearwater River near Orofino in west central Idaho. This 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, at 1519.53 ft on October 1, was filled to 1531.4 ft by the end of December, which was below the Upper Rule Curve level of 1558.0 ft. Based on the current flood control rule curves, Dworshak was to be at minimum pool (1445.0 ft) to provide 2.00 maf of flood control space by March 31. The high runoff volume forecast first issued on January 1 continued throughout the spring so the project was drafted to empty on April 3 and had to spill starting April 16 to pass inflow and stay empty. (The New Year's Day storm did not extend into the NF Clearwater River.) Starting on April 22 the project, releasing 25 kcfs (channel capacity), started to fill involuntarily because of the high flows. The project maintained 25 kcfs outflow through May 10, filling to 1452.7 ft. To alleviate flooding problems in Orofino (backwater affect from the Clearwater River), project releases were reduced to 1.3 kcfs between May 15 and 19. Between late May and early June, flows were managed with the target of refill towards the end of June but not filling too quickly to maintain flood control protection downstream until the freshet was over. The project filled on July 3. The State of Idaho issued a dissolved gas waiver allowing the project to voluntarily reach dissolved gas levels up to 120% between July 15 and August 15 so the project could stay full longer before starting to draft for the grouting contract to slow down leakage of the dam. The project stayed within 1-foot of full (1599.0 ft to 1600.0 ft) until July 16 when the out-flows were increased to 22 kcfs, where they remained through August 15 and were gradually ramped down by the end of August until the target pool level of 1500.0 ft was reached. The project passed inflow through the rest of the water year as the grouting work progressed. (The grouting work was completed December 15, 1997.)

The peak daily inflow was 48.8 kcfs on May 15, while outflow at the time was 1.3 kcfs. The peak daily outflow was 25.1 kcfs which was maintained April 21 through May 9.

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 80.7 kcfs on May 16 when Dworshak was releasing 1.0 kcfs. The unregulated peak flow during the flood season was 127.5 kcfs on May 16, well above the flow at flood stage of 111.6 kcfs.

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 Charts 78 and 90.

During the summer the projects were operated at minimum operating pool (MOP) with the intent to increase water velocities to aid downstream juvenile fish migration.

Lower Monumental and Little Goose projects operated in their top foot operating ranges October 1 through December 31 to enhance adult fish ladder access. Ice Harbor operated slightly below its top foot through December 31 to provide as good fish ladder conditions as possible (for upstream adult fish migration) and also provide reservoir space to protect workers who were installing flip lips in the tailrace. Lower Granite operated between 734.0 ft and 735.0 ft from October 1 through November 15 which was as low as possible for juvenile fish migration yet high enough for navigation restrictions. On November 15 Lower Granite operation range was increased to 734.0 ft to 738.0 ft, and was operated to maintain Lewiston below 738.0 ft if flows were low and below 737.0 ft if flows were above 50.0 kcfs for flood control. Lower Granite was drafted to 729.9 ft on January 1 because of the high inflow forecast and then began to have problems with barges that had drafts great than 14 ft which were unable to travel over the upstream lock sill. Also, undermining of the Lewiston levees was a concern.

Starting on April 9, all projects were drafted to MOP or MOP-plus-one-foot for juvenile fish migration, as required by the Biological Opinion. Required night time spill was initiated at Lower Granite, Little Goose, Ice Harbor, and Lower Monumental on April 10. Ice Harbor was spilling around the clock due to decreased powerhouse flow capacity because of out-of-service generator units. Fish transportation by both truck and barge were also initiated in April. Spill occurred at all the Lower Snake projects during most of April, May and June. Navigation companies had problems navigating barges at Ice Harbor because of the river currents caused by the newly installed flip lips. In May, various spill patterns were tested to learn which combination of flows and spillway gates had the least the impact on navigation. Lower Monumental and Little Goose refilled in early September and operated in their top foot of their operating range through the month of September to enhance adult fish ladder access. The flip lip contractor returned to work at Ice Harbor in September and the project operated slightly below its top foot through the rest of the month for both adult fish migration and contractor safety.

The regulated peak flow into Lower Granite was 225.3 kcfs on May 17 and the unregulated peak was 357.9 kcfs on May 17.

30. Mill Creek Project

Mill Creek Dam and Bennington Lake is a Corps of project in the Mill Creek basin, east of Walla Walla, Washington. This off-stream project receives high flows that were diverted from Mill Creek for flood control. The reservoir's active storage capacity of 8,200 af was used for flood control and recreation. This year's operation is graphically shown on Chart 47.

From October 1 through December 31 Bennington Lake's level ranged between 1195.0 ft and 1194.5 ft. During January two major flood control operations were required, each followed quickly by drafting the pool to prepare for possible subsequent flood control operations. The first, on January 1, was caused by storms in late December that filled Bennington Lake to a peak of 1211.7 ft. The second flood operation on January 31, was caused by storms in late January that filled the pool from 1207.8 ft to a peak of 1212.1 ft on February 1. Seepage and evaporation losses caused drawdown of Bennington Lake to conservation pool level of 1205.0 ft by April 14 and to 1193.8 ft by September 30; streamflows were not sufficient to maintain the pool at 1205.0 ft.

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 unregulated 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.

There were small two flood control regulation events this water year, both occurred in January and had inflows in the 400 cfs range and each followed quickly by drafting the pool to prepare for possible subsequent flood control operations. The early January storm filled the pool to 2075.5 ft and the late January event filled the pool to 2073.0 ft. Maximum summer operation pool of 2076.5 ft occurred in early June. The water year ended, and also the water conservation season, with a pool level consistent with the scheduled water control regulation curves. Pool drawdown does not occur until the next water year, starting after Columbus Day each October.

32. John Day Project

Lake Umatilla is the reservoir behind John Day Dam on the Columbia River that straddles the Oregon-Washington border and 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, 257-268 ft. Historically, the Corps generally operated the lake in the range of 260.0-265.0 ft from November through the spring runoff. Following the spring runoff, and continuing until mid-October, the pool is normally operated in its top 3 ft, 265.0-268.0 ft. However, in recent years the lake has been operated at lower levels in an attempt to improve juvenile fish passage through the reservoir with lower surface levels and faster water velocities. In addition, the lake may be drafted to as low as 257.0 ft for flood control and power. This year's operation is graphically shown on Chart 17.

The official range of John Day Dam forebay operation is 260.0 to 265.0 ft beginning November 1. Normally a limit of 263.5 to 265.0 ft exists on Wednesdays, weekends and holidays for water fowl hunting between mid-October to mid-January. At the end of December, the forebay was drafted to between 257.0 ft and 260.0 ft. Between mid-January through April, a contractor started working in the tailrace to install flip lips on 18 of the 20 spill bays. This work involved hard-hat diving that required work barges and crane to remain in the tailrace area for the work period. There was also a no spill objective a majority of the time for the worker's safety and impact on work schedule. Normally the pool is operated above a minimum of 262.5 ft for the benefit of the Irrigon and Umatilla Hatcheries and irrigators. The project was drafted below 262.0 ft on two different occasions for flood control for Portland-Vancouver Harbor: during December 27 - January 1 and January 31 – February 2. Also, April 24 through June 25 John Day was operated for flood control for Portland-Vancouver Harbor as well as for irrigators. Initially, the forebay was maintained below 262.0 ft. Then, when the high flows started, John Day project releases were controlled to maintain Initial Control Flow Conditions at The Dalles (flows not to exceed 530 kcfs) for flood control in the Portland area. The project was regulated to a delicate balance to maintain flood control space for Portland yet allow the forebay to occasionally fill above 262.0 ft to allow the irrigators to water their crops.

Between July and August the pool was operated according to NMFS Biological Opinion requirements and irrigation needs. In September the flip lip contractor started working again, requiring a no spill condition 6 days/week. Because of the low water conditions, there was no problem providing no spill.

33. Upper Deschutes Project

This multiple reservoir system is composed of Prineville and Ochoco reservoirs on the Crooked River, both Section 7 projects, and Crane Prairie, Wickiup, Crescent Lake, and Haystack reservoirs on the Deschutes River. Including Haystack, which is an offstream reregulating reservoir, there is a combined total active storage capacity of 559 kaf. This year's operation is graphically shown on Charts 49 and 50.

Crescent Lake storage at the beginning of the water year was 38.7 kaf. Storage peaked for the season at 86.1 kaf on July 9, which is essentially full. This was the highest reservoir level since 1976. Carryover storage at the end of the year was 71.7 kaf. The maximum combined Wickiup and Crane Prairie storage of 250.8 kaf was reached on April 30. Combined storage at the end of the year was 176.2 kaf.

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 of approximately 80 cfs until early December, when higher flood control releases began to be necessary. Peak storage of 158.7 kaf, 104% of active capacity, was reached on April 24. The maximum inflow was approximately 6.73 kcfs on January 1; maximum release was 2.96 kcfs on January 3. The reservoir had a storage of 90 kaf, 94% of normal at the end of September.

Ochoco Reservoir entered the water year with a carryover of 18.9 kaf. The outlets were closed following irrigation season and all inflow was stored until late December, when flood control releases were required. The New Year's Day storm nearly filled the reservoir and forced releases to be turned up to maximum outlet works capacity of approximately 420 cfs. Discharges continued at peak capacity until February 17 in order to draft the reservoir back down to its flood control rule curve requirement. Discharges from late February through early April ranged from 15 cfs to 300 cfs to keep the reservoir at or near its rule curve requirements. Peak discharge was 423 cfs on January 7, and peak inflow was about 2.13 kcfs on January 1. The reservoir filled by early April and remained nearly full through most of June when releases began for irrigation; the peak storage of 44.7 kaf occurred on April 23. Irrigation demand drafted the reservoir during the summer to 25.5 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 mid-Columbia River in central Washington. 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 requirements for power production, navigation, recreation, fishery, and construction activities. This year's operation is graphically shown on Charts 80 and 91.

McNary Dam had Biological Opinion flow requirements that varied throughout the spring summer (see Chapter IV, Section G, Fishery Operations). Also continuing at McNary this year was the unloading of ten decommissioned defueled submarine reactor compartments at the Hanford Reservation, one during March and the other nine in September and October 1997, necessitating special operation of the water level behind McNary Dam and the Priest Rapids discharges to allow barge docking at the Port of Benton slip. Also, special operations at McNary for national level competitive boat races, shoreline weed control, boat ramp construction, habitat island maintenance, waterfowl nesting, and waterfowl hunting occurred throughout the year. At times, these requests conflicted with each other, requiring special coordination.

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 1997. See Section g, Fishery Operations for additional information.

The peak winter flood regulated flow at The Dalles was 321.5 kcfs on January 5 and the peak unregulated flow was 398.0 kcfs on January 3. The unregulated peak snowmelt flow at The Dalles was 896.0 kcfs on June 7 and was controlled to a peak of 570.7 kcfs on June 15.

35. Columbia River at Vancouver

The Columbia River Basin reservoir system was operated for flood control once during the winter of 1996-97. Most of the flood contribution came from the Willamette River and lower Columbia River tributaries. Treaty projects' outflows were not reduced to alleviate flooding conditions in the Portland-Vancouver harbor during this high water event because there was sufficient storage available in Grand Coulee to achieve flood control objectives. **Please see Chart 79.**

The observed peak stage at Vancouver, which was the result of an unusual winter rain/snowmelt flood, was 22.1 ft, 6.1 ft over flood stage, on January 2 and the unregulated peak stage for this event was 23.9 ft on January 4. As a comparison, in 1964, the flood crest was 27.7 ft and in February 1996, 27.2 ft was reached. The all time record is 31 ft in 1948. Bankfull at Vancouver is 16 ft and a major flood is at a stage of 26 ft.

The spring snowmelt runoff peak flood stage at Vancouver was exceeded for much of May and June. Significant flood control was provided by the Treaty projects. The observed peak stage at Vancouver, was 19.0 ft on June 4 and the unregulated stage was 28.4 ft on June 8.

36. Willamette Basin Projects

There are 25 dams in the Willamette Valley of western Oregon. The Corps operates 11 storage and two reregulating reservoirs; Reclamation operates one storage project, Scoggins Dam, a Section 7 project; and the remaining 11 are single-purpose, hydroelectric plants operated by public and private utilities. The federal projects are:

Hydroelectric		Non-power
Storage	**Reregulation**	**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, 81-84, and 92.

a. CORPS PROJECTS The Willamette reservoirs operated by the Corps were about full at the beginning of the summer of 1996. Summertime rainfall was above normal, so augmentation of the mainstem flows was achieved by the normal releases from the projects as outlined in the summer augmentation plan developed in May 1996.

The summer low flow augmentation meeting was not held in May because of the above average water year. The augmentation plan was drafted and sent to the State and Federal agencies that have an interest in the Willamette flows and only minor comments were returned for inclusion in the overall plan. The following minimum flows, in cfs, for the mainstem Willamette were adopted:

Location	June	July	August	September
Albany	4,500	4,500	5,000	5,000
Salem	6,000	6,000	6,500	7,000

During the summer of 1996 precipitation was near normal so additional augmentation was not required to maintain mainstem flows. The releases from the projects were increased for local requirements for fish or other environmental concerns of the Oregon Department of Fish and Wildlife (ODFW). The flow from Lookout Point was increased in July to 2500 cfs, Cougar was increased to full load on both units in August, Fall Creek releases were between 200 cfs and 500 cfs through Labor Day, which drafted the lake 10 ft. The release was then increased to 1200 cfs to draft the lake to 710.0 ft. Heavy precipitation during October, November, and December allowed the project to be below 710.0 ft for 26 days and releases below 500 cfs for only 19 days, which are the goals for safe fish passage.

From October through April a series of storms passed throughout the valley, with rainfall averaging from 110% to 300% of normal, preventing about half of the projects from reaching minimum flood control pool. The largest runoff occurred with storms that started on December 20, reaching a peak on December 25 and 26 with 6.8 inches reported at Cougar Dam for that 48 hour period. The Willamette projects were drafting from the storm that started on the December 20th, and were about 9% full on December 24. By January 4th the system was about 69% full with the projects on the McKenzie and the Santiam Rivers receiving the blunt of the storm. The river stage at Salem reached a maximum of almost 29 ft on January 3. By comparison the February 1996 river stage at Salem peaked at 35 ft. Stream levels at control points are shown in the following table.

Location	**Obs'd Stage**	**Bankfull Stage**	**Flood Stage**	**Major Stage**
Jasper	***9.9***		10.0	15.0
Goshen	***11.8***		13.0	16.0
Eugene	***19.5***		23.0	29.0
Vida	***16.3***	6.0	11.0	14.0
Harrisburg	***12.8***	10.3	14.0	17.0
Monroe	***8.7***	9.0	9.0	
Waterloo	***9.8***	9.9	12.0	18.0
Mehama	***8.8***	11.0	13.5	
Jefferson	***14.4***	12.8	15.0	20.0
Salem	***29.0***	21.4	28.0	33.0

The projects were all back to the rule curve by the middle to the end of January and continued to fill on schedule during the refill period February through May. All the projects completed filling on schedule except for Cottage Grove, which filled to a foot and a half of the conservation pool. A summer augmentation plan was sent to interested parties in May, and because the summer runoff was forecast to be at or above normal for the June-September period no meeting was held. July through October continued to have above normal inflows and so additional augmentation of the main stem was not required. The releases from the projects were increased to meet minimum flows downstream and requirements of the Oregon DFW.

b. RECLAMATION 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 26 kaf, 48% of capacity and 100% of normal. The reservoir was further drafted 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 23.4 kaf on November 12. Storage began to accumulate when the discharge was reduced to the project minimums beginning in mid November and reached the flood control rule curve by early December, when a high water event forced storage above the curve. Releases up to about 1,250 cfs were required in mid December to draft the reservoir towards its rule curve requirement. This flood space evacuation was nearly completed when a significant flood event occurred in late December and early January. Peak inflows were captured by the reservoir during the event, forcing it to essentially fill by January 2. Significant releases were not required from the reservoir until after the downstream flows had peaked and were in recession. The gage height at the Tualatin River near Dilley flood control point peaked for the year at about 17.9 ft on January 2. The year's highest peak mean daily inflow to the reservoir occurred on December 31 at 2,007 cfs (peak hourly inflow was much higher), and peak discharge of 1,660 cfs was measured on January 3. The reservoir was drafted to its rule curve on January 15, which it essentially followed until it refilled in early May and remained full until draft began in early July.

Storage at the end of the water year was 24.4 kaf, 46% of capacity and 94% of normal. Inflow during the water year was 129.8 kaf, 142% of normal.

37. Western Washington Projects

a. HOWARD A. HANSON DAM.

Howard A. Hanson Dam, on the Green River at river mile 64.5, is a flood control and conservation storage project. The project provides winter flood protection primarily for the lower Green-Duwamish River valley between the cities of Auburn and Seattle. In the spring, over 24 kaf is stored to augment low flows for fisheries in late summer and fall. The City of Tacoma operates a major M&I water supply diversion dam and pipeline 3.5 miles downstream from Hanson Dam. The year's operation is graphically shown on Chart 51.

The project began the year with the pool at 1110.6 ft, 5.5 ft below the 98% rule curve and on December 4 it reached the normal minimum flood control level of 1070.0 ft. This pool level provides a few feet for water quality control, yet the reservoir is essentially empty. The project was not operated for flood control this year. However, seismic retrofit work on the intake tower and walkway columns required additional regulation to maintain a pool at less than 1140.0 ft although the pool did reach a winter peak of 1127.6 ft on February 16.

Beginning in early April, and continuing through September, the Corps, the city of Tacoma Water Department, the Muckleshoot Indian Tribe, and Federal and state resource agencies coordinated project refill operation, continuing a policy initiated in 1988. Due to an unusually large snowpack, refill of the reservoir was delayed to reduce the possibility of passing high inflows after the reservoir was full. Refill was initiated by capturing a constant 400 cfs (800 af/day) on May 6 at a pool of 1185.0 ft. On May 22, the capture rate was increased to insure the reservoir filled to the conservation level of 1141.0 ft by June 1. Draft of the reservoir began on August 21 to augment flows for downstream fisheries.

Peak streamflows reached 9,430 cfs on March 20 at the Green River near Auburn streamgage, well below the authorized 12.0 kcfs control flow, the unregulated streamflows was 11.9 kcfs at the Auburn gage, and the greatest release from the dam was 7,395 cfs.

b. <u>MUD MOUNTAIN DAM</u> Mud Mountain Dam, on the White River at river mile 29.6, is a single-purpose, flood control project which is normally empty except during flood control operation, project maintenance, and occasional regulation for downstream needs. The year's operation was generally according to flood control regulations and is graphically shown on Chart 52.

In January, flood control regulation by Mud Mountain Dam limited the discharge at Puyallup to a maximum of 23.46 kcfs. Without this regulation, the Puyallup gage would have reached approximately 28.2 kcfs. On January 1 the inflow peaked at approximately 12.0 kcfs while the peak pool elevation occurred on January 8 at 1062.72 ft. In addition to this normal flood control operations, special dam regulation occurred on three occasions; the first during the week of December 16 when Puget Sound Energy required flows of 2,000 cfs to test modifications to their diversion structure below Mud Mountain. Second, from January 10 to February 6 when Northwest Pipeline requested flows of 2,500 cfs to 3,500 cfs for streambed reconstruction. Erosion of the bank had exposed a high pressure gas transmission line. Third, in July and August, inspection and repair of the outlet tunnels required detailed gate operations.

c. <u>WYNOOCHEE DAM</u> Wynoochee Dam, on the Wynoochee River at river mile 51.8, provides flood control for the lower 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 ownership 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 Corps assumed flood control operation of the Wynoochee Dam Project on four occasions. The last storm on March 18 proved to be a 100 year event in the lower basin with more than 21 inches of precipitation felling over a three day period. The Spillway Gate Regulation Curve, used to balance the remaining storage volume with the observed inflow was used for the first time, although the spillway was not used.

The observed peak flow for the Wynoochee River above Black Creek gage, the control point, was 25.6 kcfs on March 19 where the zero damage flow is 18,000 cfs. Preliminary damage estimates were in excess of 1 million dollars. Unregulated, the flow would have reached 37.0 kcfs which meant flood control operations at the dam lowered the downstream stage by approximately 3.0 ft.

c. <u>LAKE WASHINGTON SHIP CANAL AND HIRAM M. CHITTENDEN LOCKS PROJECT</u> The Chittenden Locks project controls the level of both Lake Union and Lake Washington, and provides a navigation channel between these lakes and Puget Sound. Project facilities include a large and small lock, 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 began the water year at 20.9 ft, and gradually drafted to 20.0 ft by December 1 to provide shoreline protection against wind and wave action. Throughout the winter, the Locks were operated to optimize fish passage and limit salt water intrusion into Lake Union. The spring refill began February 16, but was interrupted on March 20 in preparation of a series smolt passage tests. The objective of the tests was to quantify the passage of juvenile salmon through the locks when no discharge was occurring over the spillways. To prepare for the shutdown of the spillways during this high flow period, it was necessary to hold the elevation of Lake Washington at 21.1 ft. After a series of fill and spill operations for the smolt passage tests, Lake Washington reached the normal conservation pool of 21.85 ft on June 18, and continued to fill to a maximum of 21.95

ft on June 25. Release of the storage and draft of the lake began on 24 June. The lake continued to draft until the end of the year and dropped to 20.9 ft by 30 September. Lake Washington was held within the normal operating range of 20.0 ft to 22.0 ft the entire year.

e. ROSS PROJECT Ross Dam, located on the Skagit River at mile 105.2, 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 120.0 kaf above the pool elevation of 1,592.1 ft. The storage space must remain available until at least March 15 of the following 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 provided the flow is reregulated 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.

Two storm events raised flooding concerns in the Skagit River Basin this water year. On March 19 a rain on snow caused the forecast flow at Concrete to exceed 90.0 kcfs. Fortunately, storage of inflow and less than predicted precipitation resulted in observed flows less than 90.0 kcfs. On July 9 a 30- to 40-year precipitation event caused minor flooding when the flow rose to 91.4 kcfs at Concrete. This relatively rare summer flood event heightened flood concerns because Ross Reservoir was only 0.35 ft below the summer conservation pool level of 1602.5 ft. Although flows from unregulated areas of the basin below the dam rose quickly, inflow to the dam remained below 20.0 kcfs. The maximum storm discharge from the project was 13.33 kcfs and the pool peaked at 1602.47 ft.

f. UPPER BAKER PROJECT Upper Baker Dam is located near Concrete, Washington at river mile 9.3 on the Baker River, a tributary of the Skagit River. The two dam hydroelectric project is owned and operated by Puget Sound Energy (PSE) formally Puget Sound Power & Light Company. The FERC license for Upper Baker Dam requires 16 kaf of flood control storage space to be provided by November 1 for replacement of natural valley storage eliminated by the project. An additional 58.0 kaf of flood control storage is 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 1 each 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 5,000 cfs from Upper Baker Dam. The year's operation was generally according to flood control regulations and is graphically shown on Chart 55.

In March, PSE stored most of the flow in the Baker River which assisted in keeping the flow of the Skagit River at Concrete below 90.0 kcfs. At the time, PSE's maintenance and construction work on Lower Baker Dam allowed spill only at night. The timing of the event was such that the Corps flood control operations were minimal. In July, Upper Baker Reservoir was 0.65 ft from the normal summer conservation pool elevation of 724.0 ft. Inflow peaked at approximately 20.0 kcfs and the pool rose to a maximum of 723.75 ft. The maximum discharge was 18.9 cfs.

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.

During November and December, lake elevations were held some 8 to 12 ft below the water control curves evacuation schedule, possibly because of the very high inflows which had occurred last fall. The most significant flood control operation occurred during the flood event of January 1-5 with a peak inflow of 45.0 kcfs. The maximum lake level of 764.5 ft occurred on January 4 and the maximum outflow from Mayfield Dam was 25.0 kcfs on January 9. During February through May, the lake was filled to 8 to 12 ft below the authorized project filling schedule. Storage and water releases during the conservation release season were typical of previous years.

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 design 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. From November 1987 through September 1996, sediment deposits have resulted in closing of the lowest three rows of outlets.

In March 1997 the fourth row outlets were closed and in September the fifth row was closed. Currently, the project has trapped 56.4 mcy of sediment; that 22% of the 258 mcy design capacity. The maximum pool was 927.9 ft on March 4.

38. <u>Oregon Coastal Projects</u>

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. <u>LOST CREEK DAM</u>. The lake level at the beginning of the water year was being held at constant because of anadromous fish needs downstream of the dam. Consequently, by late October, the pool level was approximately 8 ft encroached into flood control space. Following the major spawning period, the pool level was drafted to its minimum pool level by mid-November. The project experienced high runoff and major flooding through the entire major flood season (November, December, and January). There were three progressively greater flood events: the first was in late November, the second in early December, and the third in late December/early January was the largest event. The third flood event was a major flood event that started on the last day of December and lasted through January 6. The heavy tropical precipitation was related to an eastern shift of enhanced tropical convection associated with a phenomenon called the Madden-Julian Oscillation across the western tropical Pacific. Precipitation at Bigelow Camp, Rogue River was 15.5 inches between December 27 and January 2. Peak inflow to Lost Creek Lake was 26,000 cfs. Preliminary computations indicate that the last December/early January event was approximately a 20-year event in the upper Rogue. The lake filled to 1868 ft, within 4 ft of the maximum pool elevation. On January 5, a regulating outlet hatch failed, consequently water releases to keep the pool from filling needed to be released from the spillway. This was the first spillway discharge event in the history of the project. Project releases were up to 16,000 cfs for three days, 7,500 cfs of which were over the spillway. Flows at the nearest control point 20 miles downstream, Dodge Bridge, were held at flood stage of 10 ft. The regulating outlet hatch was repaired following the flood. Stage reductions at Dodge Bridge (the first downstream control point) was estimated to be 3.3 ft, 2.7 ft at Raygold, and 4.2 ft at the major damage control point of Grants Pass. There were no significant water resources issues for the rest of the water year. The reservoir elevation at the end of the water year were again focused on meeting anadromous fish needs downstream of the project. The year's operation is shown on Chart 29. Flood damages prevented this year for the Rogue River Basin (Lost Creek and Applegate Dams) was $30 M.

b. <u>APPLEGATE DAM</u>. The lake began the water year 5 ft below its Water Control Diagram minimum pool elevation of 1889.0 ft. Like Lost Creek, the project experienced three incrementally larger flood events during the major flood season. Peak inflow to Applegate Lake was approximately 26,000 cfs (similar to Lost Creek Dam). Preliminary computations indicate that the late December/early January flood event was approximately a 40-year event upstream of the dam, and an 80-year event in the middle of the Applegate River Basin. The New Year's Day flood was within 0.5 ft of reaching the Applegate Lake full pool elevation of 1987.0 ft, including a special regulation curve operation in effect. Project releases reached approximately 16.0 kcfs, 12.0 kcfs of which was spillway use. Use of the regulating outlet during spillway discharge caused significant erosion of the stilling basin area. Flood stage at the downstream control point was exceeded. Observed stages near the community of Applegate were 16.8 ft; flood stage is 13.0 ft. Stage reduction was estimated at 5.8 ft. The reservoir operation for the rest of the water year focused on meeting anadromous fish needs and other project purposes such as recreation. There were no significant water resources issues for the rest of the water year. The year's operation is shown on Chart 30.

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

d. <u>GALESVILLE DAM</u> 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. Operations were in compliance with flood control regulations. Significant flood control operations were carried out on December 8, and January 1-5. The maximum reservoir level was 1883.1 ft on January 2, with minor flow over the freeflow spillway crest, resulting from sustained the high inflow of 3,000 cfs caused by high runoffs of rainfall plus snow melt. The lake was filled between February 1 and May 1 in accordance with its water control diagram. However, the lake was held 11 ft below its normal Maximum Conservation Pool elevation throughout the conservation release season, due to cavitation problems, which were limiting the project's maximum outlet releases.

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. Minor flood control operations occurred on December 15 and January 20, with the highest lake levels during these events being 2218.4 ft and 2222.6 ft, respectively. Full pool is at 2251.3 ft.

Twin Falls Project. Note the roof access to the turbine-generator unit. Access road to the second (new) powerhouse is in the lower left. Vortex in center of afterbay leads to drain under roadway to river. Work is underway to shore up the windows in preparation for the upcoming peak river discharges.

Twin Falls New Powerhouse. Remaining falls of the original Twin Falls from surface deck of powerhouse. Note roof access to turbine-generator unit.