

ATTACHMENT 7

7Q10 Low Flow and Dilution Calculation

7-day min annual series

Hydrologic Year Min-7-day Annual Series	Log	Calendar Year Min-7-day Annual Series	Log	Log Pearson Parameters	Hydrologic Year	Calendar Year	MIn 7-day Series	Percentile
4/1/1923	1261.4	3.10						
4/1/1924	1456.7	3.16 12/31/1924	1456.71	3.16	average:	3.38	3.12	703.9086 1.00
4/1/1925	1230.3	3.09 12/31/1925	1230.29	3.09	standard deviation:	0.4872024	0.14065638	818.1714 5.00
4/1/1926	12142.9	4.08 12/31/1926	1334.86	3.13	skew coefficient:	1.0172895	0.24707881	990.7714 10.00
4/2/1927	2215.7	3.35 12/31/1927	2215.71	3.35	years in series	49	49	1046.857 15.00
4/1/1928	2900.0	3.46 12/31/1928	2900.00	3.46				1092.371 20.00
4/1/1929	1241.0	3.09 12/31/1929	1241.00	3.09	Skew	Return Period KT Values		1160.857 25.00
4/1/1930	18171.4	4.26 12/31/1930	989.29	3.00	Probability	0.1	0.1	1227.629 30.00
4/2/1931	1336.4	3.13 12/31/1931	1336.43	3.13	Recurrence	10	10	1271.857 35.00
4/1/1932	1344.0	3.13 12/31/1932	1344.00	3.13				1335.029 40.00
4/1/1933	1575.0	3.20 12/31/1933	1575.00	3.20				1340.971 45.00
4/1/1934	14942.9	4.17 12/31/1934	1106.00	3.04				1423.429 50.00
4/2/1935	1622.3	3.21 12/31/1935	1622.29	3.21				1432.971 55.00
4/1/1936	1538.0	3.19 12/31/1936	1538.00	3.19				1442.743 60.00
4/1/1937	1586.1	3.20 12/31/1937	1586.14	3.20	Merrimack at Lowell (cfs)			1458.971 65.00
4/1/1938	13528.6	4.13 12/31/1938	3030.00	3.48	7Q10	678	880	1513.6 70.00
4/2/1939	1423.4	3.15 12/31/1939	1423.43	3.15				1538 75.00
4/1/1940	1516.6	3.18 12/31/1940	1516.57	3.18				1592.029 80.00
4/1/1941	1012.3	3.01 12/31/1941	1012.29	3.01				1620.771 85.00
4/1/1942	18000.0	4.26 12/31/1942	1527.57	3.18				2090.743 90.00
4/2/1943	1614.7	3.21 12/31/1943	1614.71	3.21				2626.286 95.00
4/1/1944	1468.0	3.17 12/31/1944	1468.00	3.17				3247.143 100.00
4/1/1945	2129.7	3.33 12/31/1945	2129.71	3.33				
4/1/1946	14957.1	4.17 12/31/1946	2081.00	3.32				
4/2/1947	1086.9	3.04 12/31/1947	1086.86	3.04				
4/1/1948	1036.9	3.02 12/31/1948	1036.86	3.02				
4/1/1949	1225.9	3.09 12/31/1949	1225.86	3.09				
4/1/1950	18628.6	4.27 12/31/1950	1088.86	3.04				
4/2/1951	3247.1	3.51 12/31/1951	3247.14	3.51				
4/1/1952	1416.3	3.15 12/31/1952	1416.29	3.15				
4/1/1953	1094.7	3.04 12/31/1953	1094.71	3.04				
4/1/1954	10688.6	4.03 12/31/1954	2041.43	3.31				
4/2/1955	1335.7	3.13 12/31/1955	1335.71	3.13				
4/1/1956	1450.9	3.16 12/31/1956	1450.86	3.16				
4/1/1957	729.4	2.86 12/31/1957	729.43	2.86				
4/1/1958	13442.9	4.13 12/31/1958	1435.29	3.16				
4/2/1959	1279.6	3.11 12/31/1959	1279.57	3.11				
4/1/1960	1431.4	3.16 12/31/1960	1431.43	3.16				
4/1/1961	1425.3	3.15 12/31/1961	1425.29	3.15				
4/1/1962	25657.1	4.41 12/31/1962	1438.86	3.16				
4/2/1963	991.1	3.00 12/31/1963	991.14	3.00				
4/1/1964	686.3	2.84 12/31/1964	686.29	2.84				
4/1/1965	723.0	2.86 12/31/1965	723.00	2.86				
4/1/1966	8815.7	3.95 12/31/1966	951.29	2.98				
4/2/1967	1443.7	3.16 12/31/1967	1443.71	3.16				
4/1/1968	1289.6	3.11 12/31/1968	1289.57	3.11				
4/1/1969	1509.1	3.18 12/31/1969	1509.14	3.18				
4/1/1970	10471.4	4.02 12/31/1970	1194.29	3.08				
4/2/1971	1160.9	3.06 12/31/1971	1160.86	3.06				
4/1/1972	1600.9	3.20 12/31/1972	1600.86	3.20				
4/1/1973	1805.7	3.26 12/31/1973	1805.71	3.26				

7-day min annual series

Hydrologic Year	Min-7-day Annual Series	Log	Calendar Year	Min-7-day Annual Series	Log
4/1/1937	1870.00		12/31/1937	1141.57	3.06
4/1/1938	1141.57	3.06	12/31/1938	1725.71	3.24
4/1/1939	1725.71	3.24	12/31/1939	963.14	2.98
4/1/1940	963.14	2.98	12/31/1940	1069.43	3.03
4/1/1941	1323.14	3.12	12/31/1941	857.43	2.93
4/1/1942	857.43	2.93	12/31/1942	1166.86	3.07
4/1/1943	1166.86	3.07	12/31/1943	1248.43	3.10
4/1/1944	1248.43	3.10	12/31/1944	1238.57	3.09
4/1/1945	1238.57	3.09	12/31/1945	1695.71	3.23
4/1/1946	1695.71	3.23	12/31/1946	1621.43	3.21
4/1/1947	1621.43	3.21	12/31/1947	797.43	2.90
4/1/1948	797.43	2.90	12/31/1948	924.71	2.97
4/1/1949	924.71	2.97	12/31/1949	870.86	2.94
4/1/1950	870.86	2.94	12/31/1950	817.14	2.91
4/1/1951	817.14	2.91	12/31/1951	2180.00	3.34
4/1/1952	2180.00	3.34	12/31/1952	912.57	2.96
4/1/1953	912.57	2.96	12/31/1953	720.29	2.86
4/1/1954	720.29	2.86	12/31/1954	1280.71	3.11
4/1/1955	1280.71	3.11	12/31/1955	962.43	2.98
4/1/1956	962.43	2.98	12/31/1956	1016.29	3.01
4/1/1957	1016.29	3.01	12/31/1957	594.29	2.77
4/1/1958	594.29	2.77	12/31/1958	917.86	2.96
4/1/1959	917.86	2.96	12/31/1959	1010.29	3.00
4/1/1960	1010.29	3.00	12/31/1960	1067.57	3.03
4/1/1961	1067.57	3.03	12/31/1961	876.43	2.94
4/1/1962	876.43	2.94	12/31/1962	948.71	2.98
4/1/1963	948.71	2.98	12/31/1963	695.43	2.84
4/1/1964	695.43	2.84	12/31/1964	394.43	2.60
4/1/1965	394.43	2.60	12/31/1965	664.71	2.82
4/1/1966	664.71	2.82	12/31/1966	827.14	2.92
4/1/1967	827.14	2.92	12/31/1967	1061.43	3.03
4/1/1968	1061.43	3.03	12/31/1968	1037.14	3.02
4/1/1969	1037.14	3.02	12/31/1969	1169.71	3.07
4/1/1970	1169.71	3.07	12/31/1970	850.00	2.93
4/1/1971	850.00	2.93	12/31/1971	742.86	2.87
4/1/1972	742.86	2.87	12/31/1972	1158.57	3.06
4/1/1973	1158.57	3.06	12/31/1973	1294.43	3.11
4/1/1974	1294.43	3.11	12/31/1974	861.57	2.94
4/1/1975	861.57	2.94	12/31/1975	1024.71	3.01
4/1/1976	1024.71	3.01	12/31/1976	1338.00	3.13
4/1/1977	1338.00	3.13	12/31/1977	969.43	2.99
4/1/1978	969.43	2.99	12/31/1978	742.86	2.87
4/1/1979	742.86	2.87	12/31/1979	1163.71	3.07
4/1/1980	1163.71	3.07	12/31/1980	655.29	2.82
4/1/1981	655.29	2.82	12/31/1981	1334.14	3.13
4/1/1982	1334.14	3.13	12/31/1982	1030.57	3.01
4/1/1983	1030.57	3.01	12/31/1983	819.71	2.91
4/1/1984	819.71	2.91	12/31/1984	836.14	2.92
4/1/1985	836.14	2.92	12/31/1985	777.43	2.89
4/1/1986	777.43	2.89	12/31/1986	1545.71	3.19
4/1/1987	1545.71	3.19	12/31/1987	1045.71	3.02
4/1/1988	1045.71	3.02	12/31/1988	911.00	2.96
4/1/1989	911.00	2.96	12/31/1989	1025.43	3.01
4/1/1990	1025.43	3.01	12/31/1990	1046.29	3.02
4/1/1991	1046.29	3.02	12/31/1991	436.00	2.64
4/1/1992	436.00	2.64	12/31/1992	1360.00	3.13
4/1/1993	1360.00	3.13	12/31/1993	657.86	2.82
4/1/1994	657.86	2.82	12/31/1994	1025.43	3.01
4/1/1995	1025.43	3.01	12/31/1995	559.43	2.75
4/1/1996	559.43	2.75	12/31/1996	931.43	2.97
4/1/1997	931.43	2.97	12/31/1997	1088.86	3.04
4/1/1998	1088.86	3.04	12/31/1998	1026.71	3.01
4/1/1999	1026.71	3.01	12/31/1999	748.00	2.87
4/1/2000	748.00	2.87	12/31/2000	1290.00	3.11
4/1/2001	1290.00	3.11	12/31/2001	694.43	2.84
4/1/2002	694.43	2.84	12/31/2002	605.43	2.78
4/1/2003	605.43	2.78	12/31/2003	1049.86	3.02

Log Pearson Parameters	Year	Year
average:	2.99	2.99
standard deviation:	0.13	0.13
skew coefficient:	-0.26	-0.30
years in series	71	71
Skew	Return Period KT Values	
Probability	0.1	0.1
Recurrence	10	10
	-0.2	-1.30105
	-0.3	-1.30936
	-0.26	-1.305622
	-1.3094394	-0.30

Merrimack below Manchester		
(cfs)		
7Q10	652	650
Correction for Drainage Area:		
$(DA_{\text{Nashua}}/DA_{\text{Manchester}})^n$		1.2615
	DA (sq-mi)	
At Nashua	3999	
At Merrimack	3092	820
Merrimack at Nashua	(cfs)	
7Q10	822	820

$$\text{Lowell}_{7Q10} = \text{Manchester}_{7Q10} * (A_{\text{Lowell}}/A_{\text{Manchester}})^n$$

DA _{Lowell}	4421 sq-mi
DA _{Manchester}	3092 sq-mi
7Q10 _{Lowell, pre-WWTF}	880 cfs
7Q10 _{Manchester, pre-WWTF}	637 cfs
watershed exponent, n	0.90325

Min 7-day Series	Percentile
422.2814	1.00
598.1857	5.00
662.6571	10.00
721.4143	15.00
759.7714	20.00
819.0714	25.00
840.7429	30.00
873.3643	35.00
912.2571	40.00
934.0214	45.00
989.8571	50.00
1025.321	55.00
1031.886	60.00
1048.25	65.00
1086.729	70.00
1161.357	75.00
1263.857	80.00
1335.821	85.00
1450.143	90.00
1594.929	95.00
2180	100.00

Derivation of Merrimack River 7Q10 at Nashua, New Hampshire

4/1/2004	1049.86	3.02	12/31/2004	1385.14	3.14
4/1/2005	1385.14	3.14	12/31/2005	1227.14	3.09
4/1/2006	1227.14	3.09	12/31/2006	1442.86	3.16
4/1/2007	1442.86	3.16	12/31/2007	891.00	2.95
4/1/2008	891.00	2.95	12/31/2008	1627.14	3.21
4/1/2009	1627.14	3.21	12/31/2009	1485.71	3.17
4/1/2010	1485.71	3.17	12/31/2010	839.71	2.92
4/1/2011	839.71	2.92	12/31/2011	1141.43	3.06
4/1/2012	1141.43	3.06	12/31/2012	1080.86	3.03
4/1/2013	1080.86	3.03	12/31/2013	#N/A	#N/A

7-day min annual series

Hydrologic Year Min-7-			Calendar Year Min-7-			Hydrologic Calendar			Min 7-					
day Annual Series	Log		day Annual Series	Log		Log Pearson Paramet Year	Year	Year	Series	Percentile				
4/1/1937	1870.00		3.27	12/31/1937	1141.57	3.06	average:	2.98	2.99	450.3886	1.00			
4/1/1938	1141.57		3.06	12/31/1938	1725.71	3.24	standard deviation:	0.14	0.14	622.4571	5.00			
4/1/1939	1725.71		3.24	12/31/1939	963.14	2.98	skew coefficient:	0.00	-0.10	689.2857	10.00			
4/1/1940	963.14		2.98	12/31/1940	1069.43	3.03	years in series	32	32	724.8	15.00			
4/1/1941	1323.14		3.12	12/31/1941	857.43	2.93				775.6	20.00			
4/1/1942	857.43		2.93	12/31/1942	1166.86	3.07	Skew	Return Period KT Values			817.1429	25.00		
4/1/1943	1166.86		3.07	12/31/1943	1248.43	3.10	Probability	0.1	0.1	836.2857	30.00			
4/1/1944	1248.43		3.10	12/31/1944	1238.57	3.09	Recurrence	10	10	866.6857	35.00			
4/1/1945	1238.57		3.09	12/31/1945	1695.71	3.23		-0.2	-1.80105	-1.80105	-0.2	883.6571	40.00	
4/1/1946	1695.71		3.23	12/31/1946	1621.43	3.21		-0.3	-1.30936	-1.30936	-0.3	915.7429	45.00	
4/1/1947	1621.43		3.21	12/31/1947	797.43	2.90		0.00	-1.2846	-1.292819	-0.10	924.7143	50.00	
4/1/1948	797.43		2.90	12/31/1948	924.71	2.97						954.2	55.00	
4/1/1949	924.71		2.97	12/31/1949	870.86	2.94	Merrimack below Manchester					1000.714	60.00	
4/1/1950	870.86		2.94	12/31/1950	817.14	2.91	(cfs)					1020.457	65.00	
4/1/1951	817.14		2.91	12/31/1951	2180.00	3.34	7Q10	641	637			1051.714	70.00	
4/1/1952	2180.00		3.34	12/31/1952	912.57	2.96						1067.571	75.00	
4/1/1953	912.57		2.96	12/31/1953	720.29	2.86						1163.029	80.00	
4/1/1954	720.29		2.86	12/31/1954	1280.71	3.11						1224.8	85.00	
4/1/1955	1280.71		3.11	12/31/1955	962.43	2.98						1348.857	90.00	
4/1/1956	962.43		2.98	12/31/1956	1016.29	3.01						1666	95.00	
4/1/1957	1016.29		3.01	12/31/1957	594.29	2.77						2180	100.00	
4/1/1958	594.29		2.77	12/31/1958	917.86	2.96								
4/1/1959	917.86		2.96	12/31/1959	1010.29	3.00								
4/1/1960	1010.29		3.00	12/31/1960	1067.57	3.03								
4/1/1961	1067.57		3.03	12/31/1961	876.43	2.94								
4/1/1962	876.43		2.94	12/31/1962	948.71	2.98								
4/1/1963	948.71		2.98	12/31/1963	695.43	2.84								
4/1/1964	695.43		2.84	12/31/1964	394.43	2.60								
4/1/1965	394.43		2.60	12/31/1965	664.71	2.82								
4/1/1966	664.71		2.82	12/31/1966	827.14	2.92								
4/1/1967	827.14		2.92	12/31/1967	1061.43	3.03								
4/1/1968	1061.43		3.03	12/31/1968	1037.14	3.02								
4/1/1969	1037.14		3.02	12/31/1969	1169.71	3.07								
4/1/1970	1169.71		3.07	12/31/1970	850.00	2.93								
4/1/1971	850.00		2.93	12/31/1971	742.86	2.87								
4/1/1972	742.86		2.87	12/31/1972	1158.57	3.06								
4/1/1973	1158.57		3.06	12/31/1973	1294.43	3.11								