CHARACTERIZATION OF ROANOKE RIVER FLOWS FOR 12-MONTH PERIOD

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One concern of the Flow Committee is that our focus on instream flow regulations for spring may be too narrow, and that a 12-month approach would more appropriate for a good watershed management plan. Moreover, a holistic watershed management approach would provide the information necessary to develop instream flow models which consider current and future water demands. These demands include pollution abatement and NPDES concerns, but also must include criteria for water withdrawal, consumptive use (e.g., electrical co-generation facilities), interbasin water transfer, reservoir release schedules, irrigation, and other uses. In addition, a holistic watershed management approach must have a mechanism for interstate watershed management for those situations in which watersheds cross state boundaries.

To initiate the first step in proposing such an approach, we characterized the instream flow of the lower Roanoke River downstream of Roanoke Rapids Reservoir using preimpoundment (1912-1950) and postimpoundment (1955-1990) data from the USGS gage located near Weldon, NC. In this comparison, we assumed that precipitation was not different between the preimpoundment and postimpoundment time segments. An examination of daily average (mean) flows smoothed by a seven-day running average indicate a seasonal pattern in instream flow (Figure 20). Natural, unregulated instream flows of the preimpoundment period typically fluctuated between about 10,000 cfs to just over 15,000 cfs during January through mid-April. During the period April through June, instream flows decreased steadily. Summer average flows were the lowest for the year, increasing gradually in late fall and into early winter (Figure 20.) Using median seven-day averages, the instream flow pattern for the preimpoundment period was similar, though less variable than that observed using daily mean values (Figure 21). The plot of median values resulted in average instream flow rates lower, in some cases several thousand cfs lower, than the plot of daily mean values.

The postimpoundment daily flow pattern deviates somewhat from the average preimpoundment instream flow rates but still exhibits a seasonal pattern. Using mean flow values (Figure 20), winter postimpoundment flows typically are lower than preimpoundment values, perhaps reflecting the storing of water within the reservoir system. Spring flows during the striped bass spawning season are greater than preimpoundment values. Summer reservoir releases tend to provide more stability in summer instream flow rates; fall postimpoundment River flows are typically higher than preimpoundment daily average flows (Figure 20). Again, a plot of smoothed daily median flows shows a similar trend, with the exception that average median postimpoundment values tend to exhibit greater variability, a trend opposite that of preimpoundment values (Figures 20 and 21).

To determine whether the postimpoundment instream flows differ significantly from preimpoundment values, we calculated the preimpoundment Q_1 and Q_3 values on a weekly basis for the entire 12-month period, then compared the values to those calculated for the postimpoundment period (Table 16). A t-test was used for each of 52 weeks to determine if postimpoundment values for the week were different from the historical flow record for Q_1 values, Q_3 values, the median flow, and mean flow. Table 17 shows the results of the t-test analysis; only those weeks with significant relationships are presented.

The daily flow patterns exhibited in the previous two figures can be explained by normal operation of the reservoir system upstream with no consideration given to basinwide precipitation. During the months of January, February, and March, the Q_3 boundary of historical flows (calculated on a weekly basis) is significantly higher for the preimpoundment period than for

Table 16. Roanoke River flow data, 1912-1950 and 1955-1990.

		Preimpoundment (1912-1950)									Postimpoundment (1955-1990)								
			Median		Q1		Q3		Mean			Median		Q1		Q3		Mean	
Week	Dates	N	mean	std	mean	std	mean	std	mean	std	N	mean	std	mean	std	mean	std	mean	std
1	01JAN-07JAN	39	11776	13203	7044	4742	18562	19186	12840	11576	36	9249	4702	5487	4961	11552	4647	8725	4450
2	08JAN-14JAN	39	10607	10083	7456	6343	16741	16976	11870	10653	36	10141	5346	6995	5661	11862	4654	9563	4883
3	15JAN-21JAN	39	9714	6575	7511	3921	16775	16671	11678	8525	36	10098	5771	7110	5250	12212	5446	9512	4874
4	22JAN-28JAN	39	9022	5254	6969	3198	15982	18649	10907	8858	36	9147	5429	6715	5593	10864	4798	8885	4953
5	29JAN-04FEB	39	9777	5154	7688	3978	15916	12371	11302	6201	36	10605	5755	7618	5948	12427	5473	10005	5306
6	05FEB-11FEB	39	10949	7183	8226	3993	16708	13790	12664	8170	36	10904	5336	7782	5600	13041	5291	10455	5139
7	12FEB-18FEB	39	12062	10066	8496	4201	18315	17642	13131	10015	36	10693	5673	7214	5081	12707	5363	10019	5246
8	19FEB-25FEB	39	10713	5504	8778	3953	15666	10724	11944	6569	36	9989	5934	7282	6212	13189	5356	10020	5202
9	26FEB-04MAR	39	10808	7613	8379	3940	15097	12552	11669	7783	36	11283	6488	7981	6470	13101	5984	10674	5989
10	05MAR-11MAR	39	13263	11699	8504	4011	19832	17937	14107	10251	36	11872	6843	8206	7131	13859	6387	11227	6360
11	12MAR-18MAR	39	12174	9540	8813	3806	18548	19052	13577	10453	36	10763	6729	7824	7209	12854	5782	10351	6262
12	19MAR-25MAR	39	11416	8016	8682	4087	19460	22172	13665	11424	36	10411	7299	8304	7922	12180	6789	10184	6962
13	26MAR-01APR	39	10913	7567	8693	4432	14436	9985	11629	7300	36	10772	8047	8868	8556	12782	7402	10709	7706
14	02APR-08APR	39	9992	5199	8074	3686	15417	10583	11662	6725	36	10554	8097	8463	8343	12573	7727	10540	7720
15	09APR-15APR	39	10907	7437	8314	4329	18433	13800	12677	7591	36	11289	9201	9356	8707	13074	8541	11282	8435
16	16APR-22APR	39	8914	3699	7459	2887	13719	8977	10530	5074	36	12741	9018	10069	8485	13983	8935	12217	8457
17	23APR-29APR	39	8687	5911	6579	2339	12375	13744	9402	6663	36	10278	7332	8216	7607	12424	8057	10314	7311
18	30APR-06MAY	39	7567	3660	6348	2201	10835	9059	8414	4885	36	11190	8199	9523	8018	12223	8082	11083	7834
19	07MAY-13MAY	39	6751	2654	5755	1886	10048	9154	7681	4226	36	11518	7634	10218	7727	12647	7608	11499	7576
20	14MAY-20MAY	39	7996	5908	6486	4710	12437	10968	9269	7418	36	10744	7507	9158	6864	11841	7681	10670	7062
21	21MAY-27MAY	39	7127	4789	5377	2388	10845	9620	8027	5419	36	9382	5993	8227	5893	10971	6901	9562	6196
22	28MAY-03JUN	39	6704	3296	5101	1851	9653	6161	7510	3810	36	8412	5508	6705	4657	10152	5897	8525	5058
23	04JUN-10JUN	39	6160	3290	4733	2033	9492	9706	6975	4336	36	8148	4934	6365	4889	10054	4836	8312	4584
24	11JUN-17JUN	39	5899	2843	4499	1659	8244	5458	6512	3366	36	7133	4979	4804	4421	9505	4600	7150	4346
25	18JUN-24JUN	39	5882	5827	4512	2563	8605	9606	6479	5624	36	6479	4340	4008	3740	8997	4658	6485	3691
26	25JUN-01JUL	39	5577	4157	4204	2287	7588	7338	5919	4328	36	6159	4971	4374	4042	7764	5421	6104	4364
27	02JUL-08JUL	39	5196	2640	3980	1529	7373	4360	5649	2805	36	5100	4838	4049	4439	6931	5156	5434	4536
28	09JUL-15JUL	39	5552	3493	4317	2213	8216	6569	6212	4102	36	4936	4136	3367	3150	7536	4292	5449	3574
29	16JUL-22JUL	39	7783	10040	4843	3214	11737	13527	8408	9017	36	6400	4856	4304	4273	7999	5007	6315	4343
30	23JUL-29JUL	39	7241	9404	4907	5033	10640	15182	7877	10026	36	5110	4127	3703	3783	6359	4244	5171	3886
31	30JUL-05AUG	39	5161	3005	3898	1862	7597	4781	5692	3149	36	5198	4521	3751	3913	6768	4539	5321	3960
32	06AUG-12AUG	39	5000	3256	3747	1786	7262	7125	5476	3897	36	5081	3450	3406	2313	6887	4301	5213	2983
33	13AUG-19AUG	39	7493	11550	4175	3269	13798	34685	8572	15754	35	5163	2706	3203	1575	7351	4228	5320	2467
34	20AUG-26AUG	39	5535	5052	3952	2600	13881	24485	8329	11546	35	6017	5889	4133	4932	8166	6051	6076	5180
35	27AUG-02SEP	39	5496	6413	3677	3407	7362	9098	5705	6307	35	5486	3966	3665	3340	7093	4498	5562	3605
36	03SEP-09SEP	39	5281	5522	3575	2641	8834	10296	6130	6041	35	4499	2649	3000	1528	6772	4140	4835	2459
37	10SEP-16SEP	39	3922	2804	3112	1968	5605	5440	4586	3860	35	5589	4418	4074	4152	7463	4412	5782	3970
38	17SEP-23SEP	39	6320	14518	3752	6106	11103	23965	7184	14079	35	5506	4411	3261	3293	7238	4776	5490	3688
39	24SEP-30SEP	39	3888	3055	3074	1836	7082	9368	5206	5549	35	5660	4635	3504	3477	7596	4884	5665	3950
40	01OCT-07OCT	39	7579	14719	3684	3795	12010	21003	7906	12888	35	5746	4683	3749	4179	7843	5623	5770	4531
41	08OCT-14OCT	39	4281	3325	3183	2042	6439	6862	4744	4082	35	5840	5623	4310	5607	7287	5745	5874	5445
42	15OCT-21OCT	39	3637	2394	3153	1719	6243	8031	4700	4080	35	5379	4755	3118	2853	7180	5592	5298	4052
43	22OCT-28OCT	39	4873	4604	3672	2545	8566	14228	6039	7601	35	6059	5143	3898	4145	7628	5490	5901	4501
44	29OCT-04NOV	39	4800	5957	3447	1845	6856	9076	5178	5128	35	5202	4823	3880	4593	7042	5056	5505	4531
45	05NOV-11NOV	39	4339	2965	3629	2118	6957	6954	5078	3752	35	6455	4956	4166	4918	8240	5039	6273	4552
46	12NOV-18NOV	39	4745	3633	3918	2902	6957	7010	5483	4522	35	6630	4494	4018	4983	8552	4949	6472	4490
47	19NOV-25NOV	39	5069	2651	4067	1915	8191	7125	5979	3769	35	6899	4428	4039	4091	8432	4248	6427	4013
48	26NOV-02DEC	39	5158	3454	4132	2433	9857	14641	6661	7094	35	6842	5495	4655	5710	9213	4772	6923	4926
49	03DEC-09DEC	39	7913	8881	5684	5273	13340	17321	9159	9973	35	7675	4492	4229	4331	9827	4459	7219	3906
50	10DEC-16DEC	39	6168	3770	5098	2744	8862	6796	6862	4399	35	7635	4376	5003	4388	9701	4410	7331	4076
51	17DEC-23DEC	39	6226	3585	4945	2338	8175	5561	6656	3888	35	8598	4775	5777	4845	10617	5010	8194	4509
52	24DEC-31DEC	39	8229	7832	5600	3244	11625	10904	8936	7228	35	7410	4975	4106	3962	10417	4628	7398	4119

Table 17. Results of a t-test comparing Roanoke River flows (on a weekly basis) for the preimpoundment (1912-1950) and postimpoundment (1955-1990) periods. Only weeks having one or more significant relationships are presented. NS = not significantly different.

		Q_1 Boundary		Q_3 Boundary		Median		Mean	
Week	Date	P>T	Flow	P>T	Flow	P>T	Flow	P>T	Flow
1	Jan 1-7	0.1688	NS	0.0323	Pre>Post	0.0446	Pre>Post	0.2680	NS
2	Jan 8-14	0.7416	NS	0.0913	Pre>Post	0.2275	NS	0.8010	NS
7	Feb 12-18	0.2959	NS	0.0648	Pre>Post	0.0938	Pre>Post	0.4666	NS
10	Mar 5-11	0.8265	NS	0.0570	Pre>Post	0.1454	NS	0.5284	NS
11	Mar 12-18	0.4663	NS	0.0818	Pre>Post	0.1069	NS	0.4591	NS
12	Mar 19-25	0.7985	NS	0.0569	Pre>Post	0.1130	NS	0.5727	NS
15	Apr 9-15	0.5202	NS	0.0456	Pre>Post	0.4533	NS	0.8435	NS
16	Apr 16-22	0.0866	Post>Pre	0.8988	NS	0.3042	NS	0.0222	Post>Pre
18	Apr 30-May 6	0.0269	Post>Pre	0.4876	NS	0.0849	Post>Pre	0.0186	Post>Pre
19	May 7-13	0.0017	Post>Pre	0.1875	NS	0.0101	Post>Pre	0.0009	Post>Pre
20	May 14-20	0.0558	Post>Pre	0.7850	NS	0.4057	NS	0.0811	Post>Pre
21	May 21-27	0.0096	Post>Pre	0.9481	NS	0.2564	NS	0.0750	NS
22	May 28-Jun 3	0.0597	Post>Pre	0.7215	NS	0.3273	NS	0.1124	NS
23	Jun 4-10	0.0693	Post>Pre	0.7494	NS	0.1981	NS	0.0462	Post>Pre
30	Jul 23-29	0.2483	NS	0.0979	Pre>Post	0.1243	NS	0.2036	NS
37	Sep 10-16	0.2176	NS	0.1136	NS	0.1932	NS	0.0609	Post>Pre
39	Sep 24-30	0.5164	NS	0.7650	NS	0.6808	NS	0.0599	Post>Pre
42	Oct 15-21	0.9507	NS	0.5589	NS	0.5294	NS	0.0563	Post>Pre
45	Nov 5-11	0.5533	NS	0.3713	NS	0.2200	NS	0.0322	Post>Pre
46	Nov 12-18	0.9178	NS	0.2586	NS	0.3493	NS	0.0500	Post>Pre
47	Nov 19-25	0.9706	NS	0.8586	NS	0.6220	NS	0.0380	Post>Pre
51	Dec 17-23	0.3601	NS	0.0520	Post>Pre	0.1195	NS	0.0175	Pre>Post
52	Dec 24-31	0.0789	Pre>Post	0.5304	NS	0.2593	NS	0.5893	NS

the postimpoundment period, reflecting water storage in the reservoir (Table 17). Beginning in mid-April, the Q_1 boundary for historical postimpoundment flows is significantly higher than that of preimpoundment, reflecting releases from the reservoir in context of spawning activity of striped bass, and the MOU agreement for additional water releases during the period. From July through December, weekly average flows of the postimpoundment period are significantly higher than for the preimpoundment period.

In summary, weekly estimates of Q_1, Q_3, median, and mean flows for the preimpoundment and postimpoundment periods reflect a significant change in River flow, although the seasonal patterns are similar. In a general sense, this means that on a weekly average more water is present in the lower River in the spring and fall due to reservoir releases. The Q_3 boundary is higher for the preimpoundment period, but the <u>average</u> flow rate was not. In a following section of this report, these trends are examined in closer detail.

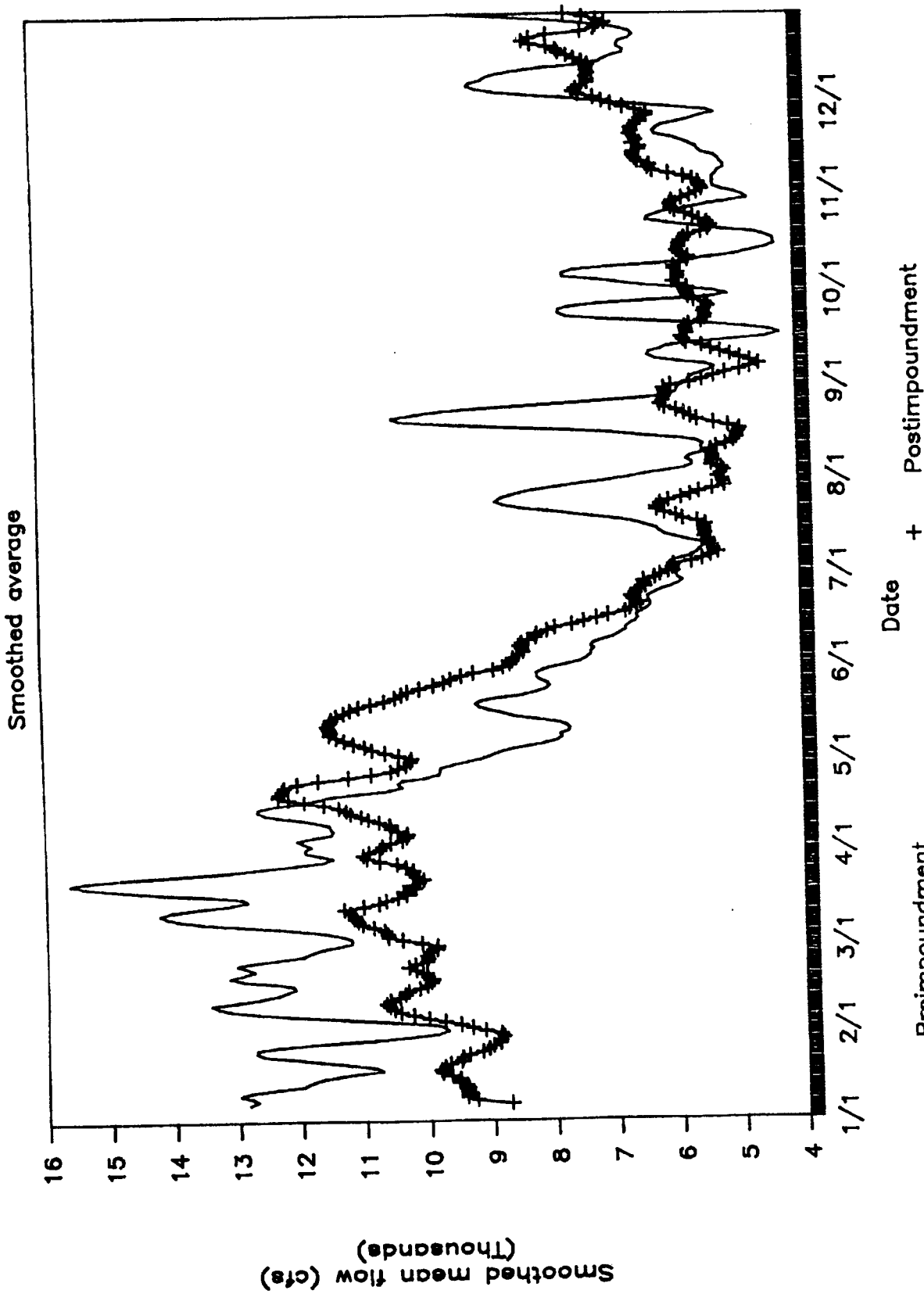

Figure 20. Roanoke River (mean) flow, 1912-1990.

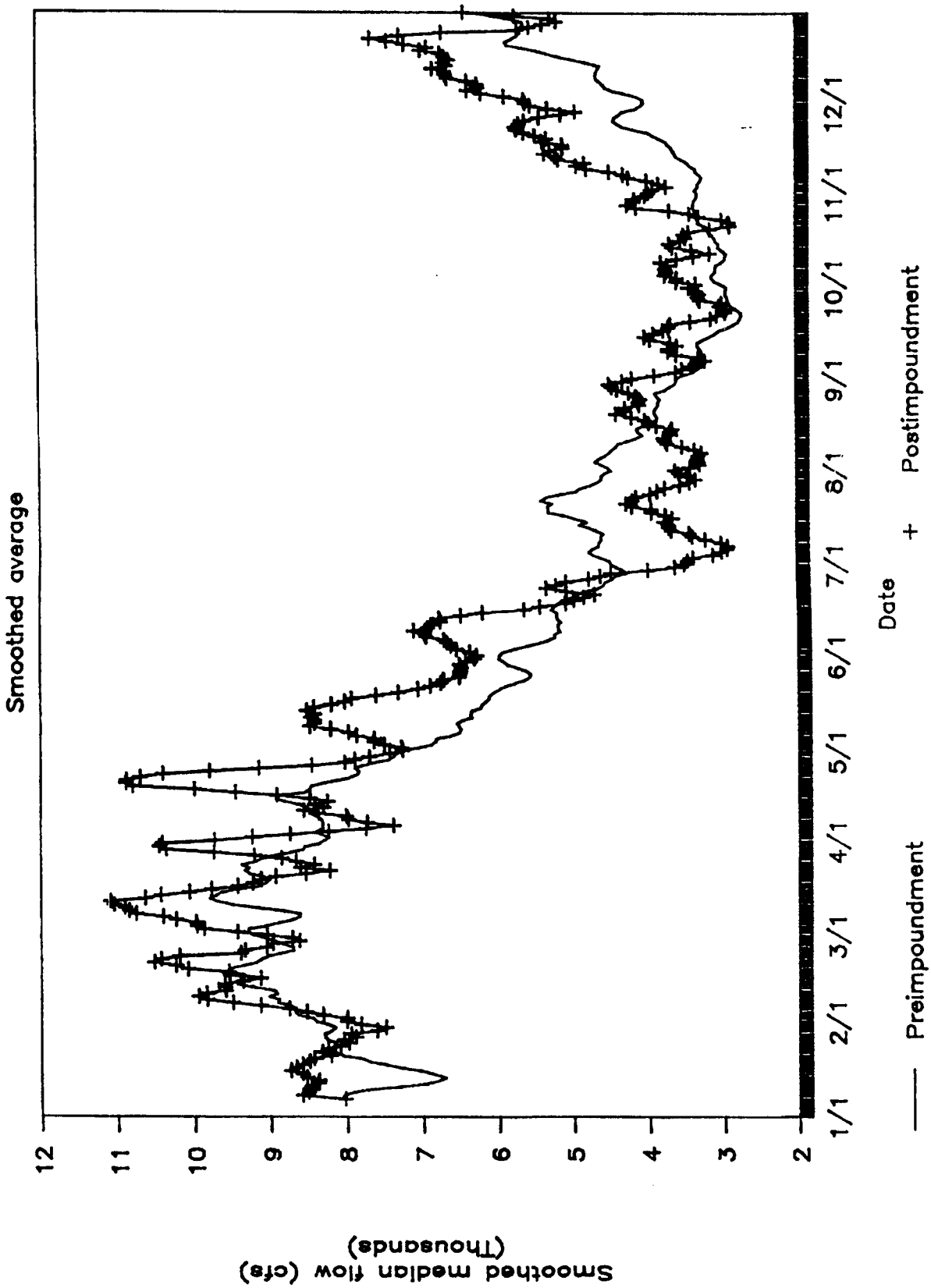

Figure 21. Roanoke River daily (median) flow, 1912-1990.