

**Upgrade of Flow Statistics Used to Estimate Surface Water Chemical
Concentration for Aquatic and Human Exposure Assessment**

Documentation of Methodology

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Submitted to:

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1. INTRODUCTION

The Exposure Assessment Branch (EAB) of EPA's Office of Pollution Prevention and Toxics (OPPT) is responsible for conducting aquatic life and human health exposure assessments for new and existing chemicals released to surface water. A critical component of this assessment is estimating the surface water concentration. EAB uses these concentrations to determine potential aquatic life toxicity and potential human exposures via drinking water and fish ingestion. EAB currently estimates chronic exposures to new and existing chemicals, yet does not estimate acute exposure.

EAB utilizes flow statistics in conjunction with chemical loading to estimate surface water concentration. Ideally, flow statistics should match the conditions in the water body associated with the type of exposure to be estimated (i.e., acute or chronic, human or aquatic toxicity). The purpose of this task is to upgrade EAB surface water flow data to represent current scientific opinion and standardized EPA policy. EAB currently has mean flow and 7Q10 flow (lowest 7-consecutive day average recurring every 10 years) estimates. Although the Office of Water (OW) continues to recommend the 7Q10 for assessing chronic aquatic toxicity, OW currently recommends the following design flows for other conditions:

- Harmonic Mean Flow (based on the inverse mean daily flow) for chronic human health exposure;
- 30Q5 flow (lowest 30-consecutive day average recurring every 5 years) for acute human health exposures; and
- 1Q10 flow (lowest 1-day average recurring every 10 years) for acute aquatic life exposures.

2. TECHNICAL APPROACH

USGS flow gaging stations are located on a limited number of reaches throughout the country. EPA's GAGE file contains estimates of mean flow and 7Q10 flow for every reach based on empirical relationships among reach length, drainage area, and flow. Harmonic mean, 1Q10, and 30Q5 flows are derived from existing mean and 7Q10 flows using simple linear regression equations based on available data from a representative sample of U.S. rivers.

Harmonic Means are estimated from the regression equation (R-squared =0.99) reported in Rossman, L.A. Design stream flows based on harmonic means. J. of Hydraulic Engineering 116(7):946-50 and presented in the Technical Support Document for Water Quality-based Toxics Control (TSD). This equation uses both the Mean and 7Q10 flows as predictor variables and is based on a log-log data transformation:

$$\text{Harmonic Mean} = 1.194 * \text{Mean}^{0.473} * 7\text{Q10}^{0.552}$$

1Q10 and 30Q5 flows are estimated using regression equations developed for this task. The data set for these regressions includes the 60 rivers used in the EPA Technical Guidance Manual for Performing Wasteload Allocations, Book 6, Design Conditions, cited in the TSD. This data set compared 1Q10 and 7Q10 data. The data, however, do not contain data for rivers with 7Q10 flows above 1000 cfs. Since many reaches of interest to OPPT have flows in excess of 1000 cfs, the data set was augmented with 17 additional reaches with 7Q10 flows up to approximately 100,000 cfs. Additional reaches were selected from OPPT's "Task 73 Report" of organic chemical manufacturers. Associated USGS stations were located using RCHDAT and PATHSCAN EPA mainframe applications. All design flows for these rivers were computed or updated using DFLOW on the EPA mainframe to represent the complete period of record. It should be noted that 30Q5 flow values were not available for four of the original 60 rivers.

Flow data were log-transformed prior to running the regressions to limit excessive influence of outliers and large flow values as well as to reduce nonconstant variance (e.g., as predictor flow values increases, the magnitude of positive and negative differences between predicted and actual values also increases). This method represents an alternative to the average 7Q10/1Q10 ratio of 1.3 given in the TSD. The TSD does not provide the means to predict 30Q5 from 7Q10 for a continuous data set: only average 30Q5/7Q10 ratios of 1.1 for small rivers (i.e., low flow of 50 cfs) and 1.4 for larger rivers (i.e., low flow of 600 cfs) are reported.

3. RESULTS

Both regression equations have an associated coefficient of variation (R-squared) of 0.99, indicating good agreement between predicted and actual values. In addition, the data set represents a sample from all regions in the nation and a large range of flow values. A table of raw data and regression results follow on the next several pages.

Upgrade of Flow Statistics

Raw Flow Data (in cfs) from USGS Gaging Stations Used to Derive Regression Equations

Station ID	River Name	State	Period of Record	7Q10	1Q10	30Q5	Source
1 01657000	Bull Run	VA	1951-1981	0.42	0.25	1.56	1
2 02092500	Trent	NC	1951-1987	1.48	1.30	4.15	1
3 06026000	Birch Cr	MT	1947-1976	2.41	1.71	4.87	1
4 12449600	Beaver Cr	WA	1960-1978	3.23	2.41	4.38	1
5 05522000	Iroquois	IN	1949-1990	4.29	3.65	8.09	1
6 09490800	N Fk White	AZ	1966-1978	5.35	4.61	6.92	1
7 14372500	E Fk Illinois	OR	1942-1989	6.73	6.41	8.19	1
8 05381000	Black	WI	1905-1989	8.07	6.64	19.04	1
9 05585000	La Moine	IL	1921-1990	8.09	6.69	18.74	1
10 10291500	Buckeye	CA	1911-1978	8.58	7.30	11.04	1
11 12321500	Boundary Cr	ID	1929-1991	13.30	11.84	18.35	1
12 01111500	Branch	RI	1940-1990	13.71	9.11	21.48	1
13 02138500	Linville	NC	1923-1988	16.85	13.85	27.61	1
14 05059000	Sheyenne	ND	1950-1990	16.88	14.14	25.12	1
15 02083000	Fishing Cr	NC	1927-1986	20.28	17.74	43.63	1
16 01196500	Quinnipiac	CT	1931-1988	32.50	18.31	47.90	1
17 02133500	Drowning Cr	NC	1940-1988	37.39	33.24	61.89	1
18 06280300	Shoshone	WY	1957-1991	45.84	40.63	57.47	1
19 02296750	Peace	FL	1931-1989	49.68	43.93	75.86	1
20 09149500	Uncompahgre	CO	1939-1990	52.05	37.39	76.73	1
21 07018500	Big	MO	1923-1988	56.85	47.99	81.54	1
22 02217500	Middle Oconee	GA	1902-1984	57.40	49.40		1
23 01600000	N Br Potomac	MD	1939-1983	61.60	54.70		1
24 09359500	Animas	CO	1946-1956	63.31	55.39	74.89	1
25 09497500	Salt	AZ	1925-1990	70.78	66.55	97.39	1
26 01481000	Brandywine	PA	1912-1979	71.05	64.86	99.48	1
27 01403060	Raritan	NJ	1904-1990	75.06	61.16	127.70	1
28 02413500	L Tallapoosa	AL	1940-1951	87.13	68.29	150.73	1
29 07288500	Big Sunflower	MS	1936-1980	88.62	86.01	111.31	1
30 01144000	White	VT	1916-1990	89.23	74.89	134.17	1
31 07013000	Meramec	MO	1923-1988	94.45	91.11	111.52	1
32 01421000	E B Delaware	NY	1913-1991	95.81	86.04	147.90	1
33 01531000	Chemung	NY	1915-1991	105.82	97.26	155.77	1
34 0709600	Arkansas	CO	1910-1990	126.86	109.91	180.03	1
35 09070000	Eagle	CO	1947-1987	131.91	117.45	147.99	1
36 01011000	Allegash	ME	1932-1990	139.14	129.44	215.40	1
37 03528000	Clinch	TN	1919-1987	140.16	133.25	196.13	1
38 13023000	Greys	WY	1937-1991	142.31	121.37	166.03	1
39 02424000	Cahaba	AL	1930-1990	152.06	147.18	187.43	1
40 05515500	Kankakee	IN	1926-1990	186.79	180.81	225.59	1
41 02490500	Bouge Chitto	MS	1945-1991	196.43	192.55	222.23	1
42 01610000	Potomac	WV	1939-1983	220.70	209.60		1
43 01315500	Hudson	NY	1908-1991	224.67	178.51	352.63	1
44 05386000	Root	MN	1938-1961	247.72	231.66	304.50	1
45 02369000	Shoal	FL	1939-1991	287.77	276.89	368.54	1
46 02135000	Little Pee Dee	SC	1942-1991	299.68	285.23	456.26	1

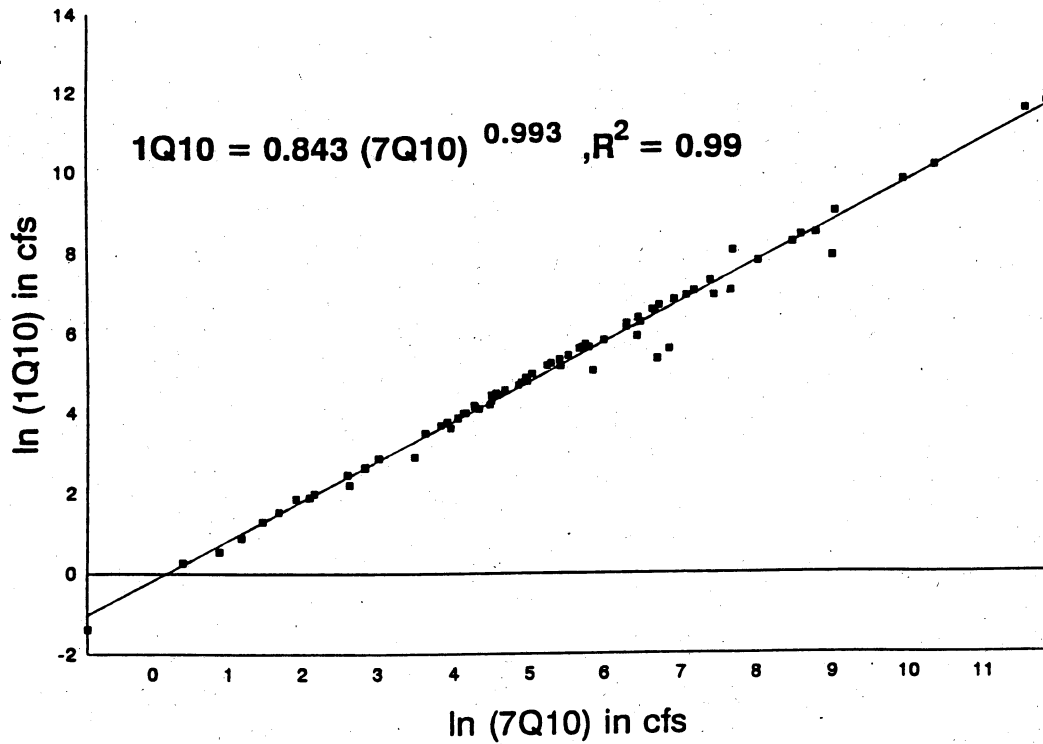
Upgrade of Flow Statistics

Raw Flow Data (in cfs) from USGS Gaging Stations Used to Derive Regression Equations

	Station ID	River Name	State	Period of Record	7Q10	1Q10	30Q5	Source
47	07378500	Amite	LA	1939-1991	312.44	307.59	372.01	1
48	08110200	Brazos	TX	1966-1978	326.94	284.39	557.86	1
49	06465500	Niobrara	NE	1939-1990	345.22	158.55	722.24	1
50	02076000	Dan	VA	1924-1952	400.43	340.13	664.99	1
51	03455000	French Broad	TN	1901-1987	537.27	467.78	765.94	1
52	05333500	St. Croix	WI	1914-1989	542.02	515.35	643.75	1
53	06287000	Bighorn	MT	1935-1991	617.83	372.06	1,214.12	1
54	03107500	Beaver	PA	1957-1990	625.10	591.35	801.45	1
55	013343000	N F Clearwater	ID	1927-1968	648.60	529.20		1
56	14233400	Cowlitz	WA	1968-1991	752.44	719.34	970.24	1
57	07341500	Red	AR	1928-1981	779.69	699.49	1,409.24	1
58	02350500	Flint	GA	1930-1958	803.26	210.95	1,135.08	1
59	01536500	Susquehanna	PA	1910-1991	827.96	798.98	1,148.47	1
60	01100000	Merrimack	MA	1924-1990	937.93	270.28	1,246.84	1
61	03341500	Wabash	IN	1928-1990	1,008.00	923.00	1,409.00	2
62	03085000	Monongahela	PA	1939-1990	1,186.00	1,020.00	1,693.00	2
63	03049500	Allegheny	PA	1939-1990	1,315.32	1,150.73	1,990.36	2
64	01463500	Delaware	NJ	1913-1990	1,636.08	1,466.39	2,216.00	2
65	02131000	Pee Dee	SC	1939-1991	1,708.07	1,015.32	2,609.06	2
66	01335770	Hudson	NY	1977-1981	2,150.00	1,151.00	2,557.00	2
67	01184000	Connecticut	CT	1929-1990	2,223.65	3,113.16	3,113.16	2
68	05543500	Illinois	IL	1920-1990	3,112.00	2,400.00	3,968.00	2
69	06893000	Missouri	MO	1929-1988	4,861.00	3,835.00	11,087.00	2
70	14211720	Willamette	OR	1973-1990	5,431.00	4,581.00	6,845.00	2
71	03568000	Tennessee	TN	1901-1986	6,609.00	4,849.00	9,528.00	2
72	03609500	Tennessee	KY	1901-1984	8,115.00	2,731.00	13,702.00	2
73	03303500	Ohio	KY	1941-1952	8,446.00	8,207.00	11,771.00	2
74	05587500	Mississippi	IL	1933-1983	20,699.84	17,676.39	27,329.63	2
75	03611500	Ohio	IL	1928-1990	31,719.00	25,076.00	48,077.00	2
76	07032000	Mississippi	TN	1933-1990	107,328.00	102,724.00	136,935.00	2
77	04216000	Niagara	NY	1926-1990	141,703.00	122,940.00	161,691.00	2

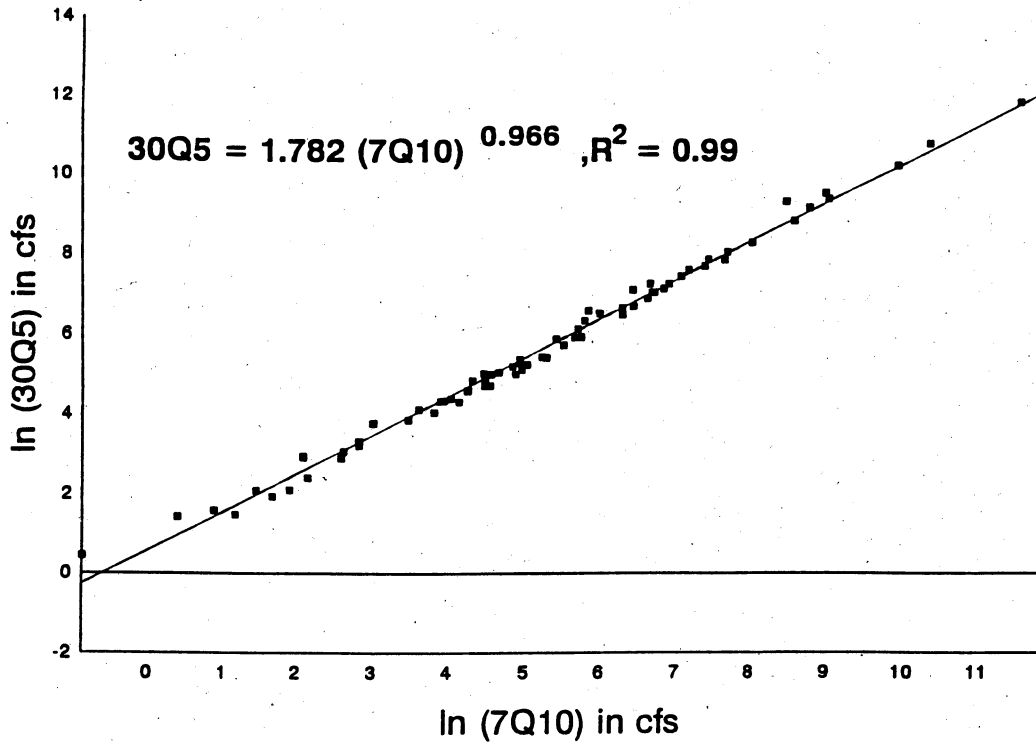
1. U.S. EPA. 1986. "Stream Design Flow for Steady-State Modeling." Technical Guidance Manual for Performing Wasteload Allocations. Book 6, Design Conditions. Office of Regulations and Standards, Washington DC.
2. River reaches selected from EPA Office of Pollution Prevention and Toxics' "Task 73 Report". USGS Station IDs obtained from RCHDAT and PATHSCAN EPA mainframe procedures. Flow values computed using DFLOW EPA mainframe procedure.

Regression of 1Q10 on 7Q10



Constant	-0.1710938
Standard Error of Y Estimate	0.26199001
R Squared	0.9890502
Number of Observations	77
Degrees of Freedom	75
X Coefficient	0.99317533
Standard Error of Coefficient	0.01206672

Regression of 30Q5 on 7Q10



Constant	0.57754504
Standard Error of Y Estimate	0.20385471
R Squared	0.99327528
Number of Observations	73
Degrees of Freedom	71
X Coefficient	0.96591165
Standard Error of Coefficient	0.00943215