CHAPTER 3.0 HYDROLOGIC CONDITIONS

3.1 INTRODUCTION

The hydrologic regime in the Deschutes River basin has been altered by over 100 years of irrigation, hydropower, and other water development activities. Irrigation development first began in the basin in the 1860s when farmers diverted water from tributaries of the Deschutes River. Irrigation became widespread in the early 1900s when several small irrigation companies were formed. Reclamation built or rehabilitated the major irrigation reservoirs in the basin in the 1940s and 1950s. The following section describes the hydrologic changes that have occurred in the Deschutes River basin as a result of water development activities that may have impacted species which are now listed under ESA. These hydrologic effects described here are part of the environmental baseline for this consultation.

3.2 HYDROLOGIC DATA

Observed hydrologic data from the last 70 to 80 years of record were analyzed to determine current basin conditions resulting from historic management practices. Data were obtained from historical databases of the USGS, the OWRD, and Reclamation. Reservoir elevations are end-of-month elevations for each month of the year for the period of record. Historic river flow hydrographs are plotted from the average daily flows over the period. A flow exceedance analysis was done on the average monthly flows calculated from the average daily flows.

Hydrologic data is reported by water year. A water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends. For example, the 2003 water year consists of the period from October 1, 2002 through September 30, 2003.

Reservoir elevations of Crane Prairie and Wickiup Reservoirs on the Deschutes River, Prineville Reservoir on the Crooked River, and Clear Lake on the White River are analyzed. Historic river flows for the following are summarized:

- Deschutes River below Crane Prairie and Wickiup Reservoirs
- Deschutes River below Bend, near Culver, Madras, and at Moody
- Crooked River below Arthur Bowman Dam (Prineville Reservoir)
- Crooked River near Culver and below Opal Springs
- Clear Creek below Clear Lake
- White River below Tygh Valley

A diagram of the water distribution system for the Deschutes River basin is shown in Figure 3-1. This figure is not comprehensive but intended only to illustrate the sequence of major storage, inflows, outflows (diversions), and major stream gages described in this report.

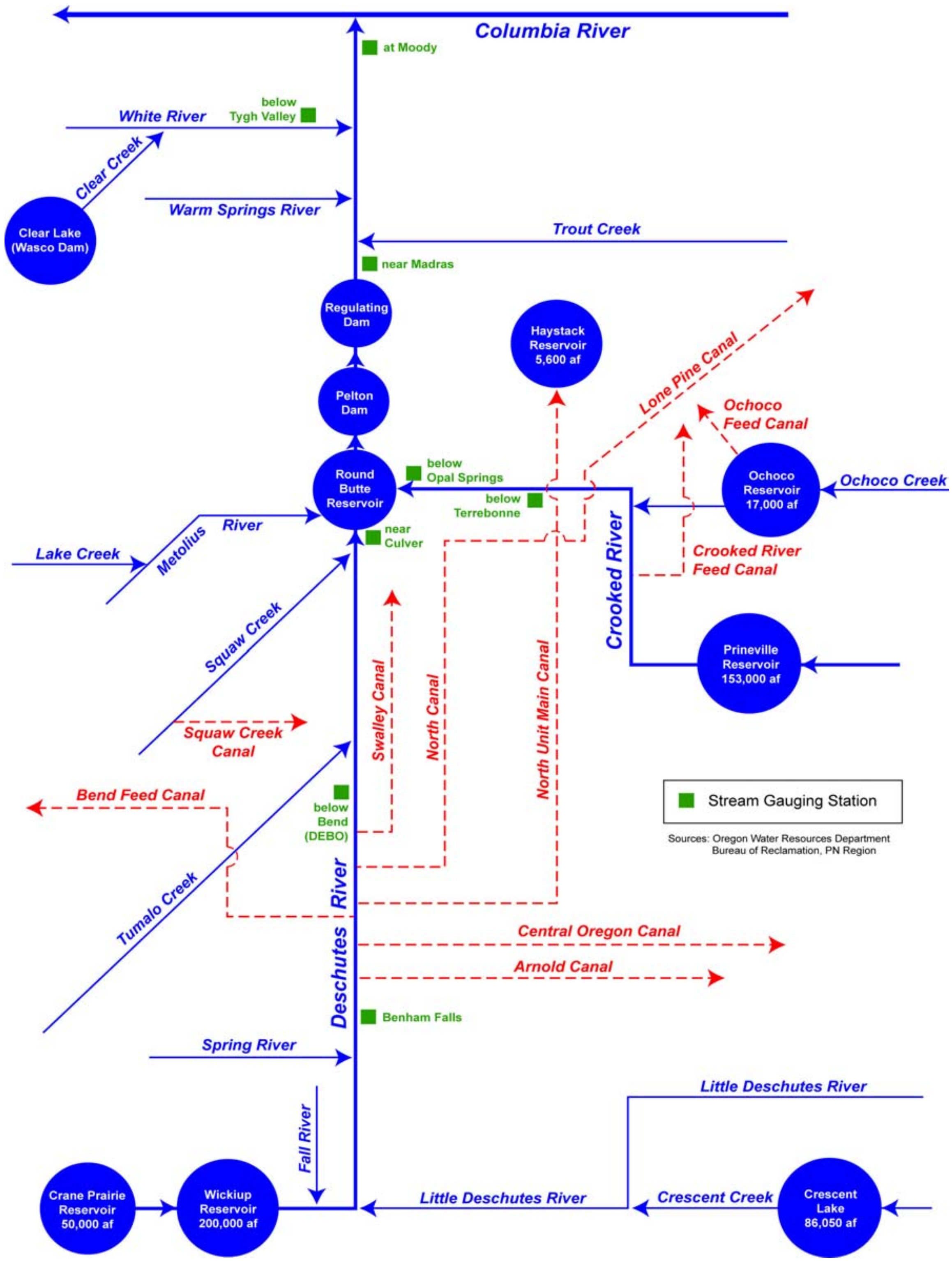

Figure 3-1. Deschutes River Basin Water Distribution System

3.3 DESCHUTES RIVER

3.3.1 Crane Prairie Reservoir

Crane Prairie Dam was privately constructed in 1922 as a rock-filled timber-crib structure and was later rehabilitated by Reclamation in 1940. Operation of Crane Prairie Dam and Reservoir changed with the construction of Wickiup Reservoir in 1949. Figure 3-2 displays the historic end-of-month elevations of Crane Prairie Reservoir for water years 1941 through 2001. The reservoir achieved full pool (elevation 4445 feet) about once every 3 years. Prior to construction of Wickiup Dam in 1949, there was a greater fluctuation in annual elevation and lower minimum elevations at Crane Prairie Reservoir. The less variable elevations and the higher minimum elevations after 1949 are most likely due to the coordinated management of Crane Prairie and Wickiup Reservoirs for filling, which is described in pages 32-42 of the Operations Report. A Crane Prairie Reservoir unofficial minimum discharge of 30 cfs was also set in the mid-1950s.

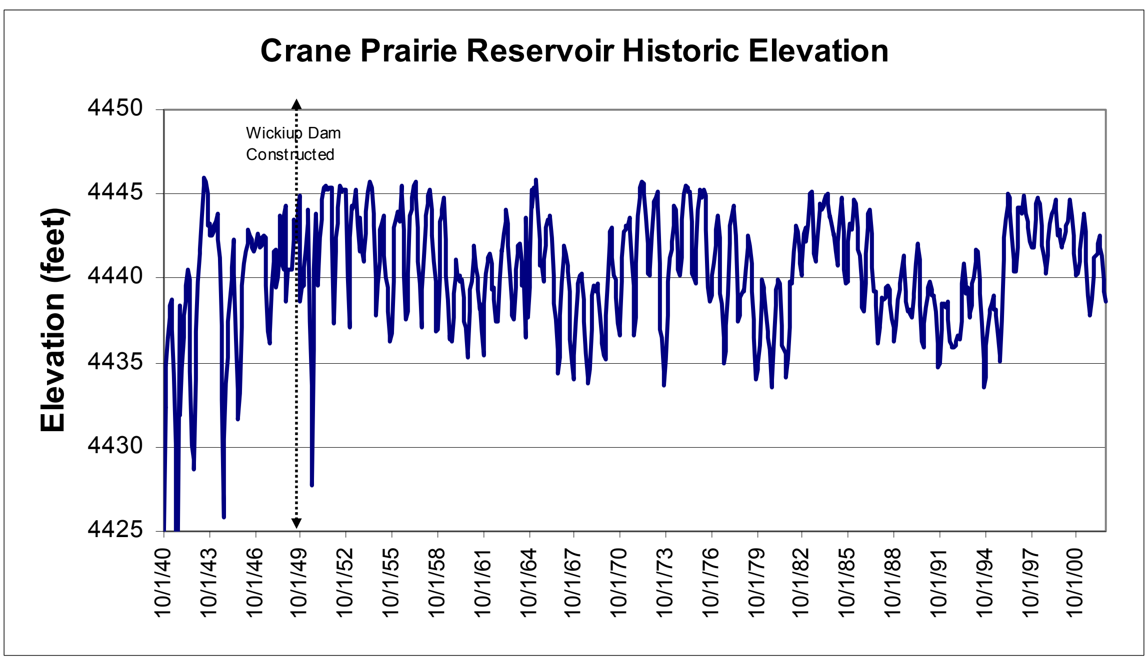

Figure 3-2. Crane Prairie Historic End-of-Month Reservoir Elevations (Water Years 1941-2001)

3.3.2 Deschutes River below Crane Prairie Dam

Figure 3-3 shows the historic average daily flow downstream from Crane Prairie Reservoir for water years 1923 through 2001; Figure 3-4 shows these flows that were less than 50 cfs. The historical record for Crane Prairie was divided into three periods: 1) water years 1923 through 1938 before Crane Prairie Dam was rehabilitated and Wickiup Dam was built, 2) water years 1939 through 1949 the period during which Crane Prairie Dam was rehabilitated and Wickiup Dam was built, and 3) the period 1950 through 2001 when both reservoirs were built and operating. The average monthly flow percent exceedance plots for water years 1923 through 1938 are shown in Figure 3-5 and water years 1950 to 2001 are shown in Figure 3-6. These two periods were chosen to compare river flows before the reservoirs were built to flows after both Crane Prairie and Wickiup Dams were built and operating.

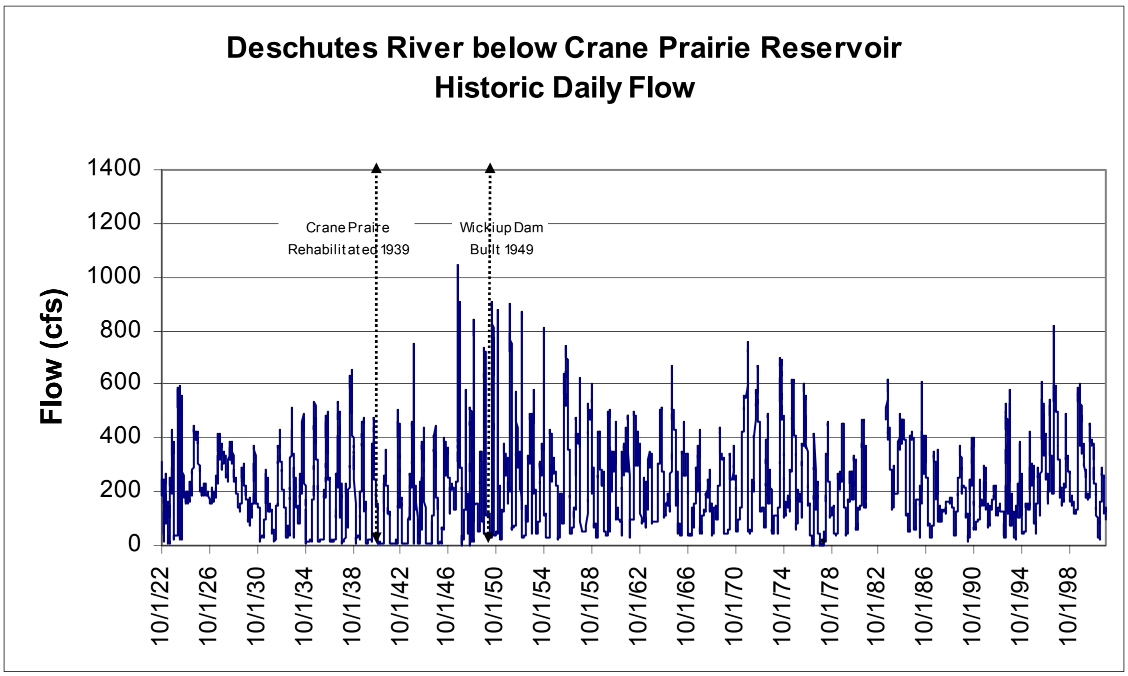

Figure 3-3. Deschutes River below Crane Prairie Reservoir, Historic Average Daily Flow (Water Years 1923-2001).

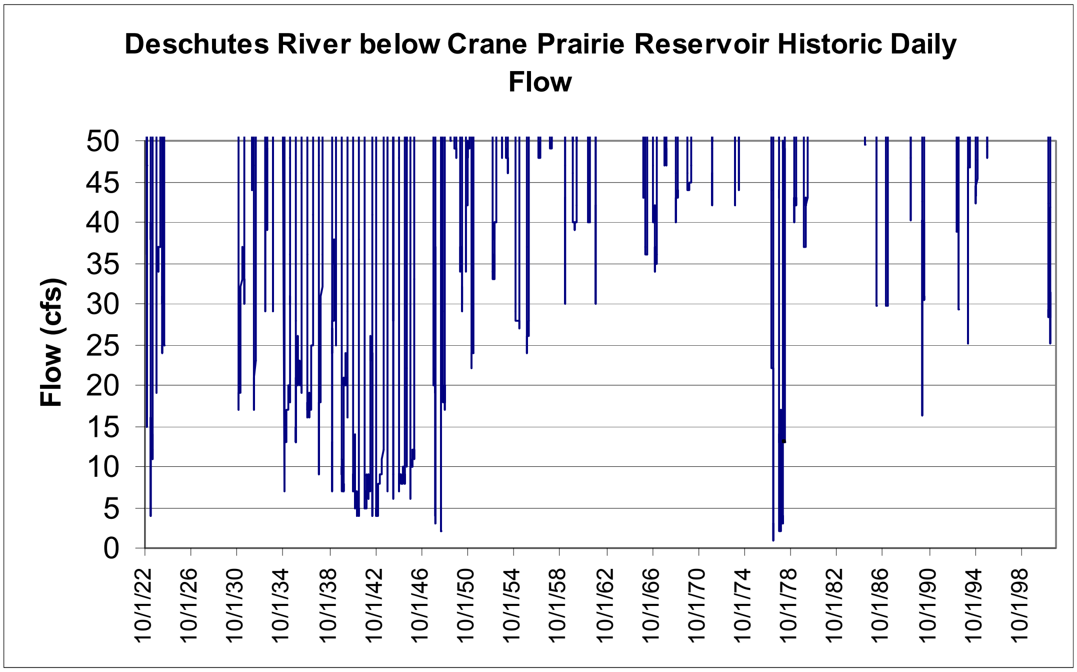

Figure 3-4. Deschutes River below Crane Prairie Dam, Historic Average Daily Flow less than 50 cfs (Water Years 1923-2001)

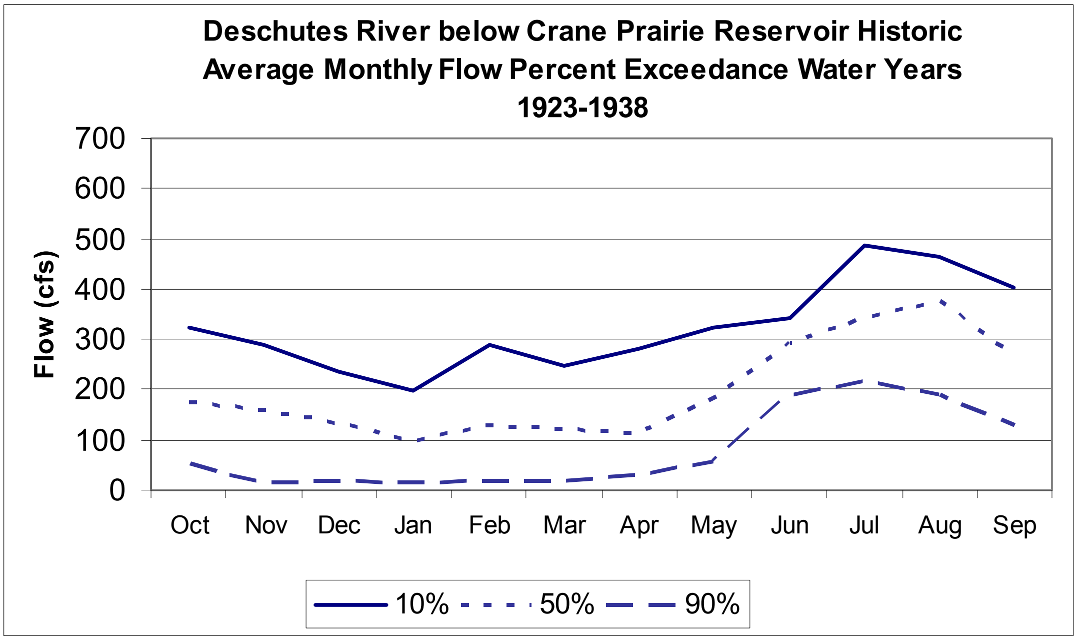

Figure 3-5. Deschutes River below Crane Prairie Dam, Average Monthly Flow Percent Exceedance Prior to Construction of Wickiup Dam (Water Years 1923-1938)

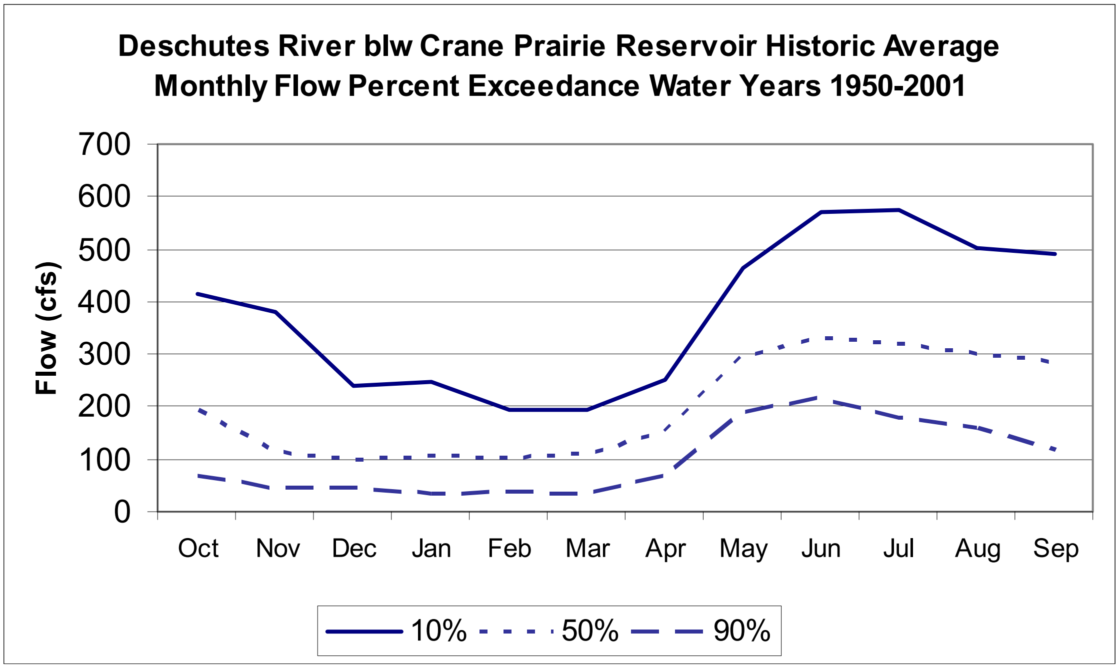

Figure 3-6. Deschutes River below Crane Prairie Dam, Average Monthly Flow Percent Exceedance After Construction of Wickiup Dam (Water Years 1950-2001)

Exceedance level values for flows or reservoir elevations are derived by sorting and ranking the data, usually by month. Flow values for October at the 10 percent exceedance level would occur when October flows are unusually high; 50 percent flows would occur in a median October; and 90 percent flows would occur when October flows are unusually low. For example, from Figure 3-5, the October 10 percent exceedance flow is 323 cfs, meaning 10 percent of the time average monthly October flows equal or exceed 323 cfs. Also, from Figure 3-5, the 90 percent exceedance flow for October is 52 cfs, meaning 90 percent of the time average monthly October flows equal or exceed 52 cfs.

Crane Prairie Dam was not rehabilitated by Reclamation until 1940, but there was a timber-crib structure at Crane Prairie that regulated the flow in the 1923 through 1938 period. From the discharge data and percent exceedance plots (Figure 3-5 and Figure 3-6), the flows were generally lower for the 90 percent exceedance during the winter months prior to construction of the reservoir (1923 through 1938) when compared to the after construction period. After Wickiup Dam was constructed in 1949, median flows downstream from Crane Prairie Dam were higher in April, May, and June due to irrigation releases and were lower in July and August due to irrigation flows being provided by Wickiup Reservoir downstream (water years 1950-2001). In the late 1930s and 1940s before Wickiup Dam was constructed, the winter minimum flows were well below 30 cfs and many times below 10 cfs. From the mid-1950s on, the minimum flows were generally in the 25 to 30 cfs range or more. During extremely dry years in the late 1970s and briefly in 1991, the flows dropped below 30 cfs, but since the mid-1950s there were fewer occurrences of very low flows. The infrequent occurrence of flows below 30 cfs since the mid-1950s, the presence of Wickiup Dam since 1949, and the management of the two reservoirs together explains the uniformity of Crane Prairie Reservoir elevation trends since the 1950s.

3.3.3 Wickiup Reservoir

Wickiup Dam was completed in 1949. Figure 3-7 displays the historic end-of-month elevations of Wickiup Reservoir for water years 1950 through 2001. During this 49-year period the reservoir filled approximately 70 percent of the time (elevation 4337.7 feet). In 1954 an official minimum winter discharge of 20 cfs was established. The elevation data show that the annual fluctuation of the reservoir elevation was greater prior to 1970. After 1970, the annual elevation ranges are more uniform and generally the reservoir is not drawn down as low as compared to pre-1970 data. There is no clear reason for this change in elevation trends. This may be due to more efficient use of the water or changes in land management and irrigation practices.

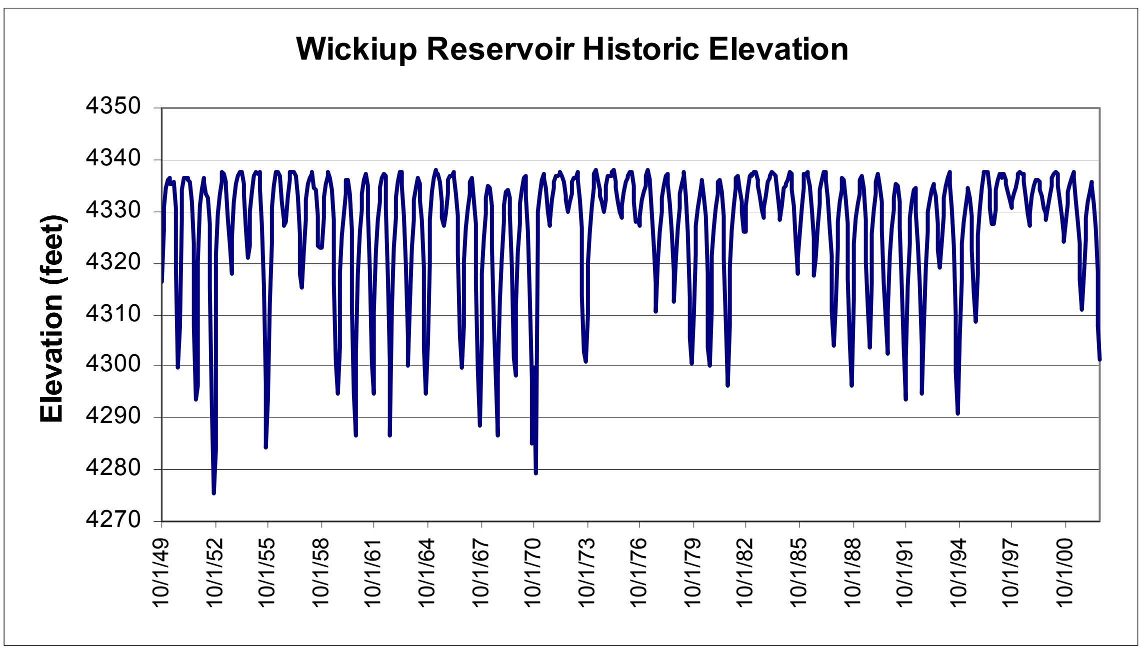

Figure 3-7. Wickiup Reservoir Historic End-of-Month Elevations (Water Years 1950-2001)

3.3.4 Deschutes River below Wickiup Dam

The average daily flows from water years 1939 to 2001 for the Deschutes River below Wickiup Dam are shown in Figure 3-8 and the average daily flows below 50 cfs are shown in Figure 3-9. The percent exceedance plot for the Deschutes River below Wickiup Reservoir for water years 1939 through 1949 is shown in Figure 3-10 and for water years 1950 through 2001 is shown in Figure 3-11.

In the period before Wickiup Dam was completed (1938 through 1948), the median (50 percent exceedance) flows are higher during the winter months and lower in the summer months when compared to the median flows after construction (1950 through 2001). The lower winter flows after construction reflect storage of water for refill and the higher summer flows are due to irrigation releases. Figure 3-8 shows a downward trend in summer discharges from 1950 on indicating more efficient irrigation practices and delivery systems in the basin, in addition to greater precipitation in later years requiring less storage water. From Figure 3-9 there is no obvious change to the frequency or level of minimum flows in the period after Crane Prairie and Wickiup Dams were constructed.

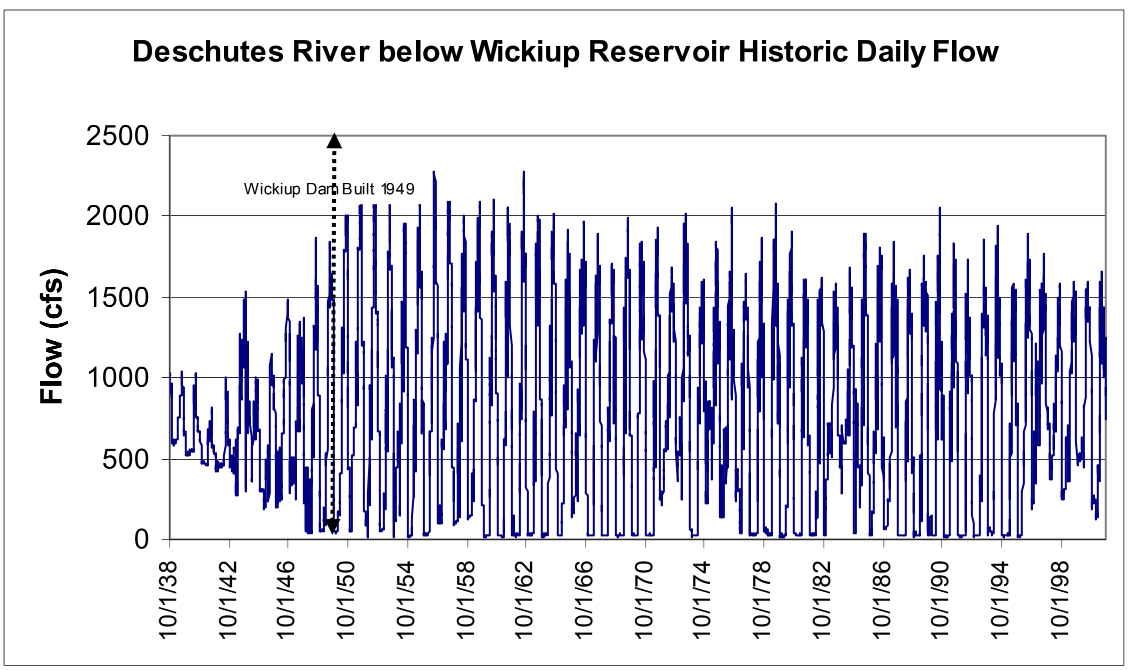

Figure 3-8. Deschutes River Below Wickiup Dam, Historic Average Daily Flow (Water Years 1939-2001)

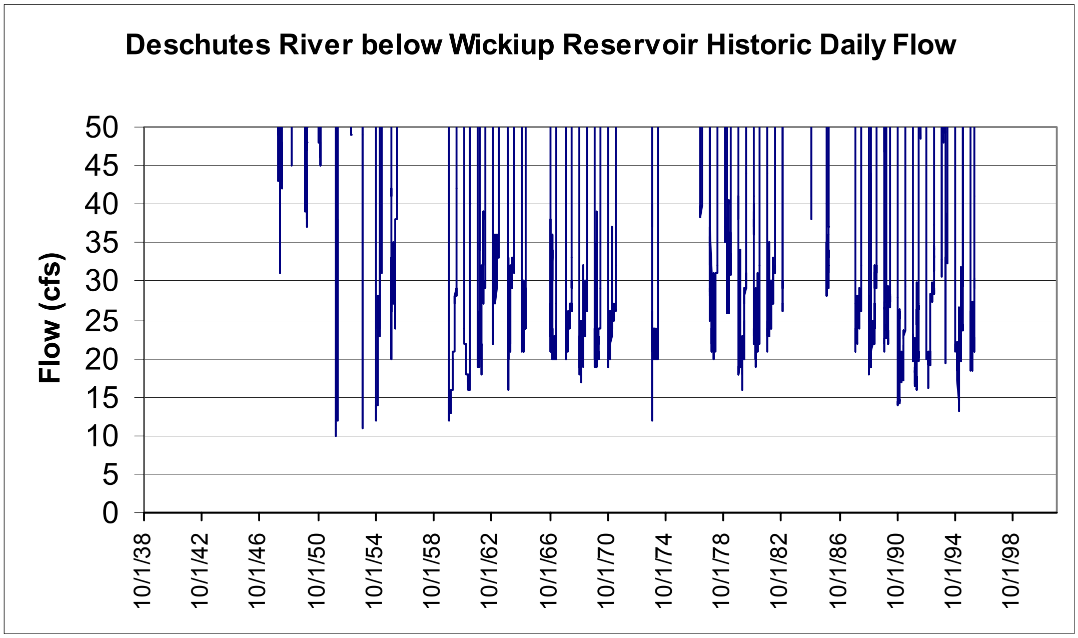

Figure 3-9. Deschutes River Below Wickiup Dam, Historic Average Daily Flows less than 50 cfs (Water Years 1939-2001)

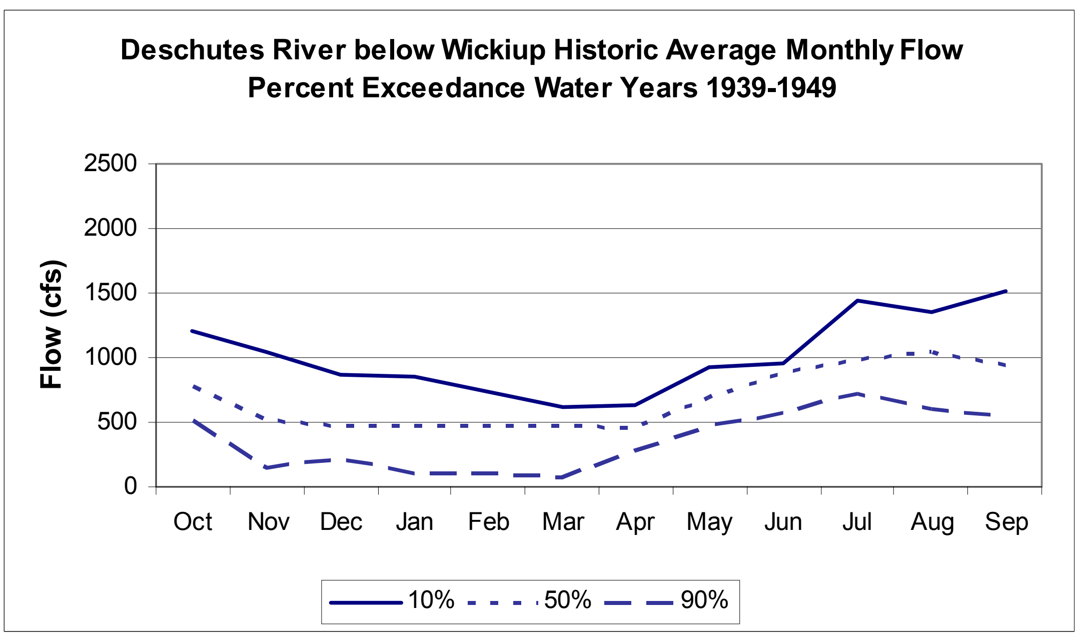

Figure 3-10. Deschutes River Below Wickiup Dam, Average Monthly Flow Percent Exeedance Before Construction of Wickiup Dam (Water Years 1939-1949)

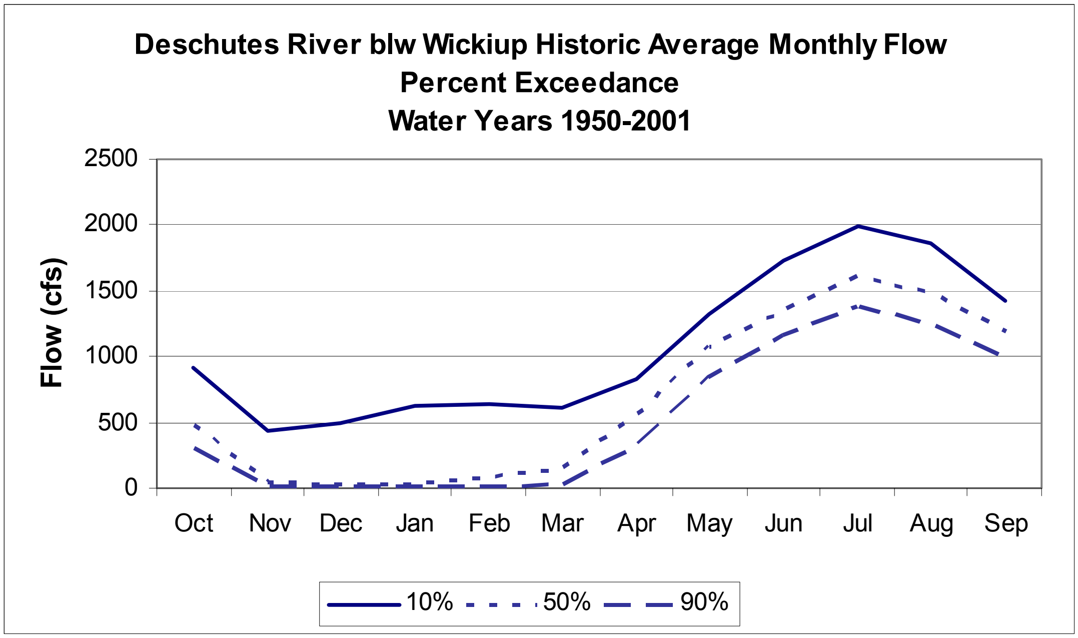

Figure 3-11. Deschutes River Below Wickiup Dam, Average Monthly Flow Percent Exceedance After Construction of Wickiup Dam (Water Years 1950-2001)

3.3.5 Deschutes River below Bend

The historic average daily flow for the Deschutes River below Bend for water years 1916 through 1990 is shown in Figure 3-12. The Deschutes River below Bend gage is located downstream of North Canal Dam near the town of Bend at RM 164.4. Two periods of record for the Deschutes River below Bend were examined: 1) water years 1916 through 1939 before Crane Prairie and Wickiup Dams were built, and 2) water years 1950 through 1990 after both Crane Prairie and Wickiup Dams were in place. The period of record from 1940 through 1949 are not included because Crane Prairie Dam was reconstructed and Wickiup Dam was constructed during these years.

The average monthly flow percent exceedance plot for water years 1916 through 1939 (before Crane Prairie and Wickiup Dams) is shown in Figure 3-13 and the exceedance plot for water years 1950 through 1990 is shown in Figure 3-14. The period before Crane Prairie and Wickiup Dams had higher flows during much of the water year. Flows were higher before the two projects due to less diversion and storage of water for irrigation.

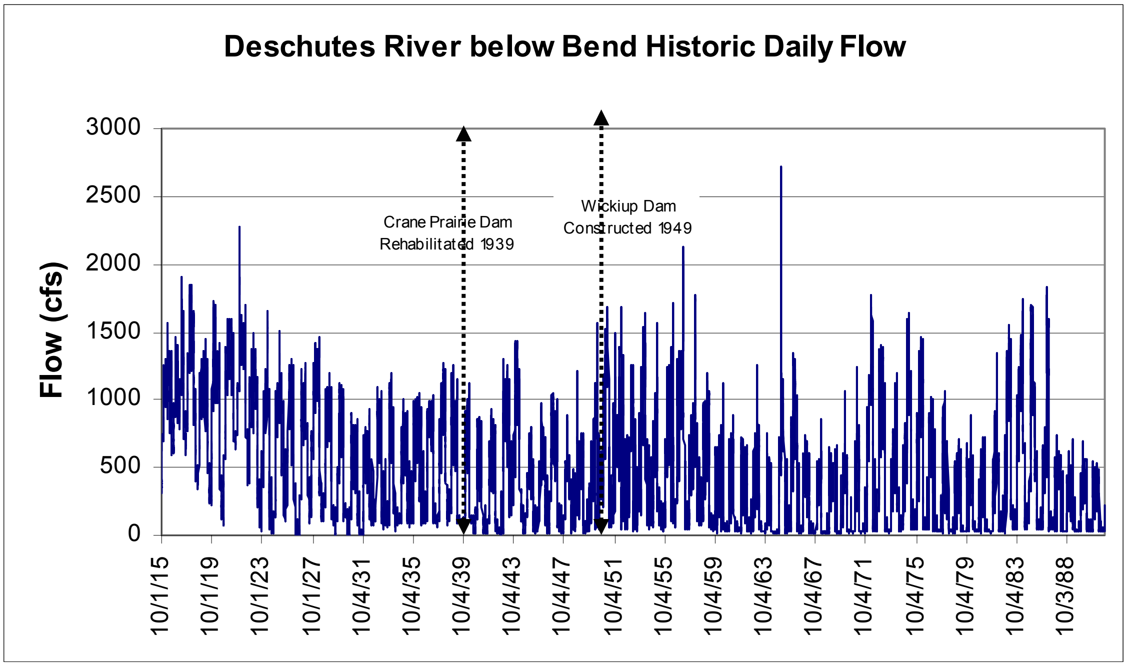

Figure 3-12. Deschutes River below Bend, Historic Daily Flow (Water Years 1916-1990)

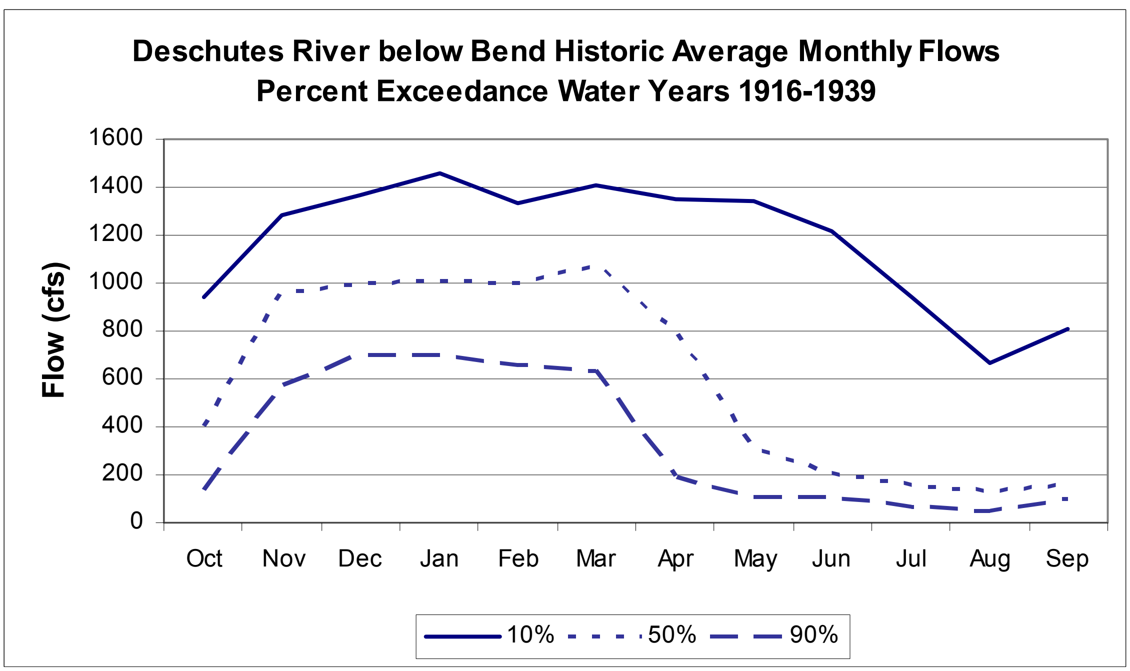

Figure 3-13. Deschutes River below Bend, Historic Average Monthly Flow Percent Exceedance (Water Years 1916-1939)

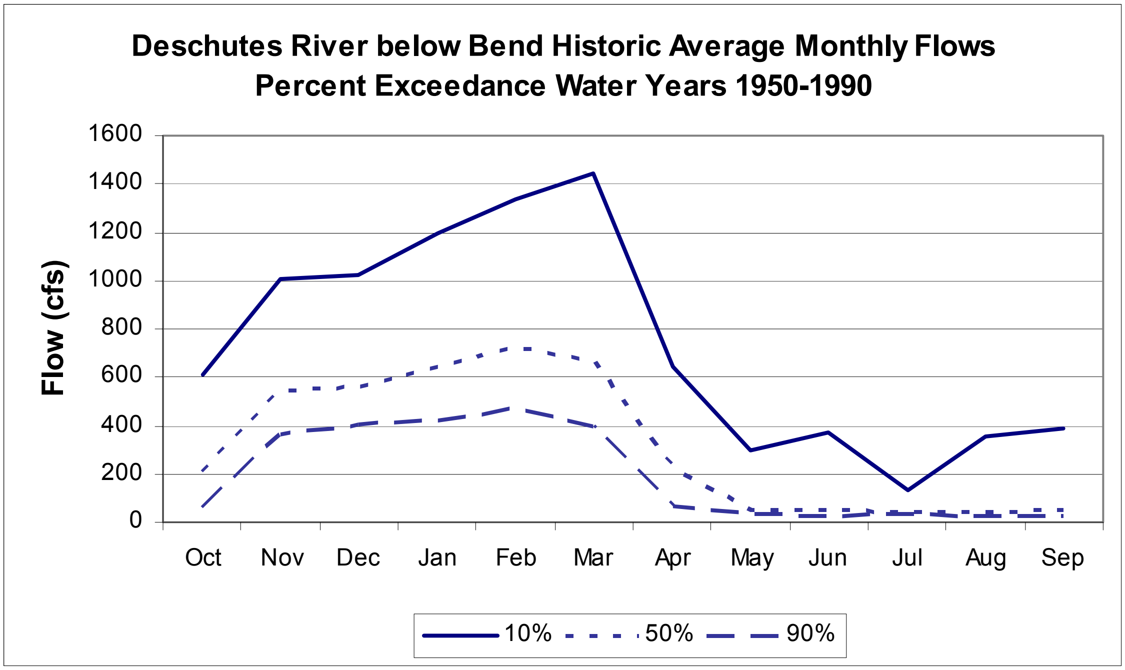

Figure 3-14. Deschutes River below Bend, Historic Average Monthly Flow Percent Exceedance (Water Years 1950-1990)

3.3.6 Deschutes River Near Culver

The historic average daily flow data for the Deschutes River near Culver for water years 1953 through 2001 are shown in Figure 3-15. The Deschutes River near Culver gage is located directly upstream from Lake Billy Chinook and downstream of Squaw Creek at RM 120.1. The flows range from a minimum of about 500 cfs to a maximum of nearly 5,000 cfs. The flows are lower during the late 1980s and early 1990s due to very dry conditions and low water supply.

The area upstream from this gage has significant groundwater discharge. Groundwater discharge was estimated from OWRD seepage runs. A seepage run consists of a series of discharge measurements made at sequentially downstream locations along a stream reach over a short period of time. The Deschutes River gained approximately 400 cfs along the 10-mile reach above the gaging station near Culver during seepage runs in May 1992 and May 1994 (Gannett et al. 2001). The consistency of the flows in both wet and dry years confirms the influence of considerable groundwater gains in this reach of the river. The exceedance plot for the Deschutes River near Culver is shown in Figure 3-16. Flows are higher during the winter when compared to the irrigation season due to significant groundwater discharge during the winter months

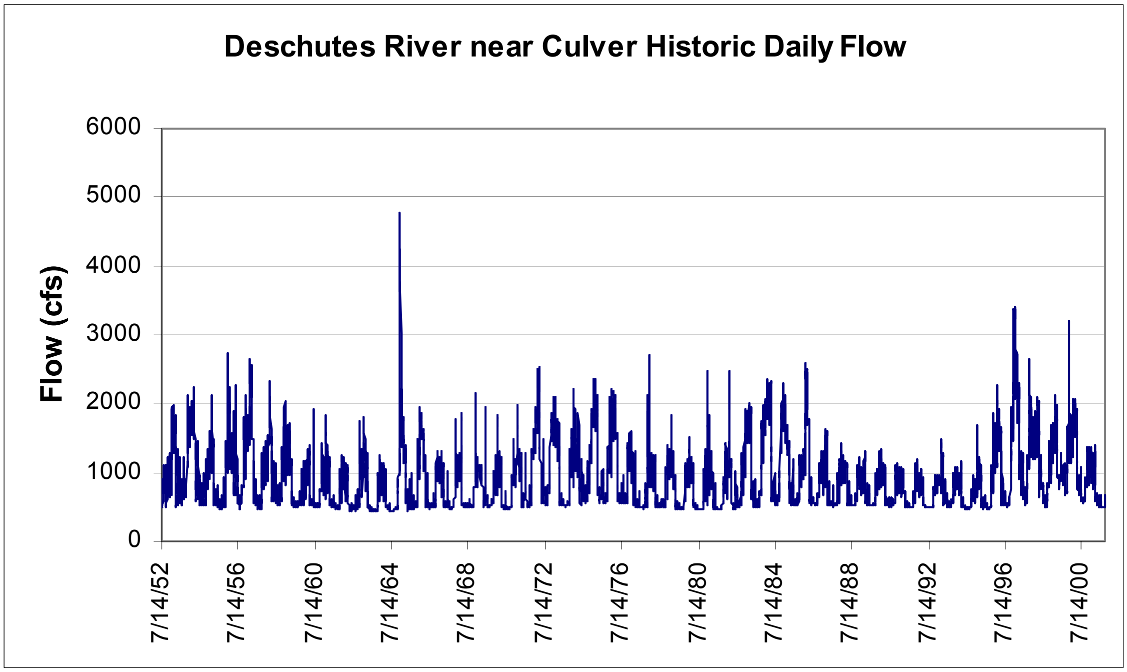

Figure 3-15. Deschutes River near Culver, Historic Average Daily Flow (Water Years 1953–2001)

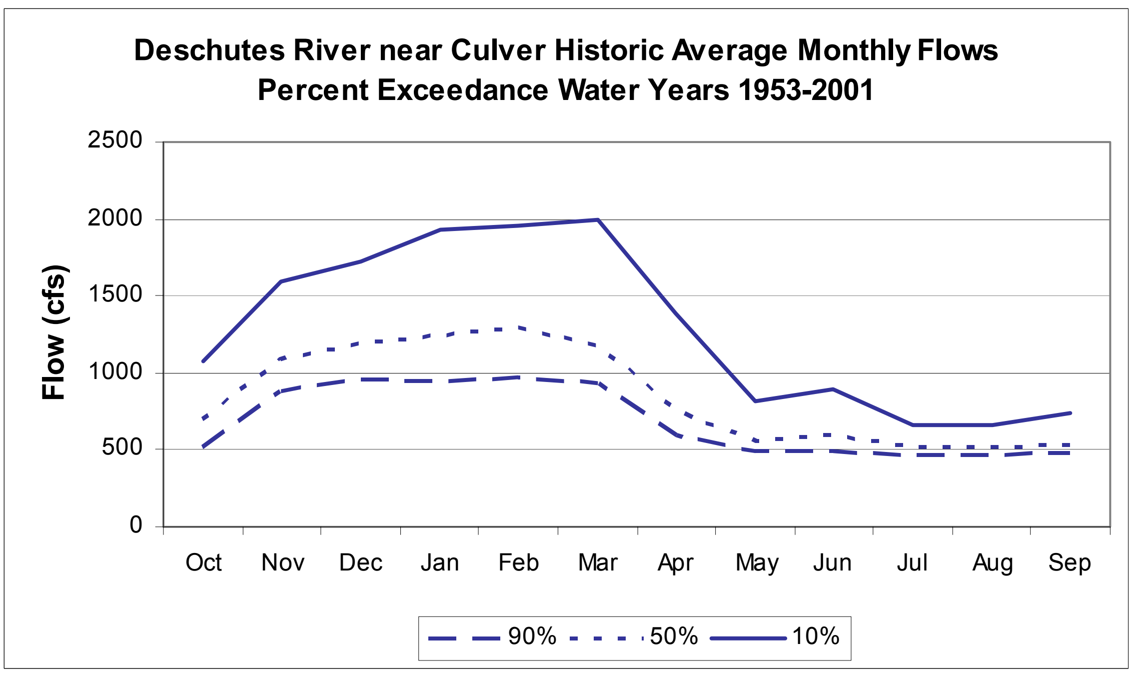

Figure 3-16. Deschutes River near Culver, Average Monthly Flow Percent Exceedance Plot (Water Years 1953-2001)

3.3.7 Deschutes River Near Madras

The Deschutes River near Madras gage is located directly downstream from Lakes Billy Chinook and Simtustus at RM 100.1. Flows at this location include contributions from the Metolius and Crooked Rivers. The average daily historic flows for water years 1925 through 2001 for the Deschutes River near Madras are shown in Figure 3-17. The daily flows ranged from 2,440 cfs to 17,800 cfs and minimum flows ranged from 2,000 to 3,000 cfs.

Two periods of record were examined for the Deschutes River near Madras: 1) water years 1925 through 1939, before any Reclamation reservoirs were in place, and 2) 1962 through 2001, when all Reclamation reservoirs were in place and operating (Crane Prairie, Wickiup, and Prineville Reservoirs). Additionally, the period after 1962 reflects operation effects from the private Pelton-Round Butte hydroelectric complex. Daily flows are less erratic post-1962.

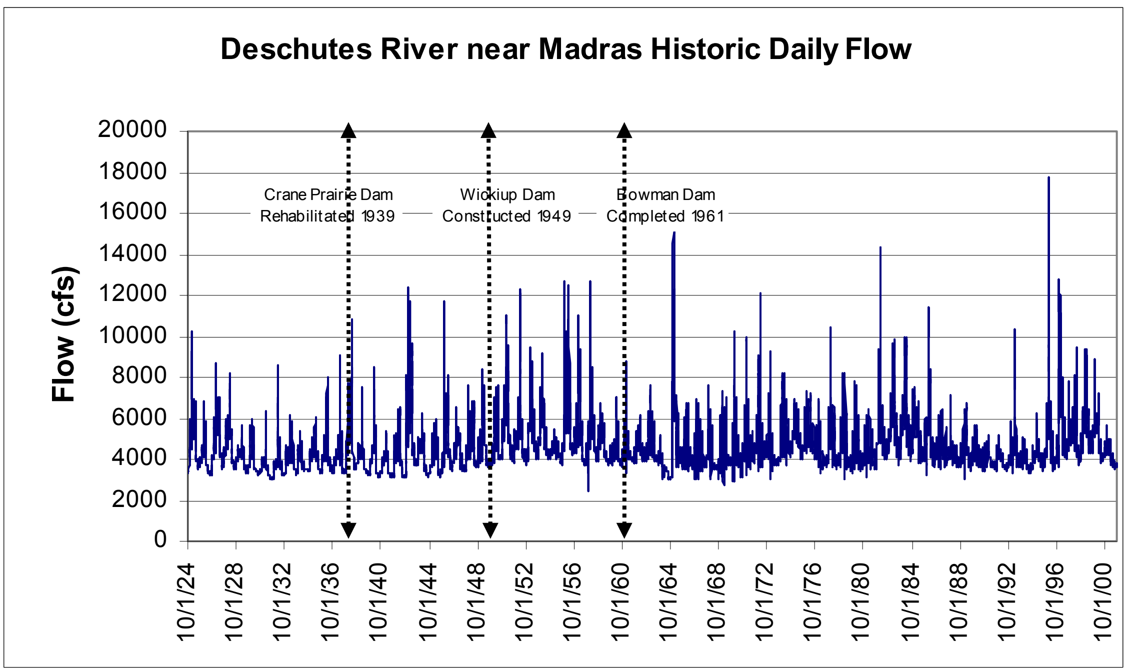

Figure 3-17. Deschutes River near Madras, Historic Average Daily Flow (Water Years 1925-2001).

The percent exceedance plot of the average monthly flows for the Deschutes River near Madras for the 1925 through 1939 period is shown in Figure **3-18** and for the 1962 through 2001 period in Figure 3-19. The exceedance plots have the same general shape with the highest flows in February and March and the lowest flows during July through November. Flows post-1962 are generally higher than prior to water development in the basin. The 50 percent exceedance is the most similar pre and post-water development with the 1962 through 2001 period having slightly higher flows during the winter which could be due to a greater amount of groundwater discharge from irrigation. The 10 percent exceedance on the 1925 through 1939 plot is much lower than the 10 percent exceedance on the 1962 through 2001 plot indicating a drier period during 1925 through 1939. With the exception of the January through March period, flows at the 90 and 50 percent exceedance are within 10 percent of each other.

Table 3-1 shows the average monthly flow exceedance for water years 1990 through 2001 for the Deschutes River near Madras gage.

Table 3-1. Average Monthly Flow (cfs) Exceedance for the Deschutes River near Madras

Gage Location (period of record)	Percent Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Deschutes River													
Near: Madras (water years 1990-2001)	90%	3708	4053	4023	4055	3952	3906	3739	3637	3643	3424	3586	3566
	50%	3977	4305	4525	4591	4836	4775	4149	4081	3923	3777	3832	3773
	10%	5410	5714	7253	9600	8974	7732	7643	5807	5899	4863	4695	4911
* Information from: http://www.wrd.state.or.us													

The Deschutes River flows near Madras reflect the influence of groundwater discharge. Gannett et al. (2001) estimated that the total groundwater discharge in the confluence area around Lake Billy Chinook was 2,300 cfs . They concluded that these groundwater discharges, along with the flow of the Metolius River (which is primarily groundwater discharge during the dry season), makes up almost all of the flows of the Deschutes River near Madras during the summer and early fall (Gannett et al. 2001).

Irrigation canal seepage is a significant source of groundwater recharge. It is estimated that 46 percent of the water diverted upstream from Lake Billy Chinook for irrigation is lost through canal leakage (Gannett et al. 2001). The average annual rate of leakage from irrigation canals to groundwater during 1994 (a year studied in detail by Gannett et al. 2001) was 356,600 acre-feet (490 cfs). Canal leakage peaked in the late 1950s when mean annual diversions were approximately 940,000 acre-feet (1,300 cfs) and nearly 435,000 acre-feet (600 cfs) was lost to groundwater recharge.

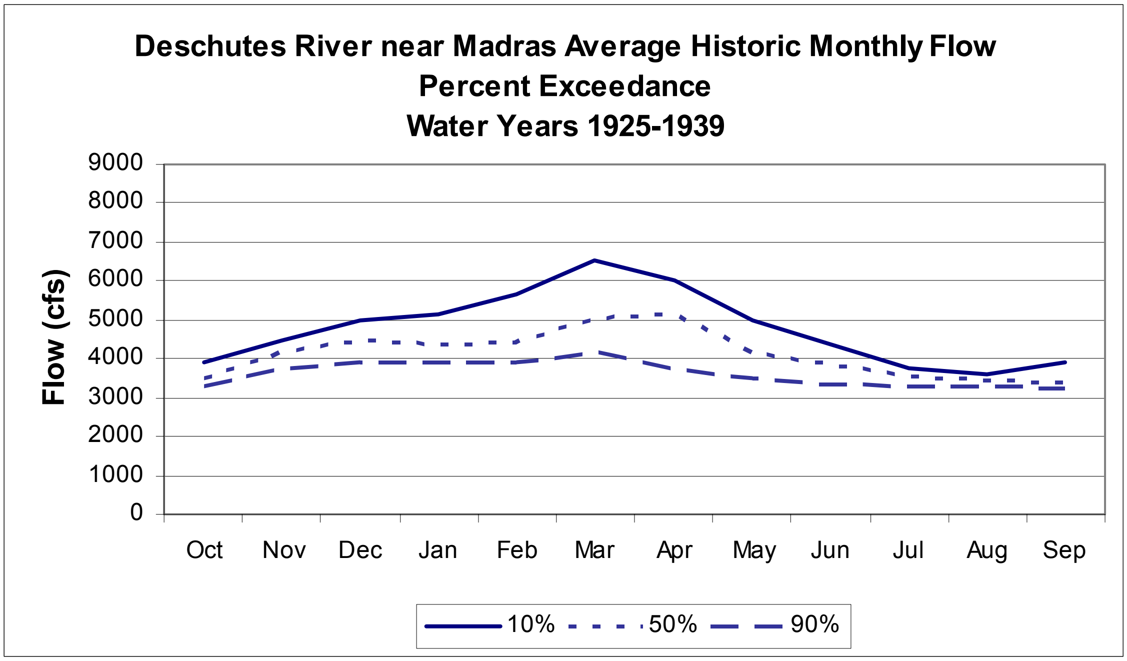

Figure 3-18. Deschutes River near Madras, Average Monthly Flow Percent Exceedance Plot (Water Years 1925-1939)

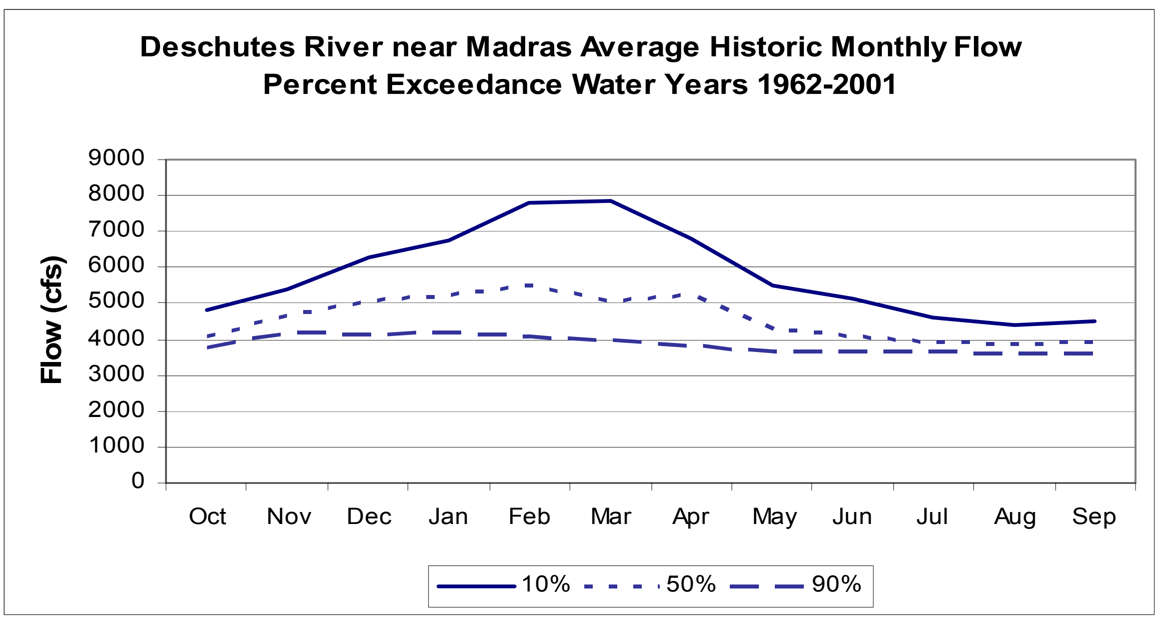

Figure 3-19. Deschutes River near Madras, Average Monthly Flow Percent Exceedance Plot (Water Years 1962-2001)

3.3.8 Deschutes River at Moody

The Deschutes River at Moody gage is located at RM 1.4 near the mouth of the Deschutes River where it enters the Columbia River. The historic average daily flow of the Deschutes River at Moody is shown in Figure 3-20. The minimum flows at Moody ranged from 2,880 to 5,000 cfs during the 1907 through 2001 water year period.

Two periods of record were examined for the Deschutes River at Moody: 1) water years 1907 through 1939, before any Reclamation projects were present in the basin, and 2) 1962 through 2001, the period when all the irrigation projects and Pelton-Round Butte hydropower complex were operating. The historic average monthly flow percent exceedance plot for water years 1907 through 1938 period is shown in Figure 3-21 and for water years 1962 through 2001 in Figure 3-22. Table 3-2 shows the average monthly flow exceedance for water years 1990 through 2001 for the Deschutes River at Moody.

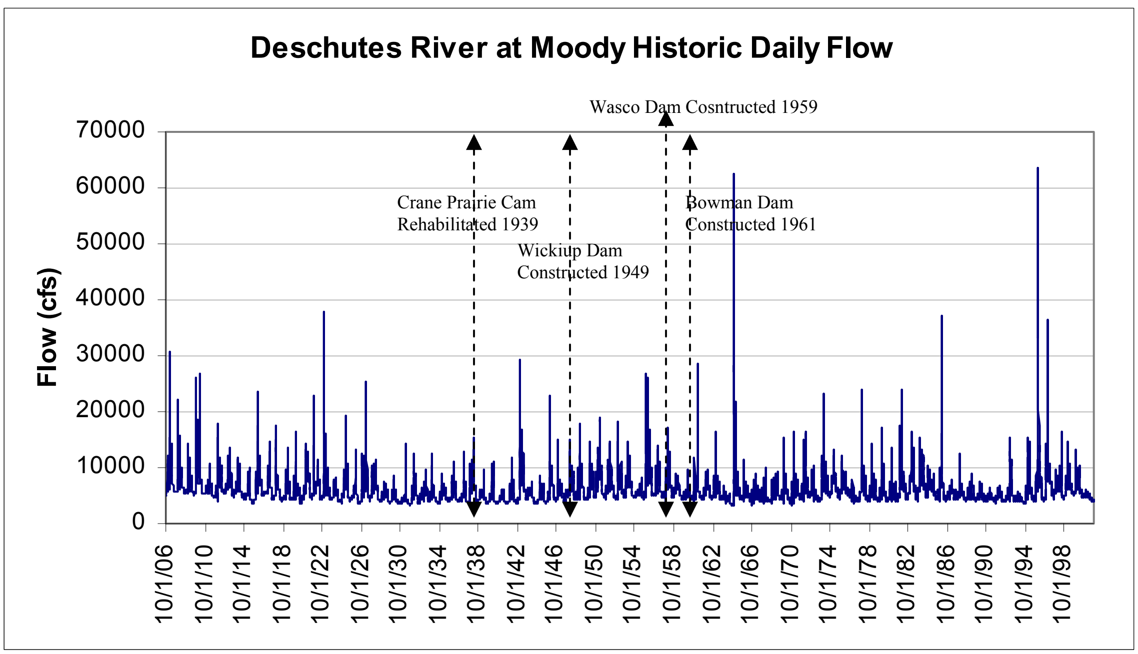

Figure 3-20. Deschutes River at Moody, Historic Average Daily Flow (Water Years 1907-2001)

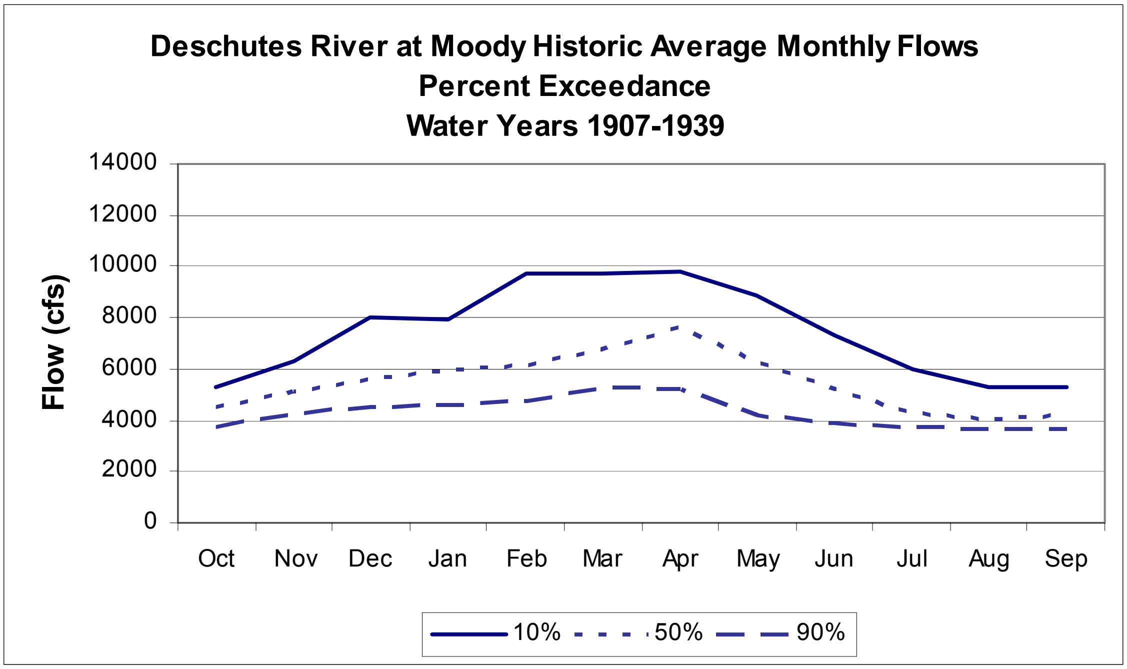

Figure 3-21. Deschutes River at Moody, Average Monthly Flow Percent Exceedance Plot (Water Years 1907-1939)

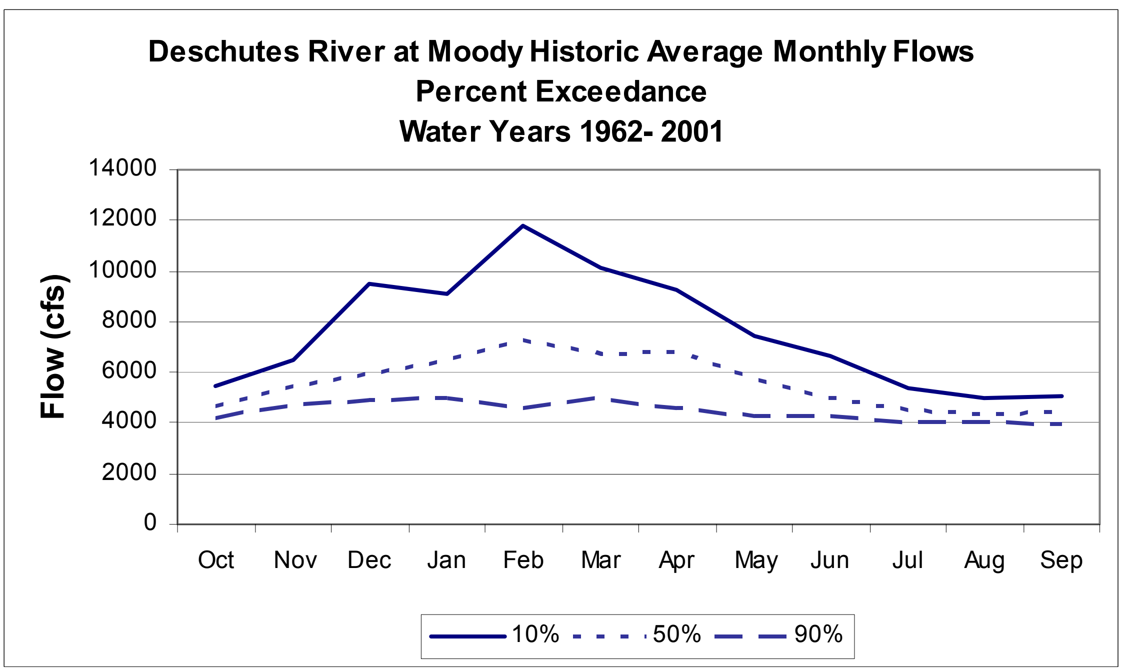

Figure 3-22. Deschutes River at Moody, Average Monthly Flow Percent Exceedance Plot (Water Years 1962-2001)

**Table 3-2. Average Monthly Flow (cfs)
Exceedance for the Deschutes River at Moody**

Gage Location (period of record)	Percent Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Deschutes River													
At:	90%	4167	4652	4446	4873	4595	4418	4560	4166	3988	3606	3748	3809
Moody	50%	4410	5043	5389	5425	5503	6717	5494	5604	4731	4309	4302	4110
(water years 1990-2001)	10%	5860	6716	11,312	14,981	16,981	9512	9880	7717	7297	5715	5351	5285
* Information from: http://www.wrd.state.or.us													

The exceedance plots reflecting flows before and after construction of Reclamation projects and the Pelton-Round Butte hydropower complex are similar, with only subtle differences. Examination of average daily flows reveal that flows after construction of Pelton-Round Butte are more uniform.

3.4 CROOKED RIVER

3.4.1 Prineville Reservoir

Bowman Dam was completed in 1961. The historic end-of-month elevations for Prineville Reservoir are shown in Figure 3-23. The historic elevations reflect the normal operating practices as described in pages 66 through 73 in the Operations Report. The reservoir fills approximately 3 out of 4 years and the minimum elevations reflect the fluctuating water supply conditions over the 40-year period. The lowest minimum elevations occurred during the extreme drought years of 1977 and 1990 through 1992. Construction modifications on Ochoco Dam started in 1994 and completed in 1997 resulted in additional storage from Prineville Reservoir being used for that period. Other than this, there does not appear to be any significant changes in reservoir elevation trends over the period of record.

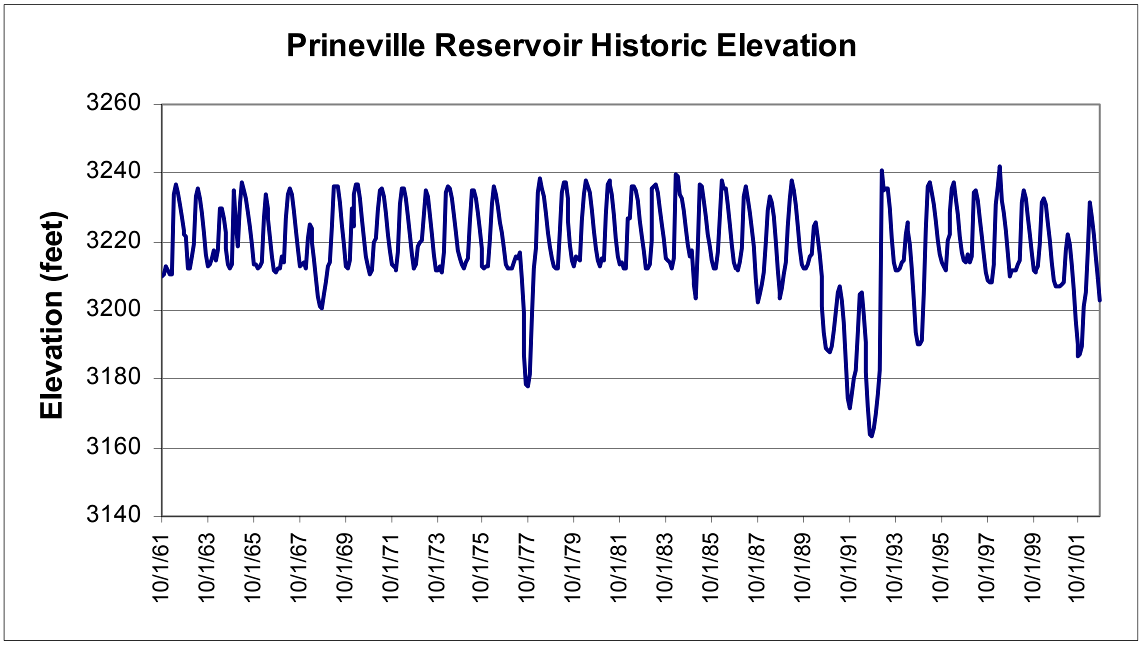

Figure 3-23. Prineville Reservoir Historic End-of-Month Elevations (Water Years 1962-2001)

3.4.2 Crooked River below Bowman Dam

The Crooked River below Bowman Dam historic average daily flows are shown in Figure 3-24. In the years before Bowman Dam was constructed there was a greater variability in the flows, with higher peak flows and lower minimum flows. The average monthly flow percent exceedance plots before construction of Bowman Dam are shown in Figure 3-25 and after construction (1961 through 2001) in Figure 3-26. In the period before Bowman Dam (1943 through 1960), the peak flows at all exceedance levels were higher and winter flows were lower than before construction of the dam. The timing of peak flows also changed after the construction of Bowman Dam. The seasonal peak flows pre-dam occurred in April at the 10, 50, and 90 percent exceedance. Post-dam peak flows occurred in March at the 10 percent exceedance, April at the 50 percent exceedance, and June or July at the 90 percent exceedance level.

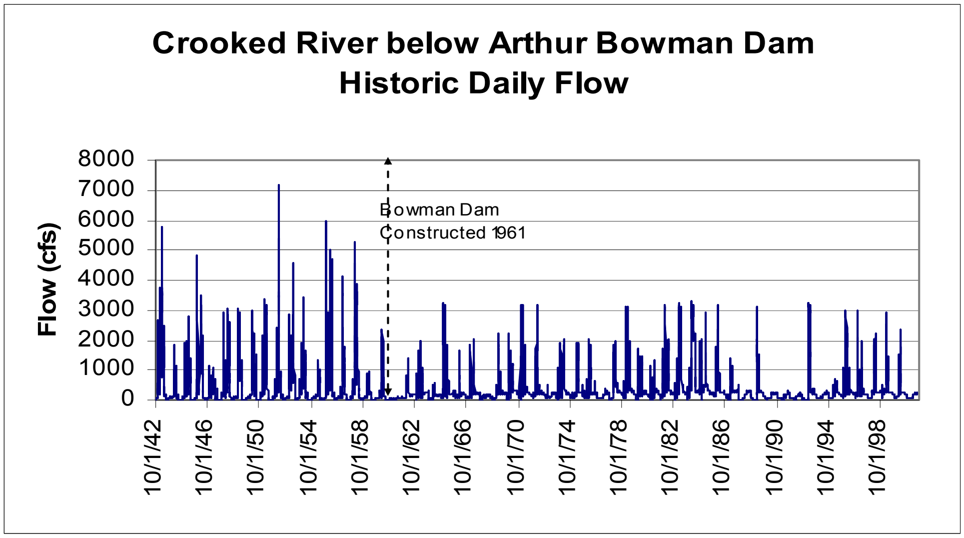

Figure 3-24. Crooked River below Bowman Dam, Historic Average Daily Flow (Water Years 1943-2001)

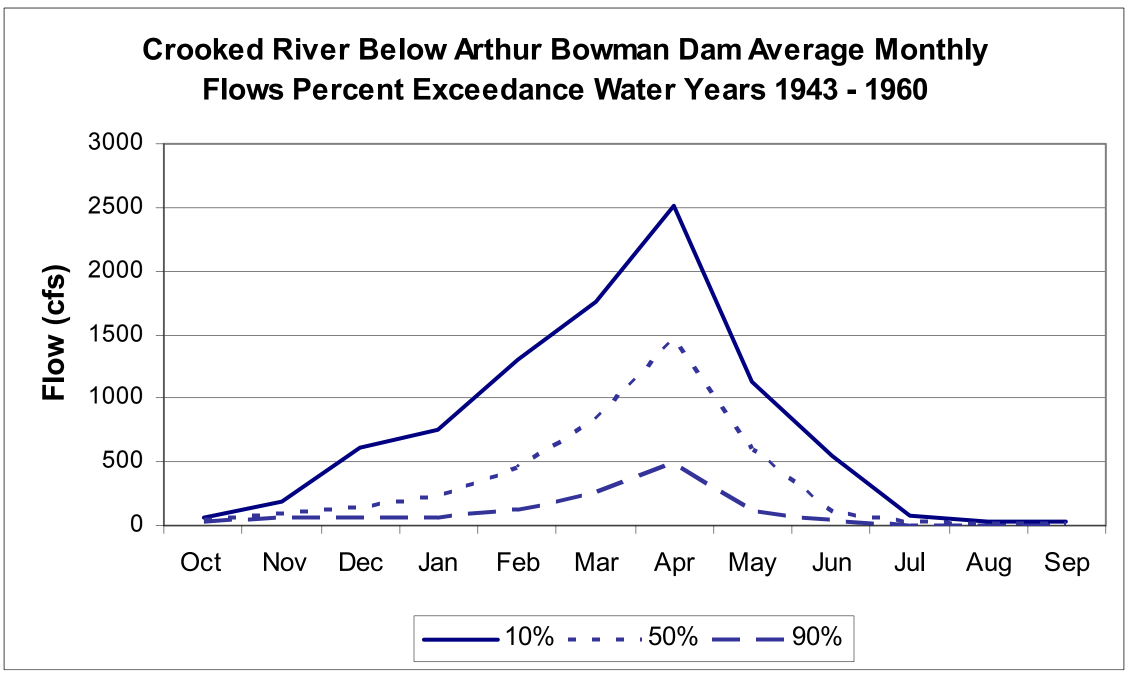

Figure 3-25. Crooked River below Bowman Dam, Average Monthly Flow Percent Exceedance Before Construction of Bowman Dam (Water Years 1943-1960)

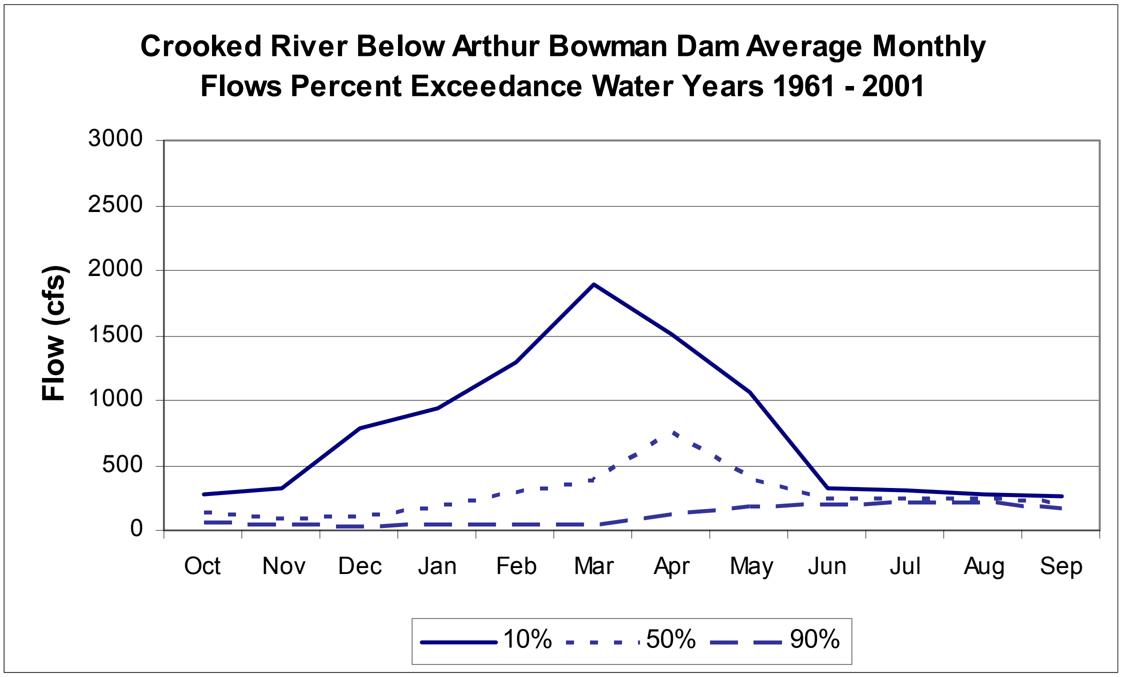

Figure 3-26. Crooked River below Bowman Dam, Average Monthly Flow Percent Exceedance After Construction of Bowman Dam (Water Years 1961-2001)

3.4.3 Crooked River Near Culver and Below Opal Springs

The Crooked River near Culver at RM 1.0 has a period of record from 1918 through 1961 (before construction of Bowman Dam), and the Crooked River below Opal Springs at RM 6.7 has a period of record from 1962 through 2001 (post-Bowman Dam). Although these gages are almost 6 miles apart, the records can be compared because nearly all of the diversions and seepage gains occur above RM 6.7. The historic average daily flows for these gages are shown in Figure 3-27 and Figure 3-28. Figure 3-29 and Figure 3-30 display the average monthly flow percent exceedance plots for these gages.

Figure 3-27 and Figure 3-28 show that the Crooked River flows were more variable before Bowman Dam was built. Maximum flows were as high as 8,000 cfs and minimums were near 1,000 cfs. After completion of the dam, flows on the Crooked River were more uniform with fewer extremes on the high and low ends of the hydrograph. The median average monthly flows ranged from 1,200 to 2,300 cfs in the years before Bowman Dam compared to median flows ranging from 1,200 to 2,000 cfs in the years after construction.

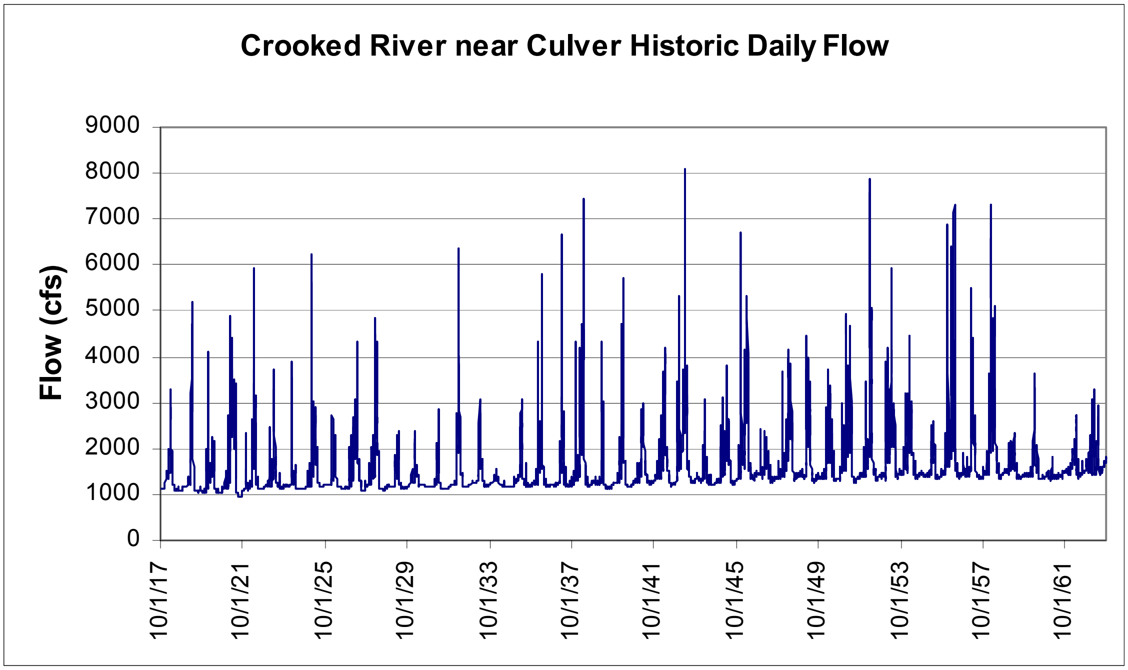

Figure 3-27. Crooked River near Culver, Historic Average Daily Flow Before Construction of Bowman Dam (Water Years 1918-1961)

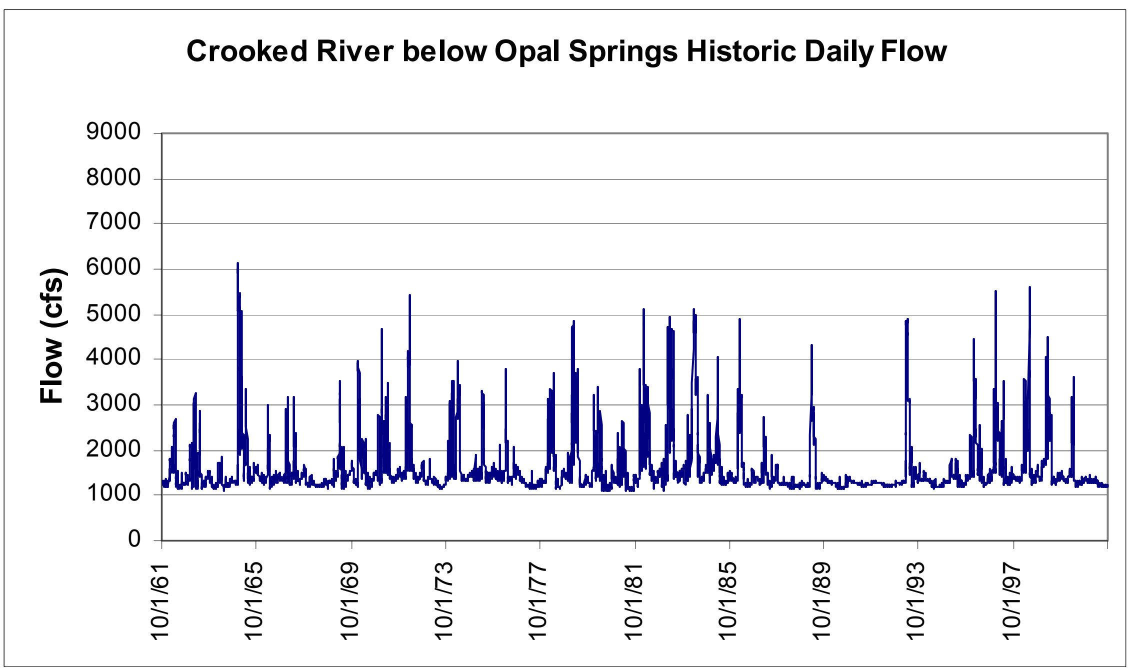

Figure 3-28. Crooked River below Opal Springs, Historic Average Daily Flow After Construction of Bowman Dam (Water Years 1962-1999)

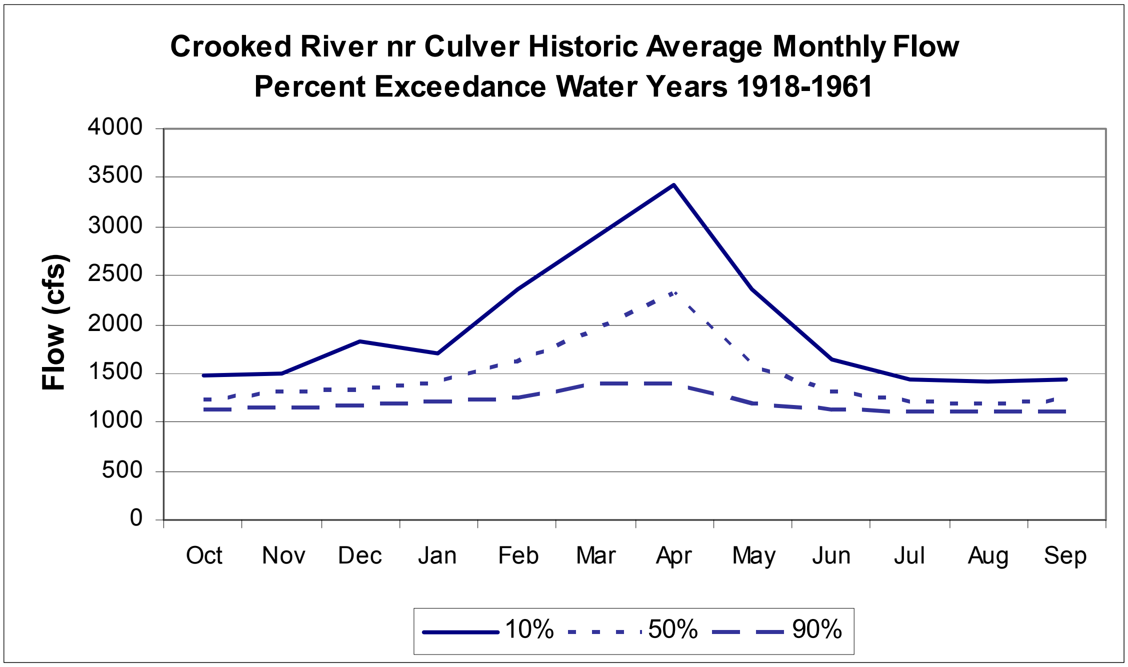

Figure 3-29. Crooked River near Culver, Historic Average Monthly Flow Percent Exceedance (Water Years 1918-1961)

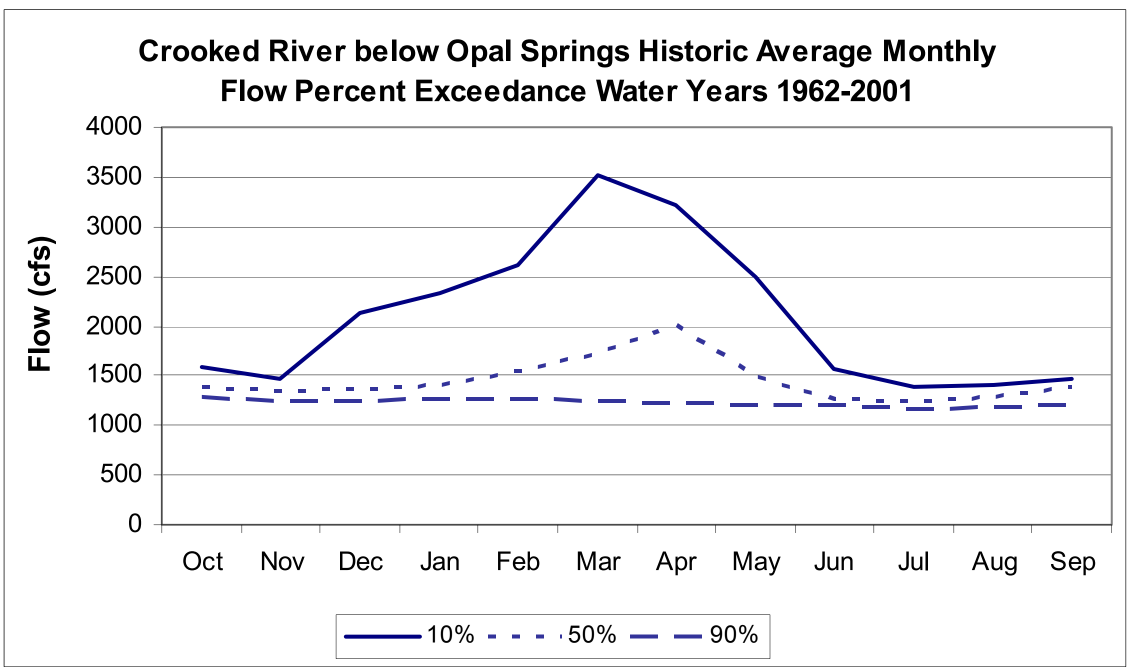

Figure 3-30. Crooked River below Opal Springs, Historic Average Monthly Flow Percent Exceedance After Bowman Dam (Water Years 1962-2001)

3.5 WHITE RIVER

3.5.1 Clear Lake

Wasco Dam (Clear Lake) was completed in 1959. The 1984 through 2001 historic end-of-month elevations for Clear Lake are shown in Figure 3-31. There are gaps in the historic elevation plot because measurements were not taken in some years and in other years some months had missing data. The available elevation data reflect the fluctuating water supply conditions during this 17-year period. Changes in elevation trends are due to changing water supply conditions, not due to changes in reservoir operations.

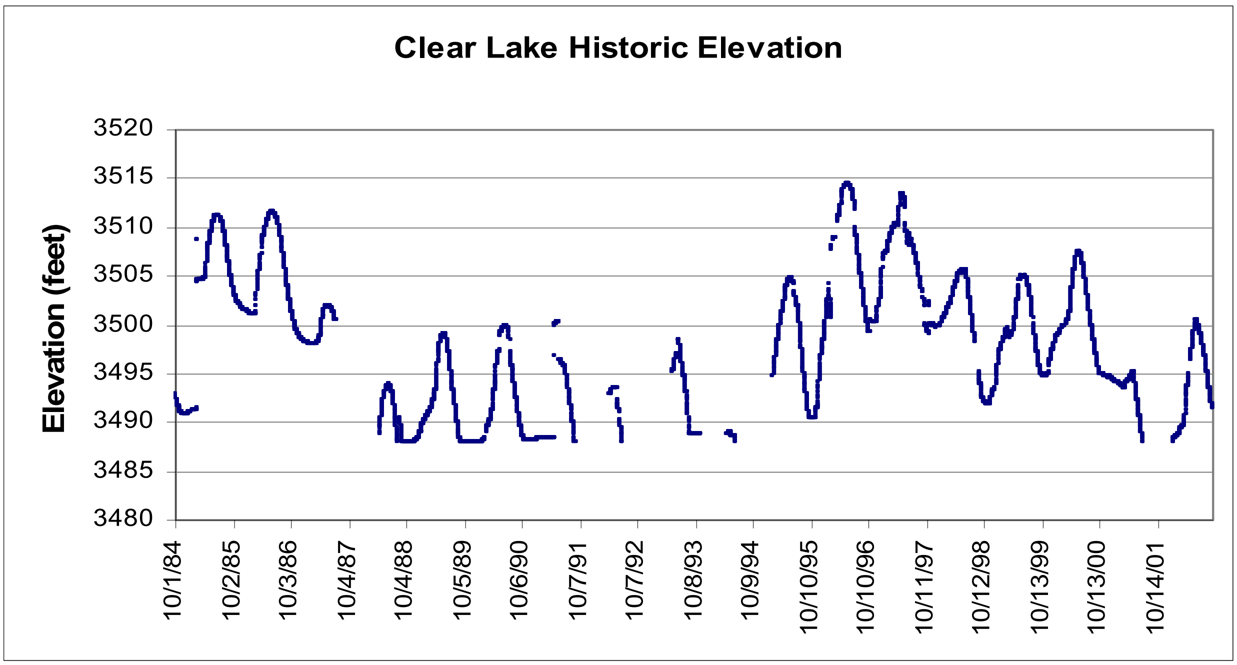

Figure 3-31. Clear Lake Historic End-of-Month Elevations (Water Years 1984-2001)

3.5.2 Clear Creek below Clear Lake

Figure 3-32 shows Clear Creek below Clear Lake historic daily flow for a period from 1968 through 1973. This figure shows the increase in outflows from Clear Lake during the irrigation season with very little outflow during the rest of the year. Exceedance plots for this site were not done because of the short period of record.

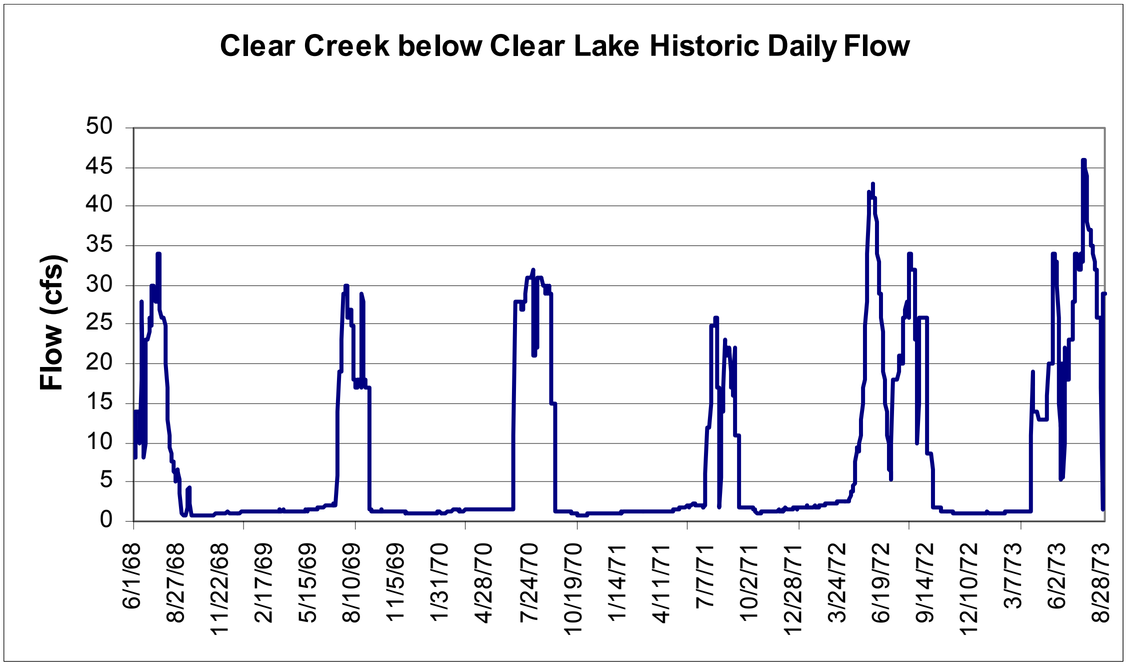

Figure 3-32. Clear Creek below Clear Lake, Historic Daily Flow (1968-1973)

3.5.3 White River below Tygh Valley

The Tygh Valley gage is located on the White River downstream of White River Falls, approximately 2 miles upstream from the confluence with the Deschutes River. The White River below Tygh Valley gage historic daily flow for water years 1918 through 1990 is plotted in Figure 3-33. (The data only goes through water year 1990 because the gage was discontinued after that year.) Figure 3-34 and Figure 3-35 show the average monthly flow percent exceedance plots for water years 1918 through 1959 before Wasco Dam, and for water years 1960 through 1990 after Wasco Dam was constructed, respectively. When comparing the two exceedance plots, they are very similar with no significant changes in flows in the periods before and after Wasco Dam. Both plots show a winter peak from rain-on-snow events and a spring snowmelt peak. Clear Lake was a natural lake before Wasco Dam was constructed and the effect of adding extra storage with the dam was to lower the spring snowmelt peak in May.

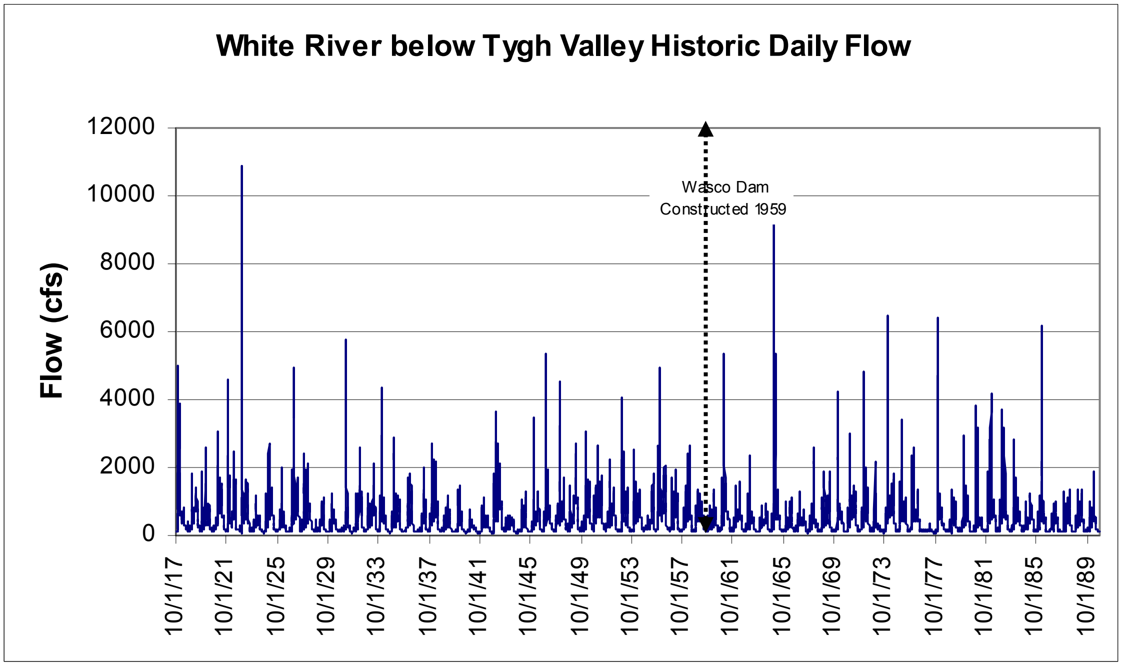

Figure 3-33. White River below Tygh Valley, Historic Average Daily Flow Percent Exceedance (Water Years 1918-1990)

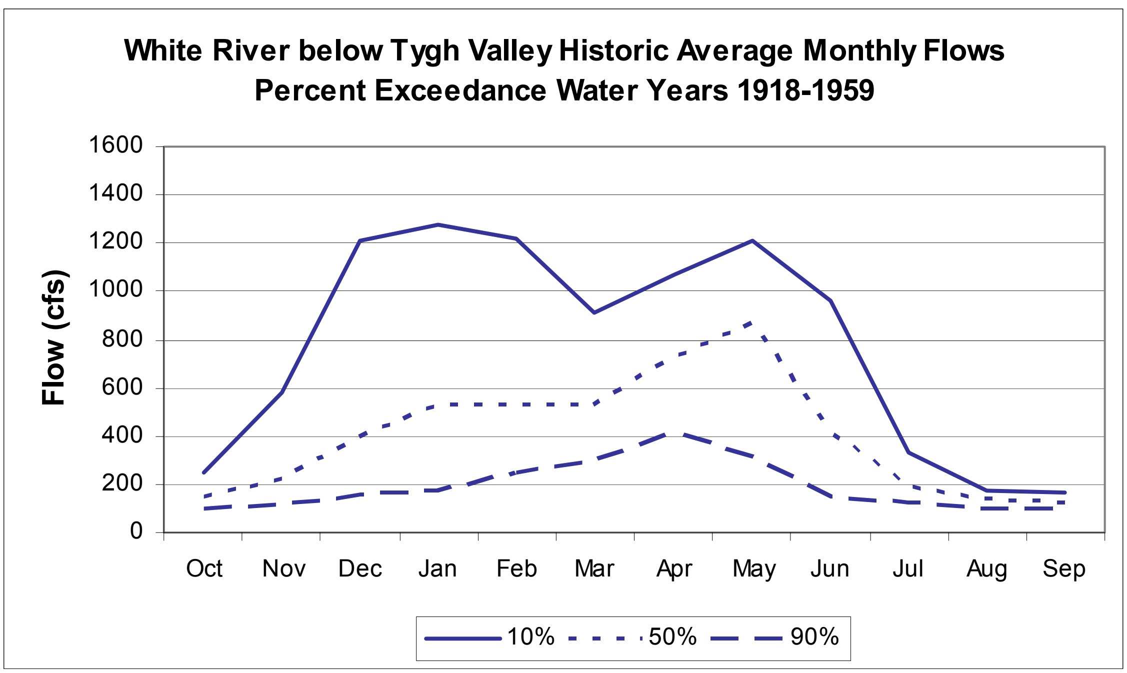

Figure 3-34. White River below Tygh Valley, Historic Average Monthly Flow Percent Exceedance Before Construction of Wasco Dam (Water Years 1918-1959)

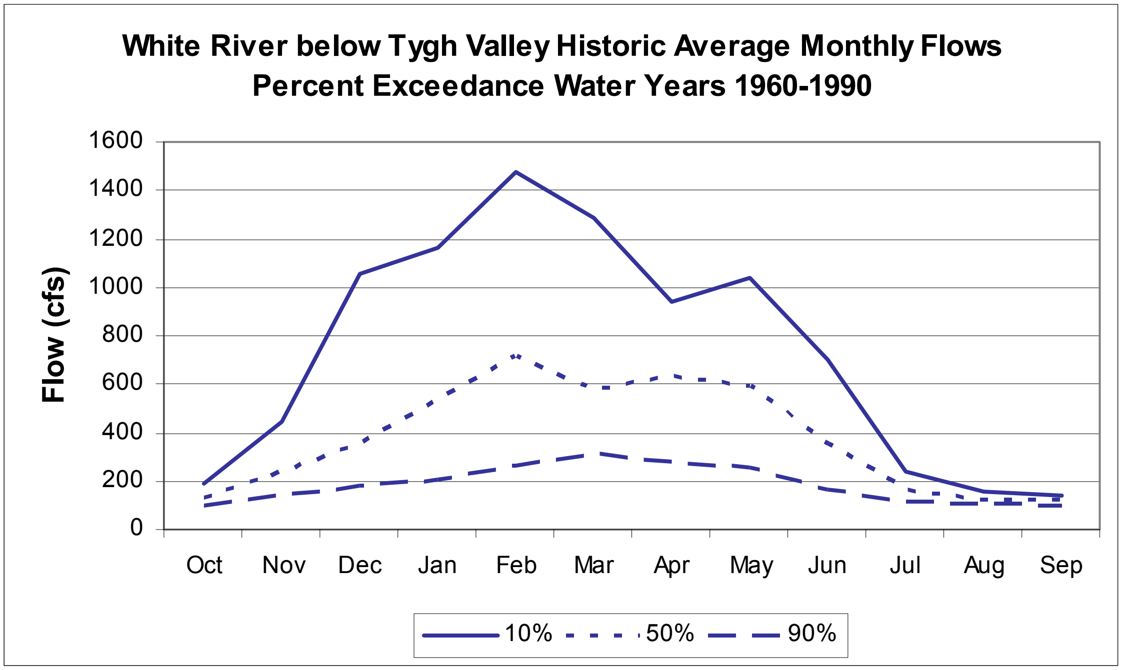

Figure 3-35. White River below Tygh Valley, Historic Average Monthly Flow Percent Exceedance After Construction of Wasco Dam (Water Years 1960-1990)

3.6 Summary Of Hydrologic Conditions

This hydrologic description examined the past and near present hydrologic conditions of reservoirs and river reaches in the Deschutes River basin. Water resources development in the Deschutes River basin, including Federal and private irrigation, groundwater development, and hydropower, has changed hydrologic conditions.

Comparisons of river flows before and after construction of Reclamation projects demonstrate that reservoir outflows change the shape of the natural hydrograph downstream due to storing and releasing water for irrigation and flood control. Winter flows are usually lower post-project when water is being stored. However, winter flows generally increased in the middle and lower reaches of the Deschutes River after construction of the Reclamation projects due to an increase in groundwater recharge from irrigation development and the resulting groundwater discharge into these areas. Irrigation releases in the summer generally have resulted in higher summer flows than occurred before these projects were constructed.

Hydrologic conditions have not changed substantially during the last 40 years since construction of irrigation and hydropower facilities in the basin. Reservoir elevation trends and river reach flows have remained relatively consistent over this period.