WATER SUPPLY FORECAST VERIFICATIONS FOR THE KENNEBEC RIVER

by

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ABSTRACT: A pilot project of water supply forecasts for the Kennebec River was started in 1948. Verification figures for the forecasts are shown for five forecast dates, January 1 through May 1, and for 12 years, 1948 through 1959. Average errors of forecast residual flow diminished steadily from January 1 through April 1. The purpose of presenting these data is to enable users to determine the usefulness of such forecasts.

Water Supply Forecasts on the Kennebec River

Commencing on January 1, 1948, a series of water supply forecasts of runoff volumes was begun for the Kennebec River at The Forks, Maine. The quantity forecast was December through May runoff in 1000 second-feet-days, with the first forecast on January 1st and continuing in most years through May 1st.

These Water Supply Forecasts were made by using a water supply forecasting scheme discussed by Bernard (1949).

The publication of these forecasts was intended as a pilot project to attempt to determine the accuracy and usefulness of such runoff forecasts in the northeastern United States.

Verification of Water Supply Forecasts

The original forecasts were based on a relationship between seasonal precipitation, weighted by stations and months, and seasonal runoff. In Figure 1, the prediction line relating the precipitation index and runoff is shown together with the observations.

The plotting of the points for the period of application (1948-59) is somewhat disappointing. It will be particularly noted that the years from 1953 through 1959 all lie above the prediction line. This suggests that there might have been some time trend in the data, due very probably to changes in the precipitation network. This seems likely when it is noted that one of the precipitation stations (Eustis, Maine) used in the original prediction equation went out of existence very early in the period of use. This is, of course, one of the normal hazards of forecasting. Even so, it will be noted that the prediction equation was highly satisfactory for the two extreme years of record -- 1957 and 1958.

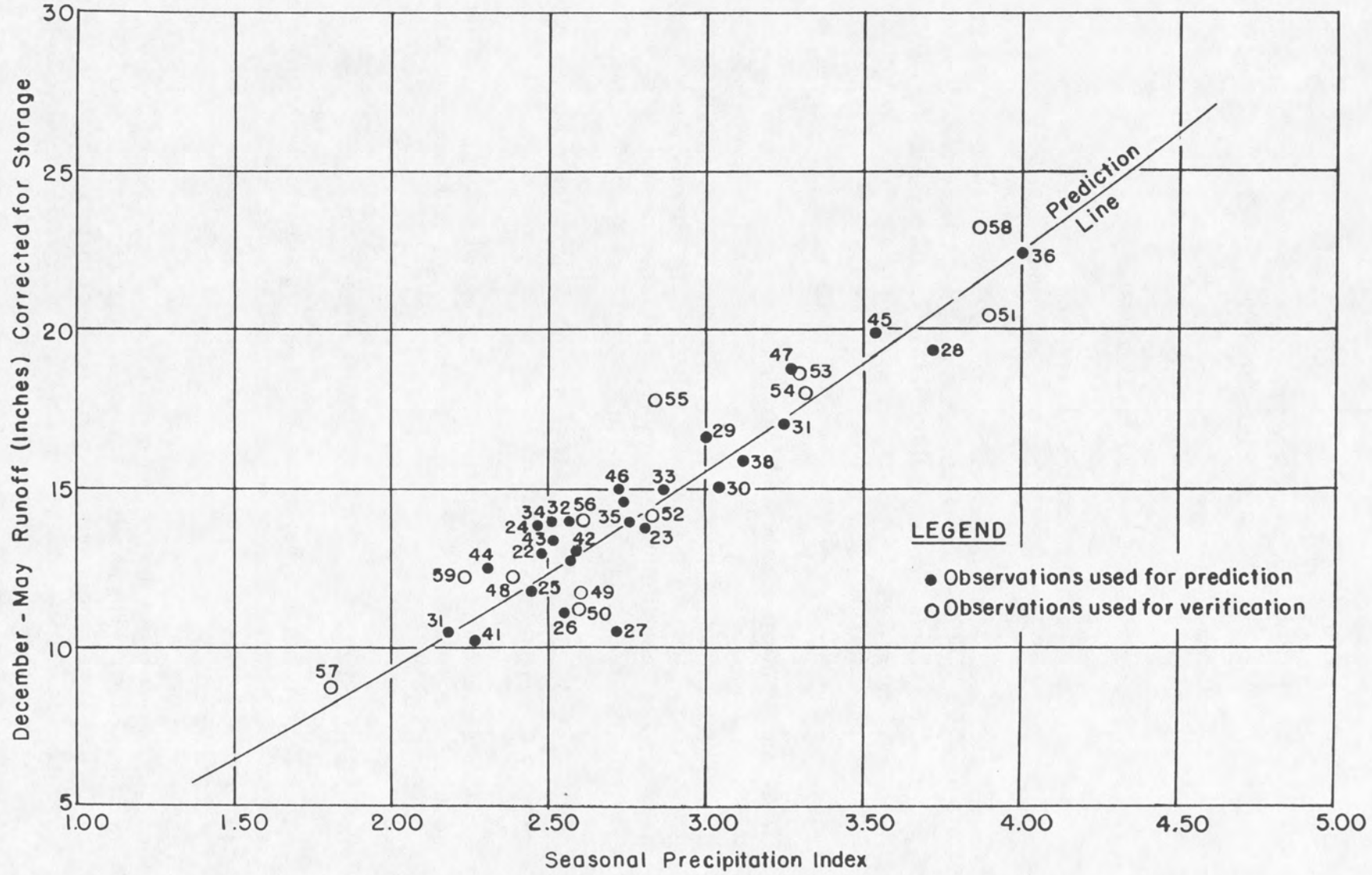

Figure 1. Water Supply Forecast Relation and Verifications for the Kennebec River at The Forks, Maine.

The reliability displayed in Figure 1 is, of course, not indicative of the forecasts as such, since the forecasts are issued early in the year before all of the precipitation is observed, and because part of the runoff had already occurred at the time of issuance. Consequently, in order to verify the forecasts of total seasonal runoff actually made, it is necessary to subtract the runoff observed to the forecast date, and to compare the residual runoff forecasts against the residual runoffs observed. Tabulations of the residual forecasts made as of the 1st day of the month for January through May and the observed runoffs are shown in Tables 1 through 5.

For each forecast date for each year, five separate forecasts are shown based upon assumptions as to the precipitation throughout the rest of the year subsequent to the forecast date. The average errors shown are for the forecast which assumes that the subsequent precipitation will be equal to the median of record. As you can see, the average error of these median forecasts diminishes steadily from January 1st through April 1st. Between April 1st and May 1st the average error remains practically constant and increases sharply as a percentage of the residual runoff. It can be concluded that there is little advantage in using the May 1st forecast.

The verification of the other forecasts made, which assume various subsequent precipitations of different probabilities, can best be made by means of a frequency study such as is shown in Table 6. It will be noted in Table 6 that many of the forecasts fall above the forecasts corresponding to the median subsequent precipitation of record, and but slightly fewer fall above the precipitation corresponding to the subsequent precipitation equal to the upper quartile. This frequency distribution is, of course, highly influenced by the fact that of the 12 years of forecasts checked, eight of them were underforecast. This, of course, would disturb the frequency distribution of forecast errors.

Future Plans for Water Supply Forecasting

This forecast procedure, for which verification figures are presented here, has now been replaced and procedures added for several other basins in upper New England and upper New York. The purpose of presenting these verifications is to provide potential users of water supply forecasts with data that will enable them to determine the potential usefulness of such forecasts, There is every reason to expect that the new procedures will prove of equal or improved accuracy.

Reference:

BERNARD, MERRILL. The Long-Term Precipitation-Runoff Relation as the Basis for Forecasting Water Supply. Trans. AGU, June 1949, Vol. 30, pp. 386-395.

TABLE 1

WATER SUPPLY FORECAST VERIFICATIONS

Kennebec River at The Forks, Me.
(Corrected for Storage)

FORECAST DATE OF JANUARY 1

Runoff in 1000 sfd between January 1 & June 1 under the assumption that precipitation through June 1 is equal to:

Year	Runoff (1000 sfd)	Minimum of Record	Lower Quartile	Median of Record	Upper Quartile	Maximum of Record
1948	Forecast	357	450	509	589	859
	Observed			510		
1949	Forecast	427	516	583	663	954
	Observed			438		
1950	Forecast	350	438	502	582	856
	Observed			447		
1951	Forecast	358	450	518	602	902
	Observed			672		
1952	Forecast	433	521	585	673	965
	Observed			515		
1953	Forecast	396	485	548	633	915
	Observed			732		
1954	Forecast	336	428	492	576	863
	Observed			644		
1955	Forecast	408	497	564	649	944
	Observed			662		
1956	Forecast	326	415	478	558	824
	Observed			571		
1957	Forecast	328	421	480	560	830
	Observed			338		
1958	Forecast	368	457	524	608	908
	Observed			811		
1959	Forecast	330	419	483	564	835
	Observed			472		

Average Error of Median Forecast	116
Average Observed Runoff	568
Error/Runoff (%)	20.4

TABLE 2

WATER SUPPLY FORECAST VERIFICATIONS

Kennebec River at The Forks, Me.
(Corrected for Storage)

FORECAST DATE OF FEBRUARY 1

Runoff in 1000 sfd between February 1 & June 1 under the assumption that precipitation through June 1 is equal to:

Year	Runoff (1000 sfd)	Minimum of Record	Lower Quartile	Median of Record	Upper Quartile	Maximum of Record
1948	Forecast	346	426	476	536	751
	Observed			497		
1949	Forecast	406	486	540	606	827
	Observed			391		
1950	Forecast	388	468	519	586	806
	Observed			401		
1951	Forecast	335	415	474	537	774
	Observed			628		
1952	Forecast	375	455	506	574	797
	Observed			470		
1953	Forecast	391	471	526	594	813
	Observed			689		
1954	Forecast	343	440	474	545	765
	Observed			609		
1955	Forecast	327	403	462	525	741
	Observed			619		
1956	Forecast	356	415	466	516	677
	Observed			504		
1957	Forecast	292	368	423	487	689
	Observed			307		
1958	Forecast	434	519	578	650	899
	Observed			717		
1959	Forecast	337	413	468	531	746
	Observed			425		

Average Error of Median Forecast	106
Average Observed Runoff	521
Error/Runoff (%)	20.3

TABLE 3

WATER SUPPLY FORECAST VERIFICATIONS

Kennebec River at The Forks, Me.
(Corrected for Storage)

FORECAST DATE OF MARCH 1

Runoff in 1000 sfd between March 1 & June 1
under the assumption that precipitation through June 1
is equal to:

Year	Runoff (1000 sfd)	Minimum of Record	Lower Quartile	Median of Record	Upper Quartile	Maximum of Record
1948	Forecast	320	375	425	475	630
	Observed			491		
1949	Forecast	413	451	497	552	717
	Observed			369		
1950	Forecast	369	432	478	533	689
	Observed			369		
1951	Forecast	396	459	514	573	750
	Observed			575		
1952	Forecast	396	455	506	561	730
	Observed			432		
1953	Forecast	371	430	481	531	696
	Observed			656		
1954	Forecast	395	458	513	569	737
	Observed			577		
1955	Forecast	361	420	471	483	694
	Observed			577		
1956	Forecast	324	383	434	484	645
	Observed			472		
1957	Forecast	251	260	361	412	563
	Observed			291		
1958	Forecast	490	554	613	676	866
	Observed			676		
1959	Forecast	306	365	416	467	624
	Observed			398		

Average Error Median Forecast	81
Average Observed Runoff	490
Error/Runoff (%)	16.5

TABLE 4

WATER SUPPLY FORECAST VERIFICATIONS

Kennebec River at The Forks, Me.
(Corrected for Storage)

FORECAST DATE OF APRIL 1

Runoff in 1000 sfd between April 1 & June 1
under the assumption that precipitation through June 1
is equal to:

Year	Runoff (1000 sfd)	Minimum of Record	Lower Quartile	Median of Record	Upper Quartile	Maximum of Record
1948	Forecast	305	355	385	425	530
	Observed			456		
1949	Forecast	359	389	418	460	566
	Observed			335		
1950	Forecast	390	441	470	512	622
	Observed			327		
1951	Forecast	461	516	550	601	723
	Observed			531		
1952	Forecast	357	408	437	479	589
	Observed			418		
1953	Forecast	357	408	438	484	602
	Observed			520		
1954	Forecast	378	433	463	509	627
	Observed			518		
1955	Forecast	383	433	463	509	623
	Observed			527		
1956	Forecast	353	403	433	475	585
	Observed			450		
1957	Forecast	206	256	281	319	425
	Observed			258		
1958	Forecast	502	557	595	647	773
	Observed			629		
1959	Forecast	317	365	395	437	551
	Observed			373		

Average Error of Median Forecast	53
Average Observed Runoff	445
Error/Runoff (%)	11.9

TABLE 5

WATER SUPPLY FORECAST VERIFICATIONS

Kennebec River at The Forks, Me.
(Corrected for Storage)

FORECAST DATE OF MAY 1

Runoff in 1000 sfd between May 1 & June 1
under the assumption that precipitation through June 1
is equal to:

Year	Runoff (1000 sfd)	Minimum of Record	Lower Quartile	Median of Record	Upper Quartile	Maximum of Record
1948	Forecast	128	149	170	204	250
	Observed			264		
1949	Forecast	147	172	193	227	278
	Observed			124		
1950	Forecast	240	261	282	320	366
	Observed			143		
1951	Forecast	199	228	254	296	351
	Observed			163		
1952	Forecast	149	175	196	230	280
	Observed			202		
1953	Forecast	70	95	112	154	205
	Observed			169		
1954	Forecast	188	214	235	273	328
	Observed			252		
1955	Forecast	99	128	145	183	234
	Observed			260		
1956	Forecast	261	286	303	341	392
	Observed			312		
1957	Forecast	71	92	113	147	189
	Observed			123		
1958	Forecast	206	244	269	311	370
	Observed			311		
1959	Forecast	89	110	136	170	216
	Observed			156		

Average Error of Median Forecast	56
Average Observed Runoff	207
Error/Runoff (%)	27.1

TABLE 6

COMPARISON OF OBSERVED RUNOFFS WITH
FORECASTS BASED ON ASSUMPTIONS OF SUBSEQUENT PRECIPITATION
OF GIVEN PROBABILITIES

Forecast Date	Category											
January 1	0	Minimum of Record	3	Lower Quartile of Record	2	Median of Record	1	Upper Quartile of Record	6	Maximum of Record	0
February 1	1		3		1		2		5		0
March 1	1		2		2		1		6		0
April 1	2		0		4		2		4		0
May 1	3		0		0		5		2		2

The vertical dividers represent the five forecasts made based on five different assumptions of precipitation of known probability. These divide the observations of runoff into six categories. Classification in a given category means that the observed runoff was equal to or greater than the lesser forecast, but less than the greater forecast. For example, in the group of forecasts made on February 1st, in one year observed runoff was less than the forecast based on assumed subsequent precipitation equal to the minimum of record. In three years, runoff was equal to or greater than the forecast based on the minimum precipitation of record, but less than the forecast based on precipitation equal to the lower quartile of record. For each forecast date, 12 observed runoffs are classified from the 12 years of forecasts made.