POTOMAC RIVER AT POINT OF ROCKS PROBABILITIES OF LOW FLOWS ONE AND TWO SEASONS AHEAD

Prepared by

Erik R. Hagen Roland C. Steiner Claire Buchanan

July, 1999 Report No. 99-2

Interstate Commission on the Potomac River Basin 6110 Executive Boulevard, Suite 300 Rockville, Maryland 20852 The Interstate Commission on the Potomac River Basin

Section for Cooperative Water Supply Operations on the Potomac

This report was prepared by the Interstate Commission on the Potomac River Basin, Section for Cooperative Water Supply Operations on the Potomac. Funds were provided for this report by the Washington Suburban Sanitary Commission, the Washington Aqueduct Division of the U.S. Army Corps of Engineers, and the Fairfax County Water Authority. The opinions expressed are those of the authors and should not be construed as representing the opinions or policies of the United States or any of its agencies, the several states, the Commissioners of the Interstate Commission on the Potomac River Basin, or the water utilities.

Table of Contents

Introduction	1
Background	1
Method	2
Probabilistic assessment—results for adjacent seasons	3
Probabilistic assessment—results across two seasons	
Probabilistic assessment—conclusions	6
Reference	
Appendix A: Histogram analysis of each season's low flows	
Appendix B: Seasonal low flows at Point of Rocks by season and corresponding dry, medium and wet designations	
List of Tables Table 1: Definition of Seasons	2
Table 2: Seasonal flow thresholds used to distinguish between dry, medium, and wet flows	3
Table 3: Transition probabilities expected assuming no pattern of persistence in flows for a ar example season (number of expected events in parenthesis)	n 4
Table 4: One-season transition probabilities (number of historical events in parenthesis)	4
Table 5: Two-season transition probabilities (number of historical events in parenthesis)	5

Introduction

Hydrologists have long known that in rivers, low flows tend to follow low flows and high flows tend to follow high flows, across both short and long term time frames (Hurst, 1957). The Water Supply Outlook (WSO) produced by ICPRB CO-OP in summer and early fall capitalizes on this concept. The WSO provides an estimate of the conditional probability of low flow occurring through the end of September as based on antecedent flow conditions.

The persistence of low flows across one and two seasons in the Potomac River basin through statistical analysis of historical data was examined. Persistence in Potomac low flow conditions allows the water manager to predict the likelihood of low flow occurrences in the Potomac even over two seasons. The ability to assess the probability of low flow in Potomac has implications for Washington metropolitan area (WMA) water supply management. Probabilistic flow assessments may allow for a more efficient, risk based approach to water supply system operation.

Background

The river/reservoir manager would prefer an ideal world in which rainfall could be accurately predicted and good estimates of future river flow obtained. Given current meteorological forecast skill, accurate estimates of Potomac flow three to six months into the future are impossible. Instead, a probabilistic statistical approach can be used to assess the likelihood of Potomac low flows.

Many factors control the rate of flow in a river including soil moisture conditions, groundwater levels, current and recent rainfall, evapotranspiration, surface runoff rates and rainfall interception by tree foliage. These factors are interrelated. For example, low soil moisture conditions can reduce the rate at which groundwater levels are recharged during a storm event by intercepting the water before it reaches the groundwater table.

Many of these factors, such as groundwater levels or soil moisture conditions, tend to cycle through long term seasonal and interseasonal patterns reflecting cumulative effects of long term moisture deficits or surplus. A six month period of low rainfall can result in extremely low soil moisture and groundwater levels. Once dry (or wet), these factors can persist even under normal rainfall conditions. For example, groundwater levels might become lower than normal during a dry fall and winter and remain lower than normal the following spring, even though precipitation may have returned to normal for two or three months in the spring. (This is the case in 1998-1999 in the lower portion of the Potomac River basin.)

When flow in the Potomac is low, most of the water in the river is due to contributions from groundwater. This flow is termed "baseflow." If baseflow is below normal, then it is also true that groundwater, soil moisture, and other factors driving Potomac flow likely are below normal, and baseflow integrates the cumulative moisture deficit or surplus of these underlying factors. A given season's lowest daily flow in the river is an excellent measure of baseflow, since the season's low flow is unlikely to have been a result of recent rainfall events. This seasonal low flow can become a surrogate measure of the relative status of the interrelated factors driving Potomac flow. Because of persistence in these underlying factors, the season's lowest flow is likely to be a valid predictor of low flows in following seasons.

This work examines the persistence of seasonal low flows in the Potomac into the first or second future season.

Method

Four seasons were defined per Table 1. Seasons were selected to correspond to intervals that are of concern to water supply managers—Potomac flow is most likely to drop to levels of concern in the summer and fall seasons.

Table 1: Definition of Seasons

Month	Season
December	
January	Winter
February	
March	
April	Spring
May	
June	
July	Summer
August	
September	
October	Fall
November	

Since more than 100 years of flow data were available as measured for the Potomac River at the Point of Rocks gage, these data were selected for use in the examination of low flow persistence.

Minimum Potomac River flows at Point of Rocks were selected for each season and each year. The minimum daily flow that occurred during each season was noted for the 100-year plus period of record (1895 to 1997). Thus, roughly 400 data points were derived, in which each data point corresponds to the lowest daily flow that occurred in a particular three-month season. For example, the winter of 1931 is associated with 90 days of daily flow data (December through February). The lowest of those 90 flows was selected as

the low flow data point for winter of 1931. This process was repeated for each season and for each year to derive a total of approximately 400 data points.

All the data points were classified by the four seasons defined in Table 1, resulting in 102-103 data points in each season. These data points were further classified into three descriptive categories: dry, medium and wet. Each descriptive category was defined by ranking each season's 102 or 103 data points from low to high, labeling the lowest third of flows "dry," the middle third of flows "medium," and the highest third of flows "wet." In other words, each season's flows were divided at the 33rd and 66th percentile. Table 2 shows the resulting thresholds which distinguish among dry, medium and wet flows for each season. This table can be interpreted as follows. The 33rd percentile flow for fall is 1,100 cfs. This means that flow in the fall at Point of Rocks was less than 1,100 cfs in 33 years out of 100. Histograms graphically show the thresholds and flow frequencies for each season (Appendix A).

Table 2: Seasonal flow thresholds used to distinguish among dry, medium, and wet flows

Percentile	Winter flow	Spring flow	Summer flow	Fall flow		
		Cubic feet pe	r second (cfs)			
33	2,046	3,593	1,403	1,100		
66	3,666	5,210	2,006	1,543		
		Million gallons	per day (mgd)			
33	33 1,323		33 1,323 2,323		907	711
66	2,370	3,368	1,297	997		

Seasonal low flows were chronologically ordered in an Excel spreadsheet along with each season's descriptive category of dry, medium, or wet (Appendix B). The number of times flows transition between descriptive categories was tallied, for every combination of categories. For example, for every dry flow in the fall, the number of wintertime dry, medium and wet flows was noted and summed for the 102 year period of record. This tally was conducted between adjacent seasons, for example from winter to spring, and also across seasons, for example from winter to summer. The results were obtained by tallying the total number of transitions between seasons and categories.

Probabilistic assessment—results for adjacent seasons

If there was no persistence between adjacent seasons, one would expect an even distribution (equal probability) of dry, medium and wet flows in subsequent seasons (Table 3).

Table 3: Transition probabilities expected assuming no pattern of persistence in flows for a an example season (number of expected events in parenthesis)

		Spring	
Summer	Dry	Medium	Wet
Dry	33% (11 or 12)	33% (11 or 12)	33% (11 or 12)
Medium	33% (11 or 12)	33% (11 or 12)	33% (11 or 12)
Wet	33% (11 or 12)	33% (11 or 12)	33% (11 or 12)

Analysis of the data reveals a departure from the pattern shown in Table 3, indicating flow persistence across seasons. Results are shown in Table 4. Note that Table 4 also shows the number of historical events for each transition in parenthesis.

Table 4: One-season transition probabilities (number of historical events in parenthesis)

Spring to summer	Summer dry	Summer medium	Summer wet		
Spring dry	59% (20)	26% (9)	15% (5)		
Spring medium	21% (7)	45% (15)	33% (11)		
Spring wet	19% (7)	28% (10)	53% (19)		
Summer to fall	Fall dry	Fall medium	Fall wet		
Summer dry	59% (20)	29% (10)	12% (4)		
Summer medium	29% (10)	47% (16)	24% (8)		
Summer wet	9% (3)	26% (9)	66% (23)		
Fall to winter	Winter dry	Winter medium	Winter wet		
Fall dry	55% (18)	33% (11)	12% (4)		
Fall medium	37% (13)	29% (10)	34% (12)		
Fall wet	9% (3)	35% (12)	56% (19)		
Winter to spring	Spring dry	Spring medium	Spring wet		
Winter dry	56% (19)	21% (7)	24% (8)		
Winter medium	30% (10)	33% (11)	36% (12)		
Winter wet	14% (5)	43% (15)	43% (15)		

Note: Shaded cells show persistence in transition to like flows.

Table 4 can be interpreted per the following example, which assumes that the date is May 31 (end of spring) and the minimum flow was 2,900 cfs in the previous three months. From Table 2, the dry, medium or wet ranking of the spring season can be determined—in this case, the ranking is "dry." The probability of a dry summer is found by identifying the "Spring dry" cell in the left most column of Table 4, and reading across to the appropriate column to determine the transition probabilities for the summer season. In this example, the probability of a dry summer is 59%, a medium summer is 26%, and a wet summer is 15%. These results can be interpreted to mean that there is a 59% chance

that at some time in the summer, flow will drop below the summertime dry threshold as reported in Table 2 (907 mgd). Note that each cell in Table 4 also gives the total number of historical events in the Potomac flow record on which the percentages are based. For example, the 34 dry springs tracked in the historic record were followed by a total of 20 dry summers, 9 medium summers, and 5 wet summers.

Table 4 shows that spring and summer dry, medium and wet categories are persistent. Fall dry and fall wet categories are persistent. Fall medium is not persistent, i.e., fall medium is about equally likely to transition to a dry, medium or wet winter. Although winter dry is persistent, winter medium is not. Winter wet is weakly persistent but often is followed by a medium spring. Key persistence periods are summer wet (strongest), spring dry and summer dry. The periods showing least transition correlation are fall medium and winter medium. It is interesting to note that wet summers and falls have a relatively low probability of being followed by dry falls and winters, respectively.

Probabilistic assessment—results across two seasons

Table 5 shows the transition probabilities two seasons ahead. Here again, the empirical probabilities depart from the equal probability model shown in Table 3, indicating a pattern of flow persistence in the Potomac across two seasons.

Table 5: Two-season transition probabilities (number of historical events in parenthesis)

Spring to fall	Fall dry	Fall medium	Fall wet
Spring dry	62% (21)	18% (6)	21% (7)
Spring medium	27% (9)	39% (13)	33% (11)
Spring wet	8% (3)	44% (16)	47% (17)
Summer to winter	Winter dry	Winter medium	Winter wet
		- 'A	
Summer dry	35% (12)	41% (14)	24% (8)
Summer medium	48% (16)	18% (6)	33% (11)
Summer wet	17% (6)	37% (13)	46% (16)
	ik.		
Fall to spring	Spring dry	Spring medium	Spring wet
Fall dry	64% (21)	15% (5)	21% (7)
Fall medium	14% (5)	43% (15)	43% (15)
Fall wet	24% (8)	38% (13)	38% (13)
	"		
Winter to summer	Summer dry	Summer medium	Summer wet
Winter dry	47% (16)	24% (8)	29% (10)
Winter medium	30% (10)	36% (12)	33% (11)
Winter wet	22% (8)	39% (14)	39% (14)

Note: Shaded cells show persistence in transition to like flows.

Low flow persistence two seasons ahead is most likely following a dry spring (62%) and a dry fall (64%). Low flow persistence is less likely from winter to summer (47%) and

from summer to winter (35%). The summer medium category is the least persistent, i.e. lowest (18%).

Probabilistic assessment—conclusions

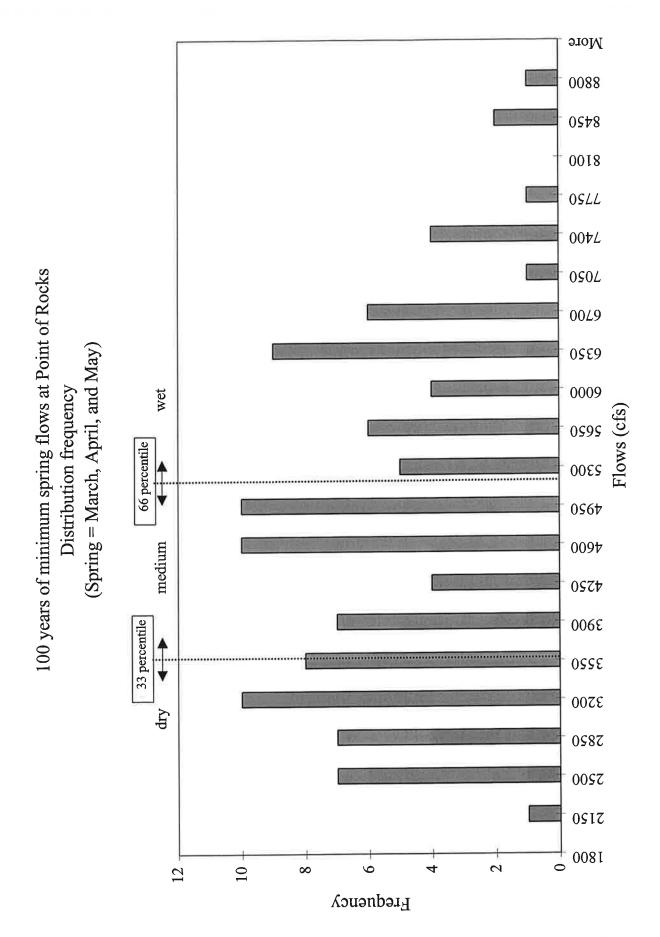
Persistence in Potomac low flow conditions allows for relatively accurate forecasting of low flow occurrences in the Potomac over a three to six month forecast period (1-2 seasons).

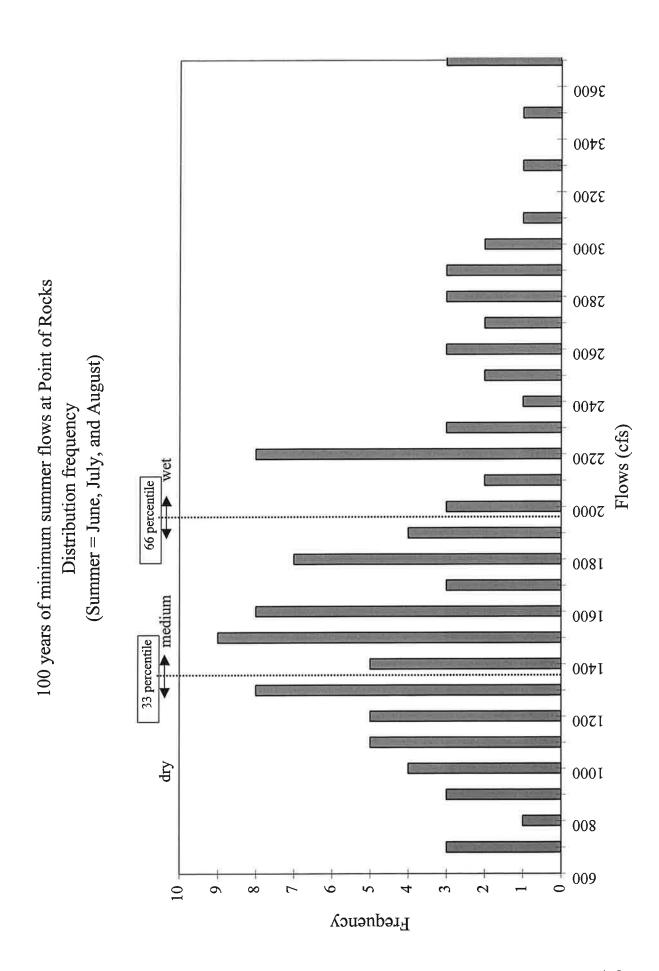
Although current levels of Washington metropolitan area (WMA) demand are not predicted to stress the regional water resources during a drought of record, growing demands may do so in the future. Assessed probabilities of low flow in the Potomac have implications for WMA water supply management. Probabilistic flow assessments may allow for a risk-based approach to water supply system operation, for example reserving more water in the water supply reservoirs during the spring and early summer when dry summers or falls are predicted on the Potomac. Risk based management schemes might extend the time that the current system of WMA reservoirs can meet growing levels of demand, and also provide for more efficient use of off-Potomac reservoirs during wet years.

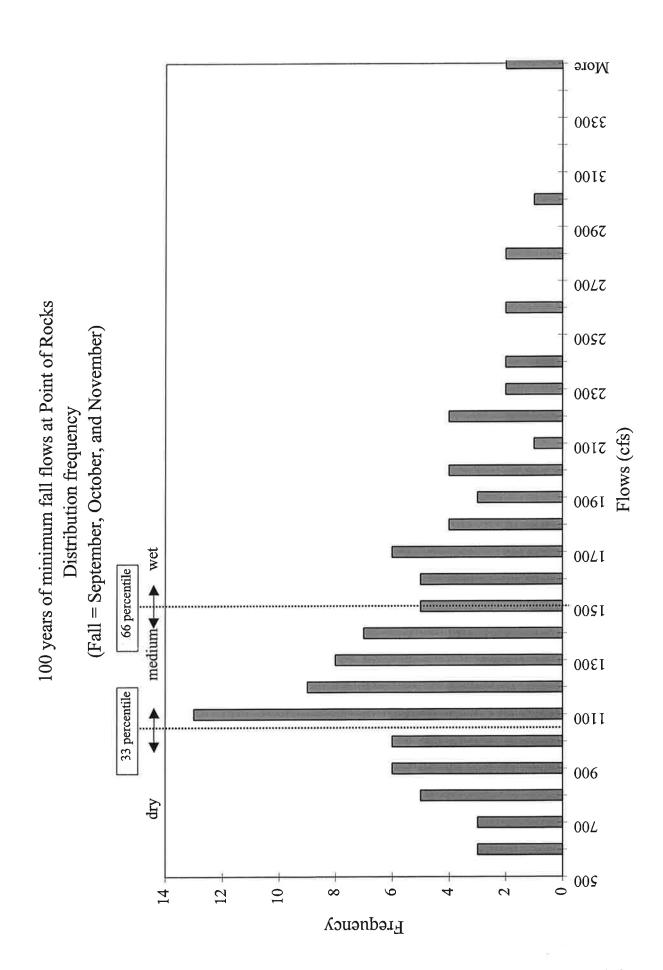
Reference

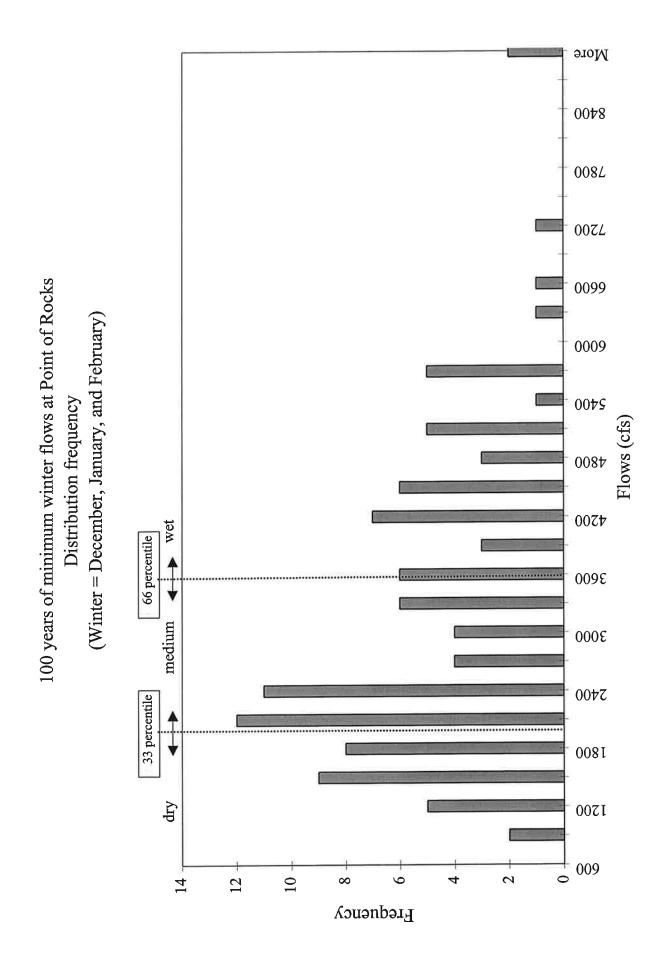
Hurst, H.E. 1957. A suggested statistical model of some time series which occur in nature, *Nature* vol. 180, p. 494.

Appendix A: Histogram analysis of each season's low flows









Appendix B: Seasonal low flows at Point of Rocks by season and corresponding dry, medium and wet designations

Name		189	895 - 1907 1907 - 1919 1919 - 1931		31	1931 - 1943			1943 - 1955			1955 - 1967							
Flow							Min.		Min.		Min.		Min.		Min.		Min.		
Season Vear Cefs Cat Vear Cefs C							Flow			Flow			Flow			Flow			
Spring 1895 6200 wet 1907 6902 wet 1919 4670 med. 1931 2610 dry 1943 6600 wet 1955 4540 med. 1941 1895 1340 dry 1907 1909 wet 1919 1400 dry 1931 845 dry 1943 995 dry 1955 2020 wet 1919 1910 dry 1931 845 dry 1943 995 dry 1955 2020 wet 1919 1910 dry 1932 882 dry 1944 1000 dry 1956 1500 dry 1956 1800 med. 1946 4640 wet 1946 4440 we	Season	Year		Year (efs) Cat.	Year	(cfs)	Cat.	Year	(cfs)	Cat.	Year	(cfs)	Cat.	Year	(cfs)	Cat.		
Summer 1895 1340 dry 1907 2100 wet 1919 1480 med. 1931 1450 med. 1931 1450 med. 1935 1496 med. 1936 1806 dry 1908 5380 wet 1920 3700 wet 1932 982 dry 1944 1000 dry 1955 1500 dry 1908 1806 1806 med. 1908 1530 wet 1920 1909 med. 1932 2940 dry 1944 1100 dry 1956 1500 dry 1908 1806 med. 1908 1806 med. 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 1908 19	Spring			1907 6	920 wet	1919	4670 1	med.	1931	2610	dry	1943	6600	wet	1955	4540	med.		
Winter 1896 180 dry 1908 5380 wet 1920 3700 wet 1932 982 dry 1944 6420 wet 1956 1500 dry 1956 1500 dry 1968 1540 med. 1908 2530 wet 1909 1909 med. 1932 2940 dry 1944 6420 wet 1956 2600 med. 1916 1808 1808 med. 1908 1520 med. 1909 1909 med. 1932 2702 dry 1944 110 dry 1956 1500 med. 1935 1808 med. 1935 1809 dry 1944 110 dry 1956 1500 med. 1935 1808 med. 1932 1809 dry 1944 110 dry 1956 1500 med. 1935 1808 med. 1945 1809 1945 1960 wet 1977 1829 1897 1340 med. 1909 1010 dry 1921 1370 dry 1933 3210 wet 1945 2500 wet 1957 3820 med. 1910 1808 med. 1921 1320 dry 1944 110 dry 1945 2530 wet 1958 2660 wet 1808 1808 med. 1910 1808 med. 1922 1320 dry 1944 1100 dry 1945 2530 wet 1945 2600 dry 1945 2800 dry 1945		1895	1340 dry	1907 3	100 wet	1919	1480 1	med.	1931	1450	med.	1943	1600	med.	1955	1460	med.		
Namer 1896 1180 dry 1908 5380 wet 1920 3700 wet 1932 2982 dry 1944 1000 dry 1956 1300 dry 1896 1540 med 1908 5250 met 1920 1990 med 1932 2990 dry 1944 1110 dry 1956 2160 wet 1897 2000 dry 1909 1520 dry 1909 1401 wet 1933 2880 med 1932 1904 1110 dry 1956 2160 wet 1897 2000 dry 1909 1200 dry 1921 1040 dry 1933 3210 wet 1935 3040 med 1957 2390 med 1937 1340 med 1909 10140 dry 1921 1040 dry 1933 3210 wet 1945 2000 med 1957 3820 med 1958 3640 med 1910 1240 dry 1921 1040 dry 1932 1300 dry 1945 2530 wet 1957 3820 med 1957 3820 med 1958 3640 med 1910 1280 med 1911 1360 dry 1923 3760 dry 1934 1110 dry 1946 1740 med 1958 2660 wet 1911 1360 dry 1923 3760 dry 1934 1110 dry 1946 1740 med 1958 2660 wet 1911 1280 dry 1923 3760 dry 1934 1110 dry 1946 1740 med 1958 2660 wet 1938 1340 med 1911 1360 dry 1923 3760 dry 1934 1110 dry 1946 1740 med 1958 2660 wet 1936 1340 med 1938 1340	1	1895	1040 dry	1907 2	260 wet	1919	1010	dry	1931	845	dry	1943	995	dry	1955	2020	wet		
Summer 1896 1840 med. 1908 2530 wet 1920 1990 med. 1932 702 dry 1944 1110 dry 1956 2160 wet 1940 1897 2000 dry 1990 1520 dry 1921 41010 wet 1945 2000 med. 1945 2300 med. 1945 2300 med. 1945 2300 med. 1945 2300 med. 1946 1840 med. 1941 1840 med. 1942 1840 med. 1941 1840 med. 1942 1840 med. 1944 1840 med. 1	Winter	1896	1180 dry	1908 5	380 wet	1920	3700	wet	1932	982	dry	1944	1000	dry	1956	1500	dry		
Summer 1896 1540 med. 1908 2530 wct 1902 1909 med. 1932 890 dry 1944 110 dry 1956 1660 wct 1897 2000 dry 1909 1520 dry 1921 4010 wct 1933 2880 med. 1945 3040 med. 1957 3820 med. 1897 2540 wct 1909 1240 dry 1921 3170 dry 1933 2120 wct 1945 5006 wct 1957 8320 med. 1897 1340 med. 1909 1010 dry 1921 1040 dry 1921 333 2210 wct 1945 2000 dry 1923 8250 dry 1933 2210 wct 1945 2000 med. 1957 8320 med. 1958 2640 med. 1910 1240 dry 1921 1322 0220 med. 1945 1045 2000 med. 1958 8266 wct 1959 82	Spring	1896	2280 dry	1908 5	750 wet	1920	4840 1	med.	1932	2940	dry	1944	6420	wet	1956	4300	med.		
Winter Spring 1897 2000 dry 1909 1520 dry 1921 4010 med. 1933 7120 wet 1945 6060 wet 1977 3820 med. 1897 2940 wet 1909 1240 dry 1921 1040 dry 1933 32210 wet 1945 2000 med. 1978 8360 dry 1922 3250 dry 1933 32210 wet 1945 2500 med. 1978 8360 dry 1922 3250 dry 1933 32210 wet 1945 2000 med. 1978 8360 dry 1922 3250 dry 1934 1680 dry 1946 4540 med. 1978 866 dry 1946 5550 wet 1978 8360 dry 1922 3250 dry 1934 1680 dry 1946 4540 med. 1958 6040 wet 1988 1740 med. 1990 1940 dry 1922 1320 dry 1934 1100 dry 1946 4540 med. 1958 6040 wet 1940 900 dry 1922 780 dry 1934 1100 dry 1946 4540 med. 1958 6040 wet 1940 900 dry 1922 780 dry 1934 1150 med. 1946 1940 med. 1958 6040 wet 1940 900 dry 1922 780 dry 1934 1150 med. 1946 1940 med. 1958 1210 med. 1940 1940 med. 1940 1940 1940 1940 med. 1940 1940 1940 1940 1940 med. 1940 1940 1940 1940 1940 1940 1940 1940	1 -	1896	1540 med.	1908 2	530 wet	1920	1990 1	med.	1932	890	dry	1944	1110	dry	1956	2160	wet		
Spring 1897 5760 wet 1909 4670 med. 1921 1370 dry 1933 2210 wet 1897 2940 wet 1909 1240 dry 1921 1370 dry 1933 2310 wet 1945 25000 med. 1947 2860 dry 1898 2400 med. 1910 1470 dry 1921 1370 dry 1933 1830 wet 1945 2530 wet 1957 863 dry 1946 2480 wet 1947 666 dry 1948 2470 med. 1948 2470 med. 1948 2470 med. 1948 2480 wet 1946 2480 wet 1941 240 med. 1948 2470 med. 1948 2480 wet 1941 2450 med. 1948 2490 wet 1948 2480 wet 19	Fall	1896	1180 med.	1908 1	520 med.	1920	1480 1	med.	1932	702	dry	1944	1100	med.					
Summer 1897 2940 wet 1909 1240 dry 1921 1370 dry 1933 1330 wet 1945 2330 wet 1957 863 dry 1898 4480 med. 1910 1480 med. 1910 12800 dry 1922 2920 med. 1934 1680 dry 1946 1540 med. 1910 1880 med. 1910 1880 med. 1912 1320 dry 1934 1110 dry 1946 1740 med. 1918 1899 6200 wet 1911 1360 dry 1922 780 dry 1935 1810 med. 1946 1740 med. 1918 1899 1540 med. 1911 2250 dry 1932 820 dry 1935 880 wet 1947 2680 dry 1958 2600 wet 1911 1360 dry 1923 780 dry 1935 1800 med. 1947 1450 dry 1959 1600 dry 1912 1912 1914 1915 1915 1915 1915 1915 1915 1915	Winter	1897	2000 dry	1909 1	520 dry	1921	4010	wet	1933	2880	med.	1945	3040	med.	1957	2390	med.		
Summer 1897 2940 wet 1909 1240 dry 1921 1370 dry 1933 2210 wet 1945 2000 med. 1957 863 dry 1946 1897 1898 2600 med. 1910 1740 dry 1922 2920 med. 1934 1680 dry 1946 5550 wet 1958 2240 med. 1958 1898 1840 med. 1910 1900 dry 1922 3250 dry 1934 1680 dry 1946 4540 med. 1958 6404 wet 1946 1898 1899 1800 med. 1910 1900 dry 1922 3760 dry 1934 1150 med. 1946 1740 med. 1958 6404 wet 1946 1899 1840 med. 1911 2250 dry 1923 2920 dry 1934 1150 med. 1946 1940 dry 1958 1210 med. 1959 1899 5320 wet 1911 2250 dry 1923 2920 dry 1935 2860 dry 1947 1878 med. 1959 1270 dry 1959 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 1890 189	Spring	1897	5760 wet	1909 4	670 med.	1921	4010	med.	1933	7120	wet	1945	6060	wet	1957	3820	med.		
Winter Spring 1898 2600 med. 1910 1740 dry 1922 3250 dry 1934 1680 dry 1946 4540 med. 1988 6040 wet 1989 1760 wet 1910 900 dry 1922 780 dry 1934 1110 dry 1946 1740 med. 1988 2660 wet 1911 1898 1760 wet 1910 900 dry 1922 780 dry 1934 1110 dry 1946 1120 med. 1958 2660 wet 1947 1899 1540 med. 1911 250 dry 1923 780 dry 1935 5850 wet 1947 2680 dry 1959 3030 dry 1946 1110 dry 1946 11		1897	2940 wet	1909 1	240 dry	1921	1370	dry	1933	2210	wet	1945	2000	med.			· 1		
Spring 1898 4480 med. 1910 2800 dry 1922 3250 dry 1934 2400 dry 1946 4540 med. 1958 6640 wet 1889 1540 med. 1910 1480 med. 1922 320 dry 1934 1110 dry 1946 1090 dry 1958 1210 med. 1978 1540 med. 1911 1360 dry 1923 780 dry 1935 5850 wet 1947 1450 dry 1959 1600 dry 1958 1540 med. 1911 2540 dry 1923 2920 dry 1935 5850 wet 1947 2680 dry 1959 1600 dry 1950 1600 dry	Fall	1897	1340 med.	1909 1	010 dry	1921	1040	dry	1933	1830	wet	1945	2530	wet	1957		· · I		
Summer 1898 1540 med. 1910 1480 med. 1922 1320 dry 1934 1110 dry 1946 1740 med. 1958 2660 wet 1899 6200 wet 1911 1360 dry 1922 780 dry 1935 1300 med. 1947 1450 dry 1959 1600 dry 1921 1899 1540 med. 1911 1250 dry 1923 2920 dry 1935 1280 med. 1947 1450 dry 1959 1600 dry 1912 1390 med. 1914 1915 1260 dry 1923 1920 dry 1935 1280 med. 1947 1450 dry 1959 1300 dry 1912 1300 med. 1914 1914 1915 1260 dry 1915 1300 med. 1914 1915 1300 dry 1915 1300 med. 1914 1760 dry 1915 1300 med. 1914 1300 med. 1914 1300 dry 1915 1300 med. 1914 1300 med. 1914 1300 dry 1915 1300 med. 1916 1300 med.	Winter	1898	2600 med.	1910 1	740 dry	1922	2920 1	med.	1934	1680	dry	1946	5550	wet					
Summer 1898 1540 med. 1910 1480 med. 1922 1320 dry 1934 1110 dry 1946 1740 med. 1958 2660 wet 1899 6200 wet 1911 1360 dry 1923 780 dry 1935 5850 wet 1947 1450 dry 1959 1600 dry 1958 1540 med. 1911 250 dry 1923 2920 dry 1935 5850 wet 1947 2680 dry 1959 1600 dry 1958 1540 med. 1911 2940 wet 1923 3676 dry 1935 1260 med. 1941 2940 wet 1924 2920 med. 1940 2940 dry 1912 1300 wet 1942 2920 med. 1940 2940 dry 1912 1300 wet 1944 1300 med. 1944 2620 wet 1960 4290 wet 1960 1400 dry 1912 1640 wet 1924 420 med. 1936 1300 med. 1948 2620 wet 1960 1660 med. 1948 1940 1949 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940 1940	Spring	1898	4480 med.	1910 2	800 dry	1922	3250	dry	1934	2400	dry				I				
Winter 1900 1940 dry 1912 210 med. 1924 1420 med. 1936 1130 med. 1948 1850 dry 1960 4350 med. 1960 1150 med. 1960 1970 med. 1960 1150 med. 1960 1970 med. 1971 1971 1971 1971 1971 1972 1970 med. 1971 1972 1970 med. 1972 1970 med. 1971 1971 1971 1971 1971 1971 1971 197		1898	1540 med.	1910 1	480 med.	1922	1320	dry	1934	1110	dry	1946	1740	med.					
Spring Summer Ray 1540 med. 1911 2250 dry 1923 2920 dry 1935 5850 wet 1947 12680 dry 1959 3030 dry 1966	Fall	1898	1760 wet	1910	900 dry	1922	780	dry	1934	1150	med.	1946	1090	dry		1210	med.		
Summer 1899 1540 med. 1911 680 dry 1923 950 dry 1935 2160 wet 1947 1780 med. 1959 1270 dry 1960 2900 dry 1912 3390 med. 1924 2920 med. 1936 4000 wet 1948 1850 dry 1960 2900 dry 1912 1640 wet 1924 1630 wet 1924 6300 wet 1936 1590 med. 1948 5210 wet 1960 4350 med. 1960 1340 dry 1912 2120 wet 1924 2600 wet 1936 1590 med. 1948 5210 wet 1960 4350 med. 1960 1760 wet 196	Winter	1899	6200 wet	1911 1	360 dry	1923	780	dry	1935	4940	wet	1947	1450	dry			- 1		
Sammer 1899 1540 med. 1911 2940 wet 1923 676 dry 1935 1280 med. 1947 995 dry 1960 4290 wet 1900 2000 dry 1912 3390 med. 1924 2920 med. 1936 4000 wet 1948 1850 dry 1960 4290 wet 1960 4350 med. 1960 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970	Spring	1899	5320 wet	1911 2	250 dry	1923	2920	dry	1935	5850	wet	1947	2680	dry					
Winter Spring 1900 2000 dry 1912 3390 med. 1924 2920 med. 1936 4000 wet 1948 1850 dry 1960 4290 wet 1971 1972 1970 med. 1974 2600 wet 1974 1975 1970 med. 1974 1975 1970 dry 1975 1970 med. 1975 1970 dry 1975 1970 med.	Summer	1899	1540 med.	1911	680 dry	1923	950	dry	1935	2160	wet	1947	1780	med.	1959				
Spring 1900 2940 dry 1912 6130 wet 1924 6130 wet 1936 1300 med. 1948 2620 wet 1960 1660 med. 1900 1040 dry 1912 1640 wet 1924 1420 med. 1936 1300 med. 1948 2620 wet 1960 1660 med. 1901 1760 dry 1913 2120 med. 1925 3580 med. 1937 1860 dry 1949 9880 wet 1961 1250 dry 1970 1280 dry 1913 1640 med. 1925 1000 dry 1937 1640 wet 1901 2280 wet 1913 1640 med. 1925 1000 dry 1937 1900 med. 1949 2720 wet 1961 1250 dry 1960 1670 med. 1960 1640 med. 1961 1250 dry 1960 1670 med. 19	Fall	1899	1540 med.	1911 2	940 wet	1923	676	dry	1935	1280	med.	1947	995	dry	1959	787	dry		
Spring 1900 2940 dry 1912 6130 wet 1924 6130 wet 1936 3600 med. 1948 5210 wet 1960 4350 med. 1970 1340 dry 1912 1240 wet 1924 1240 med. 1936 1590 med. 1948 2620 wet 1960 1510 med. 1971 1760 dry 1913 2120 med. 1925 3580 med. 1937 1860 dry 1949 9880 wet 1961 1250 dry 1971 2280 dry 1913 3090 dry 1925 3580 dry 1937 1860 dry 1949 9880 wet 1961 1250 dry 1971 1972 1972 1973 1974 1974 1974 1974 1974 1975 1974 1975 1974 1975 1974 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975 1975	Winter	1900	2000 dry	1912 3	390 med.	1924	2920	med.	1936	4000	wet	1948	1850	dry	1960	4290	wet		
Summer 1900 1340 dry 1912 2120 wet 1924 2600 wet 1936 1590 med. 1948 2620 wet 1960 1510 med. 1948 1970 1040 dry 1911 2120 wet 1925 3580 med. 1937 1860 dry 1949 9880 wet 1961 1250 dry 1970 1250 dry 1971 1260 dry 1971 1260 dry 1972 1270 med. 1972		1900	2940 dry	1912 6	130 wet	1924	6130	wet	1936	3600	med.	1948	5210	wet	1960	4350	med.		
Winter 1902 1520 med. 1914 769 dry 1926 1370 dry 1938 4220 wet 1950 3600 med. 1962 2010 dry 1902 4670 med. 1914 769 dry 1926 1370 dry 1938 3420 dry 1902 1520 med. 1914 540 dry 1926 1370 dry 1938 1420 med. 1950 1290 dry 1962 1050 dry 1971 1200 dry 1971 1200 dry 1971 1300 med. 1971 1300 med. 1971 1300 med. 1972 1520 med. 1972 1520 med. 1972 1520 med. 1974 1530 med. 1975 1520 dry 1975 1310 med. 1975 1310 med. 1975 1320 med. 1975 1320 med. 1975 1330 med. 1975 1320 med. 1975 1330 med. 1		ı	•	1912 2	120 wet	1924	2600	wet	1936	1590	med.	1948	2620	wet	1960	1660	med.		
Winter 1901 1760 dry 1913 2120 med. 1925 3580 med. 1937 1860 dry 1949 9880 wet 1961 1250 dry Spring 1901 2280 dry 1913 3090 dry 1925 3580 dry 1937 6540 wet 1949 6600 wet 1961 6040 wet Fall 1901 4080 wet 1913 1640 med. 1925 1000 dry 1937 1900 med. 1949 2720 wet 1961 1450 med. Fall 1902 2480 wet 1914 4170 wet 1926 1990 dry 1938 4220 wet 1950 3600 med. 1962 2100 dry Spring 1902 1520 med. 1914 769 dry 1926 1270 dry 1938 3420 dry 1950 3600 med. 1962 2100 dry Fall 1902 1300 med. 1914 540 dry 1926 2140 wet 1938 1110 med. 1950 2230 dry 1962 1200 dry 1962 100 dry 1962 <td>Fall</td> <td>1900</td> <td>1040 dry</td> <td>1912 1</td> <td>640 wet</td> <td>1924</td> <td>1420</td> <td>med.</td> <td>1936</td> <td>1130</td> <td>med.</td> <td>1948</td> <td>2000</td> <td>wet</td> <td>1960</td> <td>1510</td> <td>med.</td>	Fall	1900	1040 dry	1912 1	640 wet	1924	1420	med.	1936	1130	med.	1948	2000	wet	1960	1510	med.		
Summer 1901 4080 wet 1913 1640 med. 1925 1000 dry 1937 1900 med. 1949 2720 wet 1961 1450 med. 1910 2280 wet 1913 748 dry 1925 822 dry 1937 2160 wet 1949 1660 wet 1961 1230 med. 1962 2010 dry 1961 1230 med. 1962 2010 dry 1961 1230 med. 1962 2010 dry 1962 1960 dry 1961 1230 med. 1962 2010 dry 1961 1230 med. 1962 2010 dry 1961 1230 med. 1962 2010 dry 1962 1000 dry 1961 1230 med. 1962 1000 dry 1963 1060 dry 1964 1000 dry 1965 1000 dry 1966 1000	aretaur in i	1901	1760 dry	1913 2	120 med.	1925	3580	med.	1937	1860	dry	1949	9880	wet	1961	1250	dry		
Summer 1901 4080 wet 1913 1640 med. 1925 1000 dry 1937 1900 med. 1949 2720 wet 1961 1450 med. 1911 1901 2280 wet 1913 748 dry 1925 822 dry 1937 2160 wet 1949 1660 wet 1961 1230 med. 1902 4480 wet 1914 4170 wet 1926 1990 dry 1938 4220 wet 1950 3600 med. 1962 2010 dry 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970	Spring	1901	2280 dry	1913 3	090 dry	1925	3580	dry	1937	6540	wet	1949	6600	wet	1961	6040	wet		
Fall 1901 2280 wet 1913 748 dry 1925 822 dry 1937 2160 wet 1949 1660 wet 1961 1230 med. 1914 4170 wet 1926 1990 dry 1938 4220 wet 1950 3600 med. 1962 2010 dry 1938 3420 dry 1950 1950 1950 1960 1962 1950 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 1960 196		1901	4080 wet	1913 1	640 med.	1925	1000	dry	1937	1900	med.	1949	2720	wet	1961	1450	med.		
Winter Spring 1902 4480 wet Spring 1902 4670 med. 1914 3090 dry 1926 2920 dry 1938 3420 dry 1950 5210 wet 1962 6150 wet 1914 769 dry 1926 1370 dry 1938 1420 med. 1950 1290 dry 1962 1050 dry 1962 1300 med. 1915 1100 dry 1927 3920 wet 1938 1110 med. 1950 2360 wet 1962 1070 dry 1926 1370 dry 1938 1420 med. 1950 2360 wet 1962 1070 dry 1926 1370 dry 1938 1110 med. 1950 2360 wet 1962 1070 dry 1926 1370 dry 1938 1110 med. 1950 2360 wet 1962 1070 dry 1926 1370 med. 1927 3920 wet 1939 130 med. 1951 7140 wet 1963 1220 med. 1951 1300 med. 1951 1310 med. 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 3220 dry 1904 3400 dry 1916 5230 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. 1928 5370 wet 1940 5500 wet 1952 2410 wet 1964 1000 dry 1966 dry 1928 1340 med. 1940 1990 wet 1952 1500 med. 1964 665 dry 1929 1650 dry 1941 4650 wet 1953 1300 dry 1965 3230 med. 1966 1970 dry 1990 dry 1990 dry 1990 dry 1990 dry 1990 dry 1990 wet 1995 1500 med. 1964 665 dry 1929 1650 dry 1929 1650 dry 1929 1650 dry 1941 4650 wet 1953 1300 dry 1965 3230 med. 1965 3230 med. 1965 3230 med. 1966 665 dry 1990 dry		1901	2280 wet	1913	748 dry	1925	822	dry	1937	2160	wet	1949	1660	wet					
Summer 1902 1520 med. 1914 769 dry 1926 1370 dry 1938 1420 med. 1950 1290 dry 1962 1070 dry 1916 100 dry 1927 3920 wet 1939 2130 med. 1951 1740 wet 1963 2120 med. 1951 1903 23810 wet 1915 1240 dry 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 2220 dry 1903 2300 wet 1915 1310 med. 1927 970 dry 1939 1850 med. 1951 130 med. 1963 2220 dry 1964 1965 1370 dry 1965 1370 med. 1964 1965 1370 dry 1965 1370 med. 1965 1370 med. 1965 1370 med. 1966 1370 dry 1381 1420 med. 1950 1290 dry 1966 1370 dry 1381 1420 med. 1951 1300 med. 1963 1200 med. 1963 1200 med. 1963 1200 med. 1963 1200 dry 1966 1370 dry 1390 1300 dry 1390 dry		1902	4480 wet	1914 4	170 wet	1926	1990	dry	1938	4220	wet	1950	3600	med.	1962	2010	dry		
Summer 1902 1520 med. 1914 769 dry 1926 1370 dry 1938 1420 med. 1950 1290 dry 1962 1070 dry 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1916 1	Spring	1902	4670 med.	1914 3	090 dry	1926	2920	dry	1938	3420	dry	1950	5210	wet					
Winter 1903 6520 wet 1915 1100 dry 1927 3920 wet 1939 2130 med. 1951 7140 wet 1963 3220 dry 1903 4330 med. 1915 1240 dry 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 1060 dry 1904 2000 dry 1916 2380 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. 1978 1904 1750 med. 1916 2120 wet 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 3130 dry 1905 2810 dry 1917 1260 dry 1918 2660 dry 1906 2530 wet 1918 1200 dry 1918 2660 dry 1906 2530 wet 1918 1080 dry 1910 6940 dry 1906 2530 wet 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 629 dry 1966 547 dry 1906 2550 wrt 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry 1966 547 dry 1966 547 dry 1906 2450 wrt 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 wrth 1966 547 dry 1	1	1902		1914	769 dry	1926	1370	dry	1938	1420	med.	1950	1290	dry	1962	1050	dry		
Winter 1903 6520 wet 1915 1100 dry 1927 3920 wet 1939 2130 med. 1951 7140 wet 1963 2120 med. Spring 1903 4330 med. 1915 3090 dry 1927 4270 med. 1939 4830 med. 1951 5380 wet 1963 3220 dry Summer 1903 2810 wet 1915 1240 dry 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 3220 dry Fall 1904 2000 dry 1916 2380 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1963 820 dry Spring 1904 3400 dry 1916 5020 med. 1928 370 wet 1940 1900 dry 1952 2290 med. 1964 2100 med. Spring 1904 300 dry 1916 966 dry 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 3130 dry Winter 1905		1902		1914	540 dry	1926	2140	wet	1938	1110	med.	1950	2360	wet	1962	1070	dry		
Spring 1903 4330 med. 1915 3090 dry 1927 4270 med. 1939 4830 med. 1951 5380 wet 1963 3220 dry 1903 2810 wet 1915 1240 dry 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 1060 dry 1963 1904 1904 2000 dry 1916 2380 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. 1964 1975 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1976 1		1903	6520 wet	1915 1	100 dry	1927	3920	wet	1939	2130	med.	1951	7140	wet	1963	2120	med.		
Summer Fall 1903 2810 wet 1915 1240 dry 1927 2290 wet 1939 1850 med. 1951 1760 med. 1963 1060 dry Winter Winter 1904 2000 dry 1916 2380 med. 1927 970 dry 1939 1120 med. 1951 1130 med. 1963 820 dry Spring Spring Spring Summer 1904 3400 dry 1916 5020 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. Spring Spring Spring Spring Spring Spring Summer 1904 900 dry 1916 966 dry 1928 1700 med. 1940 1940 1990 wet 1952 2110 wet 1964 1000 dry Spring	Spring	1903	4330 med.	1915 3	090 dry	1927	4270	med.	1939	4830	med.	1951	5380	wet	1963	3220	dry		
Fall 1903 2000 wet 1915 1310 med. 1927 970 dry 1939 1120 med. 1951 1130 med. 1963 820 dry Winter 1904 2000 dry 1916 2380 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. Spring 1904 3400 dry 1916 5020 med. 1928 5370 wet 1940 1900 dry 1952 6420 wet 1964 3130 dry Summer 1904 1904 900 dry 1916 2120 wet 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 3130 dry Winter 1905 1520 dry 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring 1905 2810 wet 1917 1030 dry 1929 1130 dry 1941 2590 dry 1953 7250 wet 1965 3320 dry Fall		ı				1927	2290	wet	1939	1850	med.	1951	1760	med.	1963		-		
Winter 1904 2000 dry 1916 2380 med. 1928 3200 med. 1940 1900 dry 1952 2290 med. 1964 2100 med. Spring 1904 3400 dry 1916 5020 med. 1928 5370 wet 1940 1900 dry 1952 2290 med. 1964 2100 med. Summer 1904 1750 med. 1916 2120 wet 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 1000 dry Fall 1904 900 dry 1916 966 dry 1928 1340 med. 1940 1990 wet 1952 2110 wet 1964 1000 dry Winter 1905 1520 dry 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring 1905 2810 wet 1917 1030 dry 1929 1130 dry 1941 1430 med. 1953 1300 dry 1965 915 dry Fall 1905 <td></td> <td></td> <td></td> <td>1915 1</td> <td>310 med.</td> <td>1927</td> <td>970</td> <td>dry</td> <td>1939</td> <td>1120</td> <td>med.</td> <td>1951</td> <td>1130</td> <td>med.</td> <td>1963</td> <td>820</td> <td>dry</td>				1915 1	310 med.	1927	970	dry	1939	1120	med.	1951	1130	med.	1963	820	dry		
Spring Summer 1904 3400 dry Summer 1916 5020 med. 1928 5370 wet 1940 5500 wet 1952 6420 wet 1964 3130 dry Summer Fall 1904 1750 med. 1916 2120 wet 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 1000 dry Winter Spring Summer Fall 1905 2810 dry Summer 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring Summer Fall 1905 2810 wet 1917 1030 dry 1929 1130 dry 1941 1430 med. 1953 7250 wet 1965 3320 dry Winter Fall Spring Summer Fall 1906 3400 med. 1918 1700 dry 1930 3730 wet 1941 1430 med. 1953 1100 med. 1965 734 dry Spring Summer Fall 1906 2530 wet 1918 2120 wet 1930 643 dry 1942 2320 wet 1954 1400 dry 1966 629 dry Summer Fall 1906 2530 wet 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry 1906 2530 wet 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry	A STATE OF THE STA	I		1916 2	380 med.	1928	3200	med.	1940	1900	dry	1952	2290	med.	1964	2100	med.		
Summer 1904 1750 med. 1916 2120 wet 1928 1700 med. 1940 1880 med. 1952 2110 wet 1964 1000 dry Fall 1904 900 dry 1916 966 dry 1928 1340 med. 1940 1990 wet 1952 1500 med. 1964 665 dry Winter 1905 1520 dry 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring 1905 2810 wet 1917 1030 dry 1929 130 dry 1941 1430 med. 1953 7250 wet 1965 3320 dry Fall 1905 1750 wet 1917 643 dry 1929 1130 med. 1941 1430 med. 1953 1300 dry 1965 915 dry Winter 1906 3400 med. 1918 1700 dry 1930 3730 wet 1941 1430 med. 1953 1100 med. 1965 734 dry Spring 1906 2810 dry 1918 2660 dry 1930 1900 dry 1942 1250 dry </td <td>SCHOOL STATE</td> <td>ı</td> <td></td> <td></td> <td></td> <td>1928</td> <td>5370</td> <td>wet</td> <td>1940</td> <td>5500</td> <td>wet</td> <td>1952</td> <td>6420</td> <td>wet</td> <td></td> <td></td> <td>-</td>	SCHOOL STATE	ı				1928	5370	wet	1940	5500	wet	1952	6420	wet			-		
Fall 1904 900 dry 1916 966 dry 1928 1340 med. 1940 1990 wet 1952 1500 med. 1964 665 dry Winter 1905 1520 dry 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring 1905 2810 wet 1917 1030 dry 1929 130 dry 1941 2590 dry 1953 7250 wet 1965 3230 med. Fall 1905 1750 wet 1917 643 dry 1929 1130 med. 1941 1430 med. 1953 1300 dry 1965 915 dry Fall 1906 3400 med. 1918 1700 dry 1929 1130 med. 1941 928 dry 1953 1100 med. 1965 915 dry Spring 1906 3400 med. 1918 1700 dry 1930 3730 wet 1942 1250 dry 1954 1400 dry 1966 1000 dry Spring 1906		ı	-			1928	1700	med.	1940	1880	med.	1952	2110	wet	1964	1000	dry		
Winter 1905 1520 dry 1917 1260 dry 1929 1650 dry 1941 4650 wet 1953 5460 wet 1965 3230 med. Spring 1905 2810 dry 1917 2380 dry 1929 15590 wet 1941 2590 dry 1953 7250 wet 1965 3320 dry Fall 1905 1750 wet 1917 643 dry 1929 1130 med. 1941 1430 med. 1953 1300 dry 1965 915 dry Winter 1906 3400 med. 1918 1700 dry 1929 1130 med. 1941 1928 dry 1953 1300 dry 1965 915 dry Spring 1906 3400 med. 1918 1700 dry 1930 3730 wet 1942 1250 dry 1954 1400 dry 1966 1966 1000 dry Spring 1906 2810 dry 1918 2660 dry 1930 1900 dry 1942 3280 dry 1954 1400 dry 1966 2930 dry Summer 1906 2530 wet 1918 2100 dry 1930 643 dry 1942		ı				1928	1340	med.	1940	1990	wet	1952	1500	med.	1964	665	dry		
Spring Summer 1905 2810 dry Summer 1917 2380 dry 1929 1929 5590 wet 1941 1941 2590 dry 1953 1953 7250 wet 1965 3320 dry 1965 915 dry 1965 </td <td></td> <td></td> <td>•</td> <td></td> <td>-</td> <td>1929</td> <td>1650</td> <td>dry</td> <td>1941</td> <td>4650</td> <td>wet</td> <td>1953</td> <td>5460</td> <td>wet</td> <td>1965</td> <td>3230</td> <td>med.</td>			•		-	1929	1650	dry	1941	4650	wet	1953	5460	wet	1965	3230	med.		
Summer 1905 2810 wet 1917 1030 dry 1929 1130 dry 1941 1430 med. 1953 1300 dry 1965 915 dry Fall 1905 1750 wet 1917 643 dry 1929 1130 med. 1941 1430 med. 1953 1300 dry 1965 734 dry Winter 1906 3400 med. 1918 1700 dry 1930 3730 wet 1942 1250 dry 1954 1400 dry 1966 1000 dry Spring 1906 2810 dry 1918 2660 dry 1930 1900 dry 1942 3280 dry 1954 1440 dry 1966 2930 dry Summer 1906 2530 wet 1918 2120 wet 1930 643 dry 1942 2060 wet 1954 1080 dry 1966 629 dry Fall 1906 2530 wet 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry		ı	-		-	1929	5590	wet	1941	2590	dry	1953	7250	wet	1965	3320	dry		
Fall 1905 1750 wet Winter 1906 3400 med. 1918 1700 dry 1930 3730 wet 1942 1250 dry 1953 1100 med. 1965 734 dry 1966 1000 dry 1970 1970 1970 1970 1970 1970 1970 1970	-	ı	•			1929	1130	dry	1941	1430	med.	1953	1300	dry	1965	915	dry		
Winter Spring 1906 2810 dry Summer 1906 2530 wet 1918 1080 dry 1918 1080		ı			-			_	1941	928	dry	1953	1100	med.	1965	734	dry		
Spring Summer 1906 2530 wet Fall 1918 2660 dry 1930 1900 dry 1930 1900 dry 1942 3280 dry 1954 4470 med. 1954 4470 med. 1966 2930 dry 1966 629 dry 1966 629 dry 1966 629 dry 1966 629 dry 1966 547 dry		ı				1			1		-	1954	1400	dry	1966	1000	dry		
Summer 1906 2530 wet 1918 2120 wet 1930 643 dry 1942 2060 wet 1954 1080 dry 1966 629 dry 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry											-				1966	2930	dry		
Fall 1906 2530 wet 1918 1080 dry 1930 594 dry 1942 2390 wet 1954 1040 dry 1966 547 dry											-				1		-		
1000 2000 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4050 11 1007 4000 11 1007 4000 11 1007 4000 11 1007 4000 11 1007 4								-							1966	547	dry		
	Winter	1907	4010 wet			1931									1967	4850	wet		

	19	67 - 1979	19	79 - 19	91	1991 - 1998				
		Min.	-	Min.		Min.				
	Flow		Flow			Flow				
Season	Year	(cfs) Cat.	Year	(cfs)	Cat.	Year	(cfs)	Cat.		
Spring	1967	6210 wet	1979	7660	wet	1991	3380	dry		
Summer	1967	1750 med.	1979	2730	wet	1991	1500	med.		
Fall	1967	1640 wet	1979	4440	wet	1991	1000	dry		
Winter	1968	3520 med.	1980	5040	wet	1992	1920	dry		
Spring	1968	3710 med.	1980	5890	wet	1992	4630	med.		
Summer	1968	1080 dry	1980	2230	wet	1992	2460	wet		
Fall	1968	1010 dry	1980	1270	med.	1992	1610	wet		
Winter	1969	2150 med.	1981	1300	dry	1993	3740	wet		
Spring	1969	2170 dry	1981	3640	med.	1993	4840	med.		
Summer	1969	885 dry	1981	1180	dry	1993	1550	med.		
Fall	1969	1610 wet	1981	1190	med.	1993	1500	med.		
Winter	1970	2410 med.	1982	2020	dry	1994	5500	wet		
Spring	1970	4230 med.	1982	3690	med.	1994	5150	med.		
Summer	1970	2340 wet	1982	2140	wet	1994	2460	wet		
Fall	1970	1220 med.	1982	1550	wet	1994	1760	wet		
Winter	1971	4230 wet	1983	2760	med.	1995	4180	wet		
Spring	1971	5110 med.	1983	8770	wet	1995	3690	med.		
Summer	1971	2140 wet	1983	1530		1995	1770	med.		
Fall	1971	1810 wet	1983	1380		1995	1370	med.		
Winter	1972	4990 wet	1984	3600	med.	1996	4620	wet		
Spring	1972	8410 wet	1984	7060	wet	1996	7330	wet		
Summer	1972	3610 wet	1984	2940	wet	1996	3930	wet		
Fall	1972	2160 wet	1984	2190	wet	1996	4960	wet		
Winter	1973	8830 wet	1985	2300	med.	1997	5650	wet		
Spring	1973	8160 wet	1985	4020	med.	1997	4620	med.		
Summer	1973	2710 wet	1985	1920	med.	1997	1810	med.		
Fall	1973	1960 wet	1985	1350	med.	1997	1560	wet		
Winter	1974	5060 wet	1986	3200	med.	1998	4430	wet		
Spring	1974	4900 med.	1986	4120	med.	1998	6840	wet		
Summer	1974	2020 wet	1986	1440	med.	1998	2010	wet		
Fall	1974	1430 med.	1986	1170	med.	1998	1500	med.		
Winter	1975	2360 med.	1987	4680	wet	1999	1865	dry		
Spring	1975	6050 wet	1987	6380	wet	1999	3500	dry		
Summer	1975	2860 wet	1987	1290						
Fall	1975		1987	1300						
Winter	1976		1988	4400						
Spring	1976	3250 dry	1988	4290						
Summer	1976	1280 dry	1988	1230						
Fall	1976	1260 med.	1988	1320	· ·					
Winter	1977		1989	1440						
Spring	1977		1989	4320	· ·					
Summer	1977	1120 dry	1989	3450						
Fall	1977	1100 med.	1989	2790	wet					
Winter	1978	5500 wet	1990	2100						
Spring	1978	5400 wet	1990	4680						
Summer	1978	3290 wet	1990	1740						
Fall	1978	1610 wet	1990	1800						
Winter	1979		1991	3270						