Appendix A

Sanitary Sewer Overflow Supporting Information

Table 1 Revised Estimates of SSO Occurrences, Flow and Loads (Replaces Table 3.14 in November 2006 Report)

Sbsn	Dry SSO/yr	Flow on dry day to stream (MGD)	Load on dry day to stream (MPN/day)	Intermediate SSO/yr	Flow on Intermediate day to stream (MGD)	Load on Intermediate day to stream (MPN/day)	Wet SSO/yr	Flow on wet day to stream (MGD)
1	12	1.58E-05	2.81E+09	12	1.58E-05	2.81E+09	5	3.4E-04
2	4	5.38E-06	9.57E+08	4	5.38E-06	9.57E+08	2	1.8E-04
3	7	9.32E-06	1.66E+09	7	9.32E-06	1.66E+09	5	3.8E-04
4	8	1.04E-05	1.86E+09	8	1.04E-05	1.86E+09	2	1.8E-04
5	29	4.27E-05	7.60E+09	29	4.27E-05	7.60E+09	12	1.0E-03
6	8	1.15E-05	2.04E+09	8	1.15E-05	2.04E+09	2	1.6E-04
7	5	6.45E-06	1.15E+09	5	6.45E-06	1.15E+09	5	3.6E-04
8	2	2.87E-06	5.11E+08	2	2.87E-06	5.11E+08	1	4.0E-05
9	2	3.15E-06	5.60E+08	2	3.15E-06	5.60E+08	1	5.3E-05
10	5	6.73E-06	1.20E+09	5	6.73E-06	1.20E+09	1	1.1E-04
11	2	3.25E-06	5.79E+08	2	3.25E-06	5.79E+08	1	5.5E-05
12	1	1.00E-06	1.79E+08	1	1.00E-06	1.79E+08	0	1.7E-05
13	3	4.16E-06	7.40E+08	3	4.16E-06	7.40E+08	1	7.0E-05
17	8	1.04E-05	1.85E+09	8	1.04E-05	1.85E+09	2	1.8E-04
26	11	1.66E-05	2.96E+09	11	1.66E-05	2.96E+09	2	1.3E-04
27	4	6.33E-06	1.13E+09	4	6.33E-06	1.13E+09	0	2.2E-05
28	1	1.08E-06	1.93E+08	1	1.08E-06	1.93E+08	0	1.8E-05
33	5	7.91E-06	1.41E+09	5	7.91E-06	1.41E+09	2	2.0E-04
34	2	2.37E-06	4.22E+08	2	2.37E-06	4.22E+08	1	4.4E-05
35	0	3.95E-07	7.04E+07	0	3.95E-07	7.04E+07	0	0.0E+00
36	6	9.49E-06	1.69E+09	6	9.49E-06	1.69E+09	3	2.2E-04
37	11	1.66E-05	2.96E+09	11	1.66E-05	2.96E+09	2	1.6E-04
38	8	1.23E-05	2.18E+09	8	1.23E-05	2.18E+09	3	2.4E-04
39	9	1.34E-05	2.39E+09	9	1.34E-05	2.39E+09	2	2.0E-04
40	8	1.11E-05	1.98E+09	8	1.11E-05	1.98E+09	1	1.0E-04
41	8	1.04E-05	1.85E+09	8	1.04E-05	1.85E+09	0	2.0E-05
42	11	1.51E-05	2.68E+09	11	1.51E-05	2.68E+09	0	2.0E-05
43	5	6.81E-06	1.21E+09	5	6.81E-06	1.21E+09	3	2.4E-04
44	5	7.51E-06	1.34E+09	5	7.51E-06	1.34E+09	2	1.3E-04
45	7	1.11E-05	1.97E+09	7	1.11E-05	1.97E+09	6	4.9E-04
46	0	3.95E-07	7.04E+07	0	3.95E-07	7.04E+07	2	2.0E-04
47	1	1.58E-06	2.81E+08	1	1.58E-06	2.81E+08	1	4.4E-05
48	16	2.37E-05	4.22E+09	16	2.37E-05	4.22E+09	3	2.7E-04
49	13	1.98E-05	3.52E+09	13	1.98E-05	3.52E+09	3	2.4E-04
50	5	7.51E-06	1.34E+09	5	7.51E-06	1.34E+09	1	1.1E-04
51	11	1.62E-05	2.89E+09	11	1.62E-05	2.89E+09	7	6.0E-04
52	7	9.88E-06	1.76E+09	7	9.88E-06	1.76E+09	4	3.6E-04
53	3	4.74E-06	8.44E+08	3	4.74E-06	8.44E+08	1	1.1E-04
54	3	4.35E-06	7.74E+08	3	4.35E-06	7.74E+08	2	1.3E-04
55	1	1.98E-06	3.52E+08	1	1.98E-06	3.52E+08	0	0.0E+00
56	1	7.91E-07	1.41E+08	1	7.91E-07	1.41E+08	0	2.2E-05
101	0	1.12E-09	2.00E+05	0	1.12E-09	2.00E+05	0	1.9E-08
102	0	2.65E-07	4.72E+07	0	2.65E-07	4.72E+07	0	4.5E-06
103	0	6.62E-08	1.18E+07	0	6.62E-08	1.18E+07	0	1.1E-06
104	0	4.28E-07	7.62E+07	0	4.28E-07	7.62E+07	0	7.2E-06
105	0	3.04E-07	5.41E+07	0	3.04E-07	5.41E+07	0	5.1E-06
106	0	5.50E-07	9.79E+07	0	5.50E-07	9.79E+07	0	9.2E-06
107	1	2.14E-06	3.81E+08	1	2.14E-06	3.81E+08	0	3.6E-05

Table 1 Revised Estimates of SSO Occurrences, Flow and Loads (Replaces Table 3.14 in November 2006 Report), continued

Sbsn	Dry SSO/yr	Flow on dry day to stream (MGD)	Load on dry day to stream (MPN/day)	Intermediate SSO/yr	Flow on Intermediate day to stream (MGD)	Load on Intermediate day to stream (MPN/day)	Wet SSO/yr	Flow on wet day to stream (MGD)
108	2	2.63E-06	4.69E+08	2	2.63E-06	4.69E+08	1	7.5E-05
109	2	2.31E-06	4.11E+08	2	2.31E-06	4.11E+08	0	6.6E-05
110	3	5.13E-06	9.13E+08	3	5.13E-06	9.13E+08	1	1.5E-04
111	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
112	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
113	5	8.06E-06	1.44E+09	5	8.06E-06	1.44E+09	2	2.3E-04
114	3	4.77E-06	8.49E+08	3	4.77E-06	8.49E+08	1	1.4E-04
115	3	4.65E-06	8.27E+08	3	4.65E-06	8.27E+08	1	1.3E-04
116	0	6.06E-07	1.08E+08	0	6.06E-07	1.08E+08	0	1.7E-05
117	2	2.87E-06	5.11E+08	2	2.87E-06	5.11E+08	1	8.2E-05
118	2	3.43E-06	6.10E+08	2	3.43E-06	6.10E+08	1	9.8E-05
119	5	7.00E-06	1.25E+09	5	7.00E-06	1.25E+09	1	2.0E-04
120	3	4.88E-06	8.69E+08	3	4.88E-06	8.69E+08	1	1.4E-04
121	1	8.70E-07	1.55E+08	1	8.70E-07	1.55E+08	0	2.5E-05
122	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
123	1	2.04E-06	3.63E+08	1	2.04E-06	3.63E+08	0	5.8E-05
124	0	5.01E-07	8.93E+07	0	5.01E-07	8.93E+07	0	1.4E-05
125	1	1.35E-06	2.41E+08	1	1.35E-06	2.41E+08	0	3.9E-05
126	0	1.03E-07	1.83E+07	0	1.03E-07	1.83E+07	0	2.9E-06
127	0	2.04E-10	3.62E+04	0	2.04E-10	3.62E+04	0	5.8E-09
128	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
129	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
130	0	5.45E-08	9.70E+06	0	5.45E-08	9.70E+06	0	1.6E-06
131	1	2.11E-06	3.75E+08	1	2.11E-06	3.75E+08	0	6.0E-05
132	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
133	3	3.73E-06	6.64E+08	3	3.73E-06	6.64E+08	1	1.1E-04
134	1	1.30E-06	2.31E+08	1	1.30E-06	2.31E+08	0	3.7E-05
135	1	8.03E-07	1.43E+08	1	8.03E-07	1.43E+08	0	2.3E-05
136	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
137	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
138	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
139	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
140	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
141	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
142	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
143	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
144	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
145	0	8.48E-08	1.51E+07	0	8.48E-08	1.51E+07	0	2.4E-06
146	0	6.01E-07	1.07E+08	0	6.01E-07	1.07E+08	0	1.7E-05
147	0	3.12E-08	5.55E+06	0	3.12E-08	5.55E+06	0	8.9E-07
148	3	4.89E-06	8.70E+08	3	4.89E-06	8.70E+08	1	1.4E-04
149	1	1.66E-06	2.96E+08	1	1.66E-06	2.96E+08	0	4.7E-05
150	3	3.75E-06	6.67E+08	3	3.75E-06	6.67E+08	1	1.1E-04
151	2	2.23E-06	3.98E+08	2	2.23E-06	3.98E+08	0	6.4E-05
152	1	1.07E-06	1.90E+08	1	1.07E-06	1.90E+08	0	3.0E-05
153	1	1.80E-06	3.20E+08	1	1.80E-06	3.20E+08	0	5.1E-05
154	0	1.86E-08	3.30E+06	0	1.86E-08	3.30E+06	0	5.3E-07
155	0	6.17E-07	1.10E+08	0	6.17E-07	1.10E+08	0	1.8E-05

Table 1 Revised Estimates of SSO Occurrences, Flow and Loads (Replaces Table 3.14 in November 2006 Report), continued

Sbsn	Dry SSO/yr	Flow on dry day to stream (MGD)	Load on dry day to stream (MPN/day)	Intermediate SSO/yr	Flow on Intermediate day to stream (MGD)	Load on Intermediate day to stream (MPN/day)	Wet SSO/yr	Flow on wet day to stream (MGD)
156	2	3.09E-06	5.50E+08	2	3.09E-06	5.50E+08	1	5.2E-05
171	2	2.37E-06	4.22E+08	2	2.37E-06	4.22E+08	0	4.0E-05
172	0	3.72E-07	6.62E+07	0	3.72E-07	6.62E+07	0	6.2E-06
173	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
174	0	2.72E-09	4.84E+05	0	2.72E-09	4.84E+05	0	4.6E-08
175	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
176	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
177	0	1.24E-07	2.20E+07	0	1.24E-07	2.20E+07	0	2.1E-06
178	0	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0	0.0E+00
180	0	3.75E-07	6.68E+07	0	3.75E-07	6.68E+07	0	6.3E-06
181	2	2.77E-06	4.92E+08	2	2.77E-06	4.92E+08	1	4.6E-05
182	0	4.98E-07	8.86E+07	0	4.98E-07	8.86E+07	0	8.4E-06
183	2	2.95E-06	5.24E+08	2	2.95E-06	5.24E+08	1	4.9E-05
184	1	7.45E-07	1.33E+08	1	7.45E-07	1.33E+08	0	1.3E-05
185	0	5.96E-07	1.06E+08	0	5.96E-07	1.06E+08	0	1.0E-05
186	0	3.18E-07	5.66E+07	0	3.18E-07	5.66E+07	0	5.3E-06
187	0	1.24E-07	2.21E+07	0	1.24E-07	2.21E+07	0	2.1E-06
188	0	6.68E-09	1.19E+06	0	6.68E-09	1.19E+06	0	1.1E-07

Abbreviations: dL - deciliter, MPN - most probable number, SSO - sanitary sewer overflow, yr - year

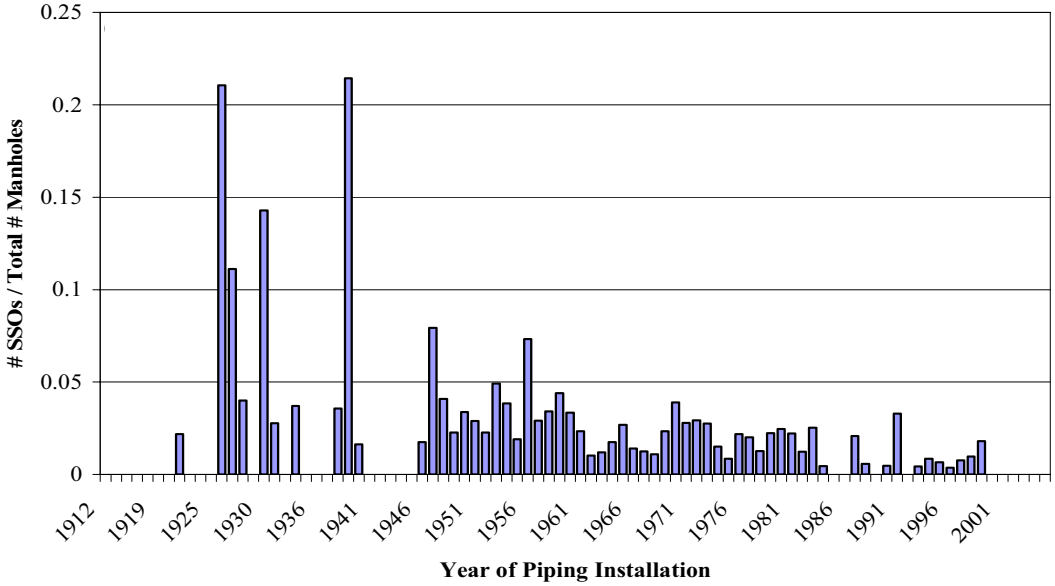


Figure 1 Influence of Age on SSOs in Buffalo and Whiteoak Bayous
(Replaces Figure 3.3 in Novemer 2006 report)

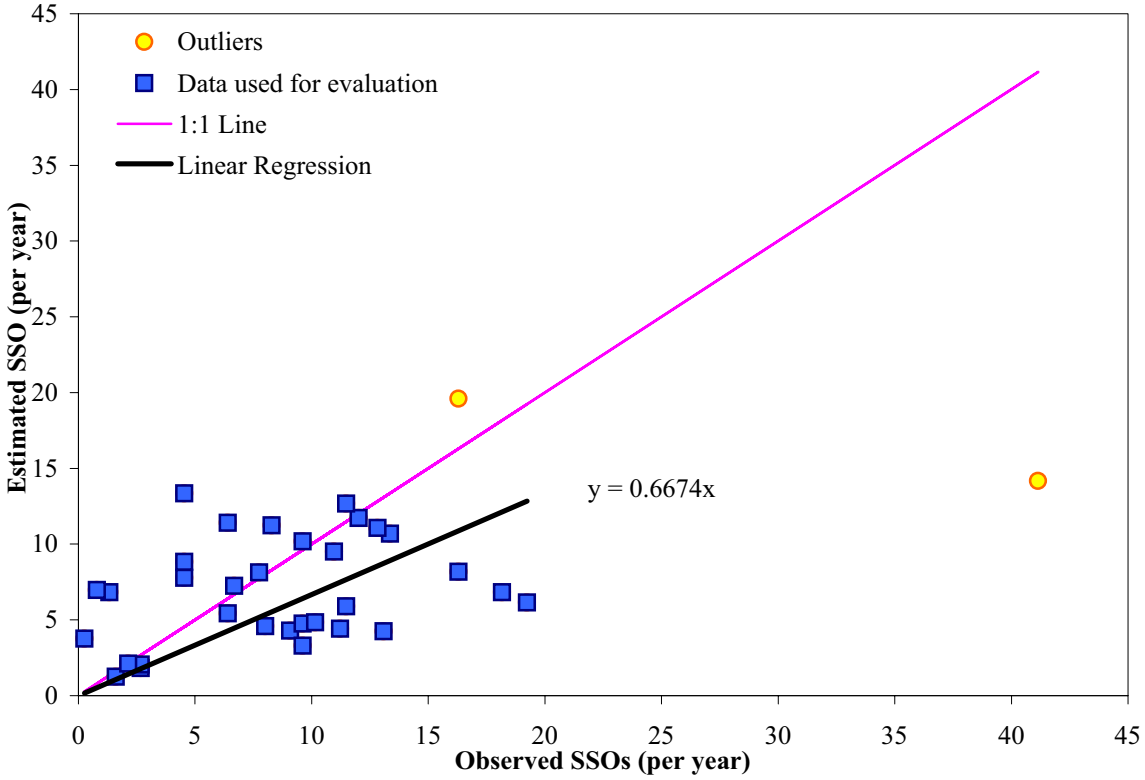


Figure 2 Comparison of Estimated and Observed SSO/year
(Replaces Figure 3.6 in November 2006 Report)

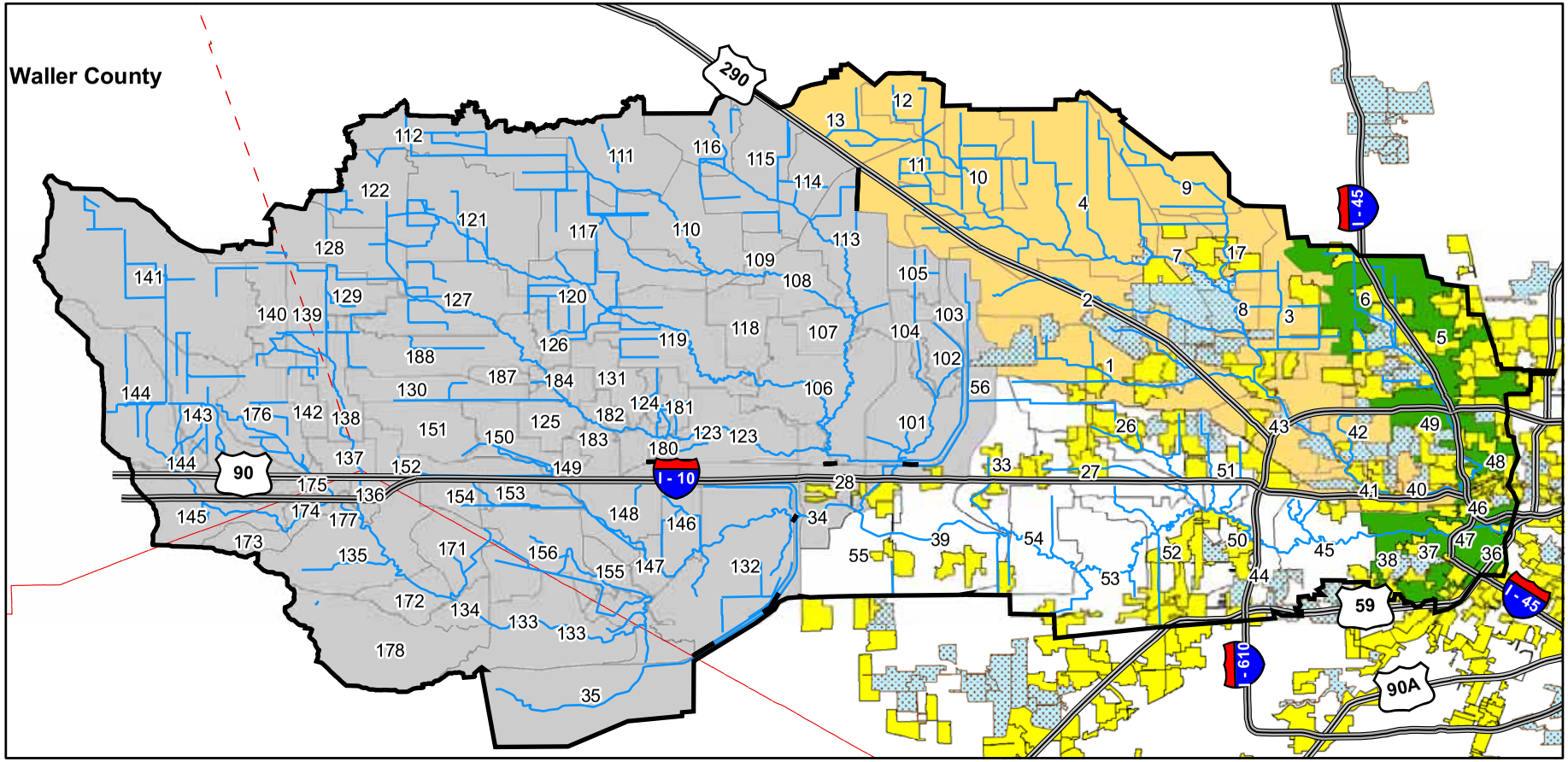


Figure 3
City of Houston Pipe Renewal

Legend

- All_BB_WOB_Outline2
- Stream
- County

Study Watersheds

- Segment 1017
- Segment 1013
- Segment 1014
- Reservoirs
- Pipe Renewal Scheduled
- Pipe Renewal Complete

0 3.5 7 14 Miles

Table 2. Example Calculation for SSO Load and flow estimates for Subbasin 1 and Subbasin 114

Number of SSO and Load Estimates for Subbasin 1 (within City of Houston limits):

Variable description	Value	Variable number	Source of value
Number of SSOs from database:	61	[1]	database
Number SSOs/year:	16	[2]	[1] / 1367 * 365
Acres in Subbasin:	7,680	[3]	GIS
Acres covered by MUDs:	7,241	[4]	GIS
% Covered by Mud	94%	[5]	[4] / [5]
Number of wet weather SSOs	17	[6]	database
Dry SSOs/year	12	[7]	(1 - [6]) / 1367 * 365
Wet SSOs/year	5	[8]	[6] / 1367 * 365
Dry E. coli concentration	4.7.E+06	[9]	Measurements
Dry Volume	1,000	[10]	US EPA (2004)
Wet E. coli concentration	3.5.E+05	[11]	1 order of magnitude less than geometric mean of sample data per US EPA SSO Report (2004)
Wet Volume	14,400	[12]	US EPA (2004)
Delivery rate	43% for Buffalo and 39% for Whiteoak	[13]	Work Order 6 Final Report, page 130;
Number dry days per year	291	[14]	NWS, Addicks average for 1948-1999
Dry E. coli load	2.80.E+09	[15]	[7] * [13] * [10] * [9] * 37.854 / [14]
Wet E. coli load	4.57.E+09	[16]	[6] * [13] * [12] * [11] * 37.854 / (365 - [14])

Number of SSO and Load Estimates for Subbasin 114 (outside City of Houston limits):

Variable description	Value	Variable number	Source of value
Census Community District (CCD):	NW	[1]	
SSOs/manhole/yr:	0.0041	[2]	See Housing Analysis below
Acres in Subbasin:	2,285	[3]	GIS
Acres covered by MUDs:	2,153	[4]	GIS
% Covered by Mud	94%	[5]	[3] / [4]
Avg # MH/acre	0.478	[7]	See Density Analysis below
Number of manholes in subbasin:	1,029	[8]	[4] * [7]
Estimated number of SSOs/year:	4	[9]	[2] * [8]
% wet weather SSOs	23%	[10]	database
Dry SSOs/year	3	[11]	(1 - [10]) * [9]
Wet SSOs/year	1	[13]	[10] * [9]
Dry E. coli concentration	4.7.E+06	[14]	Measurements
Dry Volume	1,000	[15]	US EPA (2004)
Wet E. coli concentration	3.5.E+05	[16]	1 order of magnitude less than geometric mean of sample data per US EPA SSO Report (2004)
Wet Volume	14,400	[17]	US EPA (2004)
Delivery rate	43% for Buffalo and 39% for Whiteoak	[18]	Work Order 6 Final Report, page 130;
Number dry days per year	291	[19]	NWS, Addicks average for 1948-1999
Dry E. coli load	8.47.E+08	[20]	[11] * [18] * [15] * [14] * 37.854 / [19]
Wet E. coli load	1.07.E+09	[21]	[13] * [18] * [17] * [16] * 37.854 / (365 - [19])

*** Values different than BLEST because of rounding

Supporting Tables for Example Calculation for SSO Load and flow estimates

Housing Analysis (excerpted from Table 3.10)

	% Homes Built in NW CCD	SSO / MH / yr	% Homes Built in Houston CCD * SSO/MH/yr
Built 1999 to March 2000	6%	1.94E-03	1.18E-04
Built 1995 to 1998	12%	2.87E-03	3.55E-04
Built 1990 to 1994	12%	3.00E-03	3.56E-04
Built 1980 to 1989	36%	4.05E-03	1.45E-03
Built 1970 to 1979	28%	4.81E-03	1.37E-03
Built 1960 to 1969	4%	6.53E-03	2.33E-04
Built 1950 to 1959	1%	9.26E-03	8.84E-05
Built 1940 to 1949	0%	9.98E-03	4.52E-05
Built 1939 or earlier	1%	1.03E-02	5.42E-05
Sum			4.07E-03

Maintenance hole density calculation (excerpted from Table 3.11)

Subbasin	Number MHs	Acres	% MUD	MH / acre	MH / MUD acre
1	2653	7680.3	94%	0.345	0.366
3	1735	4411.4	98%	0.393	0.401
5	2212	5263.8	99%	0.420	0.423
6	1665	3848.1	98%	0.433	0.443
7	903	1814.8	97%	0.498	0.514
8	199	760.3	100%	0.262	0.262
17	952	1999.6	89%	0.476	0.533
26	1853	4088.1	100%	0.453	0.453
27	806	2870.7	100%	0.281	0.281
28	258	887.3	40%	0.291	0.734
33	1176	3001.4	100%	0.392	0.392
34	767	1037.7	75%	0.739	0.985
41	703	1693.4	100%	0.415	0.415
42	985	2175.6	100%	0.453	0.453
43	1672	4150.2	100%	0.403	0.403
48	1241	2271.9	100%	0.546	0.546
49	1610	3018.0	100%	0.533	0.533
50	948	2001.6	100%	0.474	0.473
54	1612	3262.4	100%	0.494	0.494
55	1523	3174.3	79%	0.480	0.605
56	854	3613.6	71%	0.236	0.331
				Average	0.478

E. coli analysis

Sample ID	Date	EC Concentration (MPN/dL)	Dry or Wet?
SSO	6/28/2005	8.90E+05	Dry
Wastewater Influent 2	9/8/2005	1.94E+07	Dry
Turkey Creek Influent	8/4/2004	3.23E+06	Dry
Turkey Creek Influent	8/5/2004	7.27E+06	Dry
Turkey Creek Influent	8/6/2004	7.11E+06	Dry
West District Influent	8/4/2004	7.49E+06	Dry
West District Influent	8/5/2004	1.15E+06	Dry
West District Influent	8/6/2004	9.62E+06	Dry
Turkey Creek Influent, Wet Weather	3/2/2005	1.93E+06	Wet
Turkey Creek Influent, Wet Weather	4/11/2005	6.19E+06	Wet
West District Influent, Wet Weather	3/2/2005	3.80E+06	Wet
West District Influent, Wet Weather	3/7/2005	3.41E+06	Wet
West District Influent, Wet Weather	4/11/2005	3.40E+06	Wet

Dry Influent & SSO Geometric Mean (MPN/dL): 4.70E+06
Wet Influent Geometric Mean (MPN/dL): 3.50E+06

Appendix B

On-site Sewage Facility Supporting Information

Appendix B - OSSF Supporting Information

Delivery Rate

The delivery rate was recalculated based upon the distance of the subbasin to the nearest stream. The delivery rate was determined by locating the centroid of each zip code area in the watershed and calculating the perpendicular distance to the stream. The delivery ratios were assigned based upon distance from the stream as shown in Figure 1 of Appendix B, with delivery rates doubling every 500 ft. The new delivery rates that were calculated for each subbasin are shown in Table 1 in Appendix B.

Updated Number of Failing Septic Systems

Harris County provided a database resulting from an inventory of open discharge of sewage effluent into road side ditches. This information was used to replace the estimates of OSSFs in BLEST. These data were only evaluated to determine if failing septic systems were identified in subbasins entirely covered by municipal utility districts (MUDs). Failing septics located in subbasins more than 99% covered by MUDs were excluded and assumed to have been addressed by connecting to the MUD sanitary system.

Regions outside of Harris County were calculated using the average failing septic system density, calculated as the total number of failing septic systems in the project area divided by the area of the project watershed. The calculated septic density was 7.34×10^{-5} septic systems/acre. The new failing septic system inputs are provided in Table 2 of Appendix B.

Census Data for OSSFs

Data were obtained from the 1990 U.S. Census for comparison purposes. For census tracts partially inside the watershed, the number of septic systems in the watershed was weighted by the percent of the tract in the watershed. This approach relies on the assumption that OSSFs are evenly distributed across the census tracts. The number of septic systems calculated using census data were compared to the number of OSSFs based on the November 2006 County database and the most recent June 2007 database. As shown in Table 2 of Appendix B, the number of septic systems estimated by the census data were generally higher than those estimated using both County datasets in BLEST.

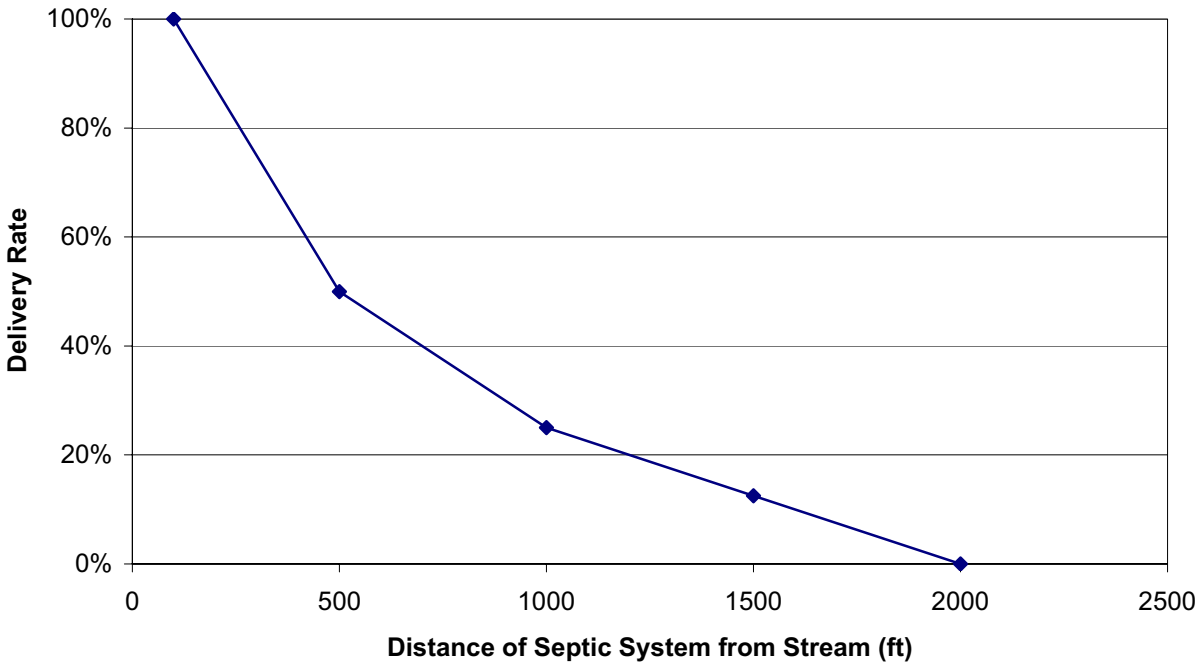


Figure 1 Delivery Rates from Septic Systems as a Function of Distance
(Declines exponentially with distance up to approximately 0.5 mile from Bayou)

Table 1 Calculated Delivery Rates By Subbasin

Subwatershed	Delivery Ratio
1	100.0%
2	41.5%
3	24.0%
4	24.1%
5	0.0%
6	0.0%
7	100.0%
8	0.0%
9	45.4%
10	48.9%
11	0.0%
12	0.7%
13	16.9%
17	10.7%
26	0.0%
27	0.0%
28	1.0%
33	0.0%
34	0.2%
35	18.2%
36	0.0%
37	0.0%
38	0.0%
39	0.0%
40	0.0%
41	0.0%
42	0.0%
43	0.0%
44	0.0%
45	0.0%
46	0.0%
47	0.0%
48	0.0%
49	0.0%
50	0.0%
51	0.0%
52	0.0%
53	0.0%
54	0.0%
55	0.1%
56	88.1%
101	0.9%
102	21.3%
103	0.0%
104	30.6%
105	50.0%
106	12.5%
107	12.5%
108	50.0%

Subwatershed	Delivery Ratio
109	0.0%
110	25.0%
111	0.0%
112	32.7%
113	19.4%
114	0.0%
115	13.5%
116	4.9%
117	12.5%
118	12.5%
119	12.5%
120	1.2%
121	5.3%
122	0.9%
123	50.0%
124	0.0%
125	0.0%
126	0.0%
127	43.7%
128	0.0%
129	0.0%
130	0.0%
131	0.0%
132	0.0%
133	49.6%
134	0.0%
135	22.2%
136	44.6%
137	12.5%
138	50.0%
139	50.0%
140	0.0%
141	0.0%
142	0.0%
143	0.0%
144	0.0%
145	0.0%
146	14.5%
147	12.5%
148	0.0%
149	50.0%
150	12.5%
151	12.5%
152	1.0%
153	0.0%
154	0.3%
155	13.0%
156	0.0%
171	0.0%

Subwatershed	Delivery Ratio
172	0.0%
173	0.0%
174	0.0%
175	0.0%
176	0.0%
177	0.0%
178	0.0%
180	0.0%
181	12.5%
182	0.0%
183	0.0%
184	0.0%
185	0.0%
186	0.0%
187	12.5%
188	24.9%

Table 2 Estimate of Septic System Totals, Flow and Loading

Sub basin	Water-shed	Number of Failing Septic Systems - Harris County Data	Number of septic systems - BLEST November 2006	Number of septic systems - 1990 Census
1	WO	2	0	169
2	WO	0	38	222
3	WO	0	1	162
4	WO	4	167	634
5	WO	0	0	198
6	WO	0	0	196
7	WO	0	1	65
8	WO	0	0	25
9	WO	0	105	641
10	WO	0	25	235
11	WO	0	0	3
12	WO	0	184	369
13	WO	0	35	636
17	WO	0	2	72
26	Buffalo	0	0	27
27	Buffalo	0	0	38
28	Buffalo	0	2	1
33	Buffalo	0	0	18
34	Buffalo	0	1	5
35	Buffalo	0.48	53	125
36	Buffalo	0	0	22
37	Buffalo	0	0	14
38	Buffalo	0	0	25
39	Buffalo	0	0	19
40	WO	0	0	25
41	WO	0	0	35
42	WO	0	0	14
43	WO	0	0	7
44	Buffalo	0	0	3
45	Buffalo	0	0	28
46	Buffalo	0	0	25
47	Buffalo	0	0	3
48	WO	0	0	52
49	WO	0	0	28
50	Buffalo	0	0	1
51	Buffalo	0	0	25
52	Buffalo	0	0	17
53	Buffalo	0	0	14
54	Buffalo	0	0	31
55	Buffalo	0	3	40
56	Buffalo	0	20	75
101	Buffalo	0	19	20
102	Buffalo	0	11	36
103	Buffalo	1	12	33
104	Buffalo	0	13	50
105	Buffalo	4	22	60
106	Buffalo	0	22	42
107	Buffalo	0	3	4
108	Buffalo	1	3	16
109	Buffalo	0	0	7
110	Buffalo	0	8	21
111	Buffalo	0	25	13
112	Buffalo	0	39	20
113	Buffalo	0	15	115
114	Buffalo	0	0	5
115	Buffalo	0	11	8
116	Buffalo	0	11	6
117	Buffalo	0	13	20
118	Buffalo	5	3	42

Sub basin	Water-shed	Number of Failing Septic Systems - Harris County Data	Number of septic systems - BLEST November 2006	Number of septic systems - 1990 Census
119	Buffalo	0	2	73
120	Buffalo	0	15	21
121	Buffalo	0	49	25
122	Buffalo	0	22	20
123	Buffalo	0	27	8
124	Buffalo	0	0	5
125	Buffalo	0	0	19
126	Buffalo	0	5	5
127	Buffalo	0	46	30
128	Buffalo	0.03	20	30
129	Buffalo	0	6	9
130	Buffalo	0	9	18
131	Buffalo	0	0	18
132	Buffalo	0.01	9	3
133	Buffalo	0.78	46	119
134	Buffalo	0.07	1	11
135	Buffalo	0.36	42	62
136	Buffalo	0.05	8	8
137	Buffalo	0.05	8	9
138	Buffalo	0.01	9	14
139	Buffalo	0.02	10	14
140	Buffalo	0.10	7	10
141	Buffalo	0.78	51	95
142	Buffalo	0.06	4	6
143	Buffalo	0.33	23	36
144	Buffalo	0.35	23	45
145	Buffalo	0.23	25	30
146	Buffalo	0	2	1
147	Buffalo	0	1	0
148	Buffalo	1	0	1
149	Buffalo	0	2	0
150	Buffalo	0	1	11
151	Buffalo	0	8	18
152	Buffalo	0.000817612	7	17
153	Buffalo	0	0	8
154	Buffalo	0.003449219	5	9
155	Buffalo	0	7	0
156	Buffalo	0.11	0	25
171	Buffalo	0.15	7	23
172	Buffalo	0.10	10	17
173	Buffalo	0.07	11	15
174	Buffalo	0.05	8	10
175	Buffalo	0.05	9	6
176	Buffalo	0.21	14	20
177	Buffalo	0.01	1	3
178	Buffalo	0.40	38	68
180	Buffalo	0	0	0
181	Buffalo	0	1	5
182	Buffalo	0	0	3
183	Buffalo	0	0	10
184	Buffalo	0	0	4
185	Buffalo	0	0	3
186	Buffalo	0	0	1
187	Buffalo	0	1	3
188	Buffalo	0	49	28

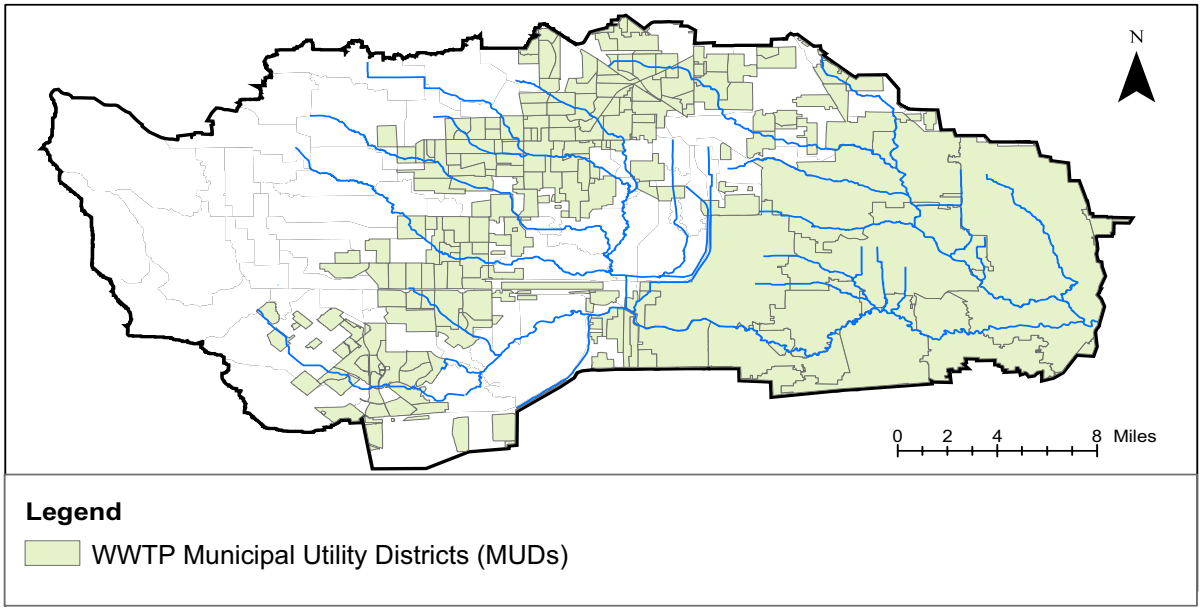


Figure 2 Location of Municipal Utility Districts (MUDs) in Buffalo and Whiteaok Bayous

Table 3 Load and Flow from Failing OSSFs

Sub watershed	EC (MPN/day)	Flow (MGD)
1	7.1E+10	3.9E-04
2	0.0E+00	0.0E+00
3	0.0E+00	0.0E+00
4	3.4E+10	1.9E-04
5	0.0E+00	0.0E+00
6	0.0E+00	0.0E+00
7	0.0E+00	0.0E+00
8	0.0E+00	0.0E+00
9	0.0E+00	0.0E+00
10	0.0E+00	0.0E+00
11	0.0E+00	0.0E+00
12	0.0E+00	0.0E+00
13	0.0E+00	0.0E+00
17	0.0E+00	0.0E+00
26	0.0E+00	0.0E+00
27	0.0E+00	0.0E+00
28	0.0E+00	0.0E+00
33	0.0E+00	0.0E+00
34	0.0E+00	0.0E+00
35	3.1E+09	1.7E-05
36	0.0E+00	0.0E+00
37	0.0E+00	0.0E+00
38	0.0E+00	0.0E+00
39	0.0E+00	0.0E+00
40	0.0E+00	0.0E+00
41	0.0E+00	0.0E+00
42	0.0E+00	0.0E+00
43	0.0E+00	0.0E+00
44	0.0E+00	0.0E+00
45	0.0E+00	0.0E+00
46	0.0E+00	0.0E+00
47	0.0E+00	0.0E+00
48	0.0E+00	0.0E+00
49	0.0E+00	0.0E+00
50	0.0E+00	0.0E+00
51	0.0E+00	0.0E+00
52	0.0E+00	0.0E+00
53	0.0E+00	0.0E+00
54	0.0E+00	0.0E+00
55	0.0E+00	0.0E+00
56	0.0E+00	0.0E+00
101	0.0E+00	0.0E+00
102	0.0E+00	0.0E+00
103	0.0E+00	0.0E+00
104	0.0E+00	0.0E+00
105	7.1E+10	3.9E-04

Sub watershed	EC (MPN/day)	Flow (MGD)
106	0.0E+00	0.0E+00
107	0.0E+00	0.0E+00
108	1.8E+10	9.8E-05
109	0.0E+00	0.0E+00
110	0.0E+00	0.0E+00
111	0.0E+00	0.0E+00
112	0.0E+00	0.0E+00
113	0.0E+00	0.0E+00
114	0.0E+00	0.0E+00
115	0.0E+00	0.0E+00
116	0.0E+00	0.0E+00
117	0.0E+00	0.0E+00
118	2.2E+10	1.2E-04
119	0.0E+00	0.0E+00
120	0.0E+00	0.0E+00
121	0.0E+00	0.0E+00
122	0.0E+00	0.0E+00
123	0.0E+00	0.0E+00
124	0.0E+00	0.0E+00
125	0.0E+00	0.0E+00
126	0.0E+00	0.0E+00
127	0.0E+00	0.0E+00
128	0.0E+00	0.0E+00
129	0.0E+00	0.0E+00
130	0.0E+00	0.0E+00
131	0.0E+00	0.0E+00
132	0.0E+00	0.0E+00
133	1.4E+10	7.5E-05
134	0.0E+00	0.0E+00
135	2.8E+09	1.6E-05
136	7.1E+08	3.9E-06
137	2.2E+08	1.2E-06
138	2.2E+08	1.2E-06
139	3.7E+08	2.0E-06
140	0.0E+00	0.0E+00
141	0.0E+00	0.0E+00
142	0.0E+00	0.0E+00
143	0.0E+00	0.0E+00
144	0.0E+00	0.0E+00
145	0.0E+00	0.0E+00
146	0.0E+00	0.0E+00
147	0.0E+00	0.0E+00
148	1.0E+10	5.7E-05
149	0.0E+00	0.0E+00
150	0.0E+00	0.0E+00
151	0.0E+00	0.0E+00

Sub watershed	EC (MPN/day)	Flow (MGD)
152	2.8E+05	1.5E-09
153	0.0E+00	0.0E+00
154	4.1E+05	2.3E-09
155	0.0E+00	0.0E+00
156	1.9E+09	1.0E-05
171	0.0E+00	0.0E+00
154	4.1E+05	2.3E-09
155	0.0E+00	0.0E+00
156	1.9E+09	1.0E-05
171	0.0E+00	0.0E+00
172	0.0E+00	0.0E+00
173	0.0E+00	0.0E+00
174	0.0E+00	0.0E+00
175	0.0E+00	0.0E+00
176	0.0E+00	0.0E+00
177	0.0E+00	0.0E+00
178	0.0E+00	0.0E+00
180	0.0E+00	0.0E+00
181	0.0E+00	0.0E+00
182	0.0E+00	0.0E+00
183	0.0E+00	0.0E+00
184	0.0E+00	0.0E+00
185	0.0E+00	0.0E+00
186	0.0E+00	0.0E+00
187	0.0E+00	0.0E+00
188	0.0E+00	0.0E+00

Appendix C

Direct Deposition

Appendix C - Direct Deposition Supporting Information

Extent of Direct Deposition Influence

Direct deposition in BLEST only accounts for loading into the bayou directly, or within a very small buffer area along the stream. Any loading deposited on the watershed will be carried via runoff to the bayou with rainfall events and accounted for in the regulated stormwater discharge portion of the load estimate.

Dog Density Calculations

The population density of dogs near the bayou was recalculated based upon a comment from Harris County (number 104) using site specific data.

The American Veterinary Medicine Association estimates approximately 0.58 dogs per household in the United States, as reported in the recently approved TMDLs for Adams and Cow Bayous in Orange County as shown in Appendix C, Table 2. An overall dog density of 0.53 dogs per acre was calculated using population data were obtained from Harris County Flood Control District for the Buffalo and Whiteoak Bayou watersheds along with 2000 US Census household sizes for Harris County.

This density was reduced by 12%, the amount of watershed that is covered by areas not suitable for recreation with dogs such as wetlands and cultivated land uses, the final value calculated for Buffalo and Whiteoak Bayous was therefore 0.41 dogs per acre.

Feral Rock Doves at Bridges

Feral rock doves were added to the direct deposition loading calculations. Pictures provided by stakeholders show the feral rock doves nesting on bridge supports over the bayou. To account for loading from rock doves, bridge locations were obtained from Harris County Flood Control District HEC-RAS models as shown in Appendix C, Figure 1. All culverts were removed from the dataset and only larger bridges with width greater than 50 ft were included in the analysis. Approximately 100 bridges were identified in the study watersheds with a width greater than 50 ft.

The bridges were the assigned by subbasin and tallied as shown in Appendix C, Table 4. It was assumed based upon photographs of feral rock dove roosting that they generally resided at the top of bridge supports. Observations regarding the bayou show that bridge piers and supports are typically located on either side of the bayou as shown in Figure 2. Although there are a few bridges where the piers are in the bayou channel itself, those types of configurations are uncommon because of their adverse impacts on water elevation.

Each bridge support was assumed to hold 20 feral rock doves, so each bridge would house an estimated 40 feral rock doves. It was also assumed that the birds would reside at the bridges 50% of the day. Although this estimate might underestimate the number of doves at any one bridge, there are numerous bridges in the watershed that do not attract any doves. The total estimated number of feral rock doves is shown in Appendix C, Table 4.

Table 1. Waterfowl Species included in BLEST

Species of waterfowl	Population Density (pairs/acre)	% Contribution
White Ibis	2.81E-05	50%
White-faced Ibis	2.15E-04	50%
Roseate Spoonbill	3.25E-05	50%
Great Blue Heron	8.27E-04	50%
Great Egret	6.08E-04	50%
Neotropic Cormorant	5.69E-05	50%
Little Blue Heron	2.94E-04	50%
Barn Swallow	2.94E-04	50%
Yellow Crowned Night Heron	2.94E-04	50%
Green Heron	2.94E-04	50%
Tricolored Heron	2.94E-04	50%
Black-crowned Night Heron	2.94E-04	50%
Yellow-crowned Night Heron	2.94E-04	50%
Black Bellied Whistling	2.94E-04	50%
Duck	2.94E-04	50%
Fulvours Whistling Duck	2.94E-04	50%
Snow Goose	2.94E-04	50%
Ross's Goos	2.94E-04	50%
Cackling Goose	2.94E-04	50%
Canada Goose	2.94E-04	50%
Wood Duck	2.94E-04	50%
Mallard	2.94E-04	50%
Mottled Duck	2.94E-04	50%
Gadwall	2.94E-04	50%
American Wigeon	2.94E-04	50%
Blue winged teal	2.94E-04	50%
cinnamon teal	2.94E-04	50%
Northern shoveler	2.94E-04	50%
Northern Pintail	2.94E-04	50%
Gree-w8inged Teal	2.94E-04	50%
Canvasback	2.94E-04	50%
Redhead	2.94E-04	50%
Ring-necked Duck	2.94E-04	50%
Lesser Scaup	2.94E-04	50%
Hooded Merganser	2.94E-04	50%
Lesser Grebe	2.94E-04	50%
Pled-billeed Grebe	2.94E-04	50%
Double-crested cormorant	2.94E-04	50%
Golden-crowned kinglet	2.94E-04	50%
Ruby-crowned kinglet	2.94E-04	50%
Blue-gray Gnatcatcher	2.94E-04	50%

Table 2. Dog density calculation

0.58	dogs per household
826,000	population of Whiteoak and Buffalo Bayou watersheds
2.79	individuals per household
325,117	area of watersheds (acre)
171,713	total dogs
0.53	dogs per acre
78%	Of the watershed suitable for dog recretation (grassland, residential, commercial land)
0.41	dog population density (dog/acre)

Table 3. Loading Rate Estimates

Animal Type	FC Rate (MPN/day)	Category	Reference
Goose	8.00E+08	Bird	Zeckoski et al (2005)
Goose	7.04E+04	Bird	Map Tech Inc (2000)
Goose	4.90E+10	Bird	US EPA (2000)
Duck	2.40E+09	Bird	Zeckoski et al (2005)
Duck	2.43E+09	Bird	US EPA (2000)
Duck	7.35E+04	Bird	Map Tech Inc (2000)
Chicken	1.36E+08	Bird	US EPA (2000)
Turkey	9.30E+07	Bird	US EPA (2000)
Dog	4.09E+09	Dog	Northern Virginia Regional Commission (2002)
Dog	9.90E+08	Dog	Map Tech Inc (2000)
Dog	4.09E+09	Dog	US EPA (2000)
Raccoon	5.90E+09	Other	Map Tech Inc (2000)
Raccoon	1.25E+08	Other	US EPA (2000)
Muskrat	1.90E+08	Other	Map Tech Inc (2000)
Deer	2.55E+09	Other	Map Tech Inc (2000)
Deer	5.00E+08	Other	US EPA (2000)
Beaver	2.50E+08	Other	US EPA (2000)
Dairy Cow	1.01E+11	Other	US EPA (2000)
Beef Cow	1.04E+11	Other	US EPA (2000)
Hog	1.08E+10	Other	US EPA (2000)
Sheep	1.20E+10	Other	US EPA (2000)
Horse	4.20E+08	Other	US EPA (2000)
Other	1.88E+08	Other	Northern Virginia Regional Commission (2002)

Values used in BLEST

	Geometric mean FC Rate (MPNday)
Bird	1.05E+08
Dog	2.55E+09
Other	2.03E+09

Table 4. Total number of feral rock doves by subbasin

Subbasin	Number of bridges	Number of Doves	Loading from Doves (MPN/day)
1	25	500	5.3E+10
2	9	180	1.9E+10
3	8	160	1.7E+10
4	31	620	6.5E+10
5	6	120	1.3E+10
6	8	160	1.7E+10
7	8	160	1.7E+10
8	0	0	0.0E+00
9	4	80	8.4E+09
10	6	120	1.3E+10
11	1	20	2.1E+09
12	0	0	0.0E+00
13	4	80	8.4E+09
17	5	100	1.1E+10
26	11	660	6.9E+10
27	6	360	3.8E+10
28	0	0	0.0E+00
33	8	480	5.0E+10
34	0	0	0.0E+00
35	4	240	2.5E+10
36	3	180	1.9E+10
37	4	240	2.5E+10
38	1	60	6.3E+09
39	4	240	2.5E+10
40	5	100	1.1E+10
41	6	120	1.3E+10
42	3	60	6.3E+09
43	5	100	1.1E+10
44	0	0	0.0E+00
45	1	60	6.3E+09
46	3	180	1.9E+10
47	13	780	8.2E+10
48	3	180	1.9E+10
49	5	300	3.2E+10
50	4	240	2.5E+10
51	0	0	0.0E+00
52	20	1200	1.3E+11
53	2	120	1.3E+10
54	2	120	1.3E+10
55	1	60	6.3E+09
56	9	540	5.7E+10
101	0	0	0.0E+00
102	0	0	0.0E+00
103	0	0	0.0E+00
104	4	80	8.4E+09
105	0	0	0.0E+00
106	0	0	0.0E+00
107	0	0	0.0E+00
108	3	60	6.3E+09

Table 4. Total number of feral rock doves by subbasin

Subbasin	Number of bridges	Number of Doves	Loading from Doves (MPN/day)
109	0	0	0.0E+00
110	4	80	8.4E+09
111	0	0	0.0E+00
112	1	20	2.1E+09
113	4	80	8.4E+09
114	3	60	6.3E+09
115	1	20	2.1E+09
116	0	0	0.0E+00
117	2	40	4.2E+09
118	1	20	2.1E+09
119	4	80	8.4E+09
120	1	20	2.1E+09
121	3	60	6.3E+09
122	0	0	0.0E+00
123	2	40	4.2E+09
124	0	0	0.0E+00
125	0	0	0.0E+00
126	1	20	2.1E+09
127	2	40	4.2E+09
128	1	20	2.1E+09
129	1	20	2.1E+09
130	0	0	0.0E+00
131	0	0	0.0E+00
132	0	0	0.0E+00
133	3	60	6.3E+09
134	2	40	4.2E+09
135	2	40	4.2E+09
136	0	0	0.0E+00
137	4	80	8.4E+09
138	3	60	6.3E+09
139	0	0	0.0E+00
140	0	0	0.0E+00
141	0	0	0.0E+00
142	0	0	0.0E+00
143	0	0	0.0E+00
144	0	0	0.0E+00
145	0	0	0.0E+00
146	0	0	0.0E+00
147	0	0	0.0E+00
148	3	60	6.3E+09
149	5	100	1.1E+10
150	4	80	8.4E+09
151	1	20	2.1E+09
152	6	120	1.3E+10
153	0	0	0.0E+00
154	0	0	0.0E+00
155	1	20	2.1E+09
156	1	20	2.1E+09
171	0	0	0.0E+00

Table 4. Total number of feral rock doves by subbasin

Subbasin	Number of bridges	Number of Doves	Loading from Doves (MPN/day)
172	2	40	4.2E+09
173	0	0	0.0E+00
174	0	0	0.0E+00
175	0	0	0.0E+00
176	0	0	0.0E+00
177	0	0	0.0E+00
178	0	0	0.0E+00
180	0	0	0.0E+00
181	2	40	4.2E+09
182	1	20	2.1E+09
183	2	40	4.2E+09
184	0	0	0.0E+00
185	1	20	2.1E+09
186	0	0	0.0E+00
187	0	0	0.0E+00
188	0	0	0.0E+00

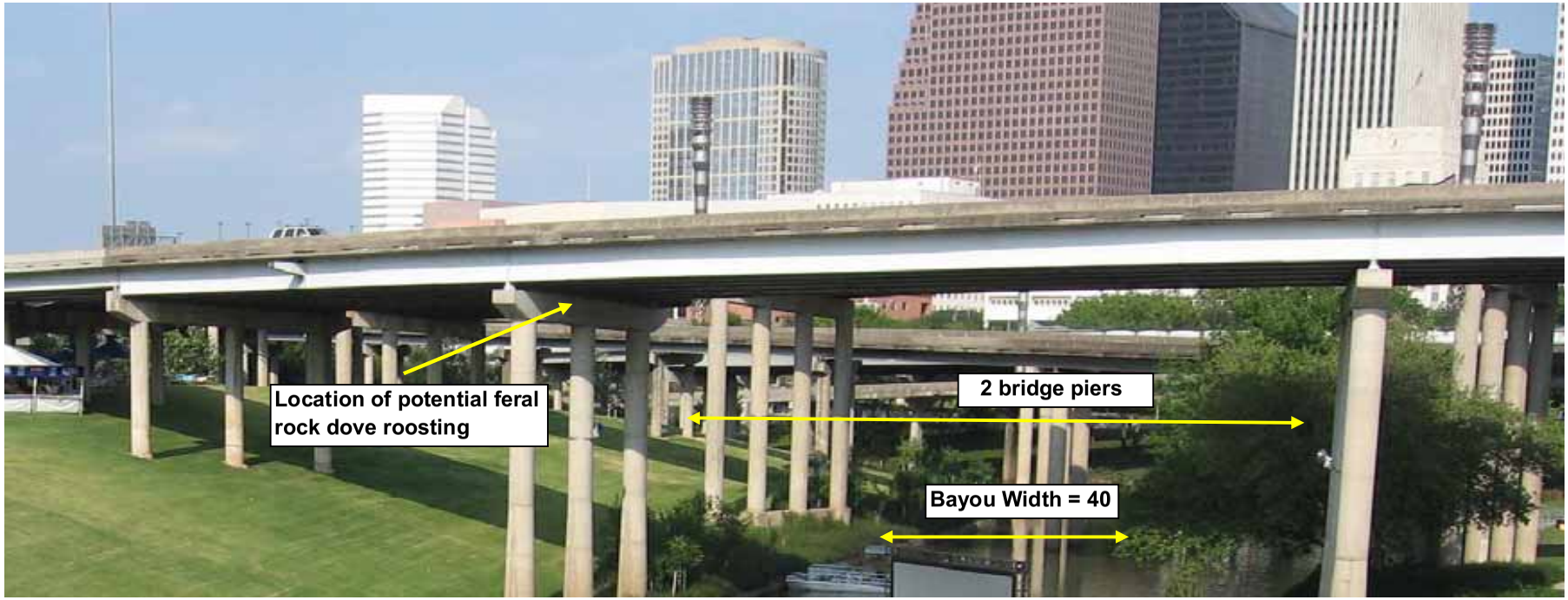
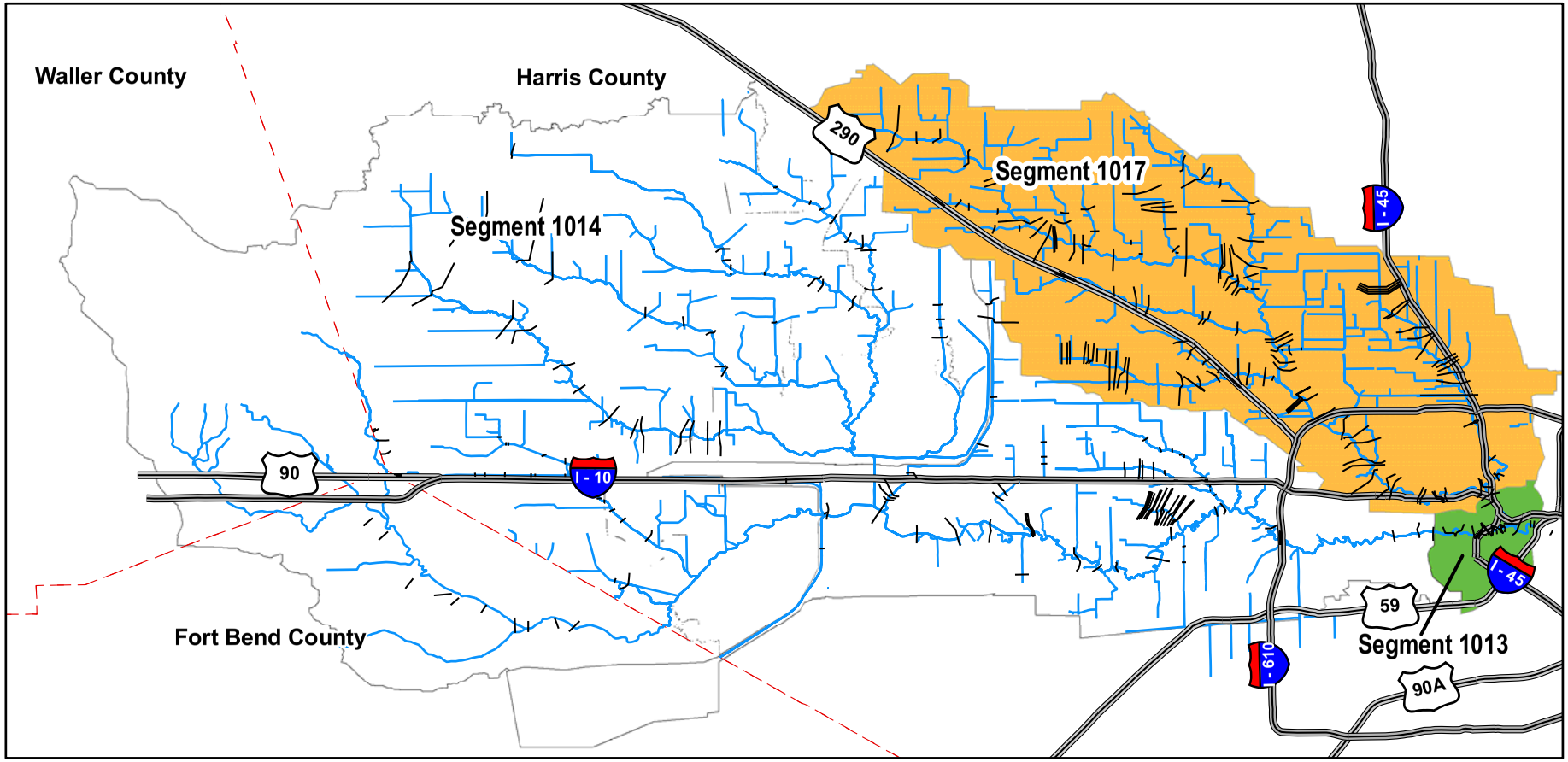


Figure 2. Illustration of Feral Rock Dove Loading Calculation using Sabine Bridge at Buffalo Bayou



Legend

County

Stream

Study Watersheds

Bridge Width

1014

1013

1017

0 3.5 7 14 Miles

Figure 1
Location of Bridges in Buffalo and Whiteoak Bayous

TEXAS PARKS & WILDLIFE

March 13, 2006

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Ron Stein
Texas Commission on Environmental Quality
Water Programs - TMDL Section (MC 203)
P.O. Box 13087
Austin, TX 78711-3087

RE: Buffalo Bayou/Whiteoak Bayou Total Maximum Daily Load (TMDL)

Dear Mr. Stein:

Thank you for the opportunity to comment on the Buffalo Bayou/Whiteoak Bayou TMDL. The Texas Parks and Wildlife Department (TPWD) is the agency with primary responsibility for protecting the state's fish and wildlife resources in Texas. In light of this role, we are concerned about water quality for fish and wildlife, as well as recreational uses of Texas water ways. In view of this, please consider the following comments on the TMDL.

TPWD staff have an ongoing interest and involvement in contact recreation issues. Staff participated several years ago in the stakeholder group charged with evaluating the appropriate use of indicator organisms in assessing whether segments were meeting their contact recreation use. Recently we have been participating in bacterial TMDL meetings around the state. One of these is the Buffalo Bayou/Whiteoak Bayou TMDL. We commend the Buffalo Bayou/Whiteoak Bayou TMDL steering committee members for their efforts over the past few years to address the difficult problems of establishing a TMDL for bacteria in these two waterbodies. A large amount of data have been collected and analyzed in support of this aim. TPWD staff believe the steering committee has done a good job in identifying many potential sources of bacterial pollution to the bayous. These include collection systems leaks, wastewater treatment plant bypasses, nonpoint source runoff from impervious surfaces, septic systems, release from sediments, pets, livestock, and wildlife. Staff have concerns about the approach taken toward wildlife as a source of bacterial load to the waterbodies. As the TMDL moves into the implementation phase, we feel the need for clarification on this issue.

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• • •

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At the steering committee meeting held on February 7, 2006, a significant portion of the meeting was set aside for a presentation by one of the TMDL contractors entitled "Wildlife in Buffalo and Whiteoak Bayous." The presentation actually contained information about possible impacts from cows, horses, dogs, not only wildlife, as pointed out by an observer at the meeting. The title of the talk is an indicator of a high level of focus on wildlife as a significant source of bacterial pollution in Buffalo and Whiteoak Bayous. The presenter put forward the speculation that as development increased in the watershed over time, wildlife inhabitating the area may have concentrated along the riparian corridors, i.e. the bayous and tributaries, and were now contributing to the bacterial loading. However, it is generally accepted by wildlife biologists that

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To manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations.

urbanization causes many species of wildlife to decline or disappear as watersheds are altered by development. Employing an assumption that pre-development wildlife populations simply move and concentrate into smaller areas as development occurs may lead to incorrect conclusions down the road, so it is important to realize that this is not a good model for current wildlife populations.

The focus on wildlife is surprising since the TMDL process has revealed many potential sources of bacteria from human sewage in this densely populated urban area. We were presented with information in previous meetings about a large volume of complaints handled by local health authorities for illegal tie-ins to the stormwater collection system, breaks in sewer lines, etc. There is clearly room for improvement in the area of keeping human waste out of the bayous.

TPWD staff believe the emphasis of this TMDL should be on controlling bacteria loads originating from human activity. The purpose of protecting human health would be better served by reducing bacteria of human origin in the waterbodies, since contact recreation criteria were based on protecting swimmers from discharges of untreated or partially treated (human) sewage. Implementation of this TMDL needs to focus on human activities which are potentially controllable, including point and nonpoint sources of human sewage, urban runoff, and agricultural activities. Another consideration is how results of bacterial source tracking are categorized, as some species might be lumped in the wildlife category which TPWD staff might not consider to be wildlife. We also wonder if some or all of the bacterial loads originating from wildlife could be considered "background" levels of bacteria in the waterbodies.

TPWD regularly participates in TMDL and other water-quality related projects around the state. While TPWD does not have authority to address human health issues, it is very important to us that water quality be protected for use by fish and wildlife and recreation. We believe it is important to have an on-going dialogue concerning this and other bacterial TMDL projects being conducted around the state, and we are committed to being involved and working toward solutions that are protective of water quality and fish, wildlife, and recreation.

Please do not hesitate to contact me at (512) 912-7095 or cindy.contreras@tpwd.state.tx.us with any questions or comments.

Sincerely,

Cindy Contreras

Cindy Contreras
Water Quality Coordinator

cc: Faith Hambleton
Jason Leifester
Pat Radloff

Appendix D

Regulated Stormwater Discharges

Table 1. Land use Categories and EMCs for Runoff Calculations

TMDL Land Use Category	JTF Land Use Category Corresponding to EMC	Fecal coliform EMC (MPN/dL)	E. coli EMC (MPN/dL)	Curve Number
Low Intensity Dev.	Single-Family Residential	63,357	39,915	92
High Intensity Dev.	Commercial	73,836	46,517	96
Cultivated	Undeveloped	44,632	28,118	84
Grassland	Undeveloped	44,632	28,118	80
Woody Land	Undeveloped	44,632	28,118	77
Woody Wetlands	Undeveloped	44,632	28,118	0
Nonwoody wetland	Undeveloped	44,632	28,118	0
Transitional	Undeveloped	44,632	28,118	94

Table 2 Definitions for dry, intermediate and wet conditions

Condition	Percentile from Flow Duration Curve	Rainfall amount (in/day) for instream flow condition	WWTP - Excess infiltration flows over dry discharges during instream intermediate flow conditions	WWTP - Biosolid flows over dry discharges during instream wet flow conditions
Dry	0-30	0	0	0
Intermediate	30-70	N/A [1]	0.25 [3]	0
Wet	70-100	0.59 [2]	0.25 [3]	0.5 [3]

[1] Intermediate instream flow condition is calculated as the sum of WWTP discharges and flow required to achieve the median flow observed in the bayou. It is independent of a defined rainfall amount.

[2] Calculated from Addicks National Weather Service Rainfall Gage as the average annual rainfall for the period from 1943 - 1999 of 44.19 in divided by the total number of rainy days where rainfall is greater than 0.01 in at that gage during that same period (74 days).

[3] The amount of rainfall that (see Figure 1 in Appendix F) is associated with incremental flows for the stated condition. Based on observed hourly flows from City of Houston WWTP plants

Table 3. Comparison of Flows Estimated Using Drainage Area Method with HSPF Flows

Segment	USGS Median Flow (MGD)	Drainage Area (acre)	Estimated Median Flow Using Drainage Area (MGD)	HSPF Value (MGD)
Res	62.3	192,726	NA	61.8
1014	NA	247,621	83.4	84.5
1013	NA	267,935	90.3	144.7
1017	32.5	57,182	32.5	33.6

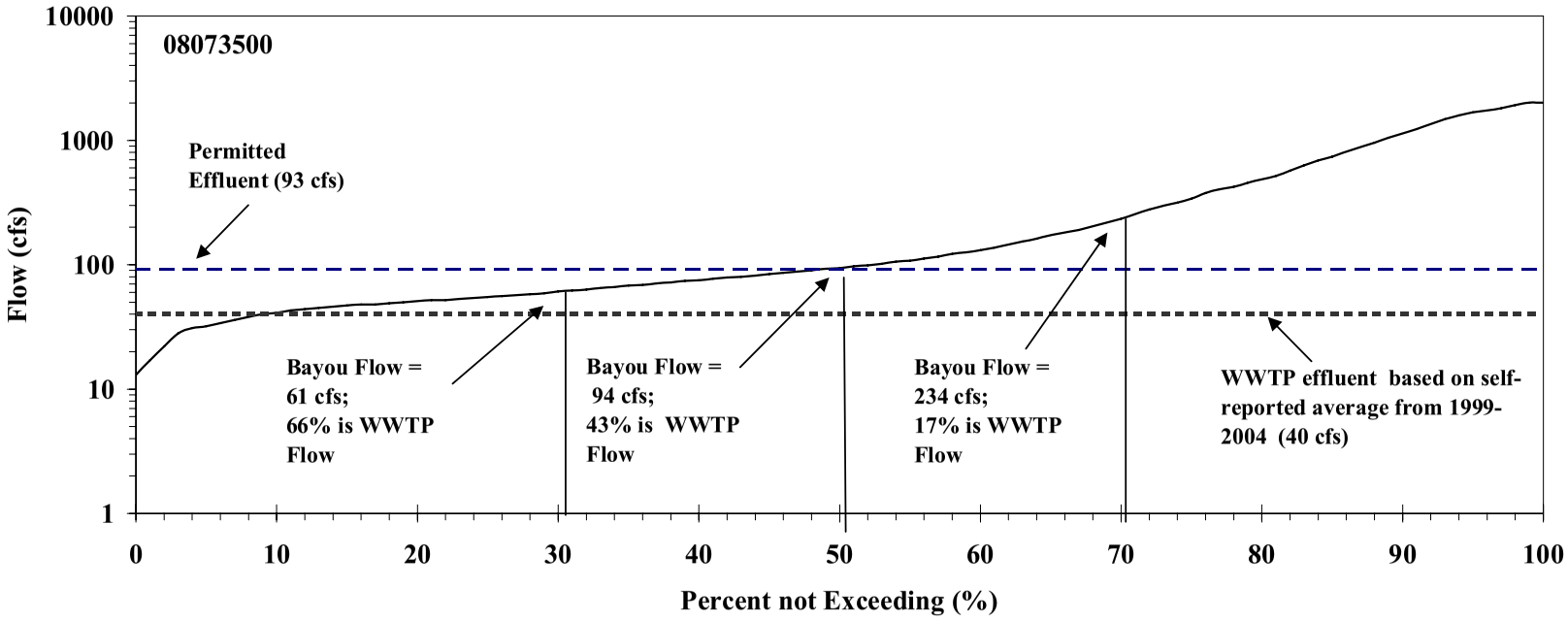


Figure 1. Flow Duration Chart of Flows since 1999 at USGS Gage 080373500 (Dairy Ashford, Mouth of Reservoirs)

Example of upstream loading from reservoirs (using November 2006 BLEST data)

	Dry	Intermediate	Wet	Variable	Source
Upstream flow from Mouth of Watersheds Draining Reservoirs (MGD)	20.62	66.04	488.00	[1]	sum of all sources in reservoir watersheds
TMDL Target Load from Mouth of Watersheds Draining Reservoirs (MPN/day)	93.44	299.23	2,211.19	[2]	sum of all sources in reservoir watersheds
Flow from all sources in Segment 1014 (MGD)	18.62	20.04	353.24	[3]	sum of all sources in segment 1014 watersheds
Loading from all sources in Segment 1014 (MPN/dL)	810.76	1,627.43	544,051.77	[4]	sum of all sources in segment 1014 watersheds
Final Flow for Segment 1014 (MGD)	39.24	86.08	841.24	[5]	[1] + [3]
Final Load for Segment 1014 (MPN/day)	904.20	1,926.66	546,262.96	[6]	[2] + [4]

Appendix E

Bed Sediment Resuspension Supporting Information

Appendix E – Bed Sediment Calculations

Bed sediment resuspension was recalculated for BLEST using a combination of calibrated literature rates and observed data. Based on work conducted by Hjulstrom in 1935, typical velocities that cause stream bed erosion exceed 2.95 ft/s for clay-sized (d < 0.004 mm) particles (Yang 2003). Although velocities are not measured on a regular basis in streams, the USGS reports velocities measured to develop stage-discharge relationships for flow. These velocities measured by the USGS from 1990 to present (with the exception of USGS 08074020, where data from 2001 to present were used because prior data were unreliable) were obtained for Buffalo and Whiteoak Bayous and used to estimate flows that occur near resuspension velocities and are presented in Table 1. This approach is intended to give an approximate rate of flow, as flow and velocity are not related in a one-to-one fashion.

Resuspension flows were calculated as the median of the four values closest to 2.95 ft/s as shown in Table 1. The median of several values was used because velocity measurements, especially those collected under high flow condition, are often inexact. Flows in Buffalo Bayou suitable for sediment resuspension ranged between 86 MGD in the upper watershed and 1964 MGD in the lower watershed. In Whiteoak Bayou, flows suitable for resuspension were 406 MGD in upper Whiteoak and 34 MGD in the lower, concrete-lined portion. The flow suitable for resuspension in lower Whiteoak Bayou is very close to the median flow.

Plots of the flows are shown in Figure 1 and demonstrate that in Buffalo Bayou, periods of flows that exceed the resuspension flow were rare, typically less than 15% of the time. In Whiteoak Bayou, the concrete lined channel where the USGS gage is located typically has flows with high velocities.

Comparisons were made with flows recorded on rainy days (i.e., rainfall > 0.01 in). The rainfall recorded by the National Climactic Data Center at the Addicks gage were used for this analysis. The number of days where resuspension occurs on rainy days is shown in Table 2. Because flows in the concrete lined portion of Whiteoak Bayou exceed the resuspension flow more than 50% of the time, sedimentation would not be expected and thus resuspension of sediment should be negligible.

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072300	216	6/20/2005 16:20	0.1	2.26
08072300	214	4/20/2005 10:22	0.23	3.32
08072300	198	3/13/2003 9:35	0.31	8.17
08072300	202	10/3/2003 11:19	0.32	2.71
08072300	144	1/21/1994 12:30	0.33	2.79
08072300	137	2/8/1993 15:45	0.35	8.04
08072300	195	8/29/2002 10:35	0.35	2.3
08072300	117	12/21/1990 9:33	0.38	1.73
08072300	149	9/23/1994 10:54	0.38	3.24
08072300	191	2/26/2002 12:08	0.38	1.97
08072300	221	7/18/2006 14:39	0.38	5.84
08072300	173	11/30/1999 12:48	0.39	1.74
08072300	175	2/29/2000 13:25	0.39	2.67
08072300	150	11/21/1994 11:45	0.4	3.58
08072300	154	10/11/1995 10:15	0.4	2.54
08072300	165	1/26/1998 13:00	0.4	8.95
08072300	189	11/14/2001 9:50	0.4	2.71
08072300	193	5/28/2002 11:05	0.4	2.54
08072300	203	11/25/2003 10:35	0.4	11.4
08072300	174	1/10/2000 11:25	0.42	2.91
08072300	185	5/2/2001 10:10	0.42	2.59
08072300	208	8/2/2004 10:40	0.44	8.96
08072300	115	8/29/1990 10:25	0.45	1.53
08072300	148	8/23/1994 13:20	0.5	4.09
08072300	172	10/4/1999 10:55	0.5	5.42
08072300	111	2/28/1990 10:40	0.52	4.54
08072300	141	8/24/1993 8:00	0.53	6.9
08072300	164	12/17/1997 12:50	0.57	15.1
08072300	136	12/19/1992 12:15	0.58	30.9
08072300	209	10/14/2004 11:50	0.59	21.9
08072300	145	3/14/1994 12:05	0.6	18.9
08072300	186	6/21/2001 10:35	0.65	2.27
08072300	120	3/27/1991 16:40	0.66	2.84
08072300	179	9/6/2000 11:15	0.67	2.25
08072300	129	6/15/1992 13:08	0.68	16.9
08072300	152	6/19/1995 10:10	0.68	6.34
08072300	156	3/12/1996 9:20	0.68	1.87
08072300	178	5/31/2000 10:10	0.68	3.43
08072300	123	8/29/1991 10:54	0.71	7.1
08072300	166	5/6/1998 13:20	0.71	2.42
08072300	190	1/8/2002 10:00	0.71	6.41
08072300	167	10/14/1998 9:45	0.72	34.4
08072300	110	1/10/1990 13:00	0.73	6.18
08072300	200	6/17/2003 11:02	0.81	20.5
08072300	124	10/16/1991 13:50	0.83	3.18
08072300	199	5/5/2003 10:00	0.84	2.68

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072300	217	7/26/2005 17:13	0.84	16.5
08072300	170	7/1/1999 10:55	0.87	5.02
08072300	146	4/22/1994 13:45	0.9	3.85
08072300	205	3/11/2004 12:50	0.91	9.96
08072300	197	1/21/2003 11:35	0.93	20.9
08072300	215	5/23/2005 11:05	0.95	2.86
08072300	219	1/24/2006 10:25	0.96	7.46
08072300	127	3/11/1992 10:39	0.97	23.9
08072300	113	6/14/1990 10:20	0.99	5
08072300	169	3/24/1999 12:30	0.99	7.49
08072300	134	9/16/1992 11:25	1	5.21
08072300	181	12/15/2000 9:35	1	4.79
08072300	220	4/11/2006 9:56	1.03	2.36
08072300	158	7/23/1996 11:21	1.05	7.65
08072300	201	8/11/2003 11:05	1.08	3.9
08072300	139	5/17/1993 15:40	1.1	7.9
08072300	218	10/13/2005 14:03	1.11	4.37
08072300	112	4/30/1990 10:05	1.12	22.6
08072300	171	8/18/1999 9:50	1.13	3.53
08072300	168	11/30/1998 11:55	1.14	11.6
08072300	119	2/14/1991 11:43	1.18	6.44
08072300	204	1/22/2004 13:40	1.18	22.8
08072300	147	6/14/1994 10:10	1.19	10.2
08072300	151	4/10/1995 11:50	1.19	22.8
08072300	160	12/9/1996 13:53	1.21	3.71
08072300	155	11/27/1995 11:13	1.24	3.06
08072300	194	7/22/2002 10:00	1.28	19
08072300	153	8/23/1995 11:05	1.32	14.5
08072300	116	10/31/1990 9:52	1.36	17.7
08072300	135	11/10/1992 11:07	1.36	11.2
08072300	162	7/10/1997 11:10	1.4	4.24
08072300	157	6/13/1996 11:00	1.41	1.86
08072300	159	11/5/1996 8:18	1.52	6.03
08072300	180	10/10/2000 11:05	1.6	8.29
08072300	138	3/29/1993 12:55	1.69	16
08072300	213	3/4/2005 9:07	1.73	187
08072300	122	7/9/1991 12:31	1.76	22
08072300	130	7/29/1992 16:29	1.77	10.9
08072300	140	6/30/1993 14:50	1.8	100
08072300	163	8/26/1997 9:55	1.8	6.11
08072300	114	8/1/1990 9:55	1.81	13
08072300	125	1/8/1992 9:52	1.87	84.7
08072300	188	10/11/2001 9:40	1.88	23
08072300	212	3/4/2005 8:54	1.94	174
08072300	121	5/20/1991 11:35	1.96	40.9
08072300	207	7/1/2004 10:07	2	200

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072300	161	2/14/1997 9:13	2.19	146
08072300	184	3/20/2001 9:30	2.2	28.2
08072300	187	8/8/2001 9:22	2.28	38
08072300	143	12/6/1993 15:07	2.3	61.1
08072300	206	4/27/2004 10:45	2.36	278
08072300	128	4/21/1992 12:15	2.49	197
08072300	192	4/9/2002 11:10	2.73	393
08072300	176	4/12/2000 11:42	2.86	535
08072300	183	1/19/2001 12:45	2.92	497
08072300	182	1/19/2001 10:20	2.96	522
08072300	177	4/12/2000 12:30	3.02	501
08072300	133	8/13/1992 14:48	3.92	443
08072300	142	10/13/1993 16:50	3.99	278
08072300	132	8/13/1992 12:52	4.04	546
08072300	118	1/18/1991 18:10	4.09	1590
08072300	131	8/13/1992 9:53	4.24	908
08072300	126	2/4/1992 10:10	4.41	1390
08072300	211	11/24/2004 10:55	4.85	1810
08072300	210	11/23/2004 12:31	5.01	2250
08072300	196	11/4/2002 13:30	5.24	2330
08072730	132	3/29/1991 14:30	0.02	0.22
08072730	125	8/28/1990 10:45	0.08	0.004
08072730	136	10/16/1991 16:55	0.1	0.06
08072730	192	1/13/2000 11:05	0.1	0.62
08072730	120	1/11/1990 10:09	0.11	0.81
08072730	131	2/14/1991 14:48	0.11	6.57
08072730	190	10/5/1999 10:00	0.12	0.54
08072730	126	11/2/1990 8:41	0.13	0.348
08072730	193	2/28/2000 11:35	0.13	0.81
08072730	191	11/22/1999 10:30	0.14	0.52
08072730	183	9/3/1998 11:25	0.15	1.38
08072730	231	6/20/2005 15:00	0.16	1.97
08072730	238	7/17/2006 15:28	0.17	3.12
08072730	237	5/22/2006 13:48	0.19	2.23
08072730	208	5/22/2002 13:15	0.21	0.69
08072730	175	12/12/1996 9:40	0.22	0.513
08072730	218	8/11/2003 11:35	0.24	3.19
08072730	144	9/16/1992 15:00	0.26	1.52
08072730	189	8/16/1999 11:40	0.26	2.28
08072730	142	6/16/1992 13:45	0.27	1.14
08072730	232	8/8/2005 13:59	0.27	2.18
08072730	127	12/21/1990 12:45	0.28	0.08
08072730	174	10/28/1996 11:00	0.28	0.74
08072730	171	7/18/1996 9:45	0.3	0.59
08072730	167	11/27/1995 13:10	0.32	0.48
08072730	123	6/13/1990 11:30	0.34	0.11

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072730	137	1/9/1992 10:28	0.35	90.9
08072730	235	1/11/2006 12:45	0.35	1.96
08072730	236	4/12/2006 11:28	0.35	1.76
08072730	135	8/29/1991 14:50	0.36	0.22
08072730	196	9/6/2000 14:20	0.38	0.64
08072730	138	1/28/1992 13:14	0.39	103
08072730	204	11/9/2001 11:58	0.39	1.04
08072730	221	1/7/2004 17:22	0.39	1.21
08072730	121	3/9/1990 11:48	0.4	1.52
08072730	202	8/8/2001 11:30	0.42	2.54
08072730	197	10/17/2000 8:52	0.43	1.46
08072730	217	7/16/2003 11:22	0.44	5.63
08072730	230	4/20/2005 14:45	0.44	1.4
08072730	164	7/10/1995 9:50	0.47	0.64
08072730	177	3/13/1997 10:25	0.47	113
08072730	151	8/24/1993 11:43	0.49	0.67
08072730	158	7/21/1994 13:50	0.49	1.24
08072730	172	7/29/1996 9:25	0.49	1.86
08072730	233	10/14/2005 8:22	0.52	2.58
08072730	133	5/22/1991 12:17	0.53	4.85
08072730	124	8/1/1990 12:35	0.54	5.64
08072730	145	11/9/1992 15:45	0.54	0.42
08072730	186	10/26/1998 12:55	0.54	144
08072730	194	4/11/2000 11:00	0.56	0.82
08072730	163	5/15/1995 14:15	0.59	0.72
08072730	168	1/16/1996 11:55	0.6	0.52
08072730	156	4/22/1994 16:45	0.61	0.25
08072730	173	10/4/1996 7:36	0.62	2.71
08072730	195	7/12/2000 14:20	0.63	0.65
08072730	134	7/10/1991 13:15	0.64	5.84
08072730	159	9/7/1994 9:35	0.64	0.45
08072730	179	7/1/1997 12:55	0.64	0.67
08072730	153	12/3/1993 14:40	0.65	0.28
08072730	170	4/30/1996 12:25	0.65	0.947
08072730	206	2/27/2002 12:10	0.65	1.16
08072730	211	10/17/2002 13:05	0.66	0.73
08072730	162	3/29/1995 11:14	0.68	2.08
08072730	169	3/6/1996 13:20	0.68	0.46
08072730	160	10/31/1994 13:55	0.69	35.5
08072730	223	3/12/2004 11:05	0.71	1.42
08072730	213	12/23/2002 9:30	0.72	2.79
08072730	220	11/19/2003 11:20	0.72	149
08072730	188	5/19/1999 14:05	0.74	1.66
08072730	199	1/29/2001 11:05	0.74	139
08072730	214	1/10/2003 12:32	0.75	3.21
08072730	198	12/13/2000 11:18	0.76	1.1

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072730	201	5/2/2001 14:00	0.76	0.64
08072730	205	1/11/2002 13:00	0.76	1.33
08072730	157	6/10/1994 13:40	0.77	0.59
08072730	224	6/24/2004 17:12	0.78	464
08072730	146	12/21/1992 8:55	0.79	14
08072730	147	2/8/1993 13:54	0.8	0.93
08072730	229	3/2/2005 10:33	0.81	23.8
08072730	182	3/24/1998 14:05	0.82	1.06
08072730	210	9/6/2002 12:56	0.83	1.02
08072730	225	8/4/2004 10:00	0.83	1.51
08072730	143	7/30/1992 14:52	0.86	4.35
08072730	215	3/12/2003 10:50	0.86	4.62
08072730	148	3/30/1993 14:15	0.87	5.02
08072730	178	5/20/1997 10:55	0.87	1.22
08072730	219	10/2/2003 11:10	0.88	1.25
08072730	226	10/15/2004 13:25	0.88	1.7
08072730	154	1/20/1994 13:20	0.89	0.39
08072730	166	10/11/1995 14:00	0.94	0.38
08072730	139	3/11/1992 13:34	0.95	14.2
08072730	228	1/5/2005 12:45	0.95	3.8
08072730	234	12/15/2005 16:55	0.96	53.6
08072730	187	12/3/1998 14:15	0.98	3.89
08072730	200	3/21/2001 10:35	0.98	7.26
08072730	176	2/5/1997 10:40	0.99	1.17
08072730	216	6/23/2003 13:41	1	0.08
08072730	185	10/21/1998 12:33	1.02	1350
08072730	140	4/22/1992 11:10	1.04	21.6
08072730	184	10/14/1998 13:15	1.07	2.19
08072730	180	10/23/1997 9:35	1.1	11.4
08072730	181	1/28/1998 10:10	1.15	4.56
08072730	207	4/8/2002 12:50	1.2	471
08072730	212	11/7/2002 12:02	1.21	348
08072730	149	5/18/1993 18:55	1.23	3.9
08072730	155	3/4/1994 13:45	1.27	2.25
08072730	122	5/1/1990 11:49	1.29	12.4
08072730	165	8/29/1995 11:35	1.33	2.19
08072730	222	1/21/2004 14:20	1.33	19.8
08072730	161	2/3/1995 11:10	1.42	8.64
08072730	129	1/15/1991 16:25	1.48	225
08072730	209	7/17/2002 11:15	1.52	10.5
08072730	203	10/11/2001 13:30	1.73	1260
08072730	227	11/23/2004 9:08	1.73	1020
08072730	128	1/11/1991 11:39	1.85	62.5
08072730	152	10/13/1993 11:55	1.92	64.2
08072730	130	1/17/1991 13:10	2.56	64.4
08072730	150	6/30/1993 11:50	3.17	73.9

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072730	141	6/8/1992 14:13	3.26	127
08072760	93	1/11/1990 12:15	0.21	1.89
08072760	156	5/26/2006 11:28	0.25	5.63
08072760	111	8/23/1993 12:45	0.27	3.58
08072760	110	3/30/1993 12:15	0.3	4.57
08072760	137	8/11/2003 13:50	0.3	5.59
08072760	129	7/23/2002 13:00	0.31	2.41
08072760	136	7/16/2003 9:33	0.32	8.58
08072760	157	7/19/2006 15:54	0.32	8.89
08072760	94	3/16/1990 11:05	0.39	2.09
08072760	143	3/12/2004 13:50	0.39	3.4
08072760	130	9/6/2002 11:39	0.4	2.94
08072760	124	12/14/2001 10:45	0.48	90.2
08072760	152	8/8/2005 12:07	0.49	4.31
08072760	98	3/28/1991 10:55	0.52	0.91
08072760	96	6/15/1990 10:00	0.56	2.41
08072760	114	4/26/1994 16:00	0.56	2.34
08072760	153	10/25/2005 14:42	0.56	4.25
08072760	112	1/20/1994 11:25	0.57	1.7
08072760	100	8/29/1991 16:30	0.58	1.2
08072760	155	4/11/2006 12:35	0.58	3.37
08072760	123	12/12/2001 9:25	0.59	135
08072760	121	6/12/2001 8:42	0.6	222
08072760	131	10/17/2002 10:40	0.6	2.97
08072760	133	1/13/2003 11:30	0.6	90.7
08072760	138	8/26/2003 10:58	0.63	3.78
08072760	144	4/12/2004 10:45	0.63	185
08072760	128	5/22/2002 9:50	0.65	2.03
08072760	139	9/12/2003 13:00	0.66	219
08072760	151	6/20/2005 13:42	0.67	3.47
08072760	147	10/15/2004 10:50	0.71	4.06
08072760	154	1/11/2006 10:19	0.73	4.52
08072760	135	5/2/2003 9:25	0.76	3.19
08072760	132	1/10/2003 8:24	0.77	2.86
08072760	146	7/23/2004 11:54	0.77	3.65
08072760	145	5/14/2004 13:20	0.78	384
08072760	149	3/2/2005 9:28	0.78	17.5
08072760	99	7/10/1991 10:59	0.86	16.2
08072760	107	9/18/1992 14:00	0.91	8.29
08072760	122	11/9/2001 9:53	0.91	2.56
08072760	148	1/5/2005 10:55	0.91	3.84
08072760	141	12/1/2003 12:30	0.93	3.35
08072760	134	3/11/2003 10:10	1	4.46
08072760	117	10/6/1998 10:55	1.01	177
08072760	103	3/10/1992 14:08	1.03	19
08072760	125	1/11/2002 10:40	1.04	2.69

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08072760	126	2/27/2002 9:50	1.08	2.57
08072760	97	2/19/1991 12:05	1.09	16.3
08072760	150	5/11/2005 9:55	1.09	9.6
08072760	101	10/17/1991 13:23	1.1	5.5
08072760	120	3/28/2001 13:15	1.14	467
08072760	104	4/20/1992 13:02	1.22	91.1
08072760	127	4/8/2002 10:30	1.28	608
08072760	95	4/30/1990 13:01	1.32	57.3
08072760	105	5/28/1992 12:30	1.32	64.2
08072760	142	1/22/2004 10:10	1.6	13.6
08072760	106	7/24/1992 9:53	1.71	28.7
08072760	115	11/1/1994 9:20	1.77	15.9
08072760	102	1/29/1992 11:42	1.88	48.4
08072760	116	3/13/1997 8:53	1.88	225
08072760	109	1/7/1993 16:28	1.94	217
08072760	118	10/22/1998 12:36	1.97	491
08072760	108	12/15/1992 15:30	2.22	293
08072760	113	2/22/1994 18:45	2.55	425
08072760	119	11/13/1998 10:06	2.84	1210
08072760	140	11/17/2003 14:30	3.38	3410
08073500	606	11/24/1992 11:10	0.65	89.1
08073500	596	7/11/1991 10:52	0.8	101
08073500	660	4/26/2002 10:32	0.83	18.9
08073500	630	6/13/1996 8:35	0.86	28.8
08073500	614	12/8/1993 9:30	0.92	117
08073500	639	4/21/1999 11:25	0.92	16.8
08073500	617	4/28/1994 8:35	0.93	46.3
08073500	628	11/29/1995 10:50	0.94	31.4
08073500	594	4/3/1991 14:37	0.98	10.3
08073500	642	10/5/1999 12:30	1	46
08073500	645	3/1/2000 13:15	1.05	44.6
08073500	619	7/26/1994 10:00	1.11	41.5
08073500	620	9/7/1994 12:25	1.13	40.6
08073500	605	10/6/1992 10:15	1.15	29.9
08073500	643	11/29/1999 11:20	1.15	49.4
08073500	637	4/1/1998 13:05	1.16	48.4
08073500	653	5/1/2001 10:20	1.16	55.6
08073500	602	5/12/1992 10:10	1.17	42.4
08073500	650	12/19/2000 9:50	1.19	53.7
08073500	634	9/3/1997 10:20	1.21	49.1
08073500	649	10/16/2000 10:02	1.22	51.6
08073500	680	6/24/2005 11:52	1.22	61.2
08073500	684	4/13/2006 11:26	1.22	56.6
08073500	591	11/5/1990 9:47	1.23	189
08073500	612	9/7/1993 13:30	1.23	42.1
08073500	644	1/11/2000 10:10	1.27	65.8

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08073500	657	11/14/2001 12:55	1.32	48.1
08073500	590	9/21/1990 12:40	1.33	48.2
08073500	627	10/10/1995 12:20	1.34	41.1
08073500	598	10/22/1991 13:24	1.36	33.2
08073500	632	12/11/1996 12:45	1.36	36.5
08073500	666	5/7/2003 12:50	1.36	59.1
08073500	662	9/5/2002 11:00	1.39	59
08073500	654	7/3/2001 9:20	1.4	50.7
08073500	592	12/18/1990 9:35	1.42	55.1
08073500	615	1/19/1994 11:55	1.42	47.9
08073500	647	7/12/2000 8:55	1.42	45
08073500	585	1/22/1990 9:55	1.44	44.7
08073500	659	2/26/2002 9:15	1.44	59.8
08073500	667	6/30/2003 11:22	1.44	71.3
08073500	675	8/16/2004 10:45	1.48	67
08073500	636	1/29/1998 10:10	1.55	82.4
08073500	672	6/3/2004 10:16	1.57	68.1
08073500	655	8/6/2001 11:27	1.58	66.5
08073500	658	1/10/2002 11:25	1.6	81.5
08073500	587	4/19/1990 10:20	1.61	296
08073500	597	9/3/1991 11:47	1.61	266
08073500	641	8/3/1999 9:30	1.61	55.7
08073500	665	3/18/2003 9:40	1.63	84.1
08073500	626	8/22/1995 13:00	1.65	57.2
08073500	616	3/15/1994 8:15	1.67	460
08073500	623	4/3/1995 10:45	1.69	91.9
08073500	670	3/10/2004 12:45	1.7	85.7
08073500	622	2/9/1995 9:40	1.73	68.1
08073500	603	7/1/1992 7:40	1.75	461
08073500	611	8/3/1993 12:00	1.75	63.7
08073500	601	3/4/1992 19:40	1.82	4410
08073500	586	3/9/1990 9:40	1.85	72
08073500	652	3/26/2001 11:05	1.87	92.6
08073500	610	6/7/1993 14:10	1.91	96.8
08073500	604	8/18/1992 10:06	1.97	669
08073500	629	3/6/1996 10:12	1.99	42.6
08073500	631	10/29/1996 12:46	2.02	53.6
08073500	608	3/2/1993 10:54	2.06	804
08073500	664	12/30/2002 11:30	2.07	102
08073500	607	1/13/1993 10:37	2.23	1250
08073500	609	4/19/1993 12:55	2.24	1210
08073500	613	10/15/1993 9:40	2.24	885
08073500	588	6/11/1990 9:50	2.29	56.7
08073500	648	9/1/2000 10:10	2.37	41.2
08073500	599	1/6/1992 12:53	2.44	1450
08073500	589	7/24/1990 9:20	2.47	94

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08073500	600	1/30/1992 11:20	2.52	1630
08073500	682	10/26/2005 14:41	2.53	63.5
08073500	593	2/15/1991 10:50	2.54	1350
08073500	618	6/14/1994 14:00	2.58	230
08073500	668	8/11/2003 9:14	2.67	197
08073500	621	11/2/1994 9:15	2.76	1800
08073500	676	10/13/2004 14:05	2.78	66
08073500	663	11/14/2002 12:15	2.99	2090
08073500	635	10/27/1997 12:50	3.02	1210
08073500	633	3/19/1997 10:37	3.04	472
08073500	673	7/6/2004 10:10	3.1	2050
08073500	638	3/23/1999 12:35	3.12	1350
08073500	669	11/21/2003 12:30	3.12	1940
08073500	646	5/23/2000 9:42	3.13	1730
08073500	677	11/4/2004 9:34	3.13	1780
08073500	686	6/26/2006 12:33	3.23	1670
08073500	625	7/11/1995 10:00	3.24	353
08073500	640	6/30/1999 9:00	3.34	627
08073500	678	2/14/2005 10:32	3.46	2120
08073500	595	5/28/1991 15:00	3.48	1380
08073500	671	4/13/2004 13:30	3.5	1790
08073500	683	1/23/2006 11:38	3.53	563
08073500	685	5/24/2006 11:04	3.59	118
08073500	681	8/9/2005 10:55	3.62	536
08073500	661	7/18/2002 12:30	3.64	725
08073500	656	10/10/2001 13:10	3.73	347
08073500	679	5/10/2005 10:14	3.75	1860
08073500	651	1/23/2001 9:30	3.79	425
08073500	624	5/17/1995 13:55	4.13	227
08073500	674	7/30/2004 10:50	4.94	205
08074500	753	1996-01-10 11:12	0.40	35.3
08074500	758	1997-11-25 09:05	1.66	37.8
08074500	733	1990-07-26 08:39	2.03	30.0
08074500	734	1990-10-30 08:54	2.06	26.6
08074500	737	1991-06-03 12:15	2.11	37.1
08074500	732	1990-04-24 13:05	2.18	39.3
08074500	797	2006-04-12 08:47	2.18	27.5
08074500	763	1999-09-07 08:27	2.29	35.1
08074500	764	1999-11-03 14:03	2.29	34.8
08074500	731	1990-01-23 08:38	2.30	32.9
08074500	760	1999-02-11 08:55	2.33	40.6
08074500	765	1999-12-30 08:26	2.34	33.4
08074500	741	1992-07-06 12:00	2.40	38.1
08074500	745	1993-08-13 11:20	2.40	36.0
08074500	746	1993-10-12 12:25	2.54	34.8
08074500	768	2000-07-10 09:40	2.55	32.6

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08074500	761	1999-05-17 12:54	2.56	50.2
08074500	757	1997-02-04 15:55	2.58	44.1
08074500	756	1996-10-21 12:55	2.60	36.4
08074500	773	2001-04-30 10:50	2.60	42.9
08074500	754	1996-04-08 14:18	2.61	38.4
08074500	755	1996-09-11 13:15	2.61	38.4
08074500	780	2002-05-24 09:35	2.61	30.5
08074500	748	1994-04-21 14:40	2.62	40.7
08074500	752	1995-06-26 13:40	2.62	39.1
08074500	749	1994-07-25 10:52	2.63	36.0
08074500	774	2001-08-06 09:42	2.64	34.3
08074500	778	2002-02-25 08:52	2.66	47.0
08074500	744	1993-04-21 14:20	2.67	50.4
08074500	783	2003-06-13 08:50	2.68	32.7
08074500	769	2000-09-05 08:41	2.70	32.1
08074500	747	1994-01-18 12:45	2.79	40.6
08074500	801	2006-09-06 12:34	2.81	40.0
08074500	742	1992-10-05 12:23	2.84	37.8
08074500	736	1991-02-25 12:44	2.85	55.3
08074500	766	2000-02-24 13:30	2.89	67.1
08074500	793	2005-06-20 10:30	2.90	52.4
08074500	770	2000-12-08 11:42	2.96	40.5
08074500	750	1994-11-01 12:10	3.01	46.1
08074500	771	2001-02-02 09:10	3.04	47.4
08074500	802	2006-11-15 10:44	3.04	43.7
08074500	796	2005-10-25 09:56	3.05	36.0
08074500	739	1992-01-10 10:27	3.06	121
08074500	799	2006-05-18 13:44	3.06	40.2
08074500	762	1999-07-06 12:00	3.08	67.8
08074500	789	2004-09-17 12:00	3.13	47.0
08074500	772	2001-03-19 11:05	3.14	60.0
08074500	775	2001-10-10 09:10	3.14	49.3
08074500	806	2007-05-21 10:12	3.17	52.1
08074500	743	1993-01-13 15:48	3.20	60.4
08074500	740	1992-03-13 10:10	3.24	65.2
08074500	803	2007-01-09 11:03	3.24	54.7
08074500	782	2003-02-18 10:50	3.26	54.1
08074500	784	2003-08-13 08:45	3.39	66.2
08074500	777	2002-01-10 09:28	3.44	53.0
08074500	786	2004-01-21 10:40	3.45	56.9
08074500	785	2003-10-08 09:54	3.53	72.1
08074500	759	1998-09-09 09:15	3.74	70.0
08074500	751	1995-04-20 11:27	3.98	68.4
08074500	804	2007-03-27 11:27	4.00	231
08074500	790	2004-12-09 11:02	4.40	78.0
08074500	791	2005-03-01 10:02	4.74	97.1

Table 1. Field measurements taken by USGS from 1990 to present
(refer to Figure 2 for locations)

Gage ID	Number	Date	Mean Vel (ft/s)	Stream Q cfs
08074500	798	2006-05-05 10:25	4.79	308
08074500	788	2004-07-26 10:10	4.88	165
08074500	805	2007-03-27 13:39	5.23	229
08074500	792	2005-05-09 09:41	6.11	1010
08074500	776	2001-12-12 08:05	6.69	3290
08074500	779	2002-04-08 10:10	6.82	9610
08074500	794	2005-07-14 17:34	6.84	1760
08074500	787	2004-06-23 08:48	7.17	1760
08074500	738	1991-09-06 11:45	7.50	1200
08074500	767	2000-04-03 08:30	7.68	1950
08074500	800	2006-06-19 12:43	7.70	13400
08074500	781	2002-10-29 09:16	7.74	9150
08074500	795	2005-07-15 12:26	8.44	2480
08074500	735	1991-01-10 13:08	8.79	2440
08074020	83	2006-04-13 09:44	0.17	11.4
08074020	81	2006-01-03 09:58	0.19	16.7
08074020	82	2006-02-14 09:28	0.19	17.9
08074020	77	2005-06-16 09:22	0.23	21.8
08074020	79	2005-08-02 08:35	0.25	18.9
08074020	86	2006-08-21 11:30	0.26	30.5
08074020	88	2007-02-07 12:27	0.27	21
08074020	89	2007-05-09 09:33	0.28	24
08074020	84	2006-05-17 11:55	0.31	14.7
08074020	76	2005-05-12 10:40	0.35	25.3
08074020	80	2005-10-12 09:45	0.35	21.5
08074020	90	2007-06-28 08:52	0.38	38.8
08074020	87	2006-10-12 11:09	0.47	22.7
08074020	64	2003-09-08 10:05	0.55	20.7
08074020	57	2002-09-11 09:47	0.58	18.7
08074020	53	2002-03-14 08:50	0.6	16.1
08074020	56	2002-08-01 12:43	0.61	16.7
08074020	52	2001-12-05 13:25	0.69	26.9
08074020	75	2005-03-22 08:49	0.7	43.5
08074020	54	2002-05-01 11:01	0.73	14.2
08074020	61	2003-04-03 09:58	0.73	23.6
08074020	66	2003-12-05 09:18	0.81	21.6
08074020	69	2004-04-28 13:00	0.84	18.8
08074020	62	2003-05-27 10:18	0.85	17.6
08074020	72	2004-10-15 12:50	0.87	22
08074020	71	2004-08-09 09:25	0.89	19
08074020	60	2003-03-07 08:07	0.91	33.1
08074020	65	2003-10-15 09:30	0.93	21.4
08074020	67	2004-01-26 12:44	1	100
08074020	68	2004-03-24 11:35	1	28.4
08074020	70	2004-07-02 11:50	1.24	66
08074020	55	2002-06-17 10:26	1.5	45.4

Table 2 Average flow at velocity that causes resuspension

Segment	Bayou	Stream Bed Type	USGS Gage used to Calculate Resupension Flows	Flows Calculated to be Suitable for Resuspension (MGD)	Flows Calculated to be Suitable for Resuspension (cfs)	% Wet Days Resuspension Occurs
1017	Whiteoak Bayou –lower	Concrete	08074500	34	52	-
1017	Whiteoak Bayou - upper	Earthen	08074020	406	629	7%
1013	Buffalo - lower	Earthen	08073500	1053	1633	1%
1014	Buffalo - lower	Earthen	08073500	1053	1633	1%
Reservoirs	Buffalo - upper	Earthen	Average of Flows from 08072300, 08072760, 08072730	331	512	7%

Note: Resuspension was assumed to not occur in concrete lined portions of Whiteoak Bayou

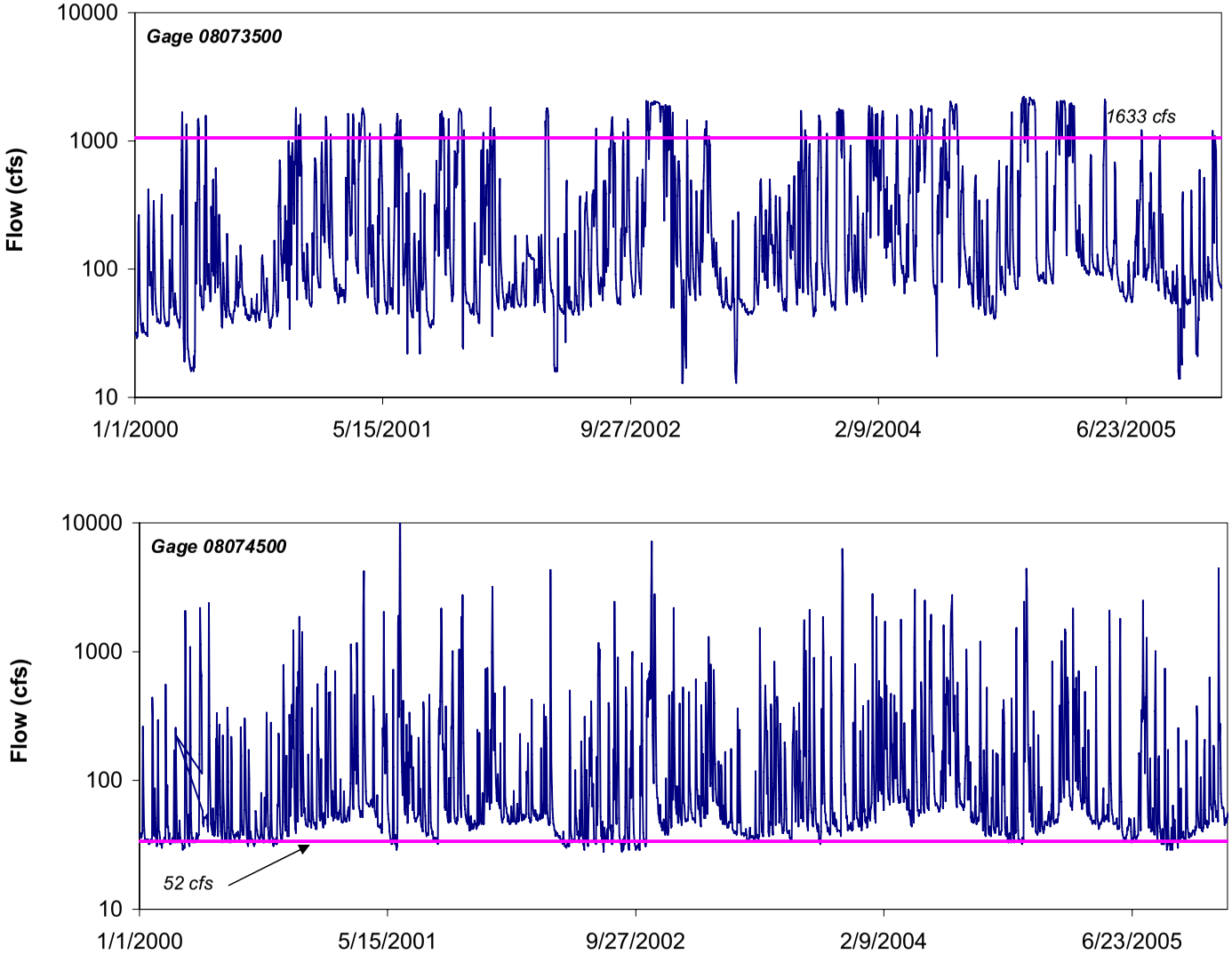


Figure 1. Flow at USGS Gages Compared with Resuspension Flow Rates (shown as straight line in figures)

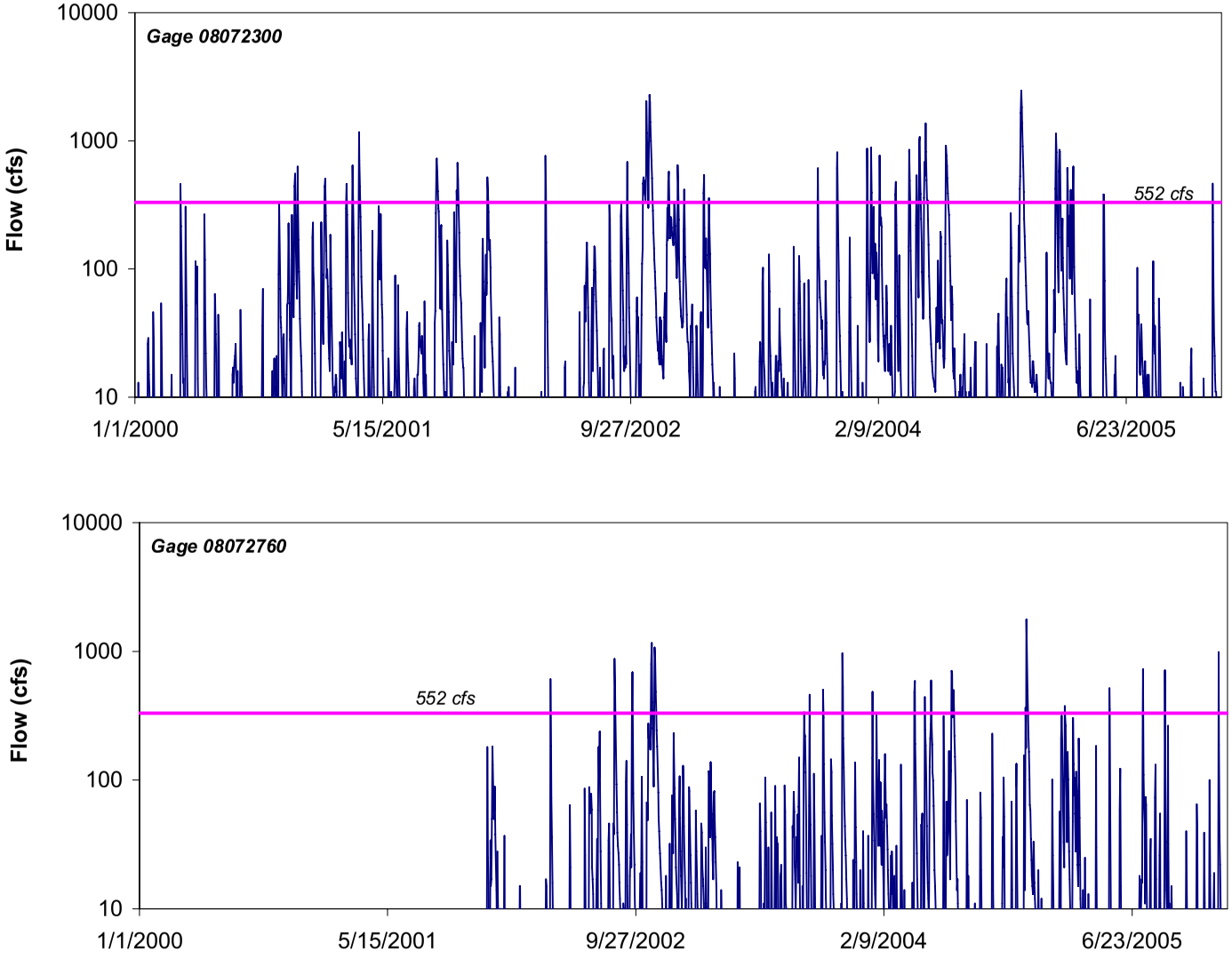
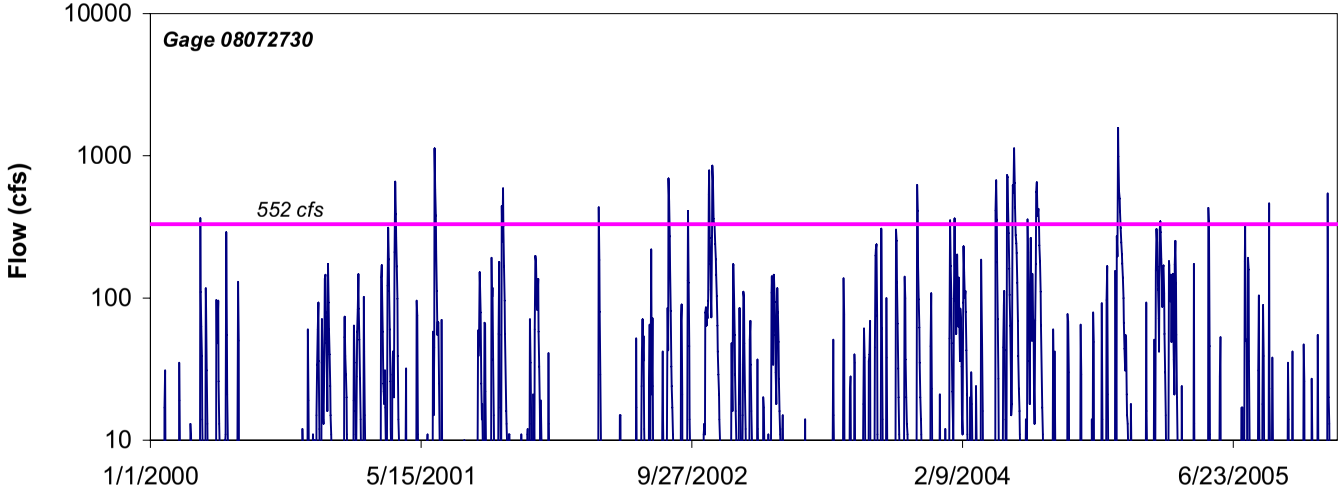


Figure 1. Flow at USGS Gages Compared with Resuspension Flow Rates (shown as straight line in figures)



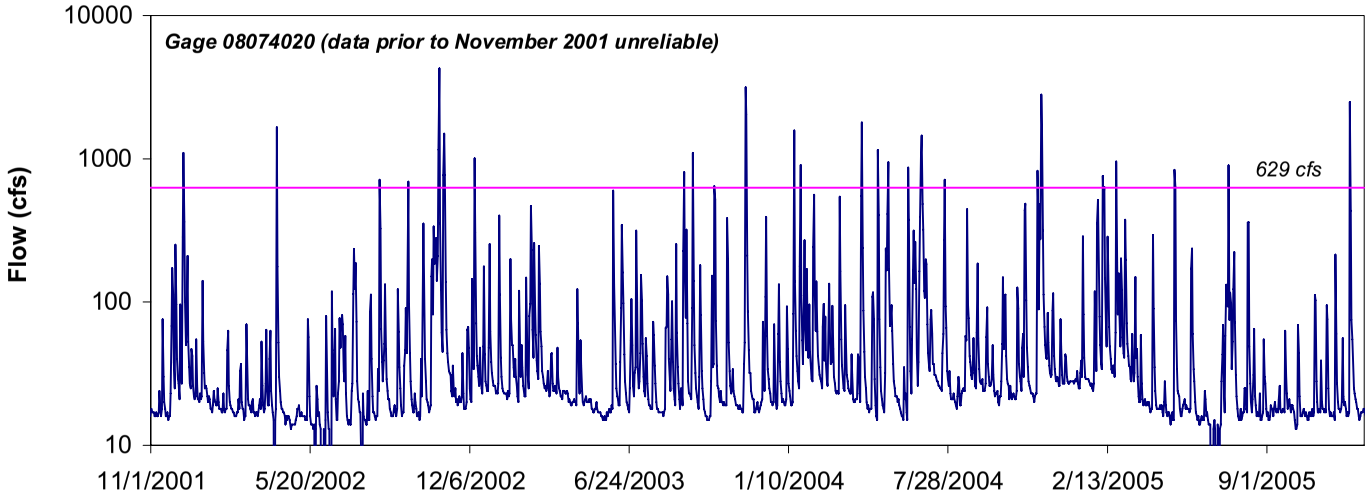


Figure 1. Flow at USGS Gages Compared with Resuspension Flow Rates (shown as straight line in figures)

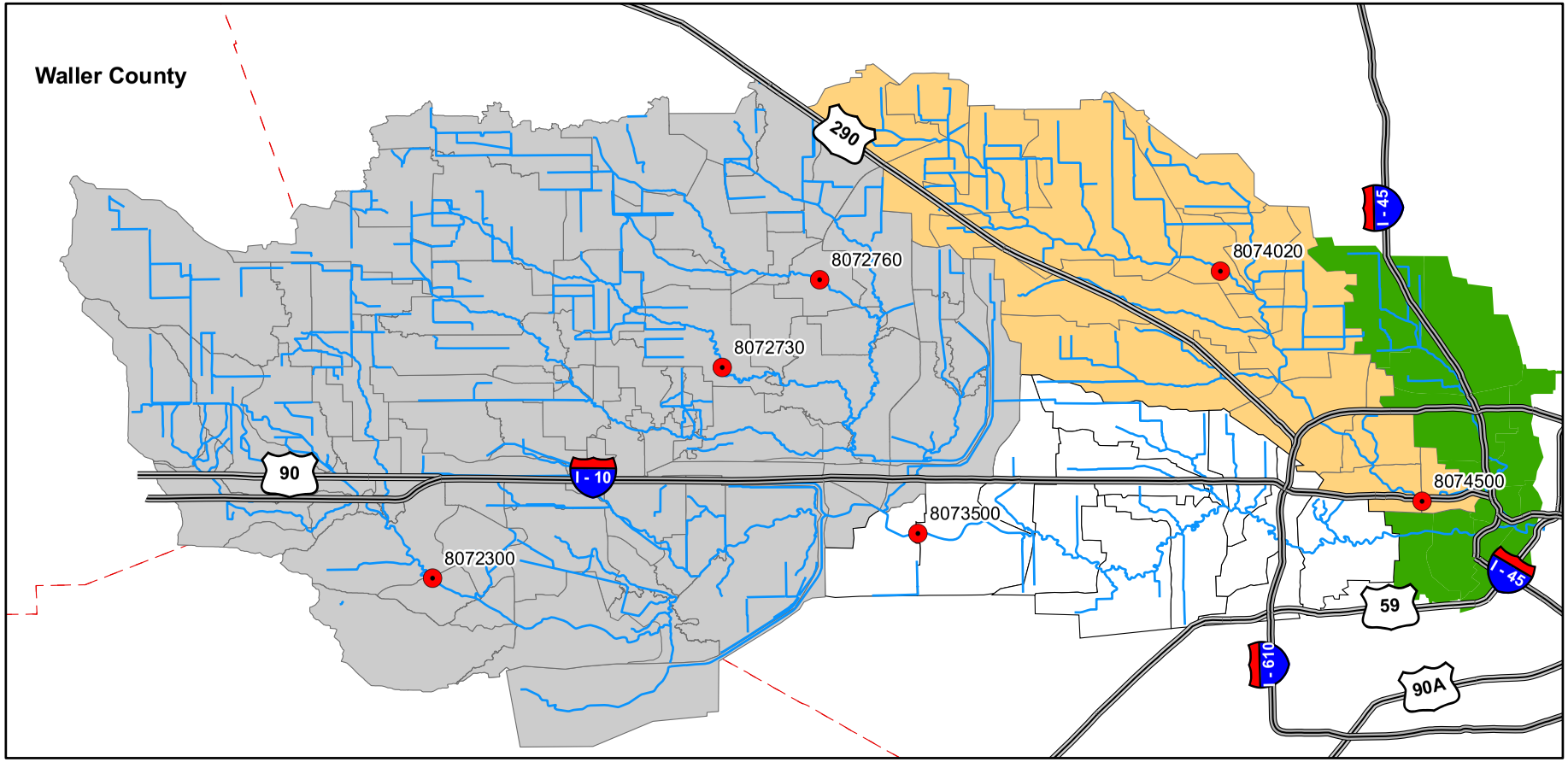


Figure 2
USGS Locations

Legend

- Stream
- County
- **Study Watersheds**
  - Segment 1017
  - Segment 1013
  - Segment 1014
  - Reservoirs
  - USGS_Gage_Locations

0 3.5 7 14 Miles

Appendix F

WWTP Supporting Information

Table 1. Rates Used to Develop Net Processes Rate

Rate (per day)	Study	Source	Notes
1.3	Clear, light/dark effect	Table 3.8, Work Order 2 Final Report	
2.2	Dark, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.4	Clear, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.4	Dark, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.5	Open, light/dark effect	Table 3.8, Work Order 2 Final Report	
3	Clear, light/dark effect	Table 3.8, Work Order 2 Final Report	Excluded because rates appear to be out of range of others
4	Dark, light/dark effect	Table 3.8, Work Order 2 Final Report	Excluded because rates appear to be out of range of others
4	Open, light/dark effect	Table 3.8, Work Order 2 Final Report	Excluded because rates appear to be out of range of others
1.6	Clear, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.6	Dark, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.6	Clear, light/dark effect	Table 3.8, Work Order 2 Final Report	
1.6	Dark, light/dark effect	Table 3.8, Work Order 2 Final Report	
2	Regrowth	Table 3.12, Work Order 2 Final Report	
1	Regrowth	Table 3.12, Work Order 2 Final Report	
1.4	Regrowth	Table 3.12, Work Order 2 Final Report	
1.4	Regrowth	Table 3.12, Work Order 2 Final Report	
0.9	Regrowth	Table 3.12, Work Order 2 Final Report	
4.5	Regrowth	Table 3.12, Work Order 2 Final Report	Excluded because rates appear to be out of range of others

Average = 1.5 per day

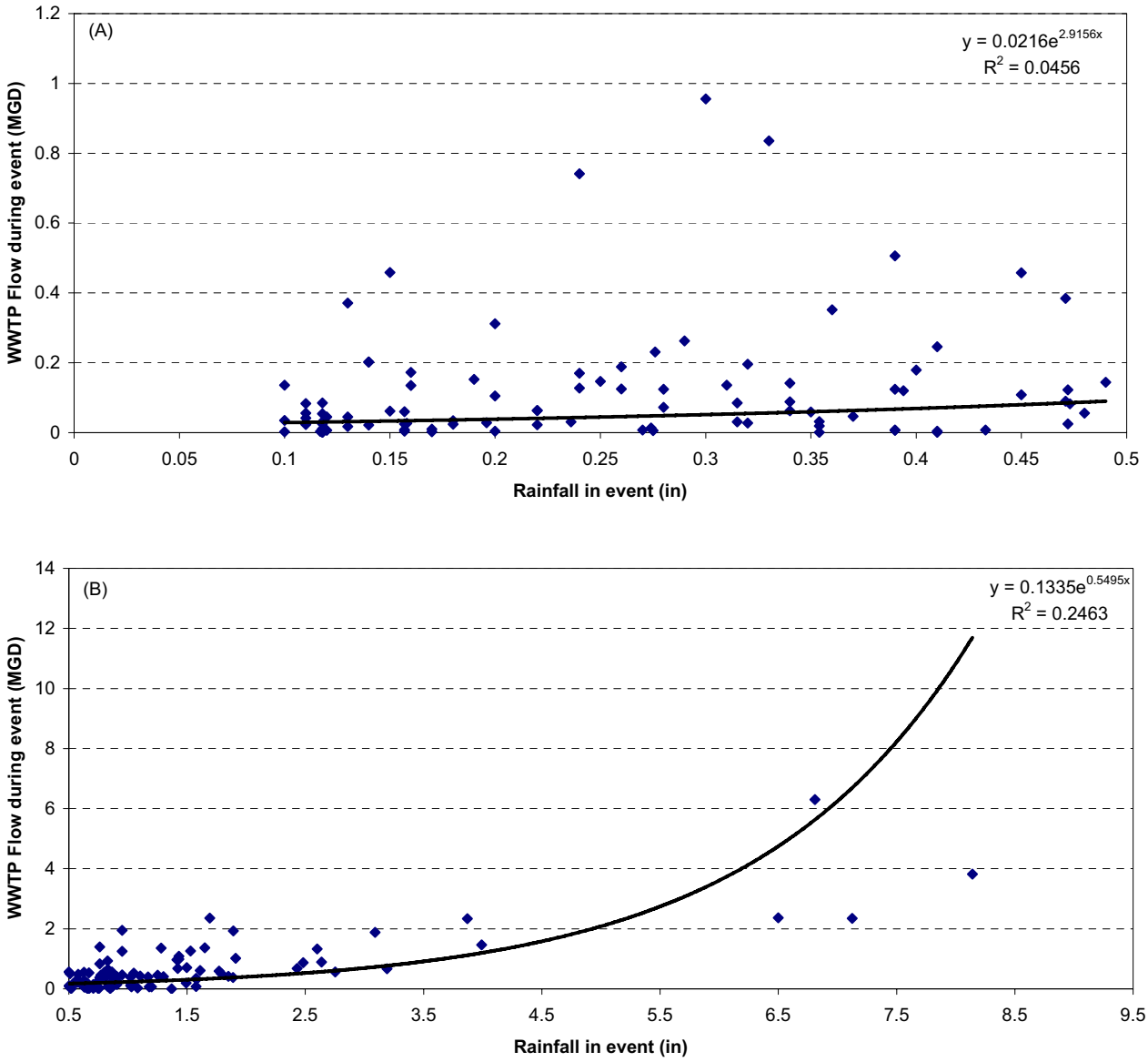


Figure 1. Effect of Rainfall on WWTP Flows

Appendix G

General Supporting Information

Table 1.1 Load Analysis for Mouth of Segment 1014

Scenario: V2.5_Calibrated

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		14.60		104.85		1,239.70
WWTPs						
WWTP Discharges	18.00	10.66	18.93	11.21	18.93	11.21
WWTP Biosolid Releases	-	-	-	-	1.13	111.55
SSO						
SSO - All Conditions	1.12E-04	19.97	1.12E-04	19.97	2.69E-03	54.11
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.62	272.84	0.62	272.84	-	-
Wet Weather Storm Sewer Discharges	-	-	4.68	7,934.94	190.67	323,215.52
Load Allocation		50.83		300.18		0.00
OSSF	1.70E-05	3.07	1.70E-05	3.07	1.70E-05	3.07
Net Die-off/Settling/Unaccounted Processes	-4.18	783.64	65.16	21,266.45	62.87	-365,132.58
Upstream Input from Reservoirs		150.82		304.57		2487.80
Upstream of Segment 1014	33.29	506.36	67.22	5,253.52	549.05	103,102.73
Margin of Safety (MOS)		11.38		37.35		196.18
Margin of Safety (5% of Target Load)		11.38		37.35		196.18
Final Load Calculation						
Calculated Load	47.72	1,596.53	156.60	34,762.00	822.64	61,365.61
Observed Load	47.72	1,596.53	156.60	34,762.00	822.64	61,365.61
Contact Recreation Target (126 MPN/dL)	47.72	227.63	156.60	746.94	822.64	3,923.69
Percent Reduction (Contact Recreation)	WLA	95%		99%		100%
	LA	94%		99%		100%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

Table 1.2 Load Analysis for Mouth of Segment 1013

Scenario: V2.5_Calibrated

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.17		319.10		1,944.97
WWTPs						
WWTP Discharges	0.00	0.00	0.00	0.00	0.00	0.00
WWTP Biosolid Releases	-	-	-	-	0.00	0.00
SSO						
SSO - All Conditions	1.38E-04	24.56	1.38E-04	24.56	2.70E-03	58.46
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	5.36E-04	0.01	5.36E-04	0.01	-	-
Wet Weather Storm Sewer Discharges			60.22	101,464.70	102.38	172,505.86
Load Allocation		0.89		0.00		0.00
OSSF	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00
Net Die-off/Settling/Unaccounted Processes	0.23	148.31	-55.54	-117,279.74	-73.19	-204,170.58
Upstream Input from Segment 1014		216.24		709.60		3727.51
Upstream of Segment 1014	47.72	1,596.53	156.60	34,762.00	822.64	61,365.61
Margin of Safety (MOS)		11.44		38.46		203.15
Margin of Safety (5% of Target Load)		11.44		38.46		203.15
Final Load Calculation						
Calculated Load	47.96	1,769.42	161.28	18,971.54	851.83	29,759.35
Observed Load	47.96	1,769.42	161.28	18,971.54	851.83	29,759.35
Contact Recreation Target (126 MPN/dL)	47.96	228.75	161.28	769.24	851.83	4,062.92
TMDL Target		228.75		1,067.16		5,875.62
Percent Reduction (Contact Recreation)	WLA	99%		100%		99%
	LA	99%		100%		100%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

Table 1.3 Load Analysis for Mouth of Watersheds Draining Reservoirs

Scenario: V2.5_Calibrated

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		150.82		304.57		2,487.80
WWTPs						
WWTP Discharges	20.58	5,438.79	21.64	5,719.04	21.64	5,719.04
WWTP Biosolid Releases	-	-	-	-	1.29	127.55
SSO						
SSO - All Conditions	9.40E-05	16.74	9.40E-05	16.74	1.67E-03	37.68
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.00	0.00	0.00	0.00	-	-
Wet Weather Storm Sewer Discharges			41.76	65,314.82	207.01	323,778.18
Load Allocation		0.00		0.00		0.00
OSSF	7.77E-04	140.28	7.77E-04	140.28	7.77E-04	140.28
Net Die-off/Settling/Unaccounted Processes	12.71	-5,089.44	3.82	-65,937.35	319.10	-226,699.99
Upstream Input		0.00		0.00		0.00
None	0.00	0.00	0.00	0.00	0.00	0.00
Margin of Safety (MOS)		7.94		16.03		130.94
Margin of Safety (5% of Target Load)		7.94		16.03		130.94
Final Load Calculation						
Calculated Load	33.29	506.36	67.22	5,253.52	549.05	103,102.73
Observed Load	33.29	506.36	67.22	5,253.52	549.05	103,102.73
Contact Recreation Target (126 MPN/dL)	33.29	158.76	67.22	320.60	549.05	2,618.74
TMDL Target		158.76		320.60		2,618.74
Percent Reduction (Contact Recreation)	WLA	97%		100%		99%
	LA	100%		100%		100%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

Table 1.4 Load Analysis for Mouth of Segment 1017

Scenario: V2.5_Calibrated

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		15.88		155.21		737.99
WWTPs						
WWTP Discharges	20.03	41.94	21.06	44.10	21.06	44.10
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
SSO						
SSO - All Conditions	1.22E-04	21.77	1.22E-04	21.77	2.48E-03	53.03
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.68	248.95	0.68	248.95	-	-
Wet Weather Storm Sewer Discharges			12.44	20,792.09	204.88	342,538.83
Load Allocation		92.48		0.00		0.00
OSSF	5.79E-04	104.62	5.79E-04	104.62	5.79E-04	104.62
Net Die-off/Settling/Unaccounted Processes	3.20	1,828.34	0.07	-13,910.87	-64.33	-264,221.21
Upstream Input		0.00		0.00		0.00
None	0.00	0.00	0.00	0.00	0.00	0.00
Margin of Safety (MOS)		5.70		8.17		38.84
Margin of Safety (5% of Target Load)		5.70		8.17		38.84
Final Load Calculation						
Calculated Load	23.91	2,245.62	34.25	7,300.66	162.87	78,643.52
Observed Load	23.91	2,245.62	34.25	7,300.66	162.87	78,643.52
Contact Recreation Target (126 MPN/dL)	23.91	114.06	34.25	163.38	162.87	776.84
TMDL Target		114.06		163.38		776.84
Percent Reduction (Contact Recreation)	WLA	95%		99%		100%
	LA	95%		100%		100%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

Table 1.1 Load Analysis for Mouth of Segment 1014 Scenario: V 2.5

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		84.34		109.76		954.85
WWTPs						
WWTP Discharges	18.00	10.66	18.93	11.21	18.93	11.21
WWTP Biosolid Releases	-	-	-	-	1.13	111.55
SSO						
SSO - All Conditions	1.12E-04	19.97	1.12E-04	19.97	2.58E-03	34.14
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.62	272.84	0.62	272.84	-	-
Wet Weather Storm Sewer Discharges	-	-	4.68	7,934.94	190.67	323,215.52
Load Allocation		0.00		0.00		0.00
OSSF	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00
Bed Sediment	-	-	-	-	-	4,211.90
Direct Deposition	-	171.21	-	171.21	-	0.00
Net Die-off/Settling/Unaccounted Processes	-	-368.76	-	-6,533.60	-	-254,490.38
Upstream Input from Reservoirs		93.25		340.23		1041.90
Upstream of Segment 1014	20.58	1,325.78	75.09	20,041.15	229.94	85,977.04
Margin of Safety (MOS)		9.35		23.68		105.09
Margin of Safety (5% of Target Load)		9.35		23.68		105.09
Final Load Calculation						
Calculated Load	39.19	1,431.69	99.31	21,917.71	440.67	159,070.98
Contact Recreation Target (126 MPN/dL)	39.19	186.94	99.31	473.67	440.67	2,101.84
TMDL Target		186.94		473.67		2,101.84
Percent Reduction (Contact Recreation)	WLA	72%		99%		100%
	LA	100%		100%		100%
Non-contact Recreation Target (605 MPN/dL)	39.19	897.60	99.31	2,274.37	440.67	10,092.15
Percent Reduction (Non-contact Recreation)	All	37%		90%		94%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

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Table 1.2 Load Analysis for Mouth of Segment 1013 Scenario: V 2.5

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		272.86		463.90
WWTPs						
WWTP Discharges	0.00	0.00	0.00	0.00	0.00	0.00
WWTP Biosolid Releases	-	-	-	-	0.00	0.00
SSO						
SSO - All Conditions	1.38E-04	24.56	1.38E-04	24.56	2.56E-03	33.90
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	5.36E-04	0.01	5.36E-04	0.01	-	-
Wet Weather Storm Sewer Discharges			60.22	101,464.70	102.38	172,505.86
Load Allocation		0.00		0.00		0.00
OSSF	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00
Bed Sediment	-	-	-	-	-	2,479.72
Direct Deposition	-	65.46	-	65.46	-	0.00
Net Die-off/Settling/Unaccounted Processes	-	-69.94	-	-78,894.81	-	-135,967.36
Upstream Input from Segment 1014		177.59		449.99		1996.74
Upstream of Segment 1013	39.19	1,431.69	99.31	21,917.71	440.67	159,070.98
Margin of Safety (MOS)		9.35		38.04		129.51
Margin of Safety (5% of Target Load)		9.35		38.04		129.51
Final Load Calculation						
Calculated Load	39.19	1,451.78	159.53	44,577.64	543.05	198,123.11
Contact Recreation Target (126 MPN/dL)	39.19	186.94	159.53	760.89	543.05	2,590.16
TMDL Target		186.94		760.89		2,590.16
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	100%		100%		100%
Non-contact Recreation Target (605 MPN/dL)	39.19	897.62	159.53	3,653.47	543.05	12,436.86
Percent Reduction (Non-contact Recreation)	All	38%		92%		94%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

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Table 1.3 Load Analysis for Mouth of Watersheds Draining Reservoirs

Scenario: V 2.5

E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		93.25		340.23		1,041.90
WWTPs						
WWTP Discharges	20.58	5,438.79	21.64	5,719.04	21.64	5,719.04
WWTP Biosolid Releases	-	-	-	-	1.29	127.55
SSO						
SSO - All Conditions	9.40E-05	16.74	9.40E-05	16.74	1.58E-03	20.94
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.00	0.00	0.00	0.00	-	-
Wet Weather Storm Sewer Discharges			53.45	83,596.26	207.01	323,778.18
Load Allocation		0.00		0.00		0.00
OSSF	6.67E-04	120.64	6.67E-04	120.64	6.67E-04	120.64
Bed Sediment	-	-	-	-	-	55,556.01
Direct Deposition	-	365.55	-	365.55	-	0.00
Net Die-off/Settling/Unaccounted Processes	-	-4,615.94	-	-69,777.07	-	-299,345.32
Upstream Input		0.00		0.00		0.00
None	0.00	0.00	0.00	0.00	0.00	0.00
Margin of Safety (MOS)		4.91		17.91		54.84
Margin of Safety (5% of Target Load)		4.91		17.91		54.84
Final Load Calculation						
Calculated Load	20.58	1,325.78	75.09	20,041.15	229.94	85,977.04
Contact Recreation Target (126 MPN/dL)	20.58	98.15	75.09	358.14	229.94	1,096.73
TMDL Target		98.15		358.14		1,096.73
Percent Reduction (Contact Recreation)	WLA	98%		100%		100%
	LA	100%		100%		100%
Non-contact Recreation Target (605 MPN/dL)	20.58	471.30	75.09	1,719.62	229.94	5,266.06
Percent Reduction (Non-contact Recreation)	All	64%		91%		94%

Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

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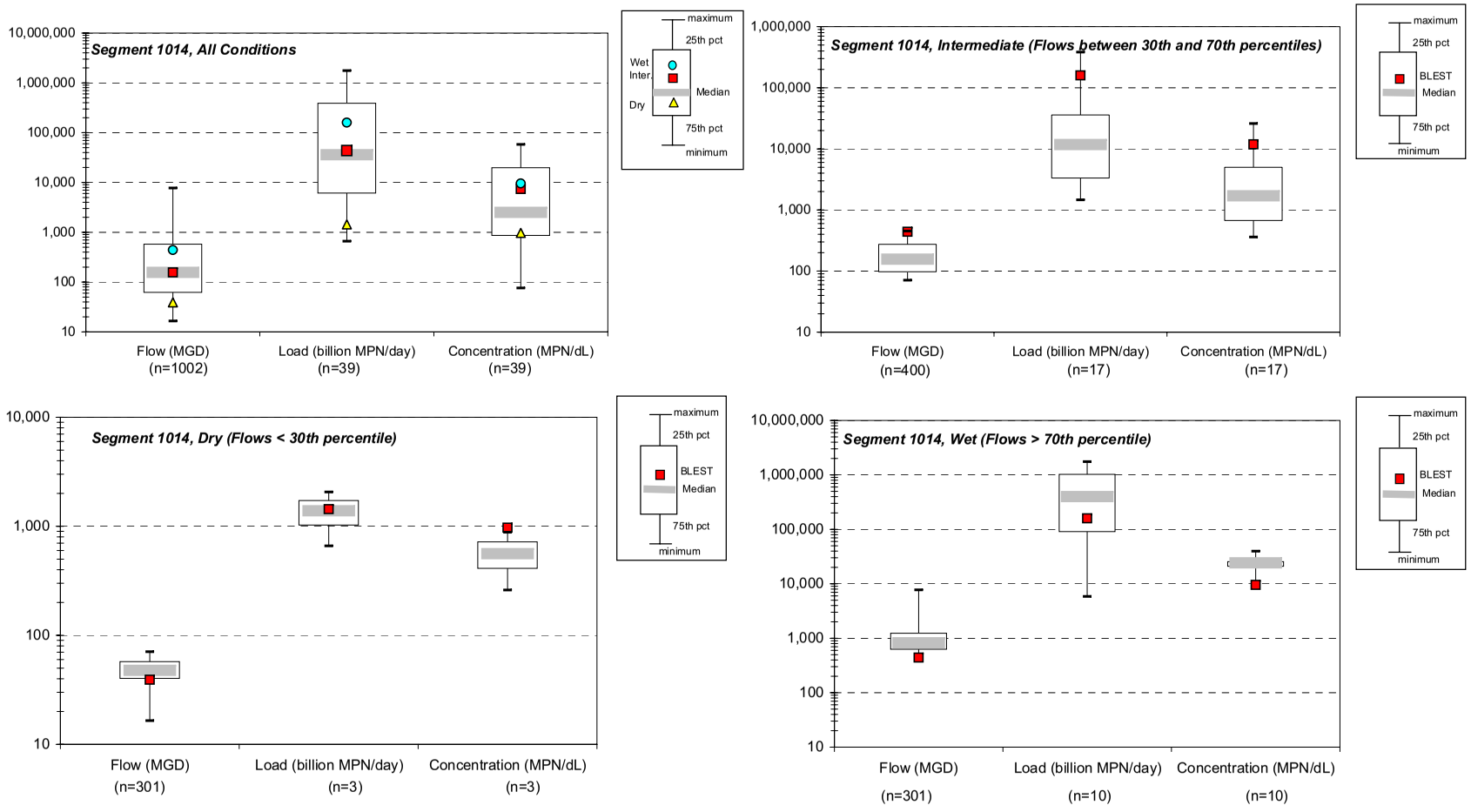
Table 1.4 Load Analysis for Mouth of Segment 1017 Scenario: V 2.5

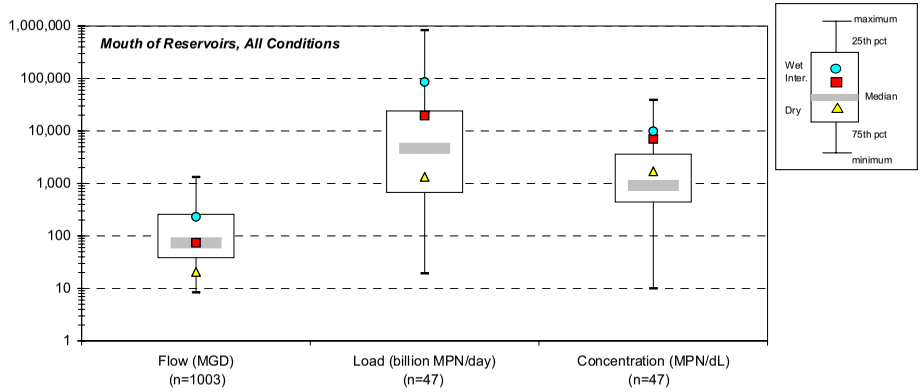
E. coli Sources	Instream Flow Condition based on Flow Duration Curve					
	Dry (< 30th percentile)		Intermediate (30th - 70th percentile)		Wet (> 70th percentile)	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		94.20		169.94		1,029.48
WWTPs						
WWTP Discharges	20.03	41.94	21.06	44.10	21.06	44.10
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
SSO						
SSO - All Conditions	1.22E-04	21.77	1.22E-04	21.77	2.36E-03	31.26
Regulated Storm Water Discharges						
Dry Weather Storm Sewer Discharges	0.76	250.09	0.76	250.09	-	-
Wet Weather Storm Sewer Discharges			15.68	26,220.41	204.88	342,538.83
Load Allocation		0.00		0.00		0.00
OSSF	5.79E-04	104.66	5.79E-04	104.66	5.79E-04	104.66
Bed Sediment	-	-	-	-	-	11,355.69
Direct Deposition	-	131.65	-	131.65	-	0.00
Net Die-off/Settling/Unaccounted Processes	-	-427.36	-	-20,798.89	-	-275,166.29
Upstream Input		0.00		0.00		0.00
None	0.00	0.00	0.00	0.00	0.00	0.00
Margin of Safety (MOS)		4.96		8.94		54.18
Margin of Safety (5% of Target Load)		4.96		8.94		54.18
Final Load Calculation						
Calculated Load	20.79	122.75	37.50	5,973.79	227.20	79,032.41
Contact Recreation Target (126 MPN/dL)	20.79	99.16	37.50	178.88	227.20	1,083.66
TMDL Target		99.16		178.88		1,083.66
Percent Reduction (Contact Recreation)	WLA	70%		99%		100%
	LA	100%		100%		100%
Non-contact Recreation Target (605 MPN/dL)	20.79	476.11	37.50	858.92	227.20	5,203.30
Percent Reduction (Non-contact Recreation)	All	0%		86%		93%

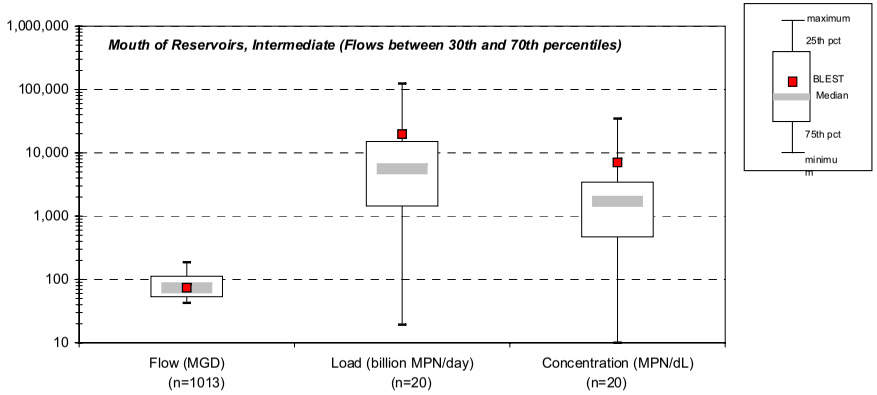
Abbreviations: MGD = million gallons per day, MOS = margin of safety, MPN = most probable number, MS4 = municipal separate storm sewer system, Q = flow, OSSF = on-site sewage facility, SSO = sanitary sewer overflows, WWTP = wastewater treatment plant

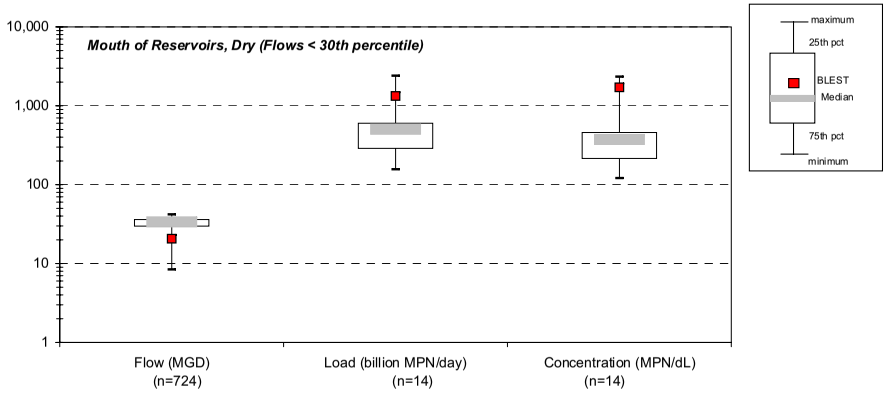
DRAFT for discussion only

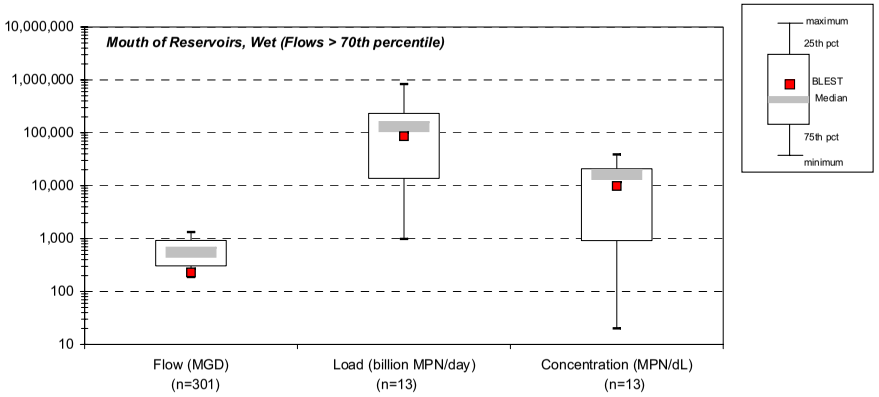


Segment 1014 BLEST Version 2.5 Results Relative to Observed Values

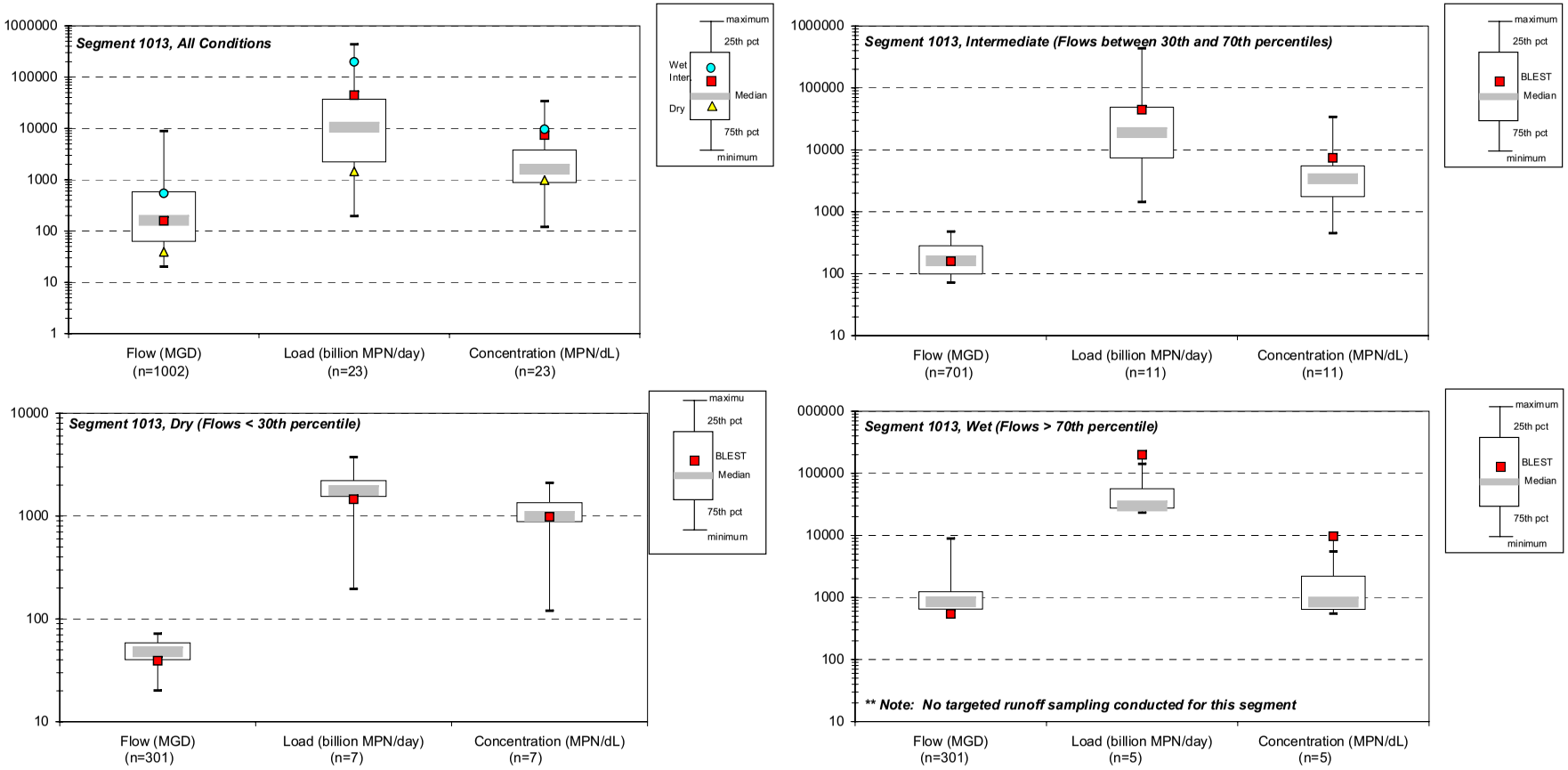




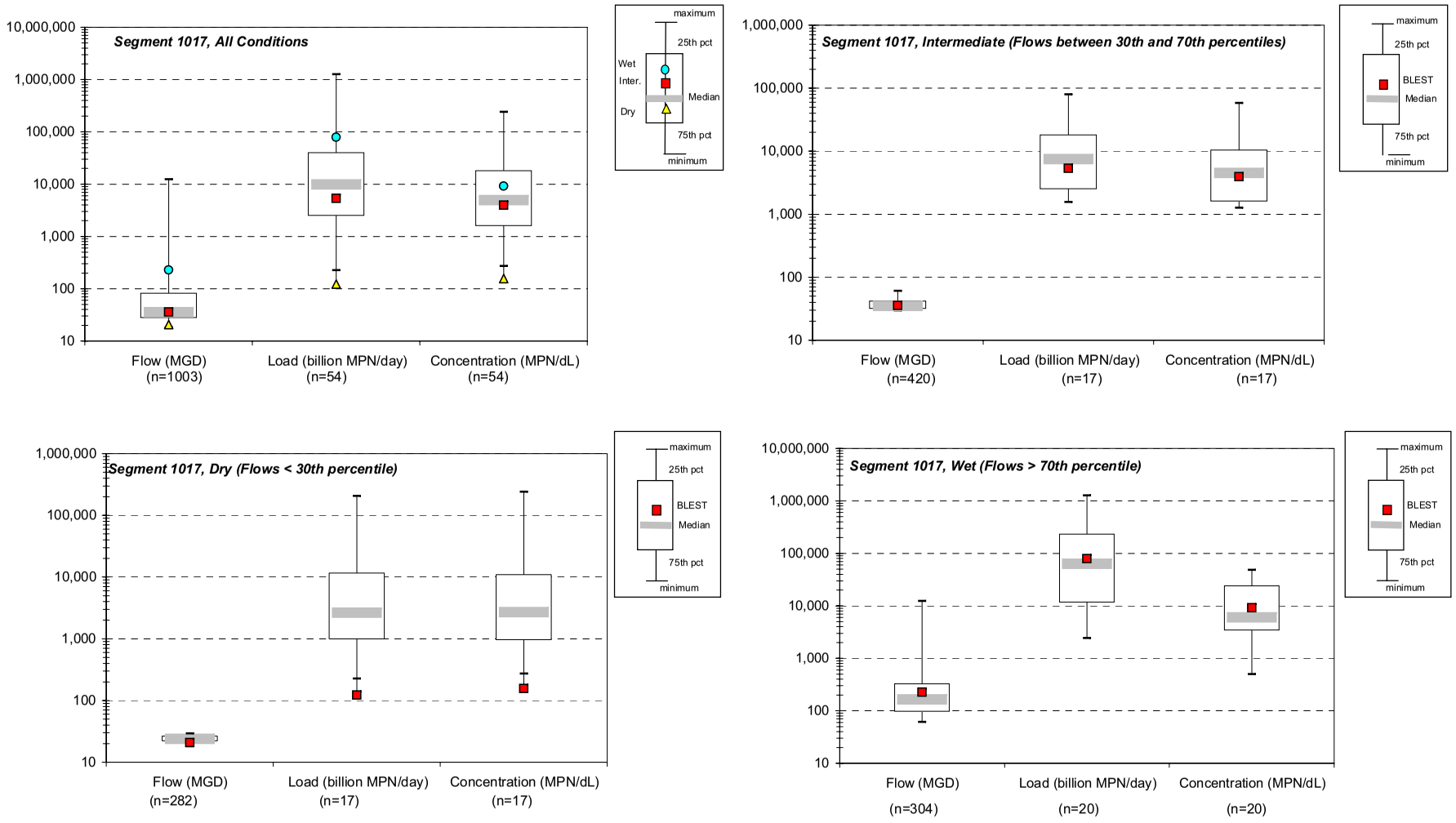




Mouth of Reservoir BLEST Version 2.5 Results Relative to Observed Values



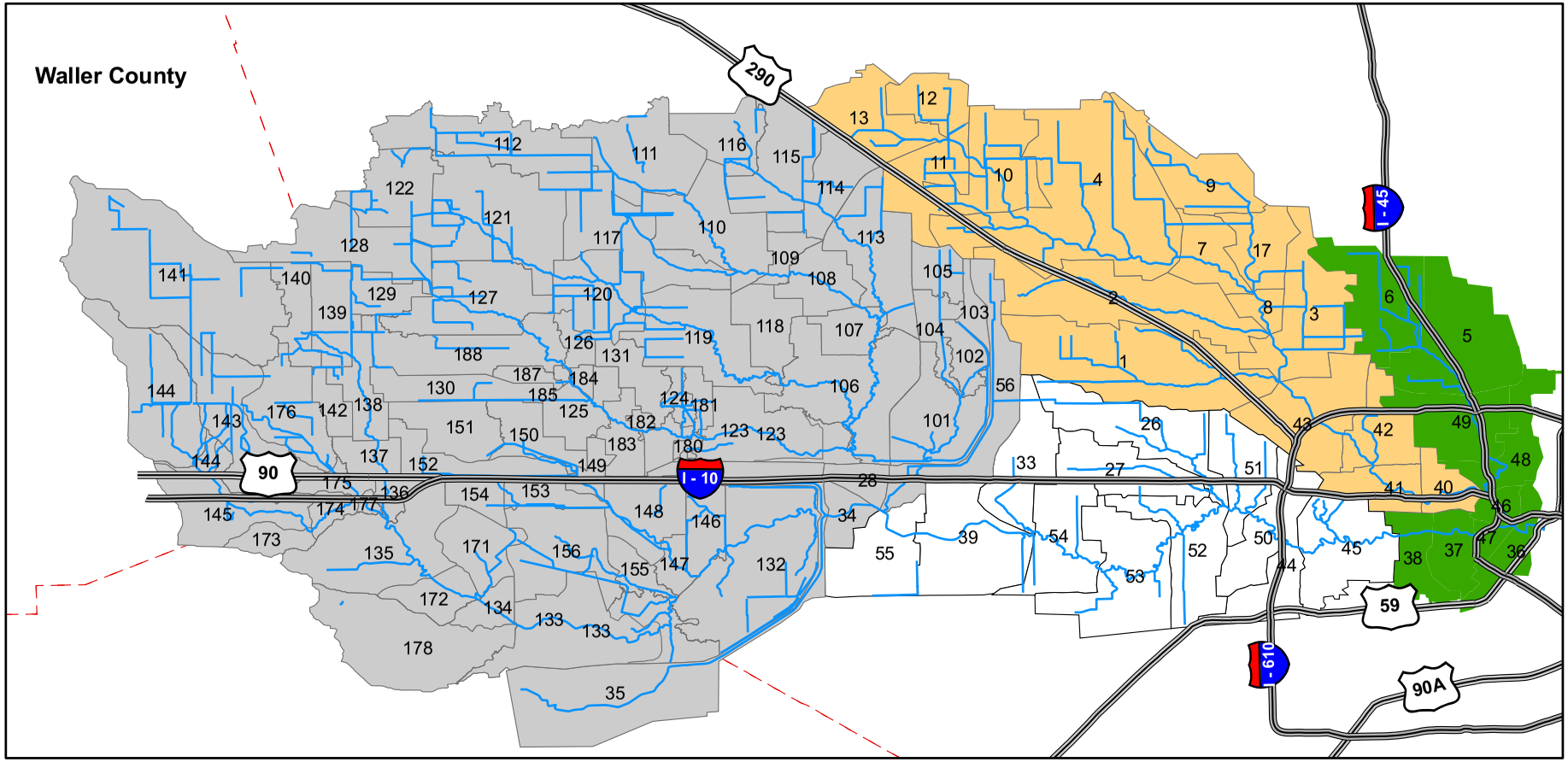
Segment 1013 Mouth BLEST Version 2.5 Results Relative to Observed Values



Segment 1017 BLEST Version 2.5 Results Relative to Observed Values

Table 1. Description of Work Orders

Work Order	Contract No. 582-0-80121	Work Order No	Period	Status
Work Order 1	582-0-80121	582-0-80121-01	9/2000 to 8/2001	Completed
Work Order 2	582-0-80121	582-0-80121-02	9/2001 to 8/2002	Completed
Work Order 5	582-0-80121	582-0-80121-05	9/2002 to 8/2003	Completed
Work Order 6	582-0-80121	582-0-80121-06	9/2003 to 8/2004	Completed
Work Order 8	582-0-80121	582-0-80121-08	9/2004 to 8/2005	Completed
Work Order 1	582-6-70860	582-6-70860-01	9/2005 to 8/2006	Completed
Work Order 9	582-6-70860	582-6-70860-09	9/2006 to 8/2007	In Progress



Replaces Figure 3.2
Buffalo and Whiteoak Bayou Watersheds

Legend

- Stream
- County
- **Study Watersheds**
- Segment 1017
- Segment 1013
- Segment 1014
- Reservoirs

0 3.5 7 14 Miles

Appendix H

Background and Summary of Buffalo and Whiteoak Bayou TMDL Study Components

Administrative Project Summary

The Total Maximum Daily Load for Fecal Pathogens in Buffalo Bayou and Whiteoak Bayou project ("the project") was initiated in March 2000 by the University of Houston and PBS&J under contract with TCEQ. PBS&J was a member of the project team through August 2005. Texas A&M University – Corpus Christi was also a member of the project team between 2003 and 2005. The study has had a stakeholder group almost since its inception, with the first stakeholder meeting on May 2000.

Over the course of this project, there have been a total of seven work orders issued by TCEQ, as summarized in Table 1. Work Order numbers are not necessarily sequential as they may have because work order numbers are assigned to projects as they occur.

Table 1. Summary of Contract Numbers and Periods

Contract No.	Work Order No.	Period	Status
582-0-80121	582-0-80121-01	6/2000 to 5/2001	Completed
582-0-80121	582-0-80121-02	7/2001 to 8/2002	Completed
582-0-80121	582-0-80121-05	9/2002 to 8/2003	Completed
582-0-80121	582-0-80121-06	9/2003 to 8/2004	Completed
582-0-80121	582-0-80121-08	9/2004 to 8/2005	Completed
582-6-70860	582-6-70860-01	9/2005 to 8/2006	Completed
582-6-70860	582-6-70860-09	9/2006 to 8/2007	In Progress

Contract 582-0-80121; Work Order #1

The scope of work performed under Work Order #1 (June 1, 2000 through May 31, 2001) included the following tasks:

- An assessment of current fecal pathogen levels and trends in Buffalo and Whiteoak Bayous;
- A survey of the current knowledge of major sources, and fate and transport of fecal pathogen contamination in surface waters;
- Selection of a fate and transport model for the scope area;
- Development of a quality assurance project plan for the project;
- Development of a work plan for additional sampling and modeling activities; and
- Participation in the Buffalo and Whiteoak Bayous stakeholder participation/communication process.

The results from Work Order 1 were detailed in a final report submitted to TCEQ in June, 2001. The work conducted under Work Order 1 demonstrated that for both Buffalo and Whiteoak Bayous, the average concentrations of fecal coliform increase from upstream to

downstream by up to two orders of magnitude. Data gatherings and analysis of nine potential sources of high indicator bacteria levels indicated that point sources, illegal discharges, sediments, runoff, and upstream sources were relatively significant contributors of bacteria in the bayous. Finally, a review of suitable models to quantify the fate and transport of the indicator bacteria suggested that HSPF is an appropriate model for the purposes of this TMDL study.

Contract 582-0-80121; Work Order #2

Work Order No. 2 (July 5, 2001 through August 31, 2002) encompassed the following tasks:

- Project administration;
- Stakeholder/public education and involvement;
- Assessment of current levels and trends of bacterial indicators of fecal pathogens in Buffalo and Whiteoak Bayous;
- Assessment of major sources of bacterial indicators of fecal contamination;
- Application of models to elucidate the sources and major processes controlling observed levels of bacterial indicators of fecal contamination; and
- TMDL allocation analysis.

A final report for Work Order No. 2 was submitted to TCEQ in January 2003. The report included identification and quantification of the sources in the watershed and the development of HSPF models to predict the fate and transport of bacteria in water and sediment.

Contract 582-0-80121; Work Order #5

Work Order #5 and its amendment (September 1, 2002 to August 31, 2003) included the following scope of work:

- Project administration;
- Stakeholder/public education and involvement;
- Supplying the information and assistance to the TCEQ TMDL Team necessary to complete a TMDL for submittal to the TCEQ Commissioners and to assist in the defense of the TMDL;
- Supplying the information and assistance to the TCEQ TMDL Team necessary to develop an Implementation Plan to reduce the levels of bacterial indicators of fecal pathogens in Buffalo Bayou and Whiteoak Bayou for submittal to the TCEQ Commissioners and to assist in the defense of the Implementation Plan; and

- Preparing a Bacteria Source Tracking study to determine the proportion of the *E. coli* in the water and sediment of the bayous that is of human origin.

The final report for Work Order 5 was submitted to TCEQ in November 2003. Several special studies were undertaken Work Order 5, including a synopsis of current understanding on sediment and bacteria source tracking, a summary of bacteria loading from various sources in Buffalo and Whiteoak Bayous, the determination of a low flow condition, HSPF modeling updates, an evaluation of load allocations using HSPF and a summary of best management practices and discussion of controls being currently used in the Houston area. The discussion of low flow conditions was completed in response to requests from stakeholders to better quantify the definition.

Contract 582-0-80121; Work Order #6

There were a total of 21 tasks included in Work Order 6 and its associated amendments (September 1, 2003 to August 31, 2004). These tasks included the following:

- Project Administration;
- Participate in stakeholder process;
- Develop a quality assurance project plan (QAPP) for additional data collection;
- Sampling
    - Assess the impact of possible biosolid releases on bacteria levels;
    - Assess sediment contributions;
    - Assess E. coli levels downstream of WWTP outfalls;
    - Investigate the levels of bacteria from Addicks and Barker reservoirs;
    - Quantify loads of bacterial indicators to the bayous from overflows and bypasses;
- Bacteria Source Tracking
    - Expand the antibiotic resistance profiling (ARP) database;
    - Expand the Houston Bacteria Source Tracking Database.
    - Finalize bacteria source tracking (BST) sampling plan;
    - Conduct bacteria source tracking (BST) sampling and analyses;

- Modeling
    - Expand the HSPF TMDL model for Buffalo and Whiteoak Bayous to include additional sources evaluated as part of this work order as appropriate;
    - Expand the HSPF TMDL model for Buffalo Bayou to include areas above Addicks and Barker reservoirs;
    - Refine the existing modeling of point sources using time-varying flow and concentrations;
- Diversions and Withdrawls
    - Review Region H Water Availability Model (WAM) including assumptions and results relating to reuse and diversions in smaller tributaries;
    - Gather, review, and summarize applications for reuse and diversion of surface waters in the Houston area;
    - Formulate how possible reductions in WWTP flow, as well as changes in stream diversions and return flows, would operate under different stream flow and seasonal conditions;
    - Use the refined model to analyze the effects of diversions and withdrawals on attaining water quality criteria under a range of flow conditions and assess the uncertainty in refined model predictions;
    - Formulate draft limitations on withdrawals and diversions that may be necessary to maintain acceptable levels of indicator bacteria; and
- Develop Work Plan for FY 2005.

The results of these tasks were presented in the Final Report for Work Order 6 submitted in November 2004. The assessment of E. coli concentrations downstream of WWTPs was completed in response to a request by stakeholders.

Contract 582-0-80121; Work Order #8

The tasks associated with Work Order 8 (September 1, 2004 to August 31, 2005) included the following:

- Project Administration;
- Participate in stakeholder process;
- Complete quality assurance project plan (QAPP) preparation for additional data collection;

- Assessment of biosolids impact on bacteria levels in BB and Whiteoak Bayou;
- Complete assessment of EC levels downstream of WWTP outfalls;
- Complete investigation of bacteria loads from overflows and bypasses;
- Bacteria Source Tracking;
- Expansion and Refinement of HSPF model to focus on low and very low flow condition;
- Additional Sources in HSPF; and
- Allocation scenarios.

The final report for Work Order 8 was submitted to TCEQ in November 2005. This report contained results of sampling during fiscal year 2005, bacteria source tracking results, as well as expanding the HSPF model to better simulate low and very low flow conditions. Finally, the Work Order 8 report presented the spreadsheet tool to be used for load allocation development.

Contract 582-0-70860; Work Order #1

The tasks associated with Work Order 1 (September 1, 2005 to August 31, 2006) included the following:

- Project Administration;
- Participate in stakeholder process;
- Assist in preparation of TMDL report;
- Assist in preparation of TMDL implementation plan; and
- Conduct indicator bacteria sampling at all municipal wastewater treatment plants discharging to Buffalo and Whiteoak Bayous.

The final report for Work Order 1 was submitted to TCEQ in November 2006. This report detailed the spreadsheet tool for load allocations for the Buffalo and Whiteoak Bayou watersheds, called the Bacteria Load Estimator Spreadsheet Tool (BLEST), and its application.

Contract 582-0-70860; Work Order #9

The tasks associated with Work Order 9 (September 1, 2006 to August 31, 2007) are the following:

- Project Administration;

- Participate in stakeholder process;
- Complete WWTP Sampling;
- Address all allocation issues;
- Assist in the preparation of the TMDL Report; and
- Support Implementation Plan activities.

This Work Order is currently in progress. So far, four stakeholder meetings, on September 6, 2006, February 8, 2007, June 25, 2007 and August 21, 2007 have been held this fiscal year. In addition to stakeholder participation, the majority of the effort for this Work Order has been focused on responding to and updating BLEST per comments received from stakeholders.

Stakeholder Involvement Summary

Over the course of the Buffalo and Whiteoak Bayou TMDLs, a total of 18 meetings have been held between May 2000 and July 2007 to present information to project stakeholders and provide an opportunity for feedback. A list of these meetings is provided in Table 1. This document provides an overview of each stakeholder meeting and specifically lists any requests that were submitted to the project team and how comments from stakeholders influenced the study. All stakeholder meeting minutes and presentations are included as Attachment A of this document.

Table 1. Stakeholder Meeting Dates and Corresponding Work Orders

Fiscal Year	Work Order	Meeting Date
2001	582-0-80121-01	May 1, 2000
		January 25, 2001
		March 8, 2001
2002	582-0-80121-02	March 7, 2002
		June 26, 2002
2003	582-0-80121-05	February 23, 2003
		April 16, 2003
		May 14, 2003
2004	582-0-80121-06	October 15, 2003
		January 28, 2004
		May 18, 2004
2005	582-0-80121-08	November 16, 2004
		April 6, 2005
		July 19, 2005
		August 18, 2005
2006	582-6-70860-01	November 1, 2005
		February 7, 2006
2007	582-6-70860-09	September 7, 2006
		February 8, 2007
		June 26, 2007

The first stakeholder meeting was held was held during **May 2000**. This meeting provided an initial overview of the project. No technical aspects of the project were presented by the project team.

The second stakeholder meeting was held on **January 25, 2001**. This meeting summarized the historical flow and bacteria data. Input received by the stakeholders included a request by Linda Broach to see better quantification of bypasses and leaks. This request was addressed in subsequent work orders when the project team sampled dry weather storm sewer discharges and evaluated bypasses within the watershed (none found).

The stakeholder meeting held on **March 8, 2001** was the project's third meeting. At this meeting, Dr. Hanadi Rifai presented a recap of historical data in the study area and then focused the discussion on the proposed monitoring plan. Input was solicited from the stakeholders on the monitoring plan during the meeting to be forwarded to Hanadi Rifai by March 23, 2001. Comments received from the stakeholders included the following:

- Donna Phillips asked about the focus on WWTPs only during dry weather. She suggested identifying a few sites for wet weather testing. This request was incorporated into Work Order 582-80121-08.

- Linda Broach asked why only one runoff sampling site was selected for Whiteoak Bayou and suggested adding an additional location. Her recommendation was implemented by the project team to include a total of three monitoring points in Whiteoak Bayou in the runoff sampling plan.

- Theo Glanton suggested evaluating both fecal coliform and E. coli. The project team implemented this suggestion for the WWTP sampling effort.

A stakeholder meeting was held on **March 7, 2002** to present findings from the Clean Rivers Program Bacteria DNA/Source Tracking as well as results from the monitoring were discussed. The results of the monitoring showed that runoff is a significant source of bacteria to the bayou, regrowth did not appear to be an important bacteria source, WWTP exceedances occur about 10% of the time and illicit discharges may be more important than WWTPs in contributing bacteria loading to the bayous. During this meeting, stakeholders posed a number of questions regarding the monitoring as well as the study in general. Monitoring questions were answered by the project team throughout the course of this stakeholder meeting but as the meeting was running beyond its scheduled time, an additional meeting was scheduled to address the general questions in more detail.

The follow-up meeting for the March 7, 2002 stakeholder meeting was held on **June 26, 2002:**

- Theo Glanton discussed fertilizers and sediment fertilizer from local store tested for bacteria and found high levels as well as in soil.

- Dr. Yu-Chun Su presented findings of contribution of bacteria from sediment on the stream bank; sediments were found to have high levels of bacteria along the bayou banks (under bridges as well as away from bridges).

- Dr. Hanadi Rifai presented information on reservoirs to show that they do constitute a source of bacteria, but also function as removal mechanisms when water is held for long periods of time.

- Dr. Rifai and Ms. Monica Suarez presented on WWTPs and offered a discussion on the plants that were not sampled and why prior notice was required. Mel Vargas suggested that the benefit of obtaining additional data is uncertain given the cost and time it would take to secure the right of entry for monitoring plants without prior notice.

- Dr. Paul Jensen presented on new standards. He provided a summary of recommendations before the standards group in the triennial standard revision. The focus of this recommendation was to get the waters of the state into 4 groups: A – managed swimming areas, B – stable waters, C – smaller, variable waters, and D- non-contact areas. Streams in category C would be subject to contact recreation standards when velocity < 2 ft/s, depth > 18 in, water clarity was sufficient to see bottom or have a known bottom, temperature greater than 59 F.

The meeting held on **February 23, 2003** focused on the identification of bacteria sources and the presentation of initial HSPF modeling results. Results of the modeling showed that nonpoint sources and upstream reservoir inputs were the major sources of bacteria. Stakeholders suggested that because such a large amount of information had been presented at this meeting, a second meeting would be helpful to recap and review. Ron Stein suggested a second meeting approximately 30 days later.

The requested meeting was subsequently held on **April 16, 2003**. The meeting focused on recapping information provided at the February 23, 2003 meeting. The project team answered questions raised by the stakeholders on the following topics:

- relationship of sediment to bacteria
- examination of flow conditions are safe for contact recreation,
- accuracy of reported flows from WWTPs,
- restoring riparian buffers to filter runoff from entering the bayous,
- lack of actual measurements of nonpoint source loads,
- using BMPs to slow down water,
- human versus animal/bird sources of bacteria, and
- how much bacteria might be contained in sediments from past discharges of wastewater treatment plants.

The stakeholder meeting held on **May 14, 2003** was intended to begin a process of brainstorming to identify questions and issues as well as elements needed to fill gaps in the TMDL study. The goal was also to agree on when/where/how to secure additional information and enable the stakeholders to make practical recommendations regarding a watershed implementation plan. A large focus of the meeting was to summarize "what we know", "what we need", and "what others can offer". At the end of this meeting, stakeholders were given three dots to vote for their selection as to what piece of work to add to the upcoming work order between TCEQ & UH. The three top choices of aspects to include in the next project team work order were to:

- Define conditions where safe contact can happen;

- More correlation data between WWTP outfalls and instream conditions; and
- Identify areas of failing septic systems.

The project team incorporated the correlation between WWTP outfalls and instream conditions into the fiscal year 2004 work plan. The project team defined what constitutes a low flow condition in the Final Report for Work Order 5. Finally, the project team conducted detailed analyses of septic systems as detailed in the Final Reports for Work Order 8 and Work Order 582-6-70860-01.

On **October 15, 2003**, a stakeholder meeting was held as a follow-up to the brainstorming session held on May 14, 2003. The addition of the task to assess E. coli levels downstream of WWTP outfalls was discussed. In addition, updates on related projects were given by Harris County and H-GAC. Finally, Carl Masterson presented the results of the stakeholder survey.

The stakeholder meeting held on **January 28, 2004** focused on a discussion of the project status, including load allocations. Runoff was noted to be an important contributor to the bayou concentrations and modeling results showed when eliminated, the standard could be met in most parts of the bayou. During this discussion, stakeholders noted that a jump in bacteria concentrations occurred near Memorial Park and suggested that this jump be investigated by the project team. Results of the investigation were to presented at the next stakeholder meeting. Ron Stein also provided an updated on the next monitoring phase of the project.

The stakeholder meeting on **May 18, 2004** focused on several technical issues. The project team provided an update on analyses conducted regarding a dog park in Buffalo Bayou. Results from the analyses of the jump in bacteria concentrations noted at the stakeholder meeting in January 28, 2004 was presented and the resulting recommendation was to shift the modeling period to a time when E. coli data are available, rather than converting fecal coliform to E. coli. Stakeholders brought up the point that we should begin looking at BMPs now even without knowing what sources are. This recommendation was implemented by TCEQ by initiating a BMP study to determine their impacts on bacteria in 2005. An End Game Strategy workgroup was formed by the stakeholders.

On **November 16, 2004**, a stakeholder meeting was convened to discuss project status and present results of the sampling conducted in 2004. Prior to the technical presentation, Tom Weber, of the TCEQ, gave an overview on different stream standards. Results of the WWTP sampling conducted to address stakeholder concerns showed that not much effect was observed from WWTP outfalls. Bacteria source tracking results were also presented.

At the **April 6, 2005** stakeholder meeting, the End Game Strategy group presented an update. They had requested a summary of what we know and what we don't know and in response, the project team created a document titled "Key Issues and Scientific Conclusions" (see Attachment A). The End Game Strategy group members stated that although they had requested this document, it did not meet their needs. They requested an executive summary covering all of the studies that was more specific that the document that was prepared. The request was responded to and the technical team developed the executive summary (see August 18, 2005 meeting). At this meeting, Ron Stein presented an overview of the TMDL process. Ron Stein laid out a

project timeline of having the TMDL adopted in June 2006 with EPA approval received in December 2006. Ron Stein also provided an update on the BMP study that was submitted as a 319 grant request.

The stakeholder meeting held on **July 19, 2005** focused on membership issues.

On **August 18, 2005** a stakeholder meeting was organized to discuss the Technical Summary document prepared by the project team (see Attachment A), the best management practices evaluation project, and the development of TMDL allocations. PBS&J announced during this meeting that they would no longer be part of the technical project team due to a conflict in philosophy.

The Technical Summary document was prepared for the End Game Strategy Workgroup and summarized all the work that has been done to date with conclusions. The Technical Summary document initiated discussion on a variety of topics, including:

- Relationship with solids and BMPs;
- What is the real problem and how bad is it;
- Can the water quality standards be achieved;
- No clear understanding on solids discharges and their contribution;
- Regrowth and its role as a contributor or a characteristic of the bayou environment; and
- Whether the WWTPs that were given advanced notice compare favorably to samples from unannounced visits by the technical team and Harris County.

In addition to this discussion, Ron Stein announced the availability of a BMP Evaluation Project. This project was applied and funded because of stakeholder concerns regarding BMPs and their effectiveness in the Houston area.

The meeting on **August 18, 2005** concluded with a presentation on load allocations. The load allocation method presented was based upon a spreadsheet tool that summarized all sources of bacteria and their estimated loading. Load reductions for median flow conditions were estimated using this spreadsheet tool to be 96% in both bayous to meet the contact recreation standard and 81% to meet the non-contact recreation standard.

The stakeholder meeting held on **November 1, 2005** included presentations on several topics, including several projects sponsored by Harris County to investigate illicit discharges, the source of the bacteria (human versus non-human), and the affinity of bacteria for sand, silt and clay from detention basins. In addition, Linda Pechacek was voted in to the stakeholder committee, and a discussion led by Carl Masterson on the implementation plan development organization.

The stakeholder meeting held on **February 7, 2006** included a presentation from Tom Weber, TCEQ, on the status of the TMDL. Tom laid out the timeline for the TMDL, stating that the TCEQ intended to have the TMDL recommendation to the Commissioners in late 2006. Mr.

Weber requested stakeholder input on three issues: background loads, the flow cutoff and loads from treatment facilities.

A decision must be made on what constitutes a background load, as it is not considered controllable (i.e., direct deposition into the water, release from sediment, runoff from birds, domestic animals and wildlife). If all are included in background load, then the background might exceed the standard –then TCEQ's ability to issue permits for new treatment facilities would be hindered. Comments and questions from the stakeholders on background loads included the following:

- It would be incorrect to assume that all background levels are natural
- The Clean Rivers Program sampled less developed streams Lake Creek and Peach Creek, and found that bacteria levels are nowhere near Buffalo and Whiteoak Bayous, and that higher concentrations in Lake Creek could be related to a higher watershed population and more impervious surface
- The appropriateness of the E. coli indicator was questioned
- Direct deposition into the water should be considered background and runoff from wildlife could be included in the Load Allocation
- The TCEQ should be cautious about taking loads out of NPS runoff as all control recommendations have to be justified
- Runoff containing bacteria from wildlife and mulch should not be included in background

The flow cutoff could be a way to address the fact that contact recreation doesn't occur at the upper end of the flow regime. Should the flow cut off be based upon safe flows or a percentile flow? Safe flow can have the rationale that equates more with what is going on in the real world, while percentile flows might be somewhat arbitrary but easy to determine. Comments and questions from the stakeholders on flow cutoffs included the following:

- Can we develop a safe flow without changing the standard?
- How will TCEQ account for WWTPs dumping pollutants just before or during safe flow events?
- A high cut off flow could help reduce what is calculated as contributing to background components.
- TNRCC had goal to develop wet weather standards in 1994, very complex issue that has not moved forward
- There could be agreement on safeness of a particular flow, while flow percentiles might be more difficult
- Regardless of flow, very few people use Buffalo Bayou for recreation

- Buffalo Bayou Partnership is spending millions of dollars to bring people closer to the bayou
- There is no link between the indicator species and pathogenic bacteria

Current permits for WWTPs require a minimum chlorine residual. If an alternative disinfection process is used then facilities are required to test for bacteria, with the stream standard being the permit limit. The TCEQ is seeking input on what a reasonable amount of bacteria loading would be. Comments and questions from the stakeholders on effluent loads included the following:

- WWTPs will not discharge zero bacteria
- Need better checks and balances so the end of the pipe meets design and the design is right
- Bacteria issue is more complex in urban areas, where streams do not dry out

Additional comments and questions from the stakeholders following Tom Weber's discussion included:

- Is the 99% stormwater reduction similar to other bacteria TMDLs (TCEQ responded no, it is likely a reflection of area and land use)
- Why were the issues discussed the only things for which comments were requested (TCEQ responded that these are the ones that the TCEQ needs the input, because without resolving them the TMDL cannot be developed)
- How will allocations for construction permits be handled (TCEQ responded that the allocation will not be broken down to that specific level)
- Still uncertainty about the background load (TCEQ responded that it is in a developmental period, and more discussions can be held during implementation planning. No new studies will be undertaken for the TMDL).

Next, the technical team presented an updated on bacteria source tracking. Updates to the model with septic system data from Harris County were also presented. Comments from the stakeholders focused on background loads and the distribution of loading by land use.

The **September 7, 2006** stakeholder meeting was held to review the allocation strategy and presentation of Harris County sampling efforts. The results of the Discharge Elimination study were presented to the stakeholder group. Findings from this study showed that most of the discharges were allowable and nutrient levels are two to three times what would be found in a natural stream. The Harris County sampling also examined WWTPs on Whiteoak Bayou that were loaded at 50% or greater levels. The samples were taken from the pipe, not at the regulatory discharge point. Measurements taken in this study showed that concentrations were higher than those collected with prior notice. In addition, the possibility of regrowth in the WWTP pipes was discussed. Allocation strategy and likely allocations were also presented, with a discussion of the spreadsheet tool (BLEST) and its estimates for load allocations. Finally, Ron

Stein discussed the organization of the implementation plan partnership and that its formation would begin during the spring of 2007.

Linda Pechacek presented comments during the **September 7, 2006** stakeholder meeting. Her comments were as follows:

- Comprehensive BMP program may not be successful in meeting bacteria in state stream standards during all flow regimes;
- Need to place importance on developing or modifying criteria to address wet weather flows;
- Afraid that regulations are getting ahead of the science and that it will cost a lot of money;
- Concerned that there is too much uncertainty in available data for TCEQ to set final TMDLs.

The **February 8, 2007** stakeholder meeting was organized to review progress on the project. Ron Stein presented TCEQ's perspective on the uncertainty in TMDL Allocations. His discussion centered on the fact that although uncertainty exists in the load estimates, the implementation strategy is the same for any magnitude of load from these sources. A comparison of HSPF, BLEST and Load Duration Curves were presented by the technical team (see Attachment A for handouts). The comparison of the three methods suggests that minimal differences exist between the load estimation methods. Finally, the meeting was concluded with a presentation from Tom Weber on the Bacteria Task Force. Comments on the BLEST model were requested with a deadline of March 8, 2007 so that a final modeling report could be completed.

The **June 26, 2007** was focused on a technical presentation given by Dr. Robin Brinkmeyer on the results of a virus study on waterbodies in Harris County. Findings of the study suggest that viruses are detected downstream of WWTPs, but the viability of the viruses is not known. TCEQ gave a presentation on Watershed Protection Plans and a brief statement was given by Mark Lowry, presenting the Joint Task Force position on the TMDL and their desire to pursue a watershed protection plan.