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**SUMMARY OF
PACKWOOD LAKE HYDROELECTRIC PROJECT
HYDROLOGY
(FERC NO. 2244)**

LAKE CREEK AND UPPER COWLITZ RIVER



Prepared for

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June 2004

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SUMMARY OF PACKWOOD LAKE HYDROELECTRIC PROJECT HYDROLOGY

1.0 INTRODUCTION

Energy Northwest, a municipal corporation and joint operating agency of the State of Washington, operates the Packwood Lake Hydroelectric Project (Project) near the town of Packwood in Lewis County, Washington. The Federal Energy Regulatory Commission (FERC) licensed the Project on July 7, 1960 (effective March 1, 1960), designated as Federal Power Commission License No. 2244. As owner of the Project, Energy Northwest intends to file an application for a new license pursuant to the regulations issued by FERC in 2003, which established the Integrated Licensing Process (ILP). Under the ILP regulations, a license applicant must file a Notice of its Intent (NOI) to file a license application no less than five years before the current license expires. At that time, the licensee must also submit to FERC and the resource agencies, a Pre-Application Document (PAD), containing existing, relevant, and reasonably available information describing the existing environment and the potential effects of the licensee's intended project proposal, including proposed project facilities and operations.

Energy Northwest has taken a proactive approach to relicensing its Packwood Lake Hydroelectric Project by initiating collaborative scoping of studies to develop the data and analyses that will be required for issuance of the water quality certification by the Washington Department of Ecology (WDOE) under Section 401 of the Clean Water Act. Energy Northwest has held meetings on March 22 and April 22, 2004 with the natural resource agencies and tribes. In those meetings, the parties expressed a desire to review the hydrologic information available for the project on Lake Creek in advance of issuance of the PAD. Because the Project flows also bypass 4 miles of the upper Cowlitz River, concerns were expressed about the potential effects of the Project on the Cowlitz River.

1.1 Study Purpose

The purpose of this study is to develop hydrological information to support the 401 Water Quality Certification investigations being conducted by Energy Northwest for the Packwood Lake Project.

1.2 Study Objectives

Currently, the FERC license for the Project requires a minimum instream flow of 3 cfs, at the drop structure immediately downstream of the outlet of Packwood Lake. There is also an instream flow requirement of 15 cfs at the confluence of Lake Creek with the Cowlitz River. Energy Northwest is not currently required to measure instream flows at the confluence, although water release flows for fish are recorded daily at the Project drop structure. In addition, Energy Northwest has agreed to install a temporary gage near the mouth of Lake Creek, and has done so in the same location as the previous USGS gage. The overall objective of this study is to develop information that supports the continuation of these instream flow requirements (issued as part of the 401 certification) for Project operation under a new FERC license. Specific study objectives are:

- Quantify the hydrology for the Packwood Lake Hydroelectric Project in Lake Creek;
- Determine the rate of inflow from the Project drop structure downstream to the confluence of Lake Creek with the Cowlitz River;
- Quantify the hydrological contribution of Lake Creek to the upper Cowlitz River, particularly during low flow months; and
- Examine the frequency of drop structure overtopping and quantify the associated discharge into upper Lake Creek.

2.0 METHODS

2.1 USGS Gage Data

Energy Northwest downloaded information from the USGS web site for the following gages:

- Lake Creek at the outlet of Packwood Lake (immediately downstream of the drop structure [No. 14225500])
- Lake Creek upstream of the confluence with the Cowlitz River (No. 14226000)
- Cowlitz River at Packwood, WA (No. 14226500)

2.2 Project Operations Data

Energy Northwest reviewed and summarized Project operations data. The data reviewed included daily lake level, project flows, fish (instream) flows, and approximate inflow to the lake. Data were also reviewed to determine the frequency and extent that Packwood Lake levels overtopped the drop structure, and the resultant flow during these spillage events.

3.0 RESULTS AND DISCUSSION

For consistency, daily flow records were analyzed for the period of record from Water Year (WY) 1912 through WY 1962. This is the period of record prior to construction and operation of the Project when all three gages listed above were recording. After Project startup in 1964, the USGS gages remained in operation; however, gage No. 14225500 (lake outlet) only reflects fish flows (i.e., instream flows, generally 3 – 5 cfs) plus any overtopping of the drop structure at the top, while the lower gage (No. 14226000) reflects only releases at the drop structure plus any accretion in the creek. While the Project kept accurate records of lake level, fish flows and project (i.e., power) flows, overflow at the drop structure and discharges into Packwood Lake from upper lake tributaries are at best estimates; accordingly Energy Northwest decided to analyze and examine only those flows for flow duration analysis that had been recorded by the USGS prior to project initiation. For estimates of inflow from the drop structure downstream to the confluence of Lake Creek with the Cowlitz River, however, Energy Northwest used the period of record where gages overlapped.

3.1 General Hydrology

Upper Lake Creek

The USGS has records for the Lake Creek Gaging Station No. 14225500 from October 11, 1911 through September 30, 1980, with a total of 18,555 daily measurements for that period of record. The record, however, is not complete for this time period. Gaps exist in the data for the following periods:

- October 1925 – September 1930 (5 years)
- November 1943 – September 1948 (4 years 11 months)
- May 1954 – August 1959 (5 years 4 months)

Table 3-1 summarizes mean monthly and annual flows for Lake Creek at the drop structure. Mean annual flow is 100.7 cfs, ranging from a low of 56.5 cfs in WY 1941 to a high of 135.6 cfs in WY 1921. September and October tend to be the driest months, averaging 55.9 and 62.8 cfs respectively. The lowest mean monthly flow during this period was 21.5 cfs in November 1936, while the wettest month during this period was 364.5 cfs in December 1933.

Data from WY 1914 was combined with data from October 1963 through September 1977 in conjunction with the same time period at the Lake Creek near the confluence with the Cowlitz River gage to estimate inflow to Lake Creek below the drop structure.

Lower Lake Creek

The USGS Gage Station No. 14226000 (Lake Creek near Mouth) includes data from September 1 1907 through November 22 1977. As was the case for Gage No. 14225500, the record is incomplete. Significant gaps exist in the data for the following periods:

- October 1912 – September 1913 (1 year)
- October 1914 – September 1962 (53 years)
- October 13 – 29, 1976

No analysis of mean monthly or annual flows was conducted at this site. Data from WY 1914 was combined with data from October 1963 through September 1977 in conjunction with the same time period at the Lake Creek gage at the Packwood Lake outlet to estimate inflow to Lake Creek below the drop structure.

Upper Cowlitz River

The USGS Gage Station No. 14226500 (Cowlitz River at Packwood) includes 29,307 daily flows from July 1, 1911 to September 30, 2002. Gaps in the record for the WY 1912 – 1962 period are:

Table 3-1 Mean monthly and annual flows (cfs) of Lake Creek near Outlet (Gage 14225500), 1912 – 1962.

WY	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Annual
1912	47.1	109.0	81.9	96.3	118.6	58.7	59.1	158.7	244.2	138.5	97.4	75.4	106.8
1913	50.1	72.9	63.0	86.5	64.8	60.2	69.7	160.2	315.8	215.1	110.2	75.5	112.1
1914	75.0	70.2	57.1	100.6	55.7	83.8	109.2	153.9	152.2	125.3	71.0	59.9	93.0
1915	63.9	137.2	55.3	42.1	34.3	38.0	86.1	83.8	95.5	90.9	69.4	51.4	70.7
1916	46.5	94.9	94.8	53.9	78.4	120.5	98.6	148.9	260.1	270.1	134.0	80.2	123.5
1917	40.0	54.0	53.6	45.7	54.6	42.4	48.9	118.7	299.3	315.8	125.5	76.4	106.4
1918	47.0	41.6	326.1	174.4	105.2	54.2	71.8	115.5	254.6	150.8	87.2	52.2	123.7
1919	66.2	69.8	104.4	122.4	61.7	44.6	83.1	160.6	169.0	151.5	70.8	49.8	96.4
1920	31.9	66.4	70.5	107.2	69.7	45.0	45.5	102.8	182.0	164.3	85.6	84.7	88.0
1921	108.0	102.2	77.0	135.1	112.7	118.3	94.1	181.9	304.7	208.3	121.5	63.7	135.6
1922	57.6	127.4	217.0	53.1	36.6	34.2	38.1	136.3	244.7	116.1	73.5	67.4	100.5
1923	43.5	43.8	64.9	223.2	57.5	46.9	111.5	168.7	198.8	195.4	79.1	50.5	107.5
1924	55.5	49.8	79.0	69.8	153.8	58.9	50.7	168.7	139.3	97.5	58.8	39.4	84.8
1925	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1926	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1927	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1928	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1929	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1930	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	40.4	N/A
1931	39.3	35.2	36.0	49.4	61.0	60.9	90.7	174.6	139.7	70.3	45.2	41.8	70.3
1932	41.4	45.5	40.6	56.9	49.4	106.5	100.8	175.8	236.4	173.9	84.1	54.8	97.3
1933	58.6	229.5	117.6	85.0	50.2	51.5	60.5	128.0	301.4	229.4	115.1	75.1	125.2
1934	147.4	134.5	364.5	201.3	85.5	128.3	153.8	133.6	98.5	66.2	47.8	39.2	134.1
1935	68.5	137.6	106.5	89.5	87.8	53.7	52.7	132.6	212.7	134.9	65.3	45.3	98.9
1936	31.4	26.2	28.4	60.2	35.6	55.0	109.2	257.4	236.7	105.8	51.3	43.5	86.8
1937	31.0	21.5	49.4	32.9	31.2	40.1	71.6	160.9	309.2	172.3	65.4	50.6	86.5
1938	42.9	114.8	114.1	91.5	48.8	50.3	114.6	196.1	208.3	121.1	50.9	35.5	99.2
1939	44.0	52.0	81.6	74.7	49.0	53.3	103.2	172.7	160.6	135.7	60.6	44.3	86.2
1940	39.4	45.5	98.0	78.7	85.2	82.8	90.8	156.2	121.3	70.1	43.7	34.2	78.9
1941	34.6	39.0	70.9	52.0	40.7	35.9	47.7	99.5	95.3	62.5	38.9	59.9	56.5
1942	93.5	90.1	143.8	53.9	48.2	43.4	70.0	116.3	164.2	139.7	46.4	31.2	87.0

Table 3-1 Mean monthly and annual flows (cfs) of Lake Creek near Outlet (Gage 14225500), 1912 – 1962.

WY	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Annual
1943	28.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1944	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1945	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1946	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1947	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1948	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1949	61.5	131.1	91.1	72.2	74.2	99.9	91.9	153.7	323.9	278.4	123.6	62.2	130.4
1950	121.9	151.6	183.9	96.8	150.6	65.4	104.1	190.5	181.1	125.6	61.8	49.0	123.3
1951	112.7	81.1	81.4	37.9	57.0	42.7	90.9	174.7	169.8	145.3	65.6	37.1	91.3
1952	34.0	23.2	26.7	144.6	138.5	54.4	67.3	147.3	170.1	200.0	89.7	45.9	94.9
1953	75.0	70.2	57.1	100.6	55.7	83.8	109.2	153.9	152.2	125.3	71.0	59.9	93.0
1954	56.5	77.3	157.5	81.3	86.5	72.1	84.7	N/A	N/A	N/A	N/A	N/A	N/A
1955	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1956	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1957	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1958	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1959	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	124.1	N/A
1960	189.3	196.6	103.9	47.7	65.6	52.4	94.7	147.0	220.8	125.5	66.4	51.8	113.4
1961	55.5	137.9	76.4	108.3	159.1	89.0	94.8	159.1	285.3	146.7	71.2	55.1	119.3
1962	57.3	64.0	92.6	137.6	68.1	46.5	124.0	167.3	176.7	147.4	94.0	47.2	101.9
Mean	62.8	86.6	102.0	90.1	74.5	63.9	85.1	153.2	206.8	152.0	77.0	55.9	100.7

- October 1913 – September 1914 (1 year)
- October 1928 – September 1929 (1 year)

Table 3-2 summarizes mean monthly and annual flows for the Cowlitz River at Packwood. For the period WY 1912 – 1962, mean annual flow is approximately 1,650 cfs, ranging from a low of 922 cfs in WY 1941 to a high of 2,406 cfs in WY 1956. September and October tend to be the driest months, averaging 606 and 916 cfs, respectively. The lowest mean monthly flow during this period of record was 196 cfs in November 1952, while the wettest mean monthly flow during this period was 6,025 cfs in December 1933. For the WY 1912 – WY 2001 period, mean annual flow was approximately 1,594 cfs.

3.2 Flow Duration Analysis

Appendix A provides a mean monthly hydrograph as well as monthly and annual flow duration curves for Lake Creek at Packwood Lake outlet and for the Upper Cowlitz River at Packwood.

Table 3-3 summarizes monthly flow statistics for the 1912 – 1962 period and compares the flow in Lake Creek immediately below the outlet to the Upper Cowlitz River at Packwood. On average, upper Lake Creek flows constitute approximately 6% of the flow in the upper Cowlitz River. During September and October, upper Lake Creek contributes less than 8% of the flow in the Upper Cowlitz River. Measurement error for flow measurements is normally considered to be $\pm 10\%$, indicating that the contribution of flow of Lake Creek as measured at the lake outlet is within the measurement error.

Tables 3-4 and 3-5 summarize flow duration statistics for Lake Creek as measured at the lake outlet and the Cowlitz River at Packwood, respectively.

3.3 Accretion to Lake Creek

Energy Northwest examined water years when the gages were installed and operating both at the outlet of Packwood Lake (USGS No. 14225500) and on Lake Creek near its confluence with the Cowlitz River. (USGS No. 14226000). The years that coincided were WY 1912, 1914, and 1963 – 1977. Due to data inconsistencies, WY 1912 was excluded from the analysis.

Table 3-6 summarizes inflow from the Packwood Lake outlet (approximate RM 5.4) to the gage located upstream from the mouth of Lake Creek (approximate RM 0.3). Average annual inflow was 26.7 cfs, with minimum inflows occurring during August (9.8 cfs), September (8.6 cfs) and October (9.2 cfs). Maximum inflows occurred during December (40.6 cfs), January (55.6 cfs) and February (40.9 cfs). Lowest mean annual accretion was during WY 1977 (14.9 cfs) while the highest mean annual accretion was during WY 1972 (42.4 cfs).

Table 3-2 Mean monthly and annual flows (cfs) of Cowlitz River at Packwood (Gage 14226500), 1912 – 1962.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1912	390	1,737	1,023	1,645	1,548	577	1,037	2,677	3,102	1,398	916	876	1,407
1913	509	1,588	849	1,017	1,011	821	1,528	2,875	3,983	2,467	1,056	762	1,538
1914													
1915	983	3,633	584	597	573	1,034	2,082	1,220	1,091	809	721	451	1,146
1916	873	1,373	1,475	764	1,902	2,681	2,130	3,015	4,964	4,691	1,837	772	2,207
1917	397	614	584	614	905	477	1,165	2,907	5,119	4,818	1,383	760	1,648
1918	525	516	5,760	3,497	1,230	850	1,682	1,979	3,436	1,512	733	572	1,858
1919	790	930	1,922	2,771	783	711	1,633	2,699	3,032	2,200	987	510	1,581
1929													
1930	298	201	706	512	2,228	1,185	2,295	2,152	2,136	1,121	616	431	1,157
1931	354	599	684	1,650	1,121	1,287	1,901	3,047	1,862	860	564	381	1,192
1932	543	1,211	1,053	1,183	1,521	2,088	2,048	3,034	3,907	2,400	929	505	1,702
1933	646	3,390	1,583	1,438	396	796	1,460	2,562	5,175	4,265	1,688	939	2,028
1934	2,586	1,939	6,025	3,572	1,499	3,157	2,662	2,229	1,351	858	618	397	2,241
1935	1,901	3,205	1,679	1,709	1,617	954	1,172	2,968	3,904	1,868	789	600	1,864
1936	411	401	603	1,318	614	1,270	2,393	4,547	3,922	1,459	752	504	1,516
1937	405	326	913	364	396	1,081	1,884	3,204	4,898	1,963	756	551	1,395
1938	601	2,708	2,002	1,606	688	938	2,572	3,319	2,879	1,159	553	451	1,623
1939	441	804	1,601	1,384	658	1,173	2,080	3,401	2,593	1,648	759	467	1,417
1940	400	576	2,037	1,134	1,639	1,753	1,620	2,443	1,408	772	545	397	1,227
1941	499	921	1,270	971	689	811	1,161	1,589	1,134	752	522	745	922
1942	1,092	1,411	2,278	761	753	700	1,482	1,976	2,506	1,389	677	425	1,287
1943	330	2,167	1,666	1,036	944	1,122	2,555	2,729	3,495	2,509	806	522	1,657
1944	435	574	1,272	758	841	939	1,200	2,071	1,802	862	504	586	987
1945	520	773	941	1,882	1,668	854	1,045	3,340	2,243	1,214	605	753	1,320
1946	999	1,167	1,621	1,395	982	1,154	1,948	4,232	4,054	2,770	995	569	1,824
1947	966	1,912	3,058	1,324	1,581	1,413	2,203	3,338	2,453	1,229	674	646	1,733
1948	2,451	2,295	1,750	1,270	1,110	974	1,249	3,337	5,041	1,844	860	572	1,896
1949	933	1,192	832	479	810	1,270	2,166	5,209	4,386	2,750	1,027	614	1,806
1950	1,001	3,076	1,532	1,421	1,514	1,950	1,757	2,937	4,902	3,942	1,544	700	2,190
1951	1,905	2,966	3,429	1,462	2,499	996	2,133	3,169	2,985	1,491	657	510	2,017
1952	1,671	1,386	1,240	487	1,207	736	2,273	3,410	2,885	1,796	730	386	1,517
1953	327	196	319	3,651	2,009	816	1,422	2,748	2,884	2,880	1,050	597	1,575

Table 3-2 Mean monthly and annual flows (cfs) of Cowlitz River at Packwood (Gage 14226500), 1912 – 1962.													
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1954	613	1,296	2,587	1,170	1,692	1,141	1,625	3,367	3,822	3,699	1,478	795	1,940
1955	894	1,822	1,105	951	951	495	1,010	2,791	5,128	3,028	1,095	648	1,660
1956	2,683	3,533	2,716	1,475	634	931	2,456	4,571	4,524	3,451	1,204	688	2,406
1957	960	1,355	2,919	728	1,032	1,557	1,950	3,750	2,683	1,149	638	518	1,603
1958	490	620	1,374	1,545	1,816	826	1,603	3,874	2,717	1,153	691	485	1,433
1959	817	3,726	3,073	2,374	832	945	2,100	2,307	3,724	2,118	740	1,527	2,024
1960	2,513	3,138	1,936	831	1,432	1,158	1,745	2,720	3,747	1,652	676	521	1,839
1961	788	2,991	1,467	2,129	3,113	1,566	1,799	2,995	4,283	1,832	898	518	2,031
1962	707	1,010	1,896	2,166	1,179	687	2,466	1,954	2,936	1,789	914	607	1,526
1963	890	2,537	2,076	927	2,608	964	1,430	2,144	2,047	1,053	668	508	1,488
1964	450	1,348	1,278	1,494	941	709	1,085	2,316	4,769	3,438	1,321	731	1,657
1965	917	1,269	2,593	2,232	1,677	979	2,036	2,308	2,841	1,562	840	447	1,642
1966	445	795	711	785	505	923	1,787	3,037	2,458	1,521	674	501	1,179
1967	576	1,006	2,194	1,569	1,293	837	707	2,810	4,637	2,002	771	526	1,577
1968	1,626	1,490	1,824	2,166	2,960	1,426	925	2,051	2,649	1,088	876	1,052	1,678
1969	1,210	2,295	1,314	1,834	537	813	1,700	4,161	3,281	1,070	570	632	1,618
1970	680	800	976	2,060	1,324	1,039	942	2,209	3,318	1,383	618	525	1,323
1971	461	1,463	1,221	1,817	2,083	841	1,226	3,665	3,752	3,835	1,585	678	1,886
1972	532	1,161	1,019	1,372	2,322	3,478	1,642	4,252	4,915	3,594	1,550	989	2,236
1973	528	834	2,450	1,663	560	644	936	2,096	1,892	1,040	618	525	1,149
1974	648	1,858	2,165	4,104	1,306	1,281	1,619	3,234	6,085	3,698	1,599	743	2,362
1975	364	700	1,966	2,671	1,057	1,152	668	2,662	4,143	2,679	1,186	612	1,655
1976	836	2,181	4,731	2,195	1,026	652	1,311	3,401	3,086	2,876	1,414	728	2,036
1977	412	646	550	862	682	718	1,670	1,548	1,982	639	721	826	938
1978	560	3,105	4,510	1,107	902	1,145	1,220	1,918	2,468	1,494	695	809	1,661
1979	412	729	1,054	467	961	1,692	1,081	2,691	1,914	970	498	474	1,079
1980	521	458	2,696	998	1,679	1,125	1,977	2,423	2,132	1,111	574	492	1,349
1981	299	1,851	3,968	1,074	2,242	816	1,758	1,715	2,144	965	593	451	1,490
1982	863	998	1,481	1,090	3,118	1,457	1,297	2,755	3,998	1,880	736	466	1,678
1983	709	963	1,806	2,147	1,506	1,886	1,388	2,716	2,477	1,924	940	651	1,593
1984	399	2,200	943	3,078	1,179	1,435	1,037	2,167	2,832	1,743	750	500	1,522
1985	559	951	643	559	530	627	1,936	3,294	3,656	1,265	531	417	1,247
1986	1,057	1,610	527	1,578	2,363	1,725	1,093	2,138	1,759	714	584	421	1,297

Table 3-2 Mean monthly and annual flows (cfs) of Cowlitz River at Packwood (Gage 14226500), 1912 – 1962.													
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1987	447	2,108	835	785	1,257	1,652	1,786	2,522	1,435	697	445	344	1,193
1988	237	223	1,082	687	1,016	1,383	2,674	2,617	2,069	1,200	608	491	1,190
1989	809	2,119	1,313	1,166	711	1,218	2,688	2,419	2,842	1,188	556	364	1,450
1990	273	1,745	1,910	2,247	1,142	1,289	2,769	2,303	2,957	1,379	642	444	1,592
1991	1,196	3,624	1,104	1,576	3,009	913	2,833	1,815	2,160	2,105	1,354	909	1,883
1992	312	1,821	1,662	1,576	2,049	1,541	1,851	1,570	842	527	456	457	1,222
1993	388	986	642	838	702	1,632	1,560	3,215	1,834	925	621	355	1,142
1994	275	220	808	1,556	603	1,740	2,021	2,434	1,801	1,024	518	451	1,121
1995	755	1,075	2,484	1,622	3,976	1,492	1,055	2,561	2,219	1,390	634	464	1,644
1996	1,548	5,023	3,447	3,015	4,690	1,175	1,848	2,035	1,999	1,302	602	406	2,257
1997	593	1,758	1,622	2,714	1,762	2,374	1,983	4,485	3,908	2,413	749	758	2,093
1998	2,035	1,471	1,091	1,329	948	1,274	1,146	2,508	2,482	1,309	584	357	1,378
1999	306	1,452	2,303	1,887	1,188	1,178	1,332	2,603	3,845	3,498	1,824	655	1,839
2000	600	3,190	2,372	853	1,077	886	2,247	2,575	3,153	1,536	734	583	1,650
2001	731	432	486	699	613	913	1,177	2,520	1,626	911	647	436	933
2002	594	2,108	1,454	2,055	1,132	974	1,892	2,396	4,488	2,072	722	425	1,693
1912-1962	916	1,632	1,784	1,426	1,240	1,147	1,817	2,967	3,327	2,039	880	606	1,649
1912-2002	796	1,598	1,758	1,519	1,386	1,198	1,700	2,787	3,100	1,857	847	586	1,594

Table 3-3. Monthly and annual flows, upper Lake Creek and Cowlitz River at Packwood, WY 1912 – 1962.

Month	Lake Cr.	Cowlitz R.	Percentage
Oct	63	916	6.9%
Nov	87	1,632	5.3%
Dec	102	1,784	5.7%
Jan	90	1,426	6.3%
Feb	74	1,240	6.0%
Mar	64	1,147	5.6%
Apr	85	1,817	4.7%
May	153	2,967	5.2%
Jun	207	3,327	6.2%
Jul	152	2,039	7.5%
Aug	77	880	8.8%
Sep	56	606	9.2%
Annual	101	1,649	6.1%

Table 3-4. Flow exceedence values, Lake Creek at Packwood Lake Outlet (Gage No. 14225500), 1912 – 1962.

Flow Exceed	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Annual
1%	292	391	600	369	250	174	212	328	478	404	159	141	379
10%	106	163	184	181	130	104	140	229	324	247	124	83	194
20%	78	112	127	126	98	82	112	202	275	201	96	68	144
30%	64	88	94	94	77	68	99	178	242	172	86	60	113
40%	54	73	79	78	64	60	88	159	212	152	77	54	89
50%	48	66	70	68	59	54	78	143	190	138	70	50	74
60%	42	55	63	59	54	50	67	129	171	126	64	45	63
70%	38	46	57	52	50	46	58	118	150	109	58	42	54
80%	34	38	48	47	43	42	50	106	134	89	50	40	46
90%	30	30	35	41	37	37	44	83	111	74	44	35	38
99%	23	20	23	30	27	33	35	56	77	54	36	27	24

Table 3-5. Flow exceedence values, Cowlitz River at Packwood (Gage No. 14226500), 1912 – 1962.

Flow Exceed	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Annual
1%	6810	10400	10900	8110	5560	4720	5500	7620	8280	6340	2420	2160	7210
10%	1780	3480	3380	2860	2380	2130	2960	4860	5400	3880	1400	845	3510
20%	1160	2200	2250	1890	1640	1460	2430	4020	4530	2780	1100	706	2440
30%	850	1650	1720	1410	1290	1200	2090	3470	3900	2290	932	634	1860
40%	655	1270	1420	1120	1080	1030	1830	3040	3470	1980	843	580	1420
50%	540	1000	1190	950	915	909	1620	2660	3110	1680	760	540	1100
60%	466	807	982	805	800	820	1430	2360	2750	1440	700	500	887
70%	415	665	834	705	682	718	1240	2080	2410	1180	639	474	729
80%	363	524	688	600	575	615	1040	1800	2060	993	593	431	593
90%	307	362	546	482	484	500	848	1470	1540	825	532	380	468
99%	194	144	158	318	262	390	546	642	776	509	385	240	144

Table 3-6. Mean monthly inflow from Lake Creek at Packwood Lake outlet (Gage No. 14225500) and Lake Creek above mouth (Gage NO. 14226000).

WY	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Annual
1912	-4.7	37.8	13.9	52.3	55.4	6.2	0.8	-4.2	36.3	11.5	3.4	3.0	17.4
1914	11.8	21.8	18.6	50.7	25.1	36.7	42.8	41.4	26.7	22.2	10.3	12.3	26.7
1963	11.7	25.8	29.4	23.0	39.8	26.5	36.4	20.3	13.5	8.8	5.1	6.5	20.4
1964	5.9	26.7	26.6	47.1	35.4	29.0	37.6	30.3	26.0	17.1	12.9	8.6	25.2
1965	12.3	21.9	79.4	87.3	52.3	28.7	23.8	26.3	21.8	14.9	9.0	6.7	32.0
1966	5.8	8.7	13.5	29.0	20.2	37.2	34.8	25.1	18.9	12.7	8.5	5.9	18.4
1967	4.8	10.4	39.8	64.1	43.1	24.3	16.0	18.4	19.4	14.1	8.2	6.1	22.4
1968	11.9	21.2	38.9	39.2	62.1	36.0	26.8	15.7	14.3	9.6	8.0	9.4	24.3
1969	19.3	38.5	47.4	55.4	22.8	29.5	33.1	26.6	24.4	13.4	8.6	7.3	27.2
1970	8.9	11.6	22.4	62.2	47.1	30.0	27.2	17.9	15.0	10.2	6.6	5.6	22.0
1971	6.1	19.1	30.2	67.6	55.4	33.6	36.2	41.5	32.5	22.0	11.2	8.8	30.3
1972	9.0	21.6	37.9	66.4	79.7	99.7	50.3	48.2	42.7	26.1	14.9	13.7	42.4
1973	9.7	16.0	54.9	47.1	23.9	19.2	14.5	13.5	12.1	9.6	7.4	6.9	19.6
1974	6.8	34.4	56.8	82.5	49.8	43.4	46.7	44.2	52.5	26.0	14.5	9.3	38.9
1975	6.7	15.0	44.6	85.5	47.2	41.6	23.2	27.1	24.5	13.0	11.5	8.6	29.1
1976	8.7	30.8	92.8	67.3	36.4	29.7	37.5	35.7	27.2	18.7	12.9	9.2	34.0
1977	7.6	11.6	12.4	15.5	15.7	23.6	22.7	19.6	18.0	11.4	8.7	12.2	14.9
Mean (excludes WY1912)	9.2	20.9	40.6	55.6	40.9	35.5	31.8	27.9	24.4	15.6	9.8	8.6	26.7

3.4 Project Spills and Overtopping

Energy Northwest examined daily operations records to determine the frequency of overtopping and whether the overtopping occurred while the project was operating or not. Daily readings were not always taken at the intake structure. When a data gap existed and spilling was observed on either side of a data gap, spill was suspected of occurring and the spill was estimated for the time period in question.

Appendix B contains the full record of days when flows overtopped or were suspected to have overtopped the drop structure. Table 3-7 summarizes overtopping events from 1967 – 2003.

Overtopping has occurred or suspected to have occurred on 504 days during this time period, averaging 13.7 days per year. In some years, no spill occurred; in 1994, spill occurred on 66 days. Of those 504 days that the drop structure was overtopped, the plant was not operational on 216 of these days. The maximum spill event was estimated at 825 cfs in 1975, averaging 120 cfs. As a comparison, during the 1912 – 1962 period (pre-project), the maximum flood was 1300 cfs (December 22, 1933). Additional flows for channel maintenance and riparian corridors would have been provided by these spill events.

Concern was expressed that a major flood that coursed through the area in 1996 may have caused major changes in the stream morphology of Lake Creek. An examination of the records, however, indicates that spill only occurred for 4 days in 1996 (February 9 – 12), with a maximum spill of approximately 405 cfs. Flows of this reduced magnitude and duration would most likely not have a significant effect on existing channel structure, given its predominantly bedrock and boulder nature.

Table 3-7. Summary of overtopping events, Packwood Lake Hydroelectric Project, 1967 – 2003.

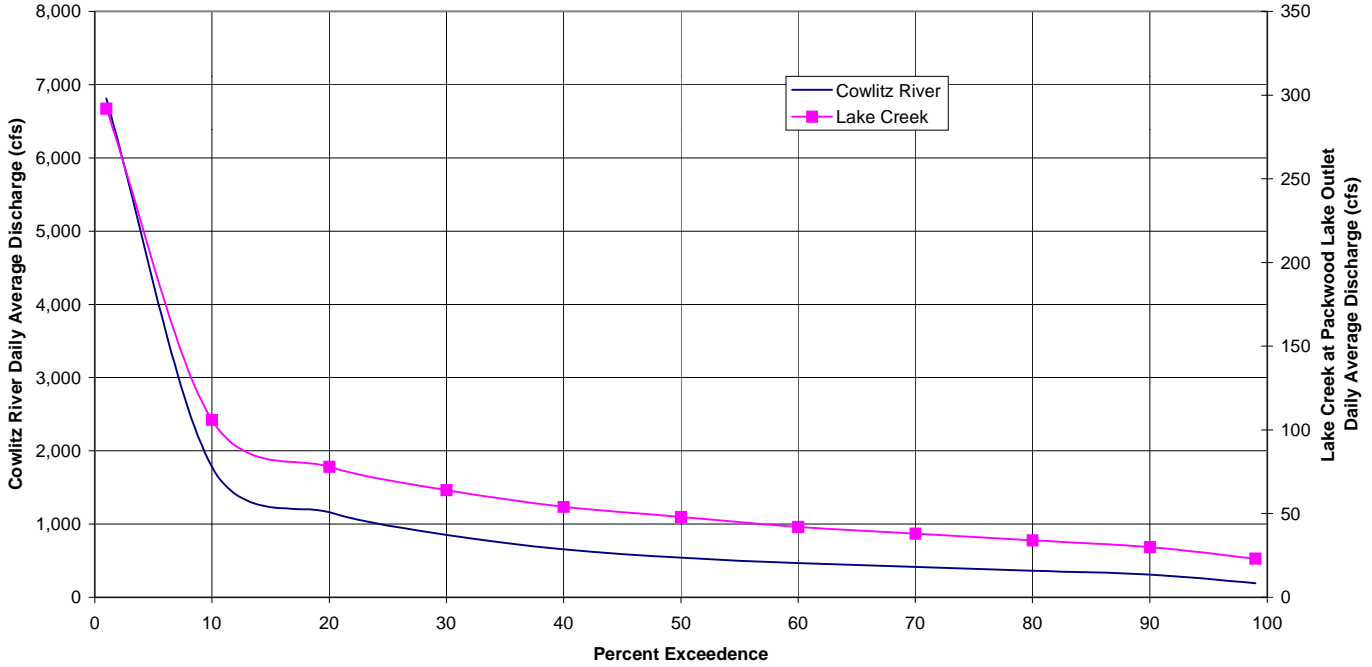
Year	Suspected		Total	Plant Down	Adj. Total	Max Flow
	Overtop	Overtop				
1967	7	2	9	0	9	212.0
1968	3		3	0	3	407.3
1969	20	6	26	0	26	225.0
1970	2		2	0	2	35.0
1971	8	2	10	0	10	198.0
1972	29	4	33	0	33	50.0
1973	2		2	2	0	14.3
1974	29	4	33	0	33	311.0
1975	11	9	20	9	11	825.3
1976	0		0	0	0	
1977	16		16	0	16	624.0
1978	0		0	0	0	
1979	0		0	0	0	
1980	6		6	0	6	310.4
1981	24		24	24	0	684.8
1982	13		13	0	13	159.5
1983	4		4	0	4	61.1
1984	0		0	0	0	
1985	14		14	0	14	330.1
1986	6		6	0	6	154.2
1987	0		0	0	0	
1988	0		0	0	0	
1989	0		0	0	0	
1990	4		4	0	4	388.2
1991	0		0	0	0	
1992	0		0	0	0	
1993	10		10	0	10	154.6
1994	7	59	66	59	7	326.3
1995	10	55	65	55	10	673.2
1996	4		4	0	4	405.5
1997	14	22	36	22	14	453.3
1998	0		0	0	0	
1999	13		13	0	13	161.1
2000	12		12	12	0	47.0
2001	33		33	33	0	275.3
2002	35		35	0	35	170.0
2003	5		5	0	5	260.0
Total	341	163	504	216	288	

APPENDIX A

FLOW DURATION CURVES

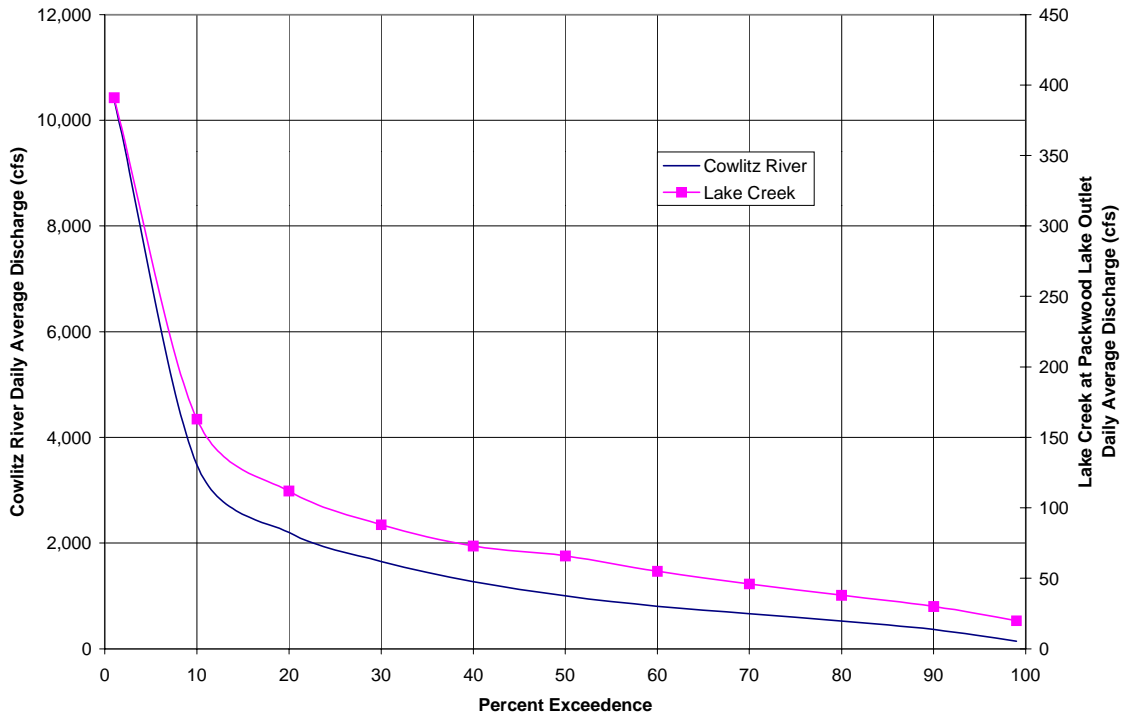
Flow Duration Curve, October 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



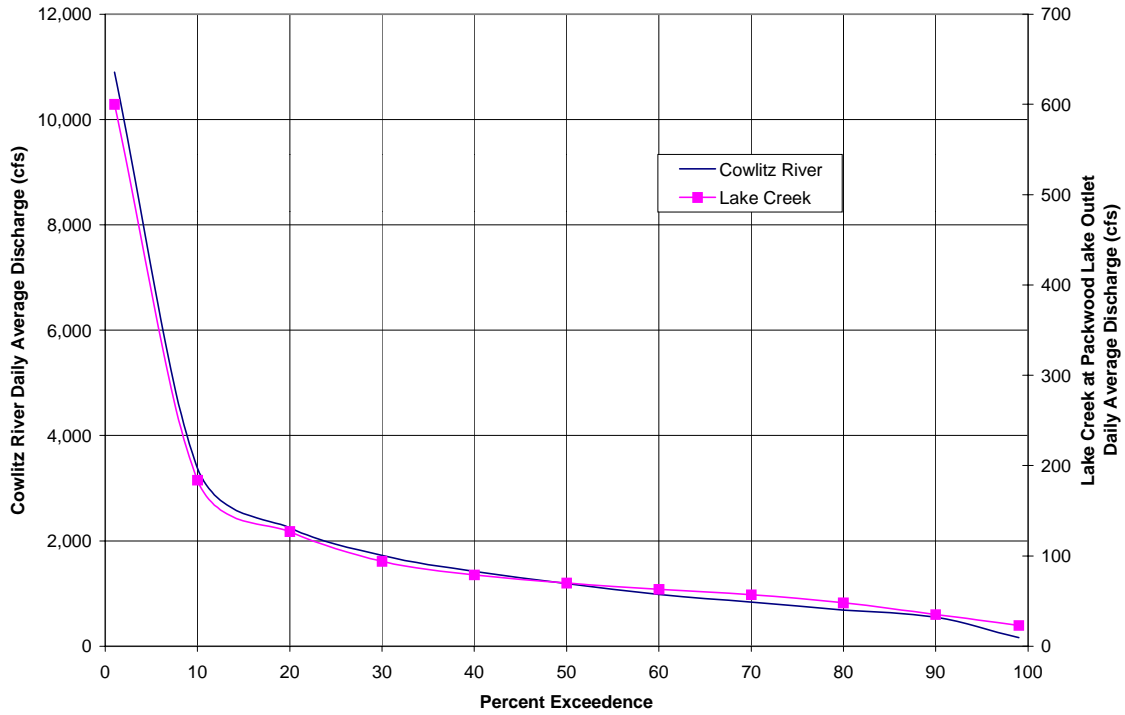
Flow Duration Curve, November 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



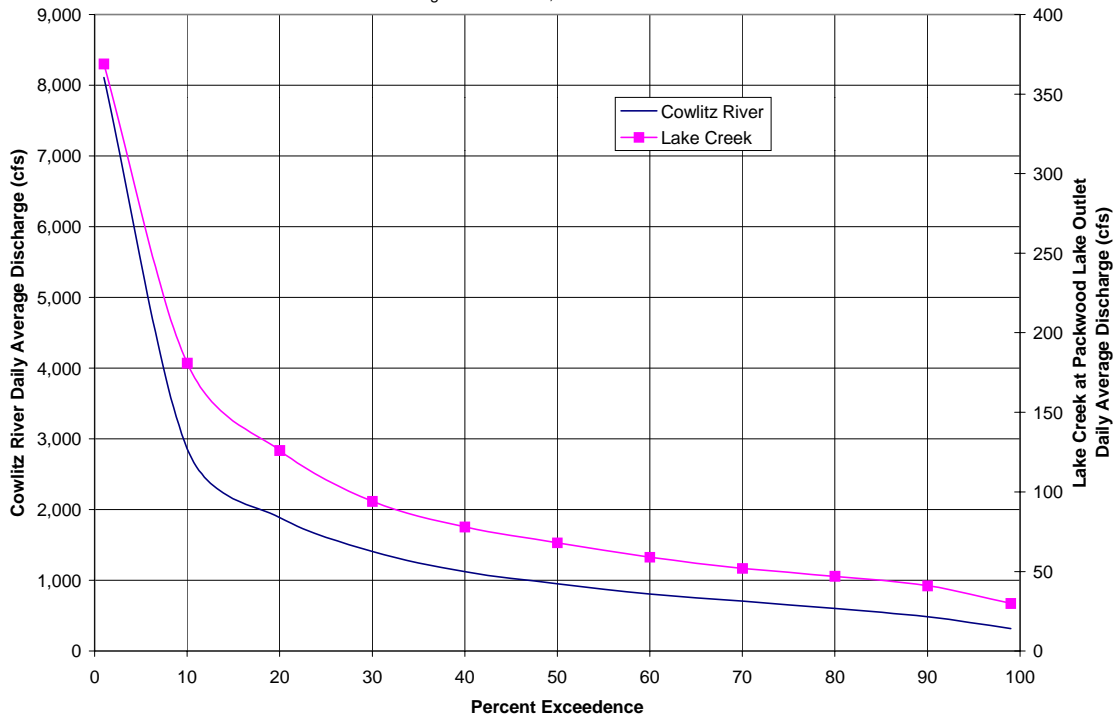
Flow Duration Curve, December 1912-1962

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



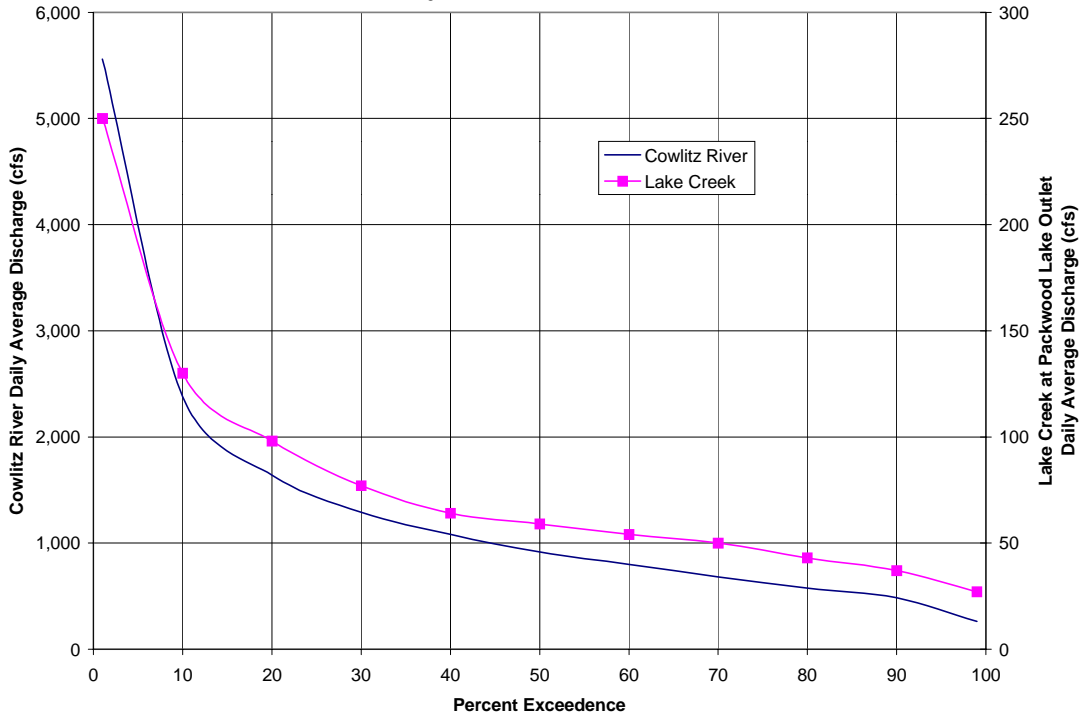
Flow Duration Curve, January 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



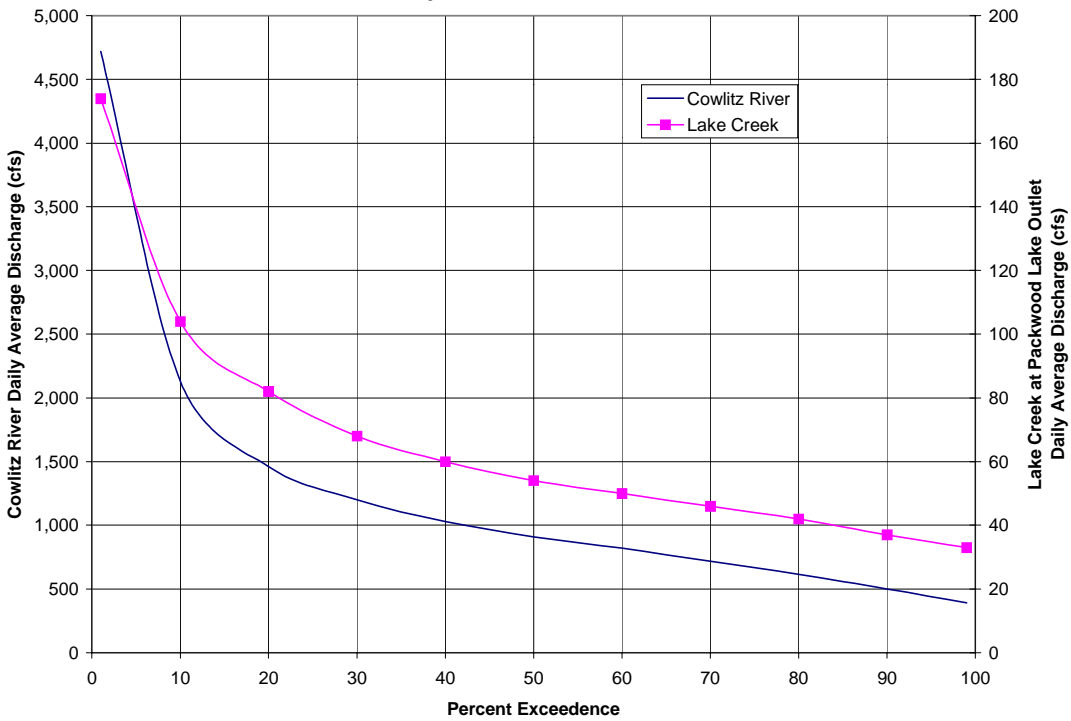
Flow Duration Curve, February 1912-1962

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



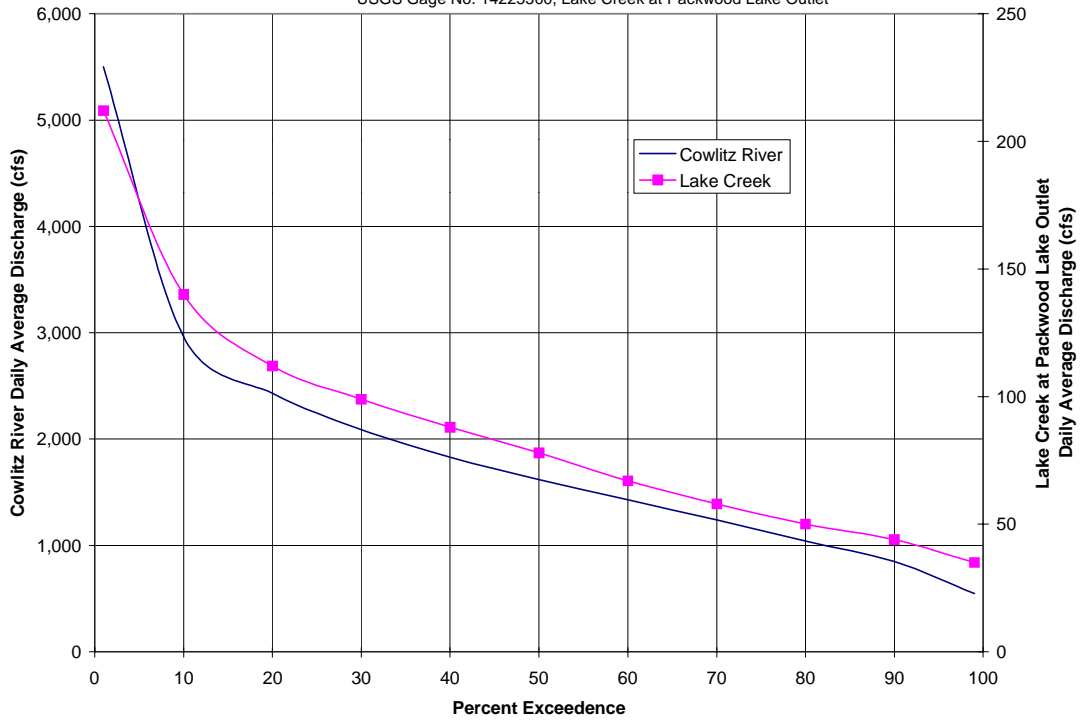
Flow Duration Curve, March 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



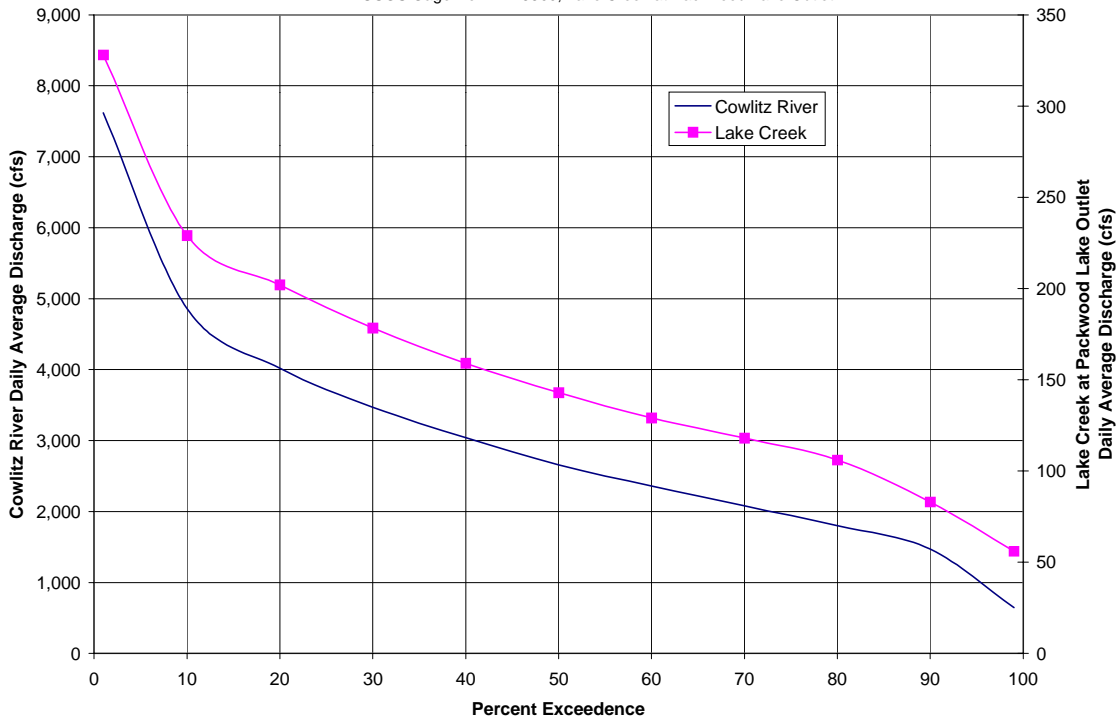
Flow Duration Curve, April 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and
USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



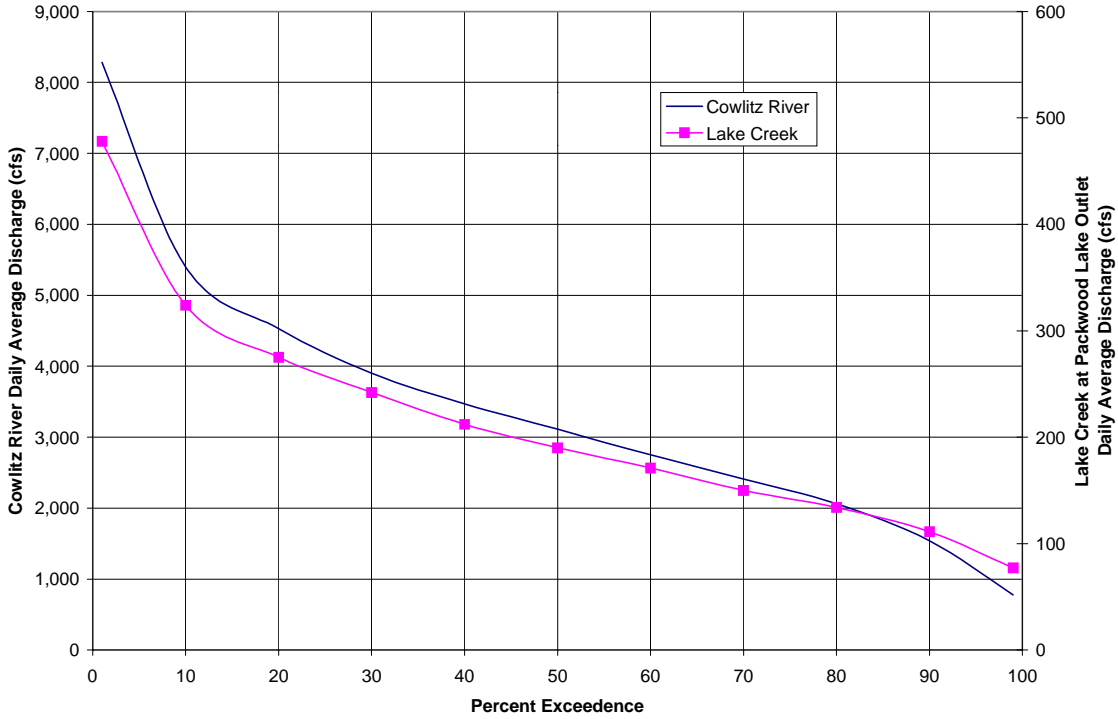
Flow Duration Curve, May 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and
USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



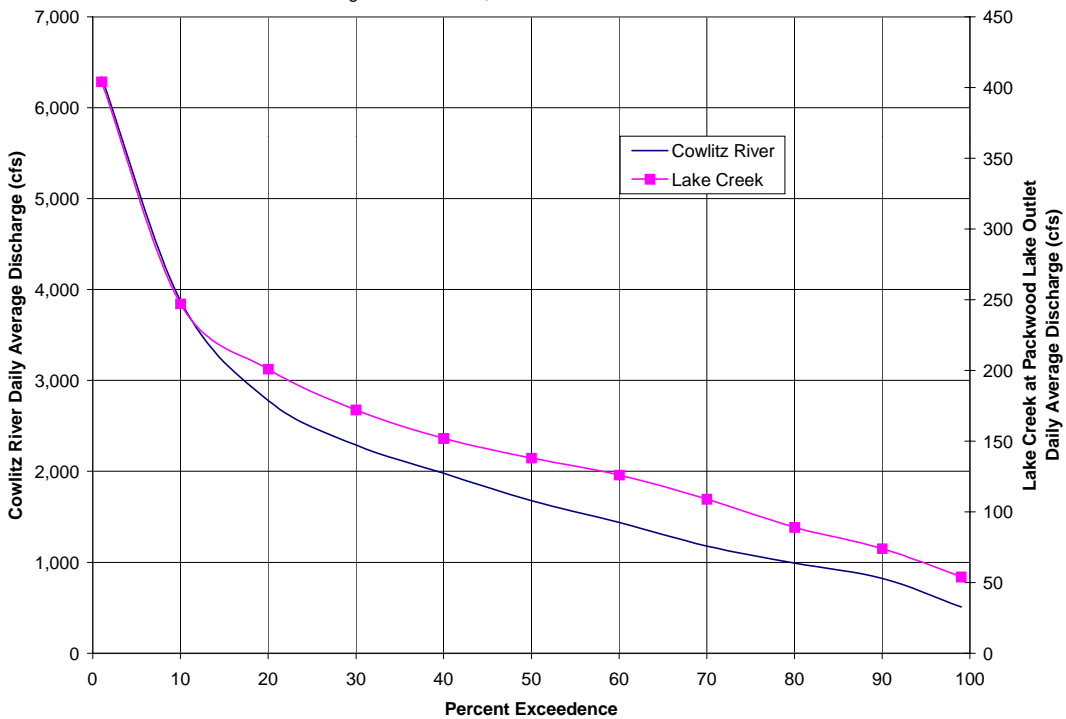
Flow Duration Curve, June 1912-1962

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



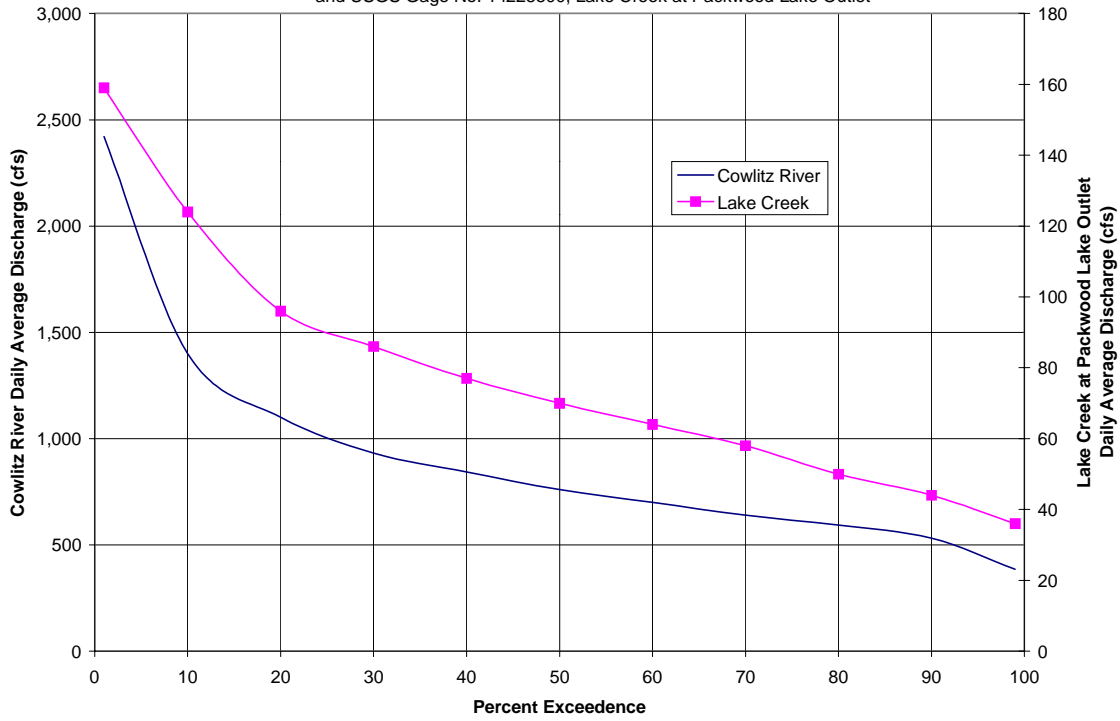
Flow Duration Curve, July 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



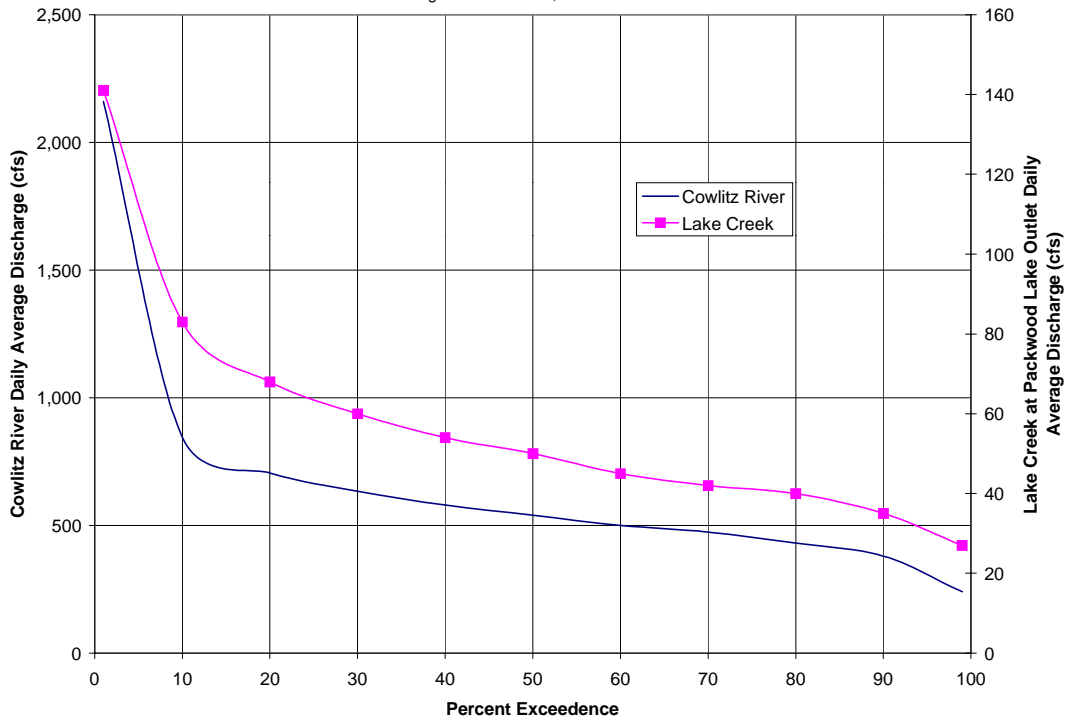
Flow Duration Curve, August 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



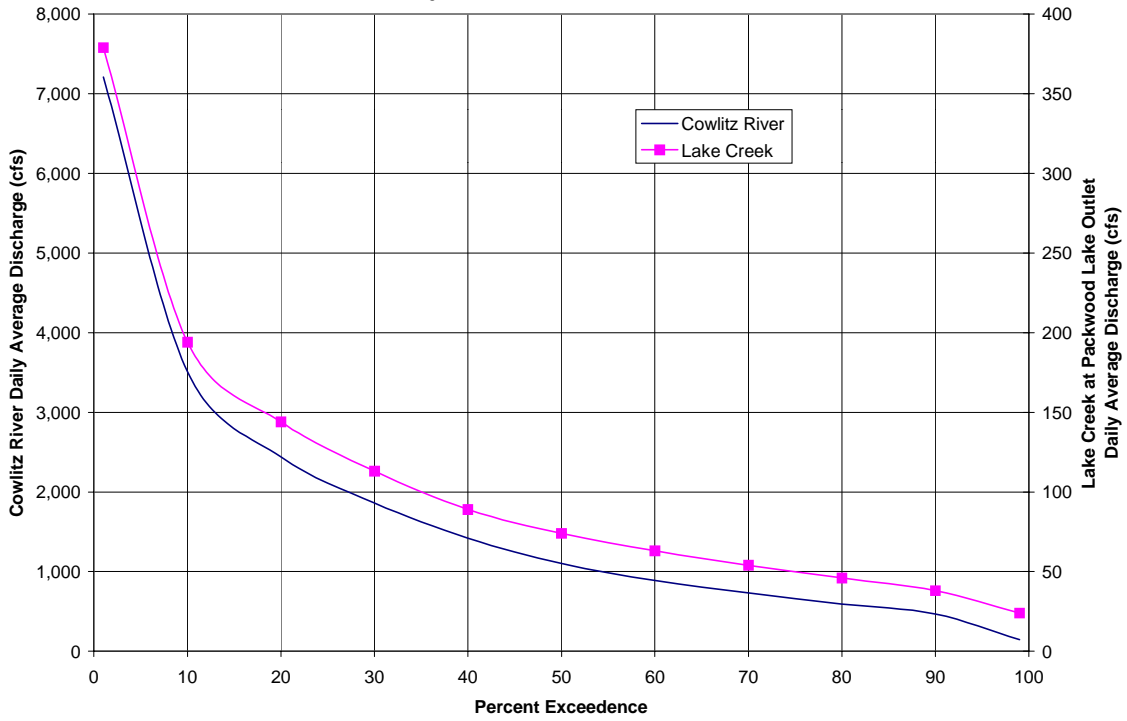
Flow Duration Curve, September 1912-62

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



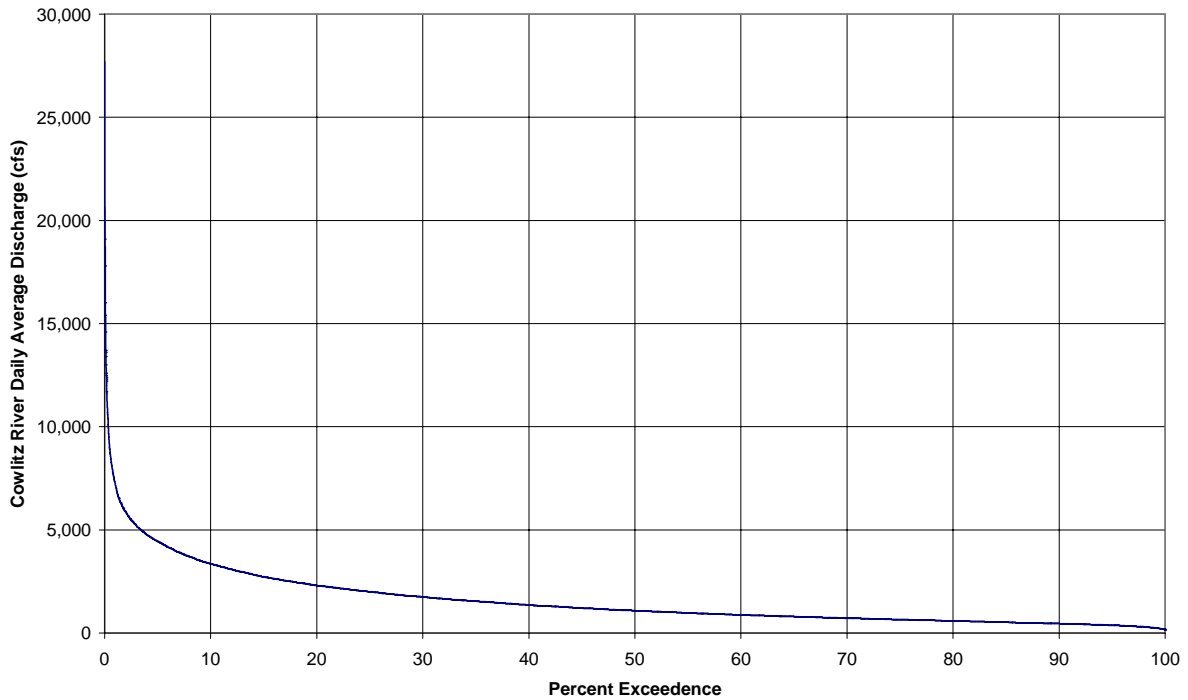
Annual Flow Duration Curve, 1912-1962

Based on average daily records at USGS Gage No. 14226500, Cowlitz River at Packwood, WA and USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



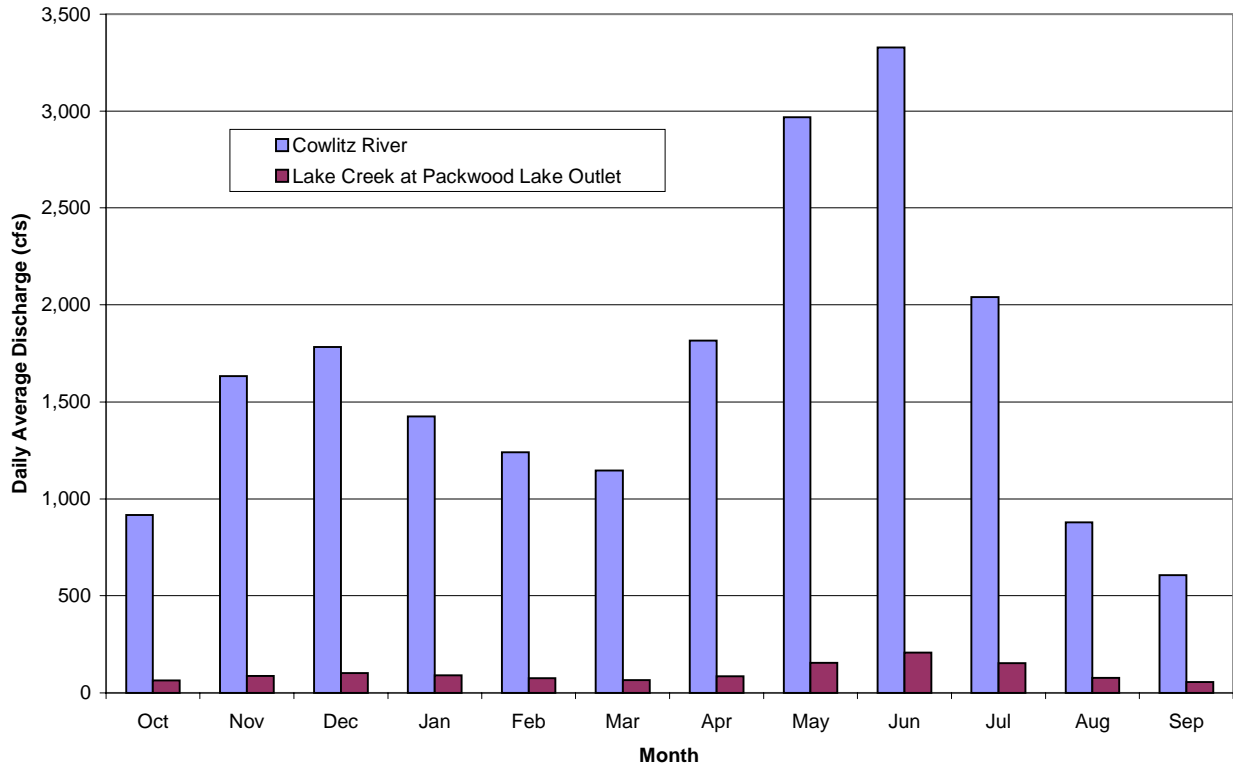
Annual Flow Duration Curve, 1912-2002

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA



Mean Monthly Flows, 1912-1962

Based on average daily records of USGS Gage No. 14226500, Cowlitz River at Packwood, WA and
USGS Gage No. 14225500, Lake Creek at Packwood Lake Outlet



APPENDIX B
OVERTOPPING EVENTS

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
6/20/1967	2858.63	8.9	45.0	53.9	N
6/21/1967	2858.88	52.0	45.0	97.0	N
6/22/1967	2859.30	167.0	45.0	212.0	N
6/23/1967	2859.07	99.0	45.0	144.0	N
6/24/1967	no reading				N
6/25/1967	no reading				N
6/26/1967	2858.75	27.0	45.0	72.0	N
6/27/1967	2858.71	20.0	45.0	65.0	N
6/28/1967	2858.58	3.6	45.0	48.6	N
6/3/1968	2858.50	0.0	7.0	7.0	N
6/4/1968	2858.59	4.5	17.0	21.5	N
6/7/1968	2859.92	402.0	5.3	407.3	N
5/14/1969	2858.69	17.0	18.0	35.0	N
5/15/1969	2858.76	29.0	17.8	46.8	N
5/16/1969	2858.69	17.0	17.8	34.8	N
5/17/1969	no reading				N
5/18/1969	no reading				N
5/19/1969	2858.75	27.0	17.7	44.7	N
5/20/1969	2859.01	83.0	17.5	100.5	N
5/21/1969	2858.99	78.0	17.3	95.3	N
5/22/1969	2859.03	88.0	40.0	128.0	N
5/23/1969	2859.13	116.0	40.0	156.0	N
5/24/1969	no reading				N
5/25/1969	no reading				N
5/26/1969	2858.91	59.0	40.0	99.0	N
5/27/1969	2858.70	19.0	45.0	64.0	N
6/2/1969	2858.81	38.0	45.0	83.0	N
6/3/1969	2858.98	76.0	45.0	121.0	N
6/4/1969	2859.11	110.0	45.0	155.0	N
6/5/1969	2859.34	180.0	45.0	225.0	N
6/6/1969	2859.24	148.0	45.0	193.0	N
6/7/1969	no reading				N
6/8/1969	no reading				N
6/9/1969	2859.05	94.0	45.0	139.0	N
6/10/1969	2858.96	71.0	45.0	116.0	N
6/11/1969	2858.90	57.0	45.0	102.0	N
6/12/1969	2858.82	40.0	45.0	85.0	N
6/13/1969	2858.68	15.5	45.0	60.5	N
5/8/1970	2858.77	30.0	5.0	35.0	N

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
5/9/1970	2858.57	2.7	5.1	7.8	N
7/22/1971	2858.54	2.7	40.0	42.7	N
7/23/1971	2858.56	1.9	40.0	41.9	N
7/31/1971	2858.77	30.0	40.0	70.0	N
8/1/1971	2859.23	145.0	40.0	185.0	N
8/2/1971	2859.27	158.0	40.0	198.0	N
8/3/1971	2859.15	121.0	40.0	161.0	N
8/4/1971	2859.08	102.0	40.0	142.0	N
8/5/1971	2858.90	57.0	40.0	97.0	N
					N
5/22/1972	2858.69	17.0	16.3	33.3	N
5/23/1972	2858.95	68.0	15.9	83.9	N
5/24/1972	2858.84	44.0	15.7	59.7	N
5/25/1972	2858.57	2.7	15.7	18.4	N
5/28/1972	2858.50	0.0	14.1	14.1	N
5/29/1972	2859.31	170.0	14.1	184.1	N
5/30/1972	2859.68	295.0	16.3	311.3	N
5/31/1972	2859.64	299.0	50.0	349.0	N
6/1/1972	2859.43	211.0	50.0	261.0	N
6/2/1972	2859.20	136.0	50.0	186.0	N
6/3/1972	2859.19	133.0	50.0	183.0	N
6/4/1972	2859.08	102.0	50.0	152.0	N
6/5/1972	2859.08	102.0	50.0	152.0	N
6/6/1972	2859.16	124.0	50.0	174.0	N
6/7/1972	2859.29	164.0	50.0	214.0	N
6/8/1972	2859.39	197.0	50.0	247.0	N
6/9/1972	2859.59	268.0	50.0	318.0	N
6/10/1972	2859.56	257.0	50.0	307.0	N
6/11/1972	2859.26	154.0	50.0	204.0	N
6/12/1972	2858.97	73.0	50.0	123.0	N
6/13/1972	2858.68	15.5	50.0	65.5	N
6/14/1972	2858.57	2.7	50.0	52.7	N
6/15/1972	2858.53	0.2	50.0	50.2	N
6/16/1972	2858.52	0.0	50.0	50.0	N
6/19/1972	2858.59	4.5	50.0	54.5	N
6/20/1972	2858.51	0.0	50.0	50.0	N
7/6/1972	2858.81	36.0	50.0	86.0	N
7/7/1972	2858.88	52.0	50.0	102.0	N
7/8/1972	2858.60	5.5	50.0	55.5	N
11/1/1973	2858.51	0.0	6.2	6.2	Y
11/2/1973	2858.63	8.9	5.4	14.3	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
1/17/1974	2859.28	161.0	19.5	180.5	N
1/18/1974	2859.09	104.0	17.6	121.6	N
1/19/1974	2858.97	73.0	8.3	81.3	N
1/20/1974	2858.68	15.5	5.6	21.1	N
6/6/1974	2859.38	194.0	50.0	244.0	N
6/7/1974	2859.29	164.0	50.0	214.0	N
6/8/1974	2859.01	83.0	50.0	133.0	N
6/9/1974	2858.76	29.0	50.0	79.0	N
6/10/1974	2858.52	0.0	50.0	50.0	N
6/11/1974	2858.67	14.1	20.3	34.4	N
6/12/1974	2859.03	88.0	20.2	108.2	N
6/13/1974	2859.32	174.0	20.0	194.0	N
6/14/1974	2859.49	232.0	18.8	250.8	N
6/15/1974	2859.59	268.0	18.8	286.8	N
6/16/1974	2859.65	291.0	18.8	309.8	N
6/17/1974	2859.59	268.0	18.4	286.4	N
6/18/1974	2859.60	272.0	4.9	276.9	N
6/19/1974	2859.57	261.0	50.0	311.0	N
6/20/1974	2859.41	204.0	50.0	254.0	N
6/21/1974	2859.26	154.0	50.0	204.0	N
6/22/1974	2859.18	130.0	50.0	180.0	N
6/23/1974	2859.10	107.0	50.0	157.0	N
6/24/1974	2859.00	107.0	50.0	157.0	N
6/25/1974	2858.86	48.0	50.0	98.0	N
6/26/1974	2858.72	22.0	50.0	72.0	N
6/30/1974	2858.56	1.9	50.0	51.9	N
7/1/1974	2858.90	57.0	50.0	107.0	N
7/2/1974	2858.78	32.0	50.0	82.0	N
7/6/1974	2858.52	0.0	50.0	50.0	N
6/3/1975	2858.71	20.0	40.0	60.0	N
6/6/1975	2858.82	40.0	40.0	80.0	N
6/7/1975	2858.67	14.1	40.0	54.1	N
7/7/1975	2858.98	76.0	18.8	94.8	N
7/8/1975	2859.21	139.0	40.0	179.0	N
7/9/1975	2859.25	151.0	40.0	191.0	N
7/10/1975	2859.23	145.0	40.0	185.0	N
7/11/1975	2859.11	110.0	40.0	150.0	N
7/12/1975	2858.98	76.0	40.0	116.0	N
7/13/1975	2858.77	30.0	40.0	70.0	N
7/14/1975	2858.51	0.0	40.0	40.0	N
12/2/1975	2859.62	280.0	18.8	298.8	Y
12/3/1975	2860.64	747.0	19.2	766.2	Y
12/4/1975	2860.75	806.0	19.3	825.3	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
12/5/1975	2859.93	406.0	20.0	426.0	Y
12/6/1975	2859.47	225.0	20.0	245.0	Y
12/7/1975	2859.00	81.0	20.0	101.0	Y
12/8/1975	2858.71	20.0	18.2	38.2	Y
12/9/1975	2858.86	48.0	19.7	67.7	Y
12/10/1975	2858.68	15.5	19.6	35.1	Y
12/2/1977	2860.30	575.0	10.0	585.0	N
12/3/1977	2860.38	614.0	10.0	624.0	N
12/4/1977	2860.22	537.0	10.0	547.0	N
12/5/1977	2859.54	250.0	8.9	258.9	N
12/6/1977	2859.54	250.0	7.3	257.3	N
12/7/1977	2859.10	107.0	6.3	113.3	N
12/8/1977	2858.76	29.0	5.0	34.0	N
12/9/1977	2858.52	0.0	5.0	5.0	N
12/11/1977	2858.59	4.5	5.0	9.5	N
12/12/1977	2858.69	17.0	11.2	28.2	N
12/13/1977	2858.93	64.0	17.6	81.6	N
12/14/1977	2860.03	450.0	17.3	467.3	N
12/15/1977	2859.97	423.0	unknown	423.0	N
12/16/1977	2859.70	311.0	8.6	319.6	N
12/17/1977	2859.30	167.0	8.6	175.6	N
12/18/1977	2858.92	61.0	8.6	69.6	N
12/26/1980	2859.50	235.0	7.4	242.4	N
12/27/1980	2859.68	303.0	7.4	310.4	N
12/28/1980	2859.38	194.0	7.4	201.4	N
12/29/1980	2858.99	78.0	4.0	82.0	N
12/30/1980	2858.88	52.0	4.0	56.0	N
12/31/1980	2858.88	52.0	3.6	55.6	N
2/15/1981	2858.71	20.0	4.8	24.8	Y
2/16/1981	2859.09	104.0	4.8	108.8	Y
2/17/1981	2859.65	291.0	4.8	295.8	Y
2/18/1981	2859.60	272.0	4.8	276.8	Y
2/19/1981	2859.89	389.0	4.9	393.9	Y
2/20/1981	2860.51	680.0	4.8	684.8	Y
2/21/1981	2860.41	629.0	4.8	633.8	Y
2/22/1981	2860.39	619.0	4.8	623.8	Y
2/23/1981	2860.43	639.0	3.8	642.8	Y
2/24/1981	2859.21	139.0	3.8	142.8	Y
2/25/1981	2859.19	133.0	3.8	136.8	Y
2/26/1981	2859.14	119.0	3.6	122.6	Y
2/27/1981	2859.11	110.0	3.6	113.6	Y

**Appendix B. Log of spill days at Packwood Lake Project, 1967
– 2003.**

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
2/28/1981	2859.07	99.0	3.6	102.6	Y
3/1/1981	2859.04	91.0	3.6	94.6	Y
3/2/1981	2859.01	81.0	3.6	84.6	Y
3/3/1981	2858.99	78.0	3.6	81.6	Y
3/4/1981	2858.99	78.0	3.6	81.6	Y
3/5/1981	2858.98	76.0	3.6	79.6	Y
3/6/1981	2858.96	71.0	3.6	74.6	Y
3/7/1981	2858.95	68.0	4.0	72.0	Y
3/8/1981	2858.94	66.0	4.0	70.0	Y
3/9/1981	2858.93	64.0	3.1	67.1	Y
3/10/1981	2858.54	0.7	2.8	3.5	Y
6/17/1982	2858.76	29.0	5.2	34.2	N
6/18/1982	2859.11	110.0	5.1	115.1	N
6/19/1982	2859.26	154.0	5.1	159.1	N
6/20/1982	2859.26	154.0	5.1	159.1	N
6/21/1982	2859.26	154.0	5.5	159.5	N
6/22/1982	2859.08	102.0	5.4	107.4	N
6/23/1982	2858.96	71.0	5.3	76.3	N
6/24/1982	2858.86	48.0	5.4	53.4	N
6/25/1982	2858.86	48.0	5.3	53.3	N
6/26/1982	2858.84	44.0	5.3	49.3	N
6/27/1982	2858.82	40.0	5.3	45.3	N
6/28/1982	2858.79	34.0	5.4	39.4	N
6/29/1982	2858.52	0.0	5.3	5.3	N
5/30/1983	2858.72	22.0	4.2	26.2	N
5/31/1983	2858.89	55.0	6.1	61.1	N
6/1/1983	2858.56	1.9	6.2	8.1	N
7/15/1983	2858.50	0.0	5.5	5.5	N
6/7/1985	2858.78	32.0	3.1	35.1	N
6/8/1985	2859.74	327.0	3.1	330.1	N
6/9/1985	2859.35	183.0	3.1	186.1	N
6/10/1985	2858.96	71.0	3.1	74.1	N
6/11/1985	2858.71	20.0	3.1	23.1	N
6/12/1985	2858.69	17.0	3.7	20.7	N
6/13/1985	2858.72	22.0	3.7	25.7	N
6/14/1985	2858.60	5.5	3.6	9.1	N
6/15/1985	2858.58	3.6	3.6	7.2	N
6/16/1985	2858.52	0.0	3.6	3.6	N
6/18/1985	2858.56	1.9	3.8	5.7	N
6/19/1985	2858.66	12.7	3.7	16.4	N
6/20/1985	2858.69	17.0	3.7	20.7	N
6/21/1985	2858.54	0.7	3.1	3.8	N

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown	
5/31/1986	2858.90	57.0		3.4	60.4	N
6/1/1986	2859.18	130.0		3.4	133.4	N
6/2/1986	2859.25	151.0		3.2	154.2	N
6/3/1986	2858.98	76.0		3.2	79.2	N
6/4/1986	2858.72	22.0		3.2	25.2	N
6/5/1986	2858.69	17.0		3.2	20.2	N
11/25/1990	2859.88	385.0		3.2	388.2	N
11/26/1990	2859.59	268.0		3.3	271.3	N
11/27/1990	2859.04	91.0		3.1	94.1	N
11/28/1990	2858.61	6.6		3.3	9.9	N
5/13/1993	2858.80	36.0		3.2	39.2	N
5/14/1993	2858.79	34.0		3.4	37.4	N
5/15/1993	2858.63	8.9		3.3	12.2	N
5/19/1993	2858.60	5.5		3.4	8.9	N
5/20/1993	2859.25	151.0		3.6	154.6	N
5/21/1993	2859.01	81.0		3.5	84.5	N
5/22/1993	2858.83	42.0		3.5	45.5	N
5/23/1993	2858.71	20.0		3.5	23.5	N
5/24/1993	2858.56	1.9		3.2	5.1	N
5/25/1993	2858.60	5.5		3.3	8.8	N
4/22/1994	2858.79	34.0		3.2	37.2	N
4/23/1994	2859.10	107.0		3.2	110.2	N
4/24/1994	2859.15	121.0		3.3	124.3	N
4/25/1994	2859.15	121.0	unknown		121.0	N
4/26/1994	2859.13	116.0		3.3	119.3	N
4/27/1994	2859.08	102.0		3.3	105.3	N
4/28/1994	2858.58	3.6		3.4	7.0	N
11/3/1994	2858.79	34.0		3.1	37.1	Y
11/4/1994	2858.88	52.0		3.3	55.3	Y
11/5/1994	2858.96	71.0		3.2	74.2	Y
11/6/1994	2858.96	71.0		3.2	74.2	Y
11/7/1994	2858.96	71.0		3.2	74.2	Y
11/8/1994	2858.93	64.0		3.2	67.2	Y
11/9/1994	2858.93	64.0		3.2	67.2	Y
11/10/1994	2858.92	61.0		3.4	64.4	Y
11/11/1994	2858.91	59.0		3.3	62.3	Y
11/12/1994	2858.90	57.0		3.4	60.4	Y
11/13/1994	2858.90	57.0		3.3	60.3	Y
11/14/1994	2858.90	57.0		3.4	60.4	Y
11/15/1994	2858.89	55.0		3.3	58.3	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
11/16/1994	2858.94	66.0	3.4	69.4	Y
11/17/1994	2858.93	64.0	3.3	67.3	Y
11/18/1994	2858.90	57.0	3.3	60.3	Y
11/19/1994	2858.82	40.0	3.3	43.3	Y
11/20/1994	2858.86	48.0	3.3	51.3	Y
11/21/1994	2858.81	38.0	3.3	41.3	Y
11/22/1994	2858.81	38.0	3.3	41.3	Y
11/23/1994	2858.79	34.0	3.3	37.3	Y
11/24/1994	2858.76	29.0	3.3	32.3	Y
11/25/1994	2858.74	25.0	3.3	28.3	Y
11/26/1994	2858.74	25.0	3.3	28.3	Y
11/27/1994	2858.74	25.0	3.3	28.3	Y
11/28/1994	2858.74	25.0	3.3	28.3	Y
11/29/1994	2858.84	44.0	3.3	47.3	Y
11/30/1994	2859.04	91.0	3.3	94.3	Y
12/1/1994	2859.50	245.0	3.3	248.3	Y
12/2/1994	2859.35	183.0	3.3	186.3	Y
12/3/1994	2859.14	119.0	3.3	122.3	Y
12/4/1994	2859.06	96.0	3.3	99.3	Y
12/5/1994	2858.96	71.0	3.3	74.3	Y
12/6/1994	2858.94	66.0	3.3	69.3	Y
12/7/1994	2858.93	64.0	3.3	67.3	Y
12/8/1994	2858.90	57.0	3.3	60.3	Y
12/9/1994	2858.93	64.0	3.3	67.3	Y
12/10/1994	2858.89	55.0	3.3	58.3	Y
12/11/1994	2858.88	52.0	3.3	55.3	Y
12/12/1994	2858.87	50.0	3.3	53.3	Y
12/13/1994	2858.86	48.0	3.3	51.3	Y
12/14/1994	2858.85	46.0	3.3	49.3	Y
12/15/1994	2858.85	46.0	3.3	49.3	Y
12/16/1994	2858.91	59.0	3.3	62.3	Y
12/17/1994	2859.01	83.0	3.3	86.3	Y
12/18/1994	2859.06	96.0	3.3	99.3	Y
12/19/1994	2859.08	102.0	3.3	105.3	Y
12/20/1994	2859.08	102.0	3.4	105.4	Y
12/21/1994	2859.18	130.0	3.3	133.3	Y
12/22/1994	2859.19	133.0	3.4	136.4	Y
12/23/1994	2859.15	121.0	3.4	124.4	Y
12/24/1994	2859.12	113.0	3.3	116.3	Y
12/25/1994	2859.10	107.0	3.3	110.3	Y
12/26/1994	2859.14	119.0	3.4	122.4	Y
12/27/1994	2859.73	323.0	3.3	326.3	Y
12/28/1994	2859.81	255.0	3.4	258.4	Y
12/29/1994	2859.54	250.0	3.4	253.4	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow Lake Cr.	Plant shutdown
12/30/1994	2859.37	190.0	3.4	193.4	Y
12/31/1994	2859.20	136.0	3.4	139.4	Y
1/1/1995	2859.13	116.0	3.4	119.4	Y
1/2/1995	2859.07	99.0	3.4	102.4	Y
1/3/1995	2859.04	91.0	3.4	94.4	Y
1/4/1995	2858.96	71.0	3.4	74.4	Y
1/5/1995	2858.93	64.0	3.4	67.4	Y
1/6/1995	2858.93	64.0	3.4	67.4	Y
1/7/1995	2858.93	64.0	3.4	67.4	Y
1/8/1995	2858.93	64.0	3.3	67.3	Y
1/9/1995	2858.93	64.0	3.4	67.4	Y
1/10/1995	2858.99	78.0	3.4	81.4	Y
1/11/1995	2858.99	78.0	3.4	81.4	Y
1/12/1995	2858.98	76.0	3.4	79.4	Y
1/13/1995	2858.88	52.0	3.4	55.4	Y
1/14/1995	2859.00	81.0	3.3	84.3	Y
1/15/1995	2859.00	81.0	3.3	84.3	Y
1/16/1995	2859.02	86.0	3.4	89.4	Y
1/17/1995	2858.99	78.0	3.4	81.4	Y
1/18/1995	2858.98	76.0	3.4	79.4	Y
1/19/1995	2858.98	76.0	3.2	79.2	Y
1/20/1995	2858.95	68.0	3.3	71.3	Y
1/21/1995	2858.95	68.0	3.3	71.3	Y
1/22/1995	2858.92	61.0	3.3	64.3	Y
1/23/1995	2858.91	59.0	3.3	62.3	Y
1/24/1995	2858.90	57.0	3.3	60.3	Y
1/25/1995	2858.90	57.0	3.3	60.3	Y
1/26/1995	2858.90	57.0	3.3	60.3	Y
1/27/1995	2858.89	55.0	3.7	58.7	Y
1/28/1995	2858.88	52.0	3.3	55.3	Y
1/29/1995	2858.94	66.0	3.3	69.3	Y
1/30/1995	2859.02	86.0	3.3	89.3	Y
1/31/1995	2859.30	167.0	3.3	170.3	Y
2/1/1995	2859.99	432.0	3.3	435.3	Y
2/2/1995	2859.85	372.0	3.3	375.3	Y
2/3/1995	2859.56	257.0	3.2	260.2	Y
2/4/1995	2859.38	194.0	3.3	197.3	Y
2/5/1995	2859.35	183.0	3.3	186.3	Y
2/6/1995	2859.34	180.0	3.3	183.3	Y
2/7/1995	2859.33	177.0	3.3	180.3	Y
2/8/1995	2859.32	174.0	3.2	177.2	Y
2/9/1995	2859.15	121.0	3.2	124.2	Y
2/10/1995	2859.08	102.0	3.3	105.3	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
2/11/1995	2859.05	94.0	3.3	97.3	Y
2/12/1995	2859.01	59.0	3.3	62.3	Y
2/13/1995	2858.95	68.0	3.2	71.2	Y
2/14/1995	2858.91	59.0	3.2	62.2	Y
2/15/1995	2858.90	57.0	3.2	60.2	Y
2/16/1995	2858.92	61.0	3.2	64.2	Y
2/17/1995	2858.98	76.0	3.2	79.2	Y
2/18/1995	2858.98	76.0	3.2	79.2	Y
2/19/1995	2859.44	214.0	3.3	217.3	Y
2/20/1995	2860.18	518.0	3.4	521.4	Y
2/21/1995	2859.92	402.0	3.4	405.4	Y
2/22/1995	2859.65	291.0	3.4	294.4	Y
2/23/1995	2859.04	91.0	3.4	94.4	Y
2/24/1995	2858.67	14.1	3.4	17.5	Y
11/14/1995	2859.48	228.0	4.8	232.8	N
11/15/1995	2859.64	287.0	3.2	290.2	N
11/16/1995	2858.96	71.0	3.2	74.2	N
11/17/1995	2858.76	29.0	3.2	32.2	N
11/29/1995	2860.49	670.0	3.2	673.2	N
11/30/1995	2860.40	624.0	3.3	627.3	N
12/1/1995	2860.36	605.0	3.4	608.4	N
12/2/1995	2859.64	287.0	3.3	290.3	N
12/3/1995	2859.05	94.0	3.3	97.3	N
12/4/1995	2858.73	23.0	3.3	26.3	N
2/9/1996	2859.91	397.0	3.5	400.5	N
2/10/1996	2859.92	402.0	3.5	405.5	N
2/11/1996	2859.22	142.0	3.5	145.5	N
2/12/1996	2858.74	25.0	3.5	28.5	N
5/14/1997	2858.58	3.6	3.2	6.8	N
5/15/1997	2859.17	127.0	3.0	130.0	N
5/16/1997	2859.30	167.0	3.0	170.0	N
5/17/1997	2859.30	167.0	3.0	170.0	N
5/18/1997	2859.23	145.0	3.2	148.2	N
5/19/1997	2858.99	78.0	3.3	81.3	N
5/20/1997	2858.76	29.0	3.0	32.0	N
5/21/1997	2858.61	6.6	3.1	9.7	N
6/1/1997	2858.88	52.0	3.3	55.3	N
6/2/1997	2859.27	158.0	3.2	161.2	N
6/3/1997	2859.13	116.0	3.3	119.3	N
6/4/1997	2859.02	86.0	3.2	89.2	N
6/5/1997	2858.90	57.0	3.2	60.2	N
6/6/1997	2858.70	19.0	3.2	22.2	N
10/14/1997	2858.66	12.7	3.0	15.7	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
10/15/1997	2858.92	61.0	3.2	64.2	Y
10/16/1997	2859.00	81.0	3.2	84.2	Y
10/17/1997	2859.02	86.0	3.4	89.4	Y
10/18/1997	2859.02	86.0	3.4	89.4	Y
10/19/1997	2859.01	83.0	3.4	86.4	Y
10/20/1997	2858.98	76.0	3.3	79.3	Y
10/21/1997	2858.96	71.0	3.3	74.3	Y
10/22/1997	2858.94	66.0	3.3	69.3	Y
10/23/1997	2858.90	57.0	3.3	60.3	Y
10/24/1997	2858.88	52.0	3.4	55.4	Y
10/25/1997	2858.88	52.0	3.4	55.4	Y
10/26/1997	2858.88	52.0	3.4	55.4	Y
10/27/1997	2858.88	52.0	3.4	55.4	Y
10/28/1997	2858.85	46.0	3.2	49.2	Y
10/29/1997	2858.98	76.0	3.2	79.2	Y
10/30/1997	2859.00	81.0	3.2	84.2	Y
10/31/1997	2860.30	450.0	3.3	453.3	Y
11/1/1997	2859.73	323.0	3.4	326.4	Y
11/2/1997	2859.36	187.0	3.3	190.3	Y
11/3/1997	2858.74	25.0	3.2	28.2	Y
11/4/1997	2858.56	1.9	3.1	5.0	Y
6/15/1999	2858.81	38.0	3.2	41.2	N
6/16/1999	2859.27	158.0	3.1	161.1	N
6/17/1999	2859.24	148.0	3.2	151.2	N
6/18/1999	2859.01	83.0	3.2	86.2	N
6/19/1999	2858.87	50.0	3.2	53.2	N
6/20/1999	2858.73	23.0	3.4	26.4	N
6/21/1999	2858.57	2.7	3.3	6.0	N
6/24/1999	2858.56	1.9	3.3	5.2	N
6/25/1999	2858.93	64.0	3.2	67.2	N
6/26/1999	2858.98	76.0	3.3	79.3	N
6/27/1999	2858.72	22.0	3.4	25.4	N
11/27/1999	2858.85	46.0	3.4	49.4	N
11/28/1999	2858.74	25.0	3.2	28.2	N
12/18/2000	2858.59	4.5	3.4	7.9	Y
12/19/2000	2858.69	17.0	3.4	20.4	Y
12/20/2000	2858.75	27.0	3.3	30.3	Y
12/21/2000	2858.79	34.0	3.3	37.3	Y
12/22/2000	2858.80	36.0	3.1	39.1	Y
12/23/2000	2858.82	40.0	3.1	43.1	Y
12/24/2000	2858.84	44.0	3.0	47.0	Y
12/25/2000	2858.84	44.0	3.0	47.0	Y

Appendix B. Log of spill days at Packwood Lake Project, 1967 – 2003.

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
12/26/2000	2858.83	42.0	3.2	45.2	Y
12/27/2000	2858.83	42.0	3.2	45.2	Y
12/28/2000	2858.83	42.0	3.0	45.0	Y
12/29/2000	2858.80	36.0	3.0	39.0	Y
11/7/2001	2858.80	36.0	3.3	39.3	Y
11/8/2001	2858.80	36.0	3.3	39.3	Y
11/9/2001	2858.90	57.0	3.3	60.3	Y
11/10/2001	2858.95	68.0	3.3	71.3	Y
11/11/2001	2858.95	68.0	3.3	71.3	Y
11/12/2001	2858.95	68.0	3.3	71.3	Y
11/13/2001	2859.04	91.0	3.3	94.3	Y
11/14/2001	2859.04	91.0	3.3	94.3	Y
11/15/2001	2859.60	272.0	3.3	275.3	Y
11/16/2001	2859.52	243.0	3.3	246.3	Y
11/17/2001	2859.30	167.0	3.2	170.2	Y
11/18/2001	2859.18	130.0	3.0	133.0	Y
11/19/2001	2858.72	22.0	3.1	25.1	Y
11/20/2001	2858.99	78.0	3.1	81.1	Y
11/21/2001	2859.09	104.0	3.1	107.1	Y
11/22/2001	2859.20	136.0	3.1	139.1	Y
11/23/2001	2859.18	130.0	3.4	133.4	Y
11/24/2001	2859.11	110.0	3.0	113.0	Y
11/25/2001	2859.05	94.0	3.1	97.1	Y
11/26/2001	2859.05	94.0	3.1	97.1	Y
11/27/2001	2858.99	78.0	3.0	81.0	Y
11/28/2001	2858.97	73.0	3.0	76.0	Y
11/29/2001	2859.00	57.0	3.0	60.0	Y
11/30/2001	2858.94	66.0	3.5	69.5	Y
12/1/2001	2858.95	68.0	31.0	99.0	Y
12/2/2001	2858.95	68.0	3.1	71.1	Y
12/3/2001	2858.97	73.0	3.4	76.4	Y
12/4/2001	2858.95	68.0	3.4	71.4	Y
12/5/2001	2858.93	64.0	3.4	67.4	Y
12/6/2001	2858.92	61.0	3.2	64.2	Y
12/7/2001	2858.94	66.0	3.2	69.2	Y
12/8/2001	2858.94	66.0	3.4	69.4	Y
12/9/2001	2858.67	14.1	3.4	17.5	Y
4/15/2002	2859.05	94.0	3.1	97.1	N
4/16/2002	2858.98	76.0	3.1	79.1	N
4/17/2002	2858.73	23.0	3.0	26.0	N
5/30/2002	2859.12	113.0	3.0	116.0	N
5/31/2002	2859.19	133.0	3.0	136.0	N

**Appendix B. Log of spill days at Packwood Lake Project, 1967
– 2003.**

Date	Lake Level	Spill (cfs)	Fish Flow	Flow in Lake Cr.	Plant shutdown
6/1/2002	2859.09	104.0	3.0	107.0	N
6/2/2002	2859.01	110.0	3.2	113.2	N
6/3/2002	2858.98	76.0	3.4	79.4	N
6/4/2002	2858.93	64.0	3.4	67.4	N
6/5/2002	2858.98	76.0	3.3	79.3	N
6/6/2002	2859.15	121.0	3.0	124.0	N
6/7/2002	2859.02	86.0	3.2	89.2	N
6/8/2002	2858.84	44.0	3.4	47.4	N
6/9/2002	2858.62	7.7	3.0	10.7	N
6/13/2002	2858.72	22.0	3.2	25.2	N
6/14/2002	2859.18	130.0	3.0	133.0	N
6/15/2002	2859.30	167.0	3.0	170.0	N
6/16/2002	2859.30	167.0	3.0	170.0	N
6/17/2002	2859.22	142.0	3.0	145.0	N
6/18/2002	2859.12	113.0	3.0	116.0	N
6/19/2002	2859.07	99.0	3.0	102.0	N
6/20/2002	2858.91	59.0	3.4	62.4	N
6/21/2002	2858.85	46.0	3.0	49.0	N
6/22/2002	2858.91	59.0	3.0	62.0	N
6/23/2002	2859.03	88.0	3.0	91.0	N
6/24/2002	2859.01	83.0	3.1	86.1	N
6/25/2002	2858.95	68.0	3.1	71.1	N
6/26/2002	2858.99	78.0	3.2	81.2	N
6/27/2002	2859.15	121.0	3.3	124.3	N
6/28/2002	2859.10	107.0	3.2	110.2	N
6/29/2002	2859.29	164.0	3.2	167.2	N
6/30/2002	2859.26	154.0	3.4	157.4	N
7/1/2002	2858.96	71.0	3.4	74.4	N
7/2/2002	2858.75	27.0	3.2	30.2	N
7/3/2002	2858.57	2.7	3.2	5.9	N
2/1/2003	2859.56	257.0	3.0	260.0	N
2/2/2003	2859.14	119.0	3.3	122.3	N
2/3/2003	2858.66	12.7	3.3	16.0	N
5/31/2003	2858.57	2.7	3.3	6.0	N
6/1/2003	2858.57	2.7	3.3	6.0	N