In cooperation with the City of Houston and the Houston-Galveston Area Council

Estimation of Minimum 7-Day, 2-Year Discharge for Selected Stream Sites, and Associated Low-Flow Water-Quality Data, Southeast Texas, 1997–98

The U.S. Geological Survey (USGS) operates a network of streamflow-gaging stations in Texas that provides discharge data used for water-management decisions and various other purposes. Operating stations at all locations where discharge data are needed is not feasible, but the statistical characteristics of the network station data can be used to estimate discharge characteristics at ungaged sites. Regionalization techniques such as regression analyses relate discharge-frequency characteristics to selected physical and climatic characteristics of drainage basins. A particular discharge-frequency characteristic that can be regionalized is the minimum 7-day, 2-year discharge[1] (7Q2). In Texas, the 7Q2 is used at stream sites to analyze permit applications for water allocation, water-supply planning, aquatic maintenance (instream flow) requirements, and waste-load allocation for point and nonpoint source discharges.

In 1997 and 1998 the USGS, in cooperation with the City of Houston and the Houston-Galveston Area Council, conducted a study to estimate low-flow discharge characteristics for selected streams in southeast Texas. The objectives of this study were to estimate the 7Q2 for 17 ungaged stream sites (fig. 1) where such data were unavailable and to summarize selected water-quality properties and constituents at each of the ungaged sites during low-flow conditions. Discharge measurements were made and water-quality data were collected using USGS methods as described by Buchanan and Somers (1969), Rantz and others (1982), and Wells and others (1990).

This fact sheet presents estimated 7Q2 for the 17 ungaged sites and statistical summaries of four water-quality properties and three water-quality constituents for the sites. The ungaged sites are located on streams in or near the Houston metropolitan area in southeast Texas (fig. 1). For this study, 85 low-flow discharge measurements made at the 17 ungaged sites were used in conjunction with continuous-record discharge data from 10 USGS streamflow-gaging stations to estimate the 7Q2 for the ungaged sites.

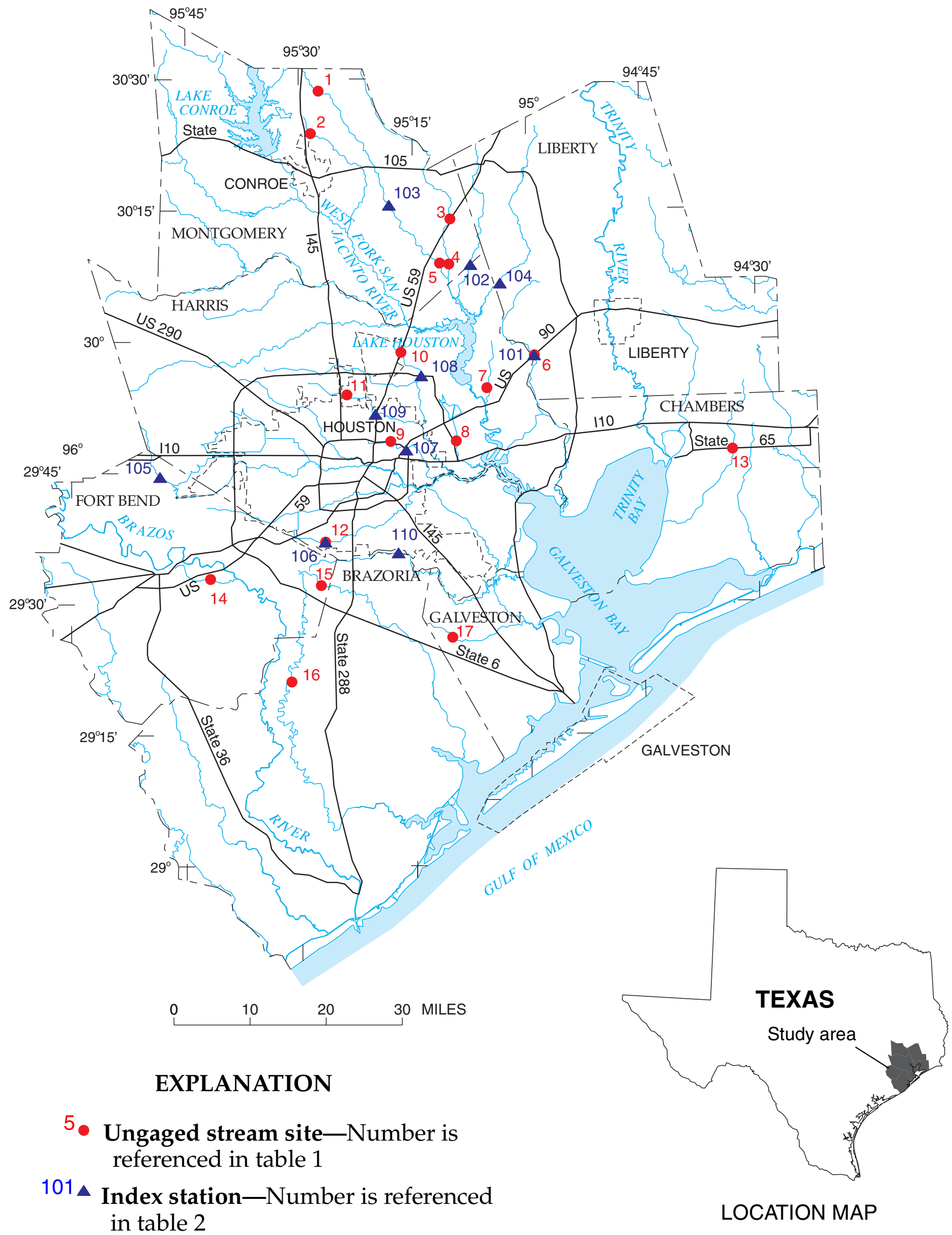

Figure 1. Locations of ungaged stream sites and index stations in or near the Houston metropolitan area, southeast Texas.

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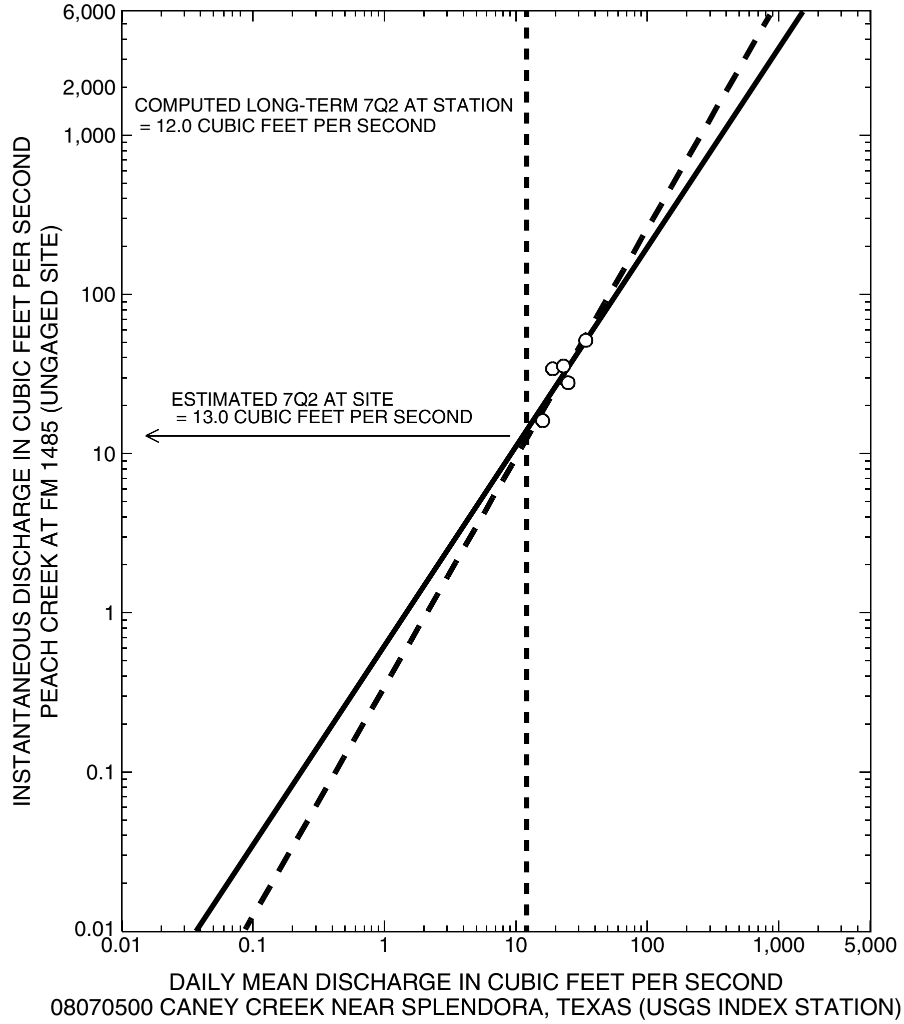
[1] Annual lowest mean discharge for 7 consecutive days with a 2-year recurrence interval.



EXPLANATION

Computed minimum 7-day, 2-year discharge (7Q2) at index station

Line of ordinary least squares

Line of organic correlation

Concurrent discharge at ungaged site and index station

Figure 2. Relation between discharge at ungaged stream site and index station.

Estimation of Minimum 7-Day, 2-Year Discharge

One technique to estimate low-flow discharge characteristics (such as 7Q2) in a region uses data from one or more index stations (Riggs, 1972; Stedinger and Thomas, 1985). These typically are USGS stations with a continuous record of discharge for a length of time sufficient (minimum 8 years) to provide reliable low-flow discharge characteristics. For an index station to be used in the analysis, the low-flow data should not have any significant temporal trends, which would skew the frequency characteristics. To test for a trend in the data, the Mann-Kendall test (Helsel and Hirsch, 1992) was used to determine the significance of Kendall's tau. In this application, a Kendall's tau p-value less than or equal to 0.10 indicated a statistically significant trend in the data. If a trend was detected in the data set, the record was truncated to a shorter period without a trend.

Initially, the 7-day minimum flow was determined for each year the index station has been operated (or for the shorter period if the data set had a trend). The 7Q2 for the index station was determined by computing the median discharge for the station time series. The median is the 50th percentile and by definition is the discharge with a 2-year recurrence interval, on the basis of station data and assuming no specified statistical distribution of the data set.

To transfer the 7Q2 from the index station to the ungaged site, a relation was developed between low-flow discharge at the station and at the ungaged site. Periodic discharge measurements were made during various low-flow conditions at the ungaged sites where the 7Q2 was to be estimated. At least five discharge measurements were made at each site. The low-flow discharge measurements then were used with concurrent discharge values determined at the appropriate index station(s) to develop the relation between low-flow discharge characteristics for the ungaged site and for the index station(s). An example of such a relation is shown in figure 2.

In figure 2, discharge measured at an ungaged site (Peach Creek at FM 1485; site 4 in fig. 1, table 1) is plotted on the ordinate (y-axis), and daily mean discharge for an index station (08070500 Caney Creek near Splendora, Tex.; station 103 in

Table 1. Ungaged stream sites and minimum 7-day, 2-year discharge estimates

[mi^2, square miles; 7Q2, minimum 7-day, 2-year discharge; ft^3/s, cubic feet per second; n/a, not available]

Site (fig. 1)	Name	Location	Latitude	Longitude	Index station(s) used for estimation (fig. 1, table 2)	Drainage area (mi^2)	7Q2 (ft^3/s)
1	Little Caney Creek	Rodgers Rd.	30°28'39"	95°27'23"	102, 103	19.3	0
2	East Fork Crystal Creek	US 75	30°23'48"	95°28'26"	102, 103	1.70	.08
3	Peach Creek	FM 2090	30°13'57"	95°10'05"	102, 103	117	17.0
4	Peach Creek	FM 1485	30°08'48"	95°10'17"	102, 103	155	17.0
5	Caney Creek	FM 1485	30°08'55"	95°11'30"	103	178	12.0
6	Cedar Bayou[1]	US 90	29°58'20"	94°59'08"	101	65.0	.27
7	Gum Gulley	Diamondhead Blvd.	29°54'38"	95°05'25"	101, 104	13.0	.70
8	Carpenters Bayou	Wallisville Rd.	29°48'35"	95°09'30"	101, 104, 107	6.00	.54
9	Hunting Bayou	Homestead Rd.	29°48'35"	95°18'06"	107	8.50	.10
10	Garners Bayou	US 59	29°58'45"	95°16'41"	108	6.00	.35
11	Halls Bayou	Airline Dr.	29°53'56"	95°25'46"	109	13.0	1.60
12	Sims Bayou[1]	Hiram Clarke St.	29°37'07"	95°26'44"	106	20.2	8.70
13	East Fork Double Bayou	State 65	29°47'23"	94°33'15"	101, 104	12.0	2.20
14	Rabbs Bayou	Crabb River Rd.	29°32'54"	95°41'49"	105, 110	7.60	1.90
15	Mustang Bayou	Trammel Fresno Rd.	29°32'09"	95°27'19"	110	6.10	0
16	Oyster Creek	FM 1462	29°21'08"	95°31'14"	110	n/a	0
17	Dickinson Bayou	FM 517	29°26'08"	95°10'11"	105, 106	15.0	3.40

[1] USGS partial-record station at site.

fig. 1) corresponding to the date of the discharge measured at the ungaged site is plotted on the abscissa (x-axis). Two relations are developed using these data pairs; a line of ordinary least squares and a line of organic correlation. The line of ordinary least squares minimizes errors in the y direction only and defines the best-fit straight line as the line that minimizes the sum of the squares of the distances of the data points from the best-fit straight line (Helsel and Hirsch, 1992, p. 275). The line of organic correlation minimizes errors in both the x and y directions and defines the best-fit straight line as the line that minimizes the sum of the areas of right triangles formed by horizontal and vertical lines extending from observations to the fitted line (Helsel and Hirsch, 1992, p. 276). In most instances, the line of organic correlation is the preferable statistical tool for 7Q2 estimation because the line of ordinary least squares tends to produce biased, in some cases highly biased, 7Q2 estimates (W.H. Asquith, U.S. Geological Survey, written commun., 1999).

The computed 7Q2 for the index station (fig. 2) is shown as a dashed line that perpendicularly intersects the abscissa at the 7Q2 value. To estimate the 7Q2 for the ungaged site, the intersection of the line of organic correlation and the index station 7Q2 line is located. A horizontal line is projected from this intersection to the ordinate, and the estimated 7Q2 for the ungaged site is determined from the scale. Although the line of organic correlation is preferable, the ordinary least-squares line can be used if, from observation, the least-squares line clearly and unequivocally fits the data better in the region of the graph for which a 7Q2 estimation is required.

This technique was used to estimate the 7Q2 for each of the 17 ungaged sites. If more than one index station was identified for the analysis for a particular ungaged site, multiple 7Q2 estimates were determined. Multiple 7Q2 estimates for an ungaged site were averaged to determine a final 7Q2 estimate. The final 7Q2 estimate for each ungaged site is listed in table 1. The index stations used for these analyses are listed in table 2.

Table 2. Index stations used for estimation of minimum 7-day, 2-year discharge

Index station (fig. 1)	USGS streamflow-gaging station no.	Name	Latitude	Longitude
101	08067500	Cedar Bayou near Crosby, Tex.	29°58'21"	94°59'08"
102	08070200	East Fork San Jacinto River near New Caney, Tex.	30°08'43"	95°07'27"
103	08070500	Caney Creek near Splendora, Tex.	30°15'34"	95°18'08"
104	08071280	Luce Bayou above Lake Houston, near Huffman, Tex.	30°06'34"	95°03'35"
105	08072300	Buffalo Bayou near Katy, Tex.	29°44'35"	95°48'24"
106	08075400	Sims Bayou at Hiram Clarke St., Houston, Tex.	29°37'07"	95°26'45"
107	08075770	Hunting Bayou at I–610, Houston, Tex.	29°47'35"	95°16'04"
108	08076180	Garners Bayou near Humble, Tex.	29°56'03"	95°14'02"
109	08076500	Halls Bayou at Houston, Tex.	29°51'42"	95°20'05"
110	08077000	Clear Creek near Pearland, Tex.	29°35'50"	95°17'11"

Table 3. Statistical summary of water-quality data for ungaged stream sites

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; Min, Minimum; Max, Maximum]

Site (fig. 1)	Water temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)			Total suspended solids[1] (mg/L)			Hardness[1] (mg/L as $CaCO_3$)			Dissolved chloride[1] (mg/L)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	17.6	20.8	23.9	570	574	578	7.2	7.2	7.2	3.6	4.6	5.5	9.6	11.4	13.2	70.0	140	211	46.6	50.0	53.1
2	21.4	29.6	36.4	645	678	711	7.2	7.3	7.6	4.3	5.8	6.9	2.0	5.7	9.2	111	132	143	59.8	73.4	84.2
3	19.0	24.5	28.5	67.0	69.8	73.0	6.4	6.6	6.8	6.2	6.8	7.8	3.0	5.2	6.8	11.9	13.6	15.9	12.2	13.2	13.9
4	19.4	25.6	29.8	90.0	104	114	6.1	6.5	7.0	7.7	8.0	8.4	2.8	6.4	9.6	17.9	19.8	21.1	16.3	19.2	20.6
5	22.7	25.7	28.6	92.0	116	136	6.3	6.7	7.2	6.5	7.9	8.6	5.2	8.5	14.8	25.5	32.3	39.0	14.0	15.5	17.0
6	21.4	26.7	30.5	621	858	1,180	7.9	8.1	8.4	6.4	8.6	10.1	25.8	46.9	68.0	126	130	134	99.3	122	145
7	14.9	24.7	30.6	470	645	918	7.7	7.8	7.9	7.6	8.1	8.6	2.0	27.6	100	118	183	273	62.8	78.0	104
8	15.4	24.8	30.2	402	824	1,170	7.4	8.0	8.6	4.3	6.3	8.4	16.0	29.2	42.8	122	215	310	52.6	130	181
9	20.9	31.5	37.4	388	691	1,060	7.9	8.5	9.1	2.1	10.8	20.0	18.0	27.0	42.4	89.2	117	158	23.7	55.8	72.7
10	17.3	25.8	32.7	565	729	803	8.2	8.3	8.6	4.5	7.4	9.7	23.5	41.7	60.0	125	168	211	74.1	100	117
11	21.4	28.6	32.0	749	780	829	7.5	7.7	8.0	5.0	7.3	9.5	10.0	14.7	20.8	168	172	179	90.7	93.8	96.3
12	31.1	31.8	32.5	1,210	1,360	1,510	7.4	7.7	8.0	6.4	8.4	10.4	14.0	18.6	23.2	213	244	276	192	249	306
13	15.9	22.0	29.4	388	422	481	7.0	7.5	7.9	7.4	8.2	9.6	33.4	86.2	139	138	145	152	28.3	37.6	46.9
14	20.0	23.8	27.6	877	900	924	8.5	9.0	9.5	5.2	6.8	8.5	86.0	126	165	156	176	196	133	141	150
[2]15	25.9	25.9	25.9	617	617	617	7.4	7.4	7.4	7.7	7.7	7.7	83.2	83.2	83.2	174	174	174	83.0	83.0	83.0
16	21.0	21.1	21.3	656	783	911	7.5	7.6	7.7	5.7	6.2	6.7	16.8	29.9	43.0	230	237	244	61.4	87.2	113
17	19.8	26.1	28.8	610	773	960	7.4	7.7	8.2	5.0	5.6	5.9	37.0	54.3	88.0	188	217	234	78.6	124	170

[1] Analyses by City of Houston Wastewater Quality Control Laboratory.

[2] Summary statistics from one sample.

Statistical Summary of Water-Quality Data

Selected water-quality data also were determined at each of the 17 ungaged sites. During site visits for low-flow discharge measurements, USGS personnel measured water temperature, specific conductance, pH, and dissolved oxygen with field meters and collected water-quality samples from the centroid of flow. These samples were analyzed by the City of Houston Wastewater Quality Control Laboratory for concentrations of total suspended solids, hardness, and dissolved chloride. Statistical summaries of these water-quality data are listed in table 3.

These water-quality data (specifically total suspended solids, hardness, and dissolved chloride) are used in trace metal limit determinations as part of the waste-load allocation process. For instance, the limiting criteria for several trace metals, such as cadmium, copper, and lead, are defined as a function of hardness. These data typically are collected during various flow conditions, which can affect concentrations.

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—Jeffery W. East

Information on technical reports and hydrologic data related to this study can be obtained from:

Subdistrict Chief
U.S. Geological Survey
2320 La Branch Street
Houston, TX 77004

Phone: (713) 718–3655
FAX: (713) 718–3661
World Wide Web: http://tx.usgs.gov