

Total Maximum Daily Loads for Indicator Bacteria in Buffalo Bayou and Whiteoak Bayou

Contract No. 582-6-70860
Work Order No. 582-6-70860-09

QUARTERLY REPORT 2

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CHAPTER 1

INTRODUCTION

Buffalo Bayou (Segments 1013 and 1014) and Whiteoak Bayou (Segment 1017) are considered impaired water bodies for contact recreation because they do not meet indicator bacteria (*E. coli*) water quality standards. As a result, the three segments of the two bayous were placed on the Texas Clean Water Act 303(d) List in 1996 and the current study was initiated in 2001. In 2002, eleven (11) tributaries of these bayous were placed on the 303(d) list for not meeting contact recreation water quality standards. The purpose of this study is to provide the Texas Commission on Environmental Quality (TCEQ) with the information and assistance necessary for the preparation of a Total Maximum Daily Load (TMDL) for the indicator bacteria (*E. coli*) impairments in Buffalo and Whiteoak Bayous and their listed tributaries.

The information gathered under this project will be used to develop the TMDL allocations. First, the TMDL allocations identify how much indicator bacteria (*E. coli*) the water bodies can assimilate and maintain the contact recreation standard (load capacity). Second, the TMDL allocations identify how much reduction is needed to the sources of indicator bacteria (*E. coli*) to reach the contact recreation standard. Reductions are identified for two broad categories of indicator bacteria sources, those sources that are covered by permits referred to as the waste load allocation (WLA) and those sources that are not covered by a permit referred to as the load allocation (LA). This relationship is referred to as the TMDL equation and it is expressed as **LC = LA + WLA.**

For the TMDL, the reductions will be assigned to the two broad categories and during the

development of the subsequent implementation plan, details of the reductions required for individual components of the WLA and LA will be determined. During the course of this project, several different elements of the LA and WLA categories have been studied. This was done so that the indicator bacteria (E. coli) loads for each broad category could be estimated. So for example, the waste load allocation reduction was based on studies of waste water treatment plant operations, and discharges, dry and wet weather storm sewer discharges, and storm sewer overflows. These studies provide an estimate of all indicator bacteria loads from permitted sources. Included in this estimate are loads from other permits such as construction permits, industrial discharge permits, and future Phase II MS4 permits. Although these sources are not specifically identified, their discharges are contained in the discharge through the storm sewer. As a result, the loads from these permitted sources are included in the general WLA category that will be presented in the TMDL allocations and report. During the development of the Implementation Plan, specific reduction strategies and schedules will be established for all specific permits under the WLA. The same approach will be used for the LA component of the TMDL allocations.

During the conduct of the project, quarterly progress reports are developed to track contractual progress and to provide documentation of the progress of the study. This quarterly report is part of a larger study with several work orders since the initiation of the project. During fiscal year 2001, Work Order 582-0-80121-01 provided analysis of historical information for current levels and trends as well as an assessment of the major sources of bacteria to the two bayous. Work Order 582-0-80121-02, completed in fiscal year 2002, investigated suspected sources of bacteria, including sediment, wastewater treatment plants, and dry weather storm

sewer flows. A water quality model was developed during Work Order 582-0-80121-02. Work Order 582-0-80121-05, completed in fiscal year 2003, investigated bacteria in sediment, potential load allocation issues and best management practices that may be practical for application in the study watersheds. During fiscal year 2004, Work Order 582-0-80121-06 identified and studied additional potential sources of bacteria into the bayous. Work Order 582-0-80121-08, completed in fiscal year 2005, focused on completing source data collection, as well as refining and developing load allocation methodologies. The development of the mass balance tool (Bacteria Load Estimator Spreadsheet Tool - BLEST) was detailed in Work Order 582-6-70860-01 for load and wasteload allocation determination. In the work order numbering sequence above, it is noted that several work orders were issued under this contract that were for work for other projects not related to this indicator bacteria TMDL project. Those work orders are not included in this report.

This document is the second quarterly progress report for contract #582-6-70860-09. The report consists of two chapters that summarize the progress of work between December 2006 and February 2007.

CHAPTER 2

STAKEHOLDER/PUBLIC EDUCATION AND INVOLVEMENT

The University of Houston supported the stakeholder process facilitated by the Houston Galveston Area Council (HGAC) and Mary Jane Naquin, an independent consultant. The University of Houston performed the following support tasks during the time covered by this progress report:

- Participation in a stakeholder meeting on February 8, 2007;
- Development of informational materials summarizing the technical aspects of the project for electronic and hard copy distribution at the stakeholder meeting including tables, figures and quarterly reports; and
- Preparation of responses to questions and information requests from stakeholders.

Slides from the Stakeholder Meeting are presented in Appendix A.

CHAPTER 3

ANALYSIS OF WASTEWATER TREATMENT PLANT SAMPLING

To date, there have been several WWTP sampling efforts conducted in Buffalo and Whiteoak bayous. The University of Houston collected samples at more than 60 WWTPs in the Summer of 2001. In addition, between June and August 2006, the TCEQ Region 12 staff also completed a sampling program to characterize effluent from the majority of wastewater treatment plants (WWTPs) operating in the Buffalo and Whiteoak Bayou watersheds. Finally, the Harris County Public Infrastructure Department Storm Water Quality Section commissioned a study of 26 WWTPs in Whiteoak Bayou and sampling was conducted between May and August 2006. As detailed in this chapter, these data were compared and input into BLEST to evaluate the effect on wasteload and load allocations.

3.1 COMPARISION OF WWTP DATA

Data collected by the University of Houston in the summer of 2001 as well as data collected by the TCEQ and Harris County in summer of 2006 are summarized in Table 3.1. TCEQ sampled a total of 100 plants, while the University of Houston collected a total of 69 samples at peak flow and 64 samples at off-peak flow conditions. Harris County collected samples from a total of 26 plants in the Whiteoak Bayou watershed only. Additionally, and as part of this TMDL project, end of pipe (EOP) sampling was conducted in 2004 and 2005. The EOP sampling (Table 3.1) included 14 plants, with some sampled twice in the two events.

Table 3.1. Summary of Sampling Data for WWTPs in Buffalo and Whiteoak Bayous

Permit #	NPDES ID	Subbasin	Watershed	BLEST Flows (MGD)	Summer (2000) - UH				Summer (2006) - TCEQ		End of Pipe (2004) - UH		End of Pipe (2005) ⁵ - UH		End of Pipe Rnd 1 (2006) - Harris County		End of Pipe Rnd 2 (2006) - Harris County	
					Peak Flow (MGD)	Off-Peak Flow (MGD)	Peak E. coli (MPN/dL)	Off-Peak E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)
02731-000	TX0087416	27	BB	0.0017	-	-	-	-	-	-	-	-	-	-	-	-	-	
10495-030	TX0063002	33	BB	9.5247	-	-	-	-	18.500	5	-	-	-	-	-	-	-	
10495-135	TX0026395	35	BB	0.5412	1.600	0.576	4	9	0.499	2	-	-	-	-	-	-	-	
12346-001	TX0086185	35	BB	0.1801	0.197	-	1	-	0.140	1,540	-	-	-	-	-	-	-	
12427-001	TX0088218	35	BB	0.0001	-	0.022	-	1	-	-	-	-	-	-	-	-	-	
12682-001	TX0092584	35	BB	0.0407	0.104	0.124	1	1	-	-	-	-	-	-	-	-	-	
13021-001	TX0096911	35	BB	0.1435	-	-	-	-	-	-	-	-	-	-	-	-	-	
13228-001	TX0100137	35	BB	0.0390	-	-	-	-	-	-	-	-	-	-	-	-	-	
14182-001	TX0122536	35	BB	0.0217	-	-	-	-	-	-	-	-	-	-	-	-	-	
12233-001	TX0083933	44	BB	0.0006	-	-	-	-	0.005	26	-	-	-	-	-	-	-	
10584-001	TX0047457	53	BB	2.9818	-	-	-	-	8.390	52	#	73	-	-	-	-	-	
10495-109	TX0035017	55	BB	4.4216	-	-	-	-	-	-	#	121	-	-	-	-	-	
12355-001	TX0086177	56	BB	0.0003	-	-	-	-	0.000	5	-	-	-	-	-	-	-	
12830-001	TX0094056	56	BB	0.0022	-	-	-	-	-	-	-	-	-	-	-	-	-	
14070-001	TX0089940	56	BB	0.0015	0.003	0.004	1	1	0.009	2	-	-	-	-	-	-	-	
14117-001	TX0119571	56	BB	0.0977	-	-	-	-	0.182	1	-	-	-	-	-	-	-	
03153-000	TX0074292	104	BB	0.0102	0.029	0.032	1	3	-	-	-	-	-	-	-	-	-	
12466-001	TX0089061	105	BB	0.0013	0.008	0.005	295	4	-	-	-	-	-	-	-	-	-	
13484-001	TX0104311	105	BB	0.0420	0.029	0.056	1	1	0.009	1	-	-	-	-	-	-	-	
10932-001	TX0068047	106	BB	0.0191	-	-	-	-	0.000	1	-	-	-	-	-	-	-	
11290-001	TX0046621	106	BB	2.5394	-	-	-	-	3.243	32,550	-	-	-	-	-	-	-	
11523-001	TX0052906	108	BB	0.7848	0.550	1.310	33	29	1.343	2	-	-	x	x	-	-	-	
12124-001	TX0079707	108	BB	0.2510	-	-	-	-	0.192	1	-	-	-	-	-	-	-	
12474-001	TX0089494	108	BB	0.0148	-	-	-	-	0.051	8	-	-	-	-	-	-	-	
12927-001	TX0095532	108	BB	0.0046	-	-	-	-	0.182	2	-	-	-	-	-	-	-	
13778-001	TX0097985	108	BB	0.0010	-	-	-	-	0.012	1	-	-	-	-	-	-	-	
11836-001	TX0091626	109	BB	0.2909	-	-	-	-	0.140	207,500	-	-	-	-	-	-	-	
11935-001	TX0075981	109	BB	0.1451	0.145	0.0	1	1	0.144	1	-	-	-	-	-	-	-	
11486-001	TX0062031	110	BB	0.5457	-	-	-	-	0.001	512	-	-	-	-	-	-	-	
11682-001	TX0064734	110	BB	0.4431	-	-	-	-	0.785	2	-	-	-	-	-	-	-	
11414-001	TX0104795	113	BB	0.0406	0.012	0.013	1	1	0.011	1	-	-	-	-	-	-	-	
11472-001	TX0026263	113	BB	0.3831	0.550	0.510	1	1	0.328	1	-	-	-	-	-	-	-	
11947-001	TX0075884	113	BB	1.8087	-	-	-	-	0.906	18	-	-	-	-	-	-	-	
12128-001	TX0079537	113	BB	0.5188	0.589	0.636	10	27	0.375	2	-	-	-	-	-	-	-	
12304-001	TX0085588	113	BB	0.3482	0.613	0.598	3	1	-	-	-	-	-	-	-	-	-	
12310-001	TX0085871	113	BB	0.0207	0.008	0.006	1	1	0.059	1	-	-	-	-	-	-	-	
12685-001	TX0093581	113	BB	0.0700	0.094	0.083	1	1	0.061	1	-	-	-	-	-	-	-	
12223-001	TX0083496	114	BB	0.1961	0.440	0.650	7	1	0.001	2	-	-	-	-	-	-	-	
12726-001	TX0100161	115	BB	0.2920	0.066	-	66	-	0.396	1	-	-	-	-	-	-	-	
12447-001	TX0088838	116	BB	0.1944	-	-	-	-	0.420	3	-	-	-	-	-	-	-	
13328-001	TX0101371	116	BB	0.0266	-	-	-	-	0.450	56	-	-	-	-	-	-	-	
11906-001	TX0074896	117	BB	0.3069	0.320	0.310	1	1	1.333	884	-	-	-	-	-	-	-	
12209-001	TX0083500	119	BB	0.2361	-	-	-	-	0.732	1	-	-	-	-	-	-	-	
12834-001	TX0094307	119	BB	0.0637	0.005	0.004	1	1	0.162	1	2.66E-05	100	-	-	-	-	-	
12841-001	TX0097373	119	BB	0.0430	-	-	-	-	0.009	1	-	-	-	-	-	-	-	
12949-001	TX0095702	119	BB	0.0231	0.006	-	1	-	0.164	4	-	-	-	-	-	-	-	

Table 3.1 Summary of Sampling Data for WWTPs in Buffalo and Whiteoak Bayous, continued

Permit #	NPDES ID	Subbasin	Watershed	BLEST Flows (MGD)	Summer (2000) - UH				Summer (2006) - TCEQ		End of Pipe (2004) - UH		End of Pipe (2005) ⁵ - UH		End of Pipe Rnd 1 (2006) - Harris County		End of Pipe Rnd 2 (2006) - Harris County	
					Peak Flow (MGD)	Off-Peak Flow (MGD)	Peak E. coli (MPN/dL)	Off-Peak E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)
11792-002	TX0070971	120	BB	0.2248	0.301	0.241	4	7	0.420	24	-	-	-	-	-	-	-	-
13921-001	TX0117421	122	BB	0.0062	0.018	0.003	1	3	0.000	1	-	-	-	-	-	-	-	-
11696-002	TX0000000	123	BB	0.1250	0.110	0.469	1	2	0.105	1	-	-	-	-	-	-	-	-
12516-001	TX0089907	123	BB	0.0009	-	-	-	-	-	-	0.01	8	-	-	-	-	-	-
11969-001	TX0076660	124	BB	0.6346	0.085	0.064	25	28	0.785	5	-	-	-	-	-	-	-	-
12140-001	TX0079618	125	BB	0.1393	0.159	-	1	-	0.286	1	-	-	-	-	-	-	-	-
12858-001	TX0094579	133	BB	0.0061	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13172-002	TX0098965	133	BB	0.3159	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13245-001	TX0099856	133	BB	0.1311	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13558-001	TX0098957	133	BB	0.9359	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12370-001	TX0087157	135	BB	0.1109	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14011-001	TX0118109	135	BB	0.0083	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10706-001	TX0025747	136	BB	1.1267	-	-	-	-	-	-	-	-	-	-	-	-	-	-
02229-000	TX0079057	144	BB	0.0077	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12356-001	TX0086690	146	BB	0.1477	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12479-001	TX0089346	147	BB	0.4285	0.443	-	54	-	-	-	-	-	-	-	-	-	-	-
12289-001	TX0085332	148	BB	0.5206	2.109	-	6	-	0.164	100	-	-	-	-	-	-	-	-
11883-001	TX0071625	149	BB	0.5450	0.610	0.469	1	1	-	-	-	-	-	-	-	-	-	-
11598-001	TX0058408	150	BB	0.6927	0.812	0.795	45	52	-	-	-	-	-	-	-	-	-	-
14109-001	TX0119121	151	BB	0.0014	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11152-001	TX0021512	153	BB	1.6229	-	-	-	-	1.345	1	-	-	-	-	-	-	-	-
11893-001	TX0074004	155	BB	1.3135	-	-	-	-	0.286	84	-	-	-	-	-	-	-	-
13674-001	TX0118541	155	BB	0.0332	-	-	-	-	0.499	166	-	-	-	-	-	-	-	-
13775-001	TX0115894	171	BB	0.0941	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14134-001	TX0119873	171	BB	0.0127	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12298-001	TX0085448	178	BB	0.0837	0.021	0.051	1	1	-	-	-	-	-	-	-	-	-	-
10495-139	TX0026875	1	WOB	0.4827	1.790	0.090	1	1	1.236	201	-	-	-	-	-	-	-	-
10495-076	TX0063011	2	WOB	8.6978	-	-	-	-	5.800	2	-	-	-	-	19.200	10	14.33	84
11193-001	TX0075434	2	WOB	0.5063	1.450	0.950	1,296	127	0.585	1	-	-	-	-	1.266	32	2.567	1
12139-001	TX0081256	2	WOB	0.0238	0.007	0.0000041	2,076	4	0.007	31	-	-	-	-	0.054	1	0.027	1
12222-001	TX0083950	2	WOB	0.0675	4.500	1.180	22,027	7,597	0.002	1	0.02	<1	-	-	-	-	-	-
13996-001	TX0117684	2	WOB	0.0016	-	-	-	-	0.000	5	-	-	-	-	0.027	1	0.051	1
02710-000	TX0095435	4	WOB	0.0008	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04760-000	TX0089940	4	WOB	0.0015	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11051-001	TX0075841	4	WOB	0.0345	0.027	0.032	49	44	0.037	6	-	-	-	-	0.165	2	0.122	1,800
11188-001	TX0026697	4	WOB	0.2526	0.512	0.251	1	1	0.422	1	-	-	-	-	0.981	2	1.858	1
11273-001	TX0026352	4	WOB	0.4222	0.214	0.213	2	1	0.316	1	-	-	-	-	1.025	116	1.056	1
11375-001	TX0026247	4	WOB	0.0968	0.156	0.111	32	3	0.041	1	#	<1	0.002-0.043	<1 - 44	-	-	-	-
11389-001	TX0075736	4	WOB	0.0093	0.009	0.011	1	3	0.003	1	-	-	-	-	-	-	-	-
11485-001	TX0062235	4	WOB	0.4073	0.452	0.287	1	1	0.182	1	-	-	0.011-0.36	<1 - 48,840	1.351	1	1.416	1
11538-001	TX0057029	4	WOB	1.0430	-	-	-	-	0.985	11	-	-	-	-	3.000	298	3.300	1,200
11670-001	TX0063479	4	WOB	0.3245	0.497	0.300	15	19	0.197	1	-	-	-	-	0.668	4	1.593	1
12342-001	TX0085821	4	WOB	0.0190	0.023	0.011	2	1	0.005	1	-	-	-	-	-	-	-	-
12443-001	TX0088676	4	WOB	0.0013	0.001	0.001	1	14	0.004	33	-	-	-	-	-	-	-	-
12552-001	TX0090115	4	WOB	0.0058	-	-	-	-	0.004	1,935	-	-	-	-	-	-	-	-
12552-002	TX0117064	4	WOB	0.0047	-	-	-	-	0.004	1	-	-	-	-	-	-	-	-

Table 3.1 Summary of Sampling Data for WWTPs in Buffalo and Whiteoak Bayous, continued

Permit #	NPDES ID	Subbasin	Watershed	BLEST Flows (MGD)	Summer (2000) - UH				Summer (2006) - TCEQ		End of Pipe (2004) - UH		End of Pipe (2005) ⁵ - UH		End of Pipe Rnd 1 (2006) - Harris County		End of Pipe Rnd 2 (2006) - Harris County	
					Peak Flow (MGD)	Off-Peak Flow (MGD)	Peak E. coli (MPN/dL)	Off-Peak E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)	Flow (MGD)	E. coli (MPN/dL)
13433-001	TX0103705	4	WOB	0.0117	0.002	0.0000163	1	1	0.350	1	-	-	-	-	-	-	-	-
13509-001	TX0092746	4	WOB	0.0133	0.002	0.004	74	68	0.011	1	-	-	-	-	-	-	-	-
13578-001	TX0097098	4	WOB	0.0063	0.002	0.005	1	1	0.001	3	-	-	-	-	-	-	-	-
13623-001	TX0109126	4	WOB	0.0723	0.400	0.330	1	1	0.033	1	-	-	-	-	0.278	104	0.384	12
13689-001	TX0111937	4	WOB	0.3366	0.130	0.247	314	38	0.250	105	-	-	-	-	1.770	700	1.360	600
13727-001	TX0113697	4	WOB	0.0070	0.019	0.006	1	1	0.004	1	-	-	-	-	-	-	-	-
13807-001	TX0082597	4	WOB	0.0007	0.000	0.004	1	1	0.007	9	-	-	-	-	-	-	-	-
13939-001	TX0082988	4	WOB	0.0012	-	-	-	-	0.004	1	-	-	-	-	-	-	-	-
13983-001	TX0095435	4	WOB	0.0009	-	-	-	-	trickle	1	-	-	-	-	-	-	-	-
14316-001	TX0123650	4	WOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10495-099	TX0057347	7	WOB	1.6974	-	-	-	-	1.249	1	#	5,905	0.28 - 3	<1 - 6,695	3.606	52	6.650	500
12573-001	TX0090735	9	WOB	0.0097	0.015	0.015	1	1	-	-	-	-	-	-	-	-	-	-
12714-001	TX0092908	9	WOB	0.1437	0.232	0.122	2	1	0.148	6	-	-	-	-	0.658	108	0.319	1
14359-001	TX0119431	9	WOB	0.0313	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14506-001	TX0126462	9	WOB	-	-	-	-	-	0.148	241,920	-	-	-	-	0.038	1	0.045	1
14538-001	TX0020788	9	WOB	-	-	-	-	-	1.540	1	-	-	-	-	5.137	102	5.765	16
11563-001	TX0053325	10	WOB	0.6681	0.745	0.613	15	13	4.376	11	-	-	>0.046	204.00	0.957	196	2.028	1,800
11979-002	TX0076651	10	WOB	0.1889	0.272	0.230	1	1	0.164	1	-	-	-	-	0.372	1	0.461	1
12397-001	TX0087416	10	WOB	0.0044	-	-	-	-	0.022	179	-	-	-	-	-	-	-	-
12574-001	TX0091316	10	WOB	0.1219	0.164	0.143	1	2	0.231	1	-	-	-	-	-	-	-	-
12681-001	TX0092606	10	WOB	0.1828	-	-	-	-	0.182	1	-	-	-	-	0.701	1	0.767	1
14072-001	TX0082317	10	WOB	1.0091	1.520	1.300	17	1	1.815	1	-	-	-	-	1.988	94	2.242	1,100
12121-001	TX0079146	11	WOB	0.9316	1.200	1.000	21	6	1.022	1	-	-	-	-	0.940	56	2.191	290
12795-001	TX0093726	11	WOB	0.1907	0.295	0.021	30	322	0.338	118	x	x	x	x	1.024	42	0.768	1
10876-001	TX0022853	13	WOB	0.8689	1.399	1.114	3	6	1.373	2	-	-	-	-	1.894	5,000	2.587	2,600
10876-002	TX0091804	13	WOB	0.8814	1.076	0.725	9	1	1.746	27	-	-	-	-	3.025	6,300	2.723	10,300
12465-001	TX0088927	13	WOB	0.0052	0.005	0.004	1	193	0.015	1	0.01	<1	-	-	-	-	-	-
11005-001	TX0020095	17	WOB	0.1472	0.095	0.218	2	1	0.105	1	-	-	-	-	0.321	2	0.239	2
12132-001	TX0079634	40	WOB	0.0391	0.019	0.00000000	1	1	0.007	17	-	-	-	-	-	-	-	-
13764-001	TX0092932	42	WOB	0.0565	-	-	-	-	0.051	9	-	-	-	-	-	-	-	-
11284-001	TX0053091	181	WOB	0.5743	0.704	0.625	8	8	0.661	32	-	-	-	-	-	-	-	-
12110-001	TX0079201	181	WOB	0.0670	0.141	0.183	1	1	0.051	2	-	-	-	-	-	-	-	-
12802-001	TX0093891	181	WOB	0.1530	0.119	0.082	9	1	1.607	1	-	-	-	-	-	-	-	-
11989-001	TX0076775	183	WOB	0.2889	0.525	0.230	1	1	0.286	1	-	-	-	-	-	-	-	-
12189-001	TX0082830	183	WOB	0.0621	-	-	-	-	0.028	3	-	-	-	-	-	-	-	-
12247-001	TX0084468	183	WOB	0.1857	0.006	0.006	1	1	0.171	11	-	-	-	-	-	-	-	-
11917-001	TX0074403	185	WOB	0.3131	0.483	0.250	1	1	0.003	1	-	-	-	-	-	-	-	-
11986-001	TX0076791	-	Outside	-	-	-	-	-	-	-	-	-	-	0.048	70	0.103	1	-
13770-001	TX0090735	-	Outside	-	-	-	-	-	0.008	238	-	-	-	-	-	-	-	-
Number of samples collected:					69	64	69	64	99	99					26	26	26	26
Number > 394 MPN/dL							3	1		7						3		8
Flow weighted geometric mean (MPN/dL):							19.6	5.8		14.8			1.4	N/C		43.9		84.4

Notes:

1. E. coli concentrations less than detection limit have been divided by 2 in this table
2. Duplicates, if available, were averaged

3. Samples presented with a range represent more than 25 samples at each plant
- data not available/not collected

N/C - not calculated

x - flow and E. coli not be measured because pipe submerged

- flow not measured at these plants

It is important to mention that each of the three sampling efforts were motivated by specific, and often different, goals. For example, the University of Houston data that were collected aimed to characterize dry weather peak and off-peak flow conditions at WWTPs at the regulatory discharge point, the weir. Advance notice was given to all the plants. The TCEQ sampling was designed to assess typical conditions at the regulatory discharge point during dry weather. Samples were collected primarily in the morning to mid-afternoon, but plant operators were not given prior notice of the sampling. The end of pipe sampling was conducted in 2004 and 2005 by UH during dry weather conditions to assess the impact of discharges on the water quality in the bayou. The sampling entailed collection of samples at the pipe discharging WWTP effluent into the bayou, as well as samples in the mixing zone of the piped discharge, approximately 100 meters upstream of the pipe and approximately 300 meters downstream. Finally, the Harris County Storm Water Quality Section performed two rounds of sampling, with samples were collected from 26 WWTPs within Whiteoak Bayou at the pipe discharging into the bayou during dry weather. Round 1 of sampling was conducted in May 2006, while round 2 was conducted in August 2006.

A wide range of concentrations was measured during these sampling events, with concentrations spanning the detection limits, from less than 1 to over 241,920 MPN/dL. The number of plants exceeding the instantaneous water quality standard (394 MPN/dL) varied from sampling event to sampling event. The University of Houston 2001 sampling noted 4% exceedances during peak conditions and 2% exceedances during off-peak conditions. The TCEQ sampling yielded exceedances of 7%, while the Harris County Stormwater Quality sampling had 12% and 31% exceedances, for rounds 1 and 2, respectively. The large difference

between the results of data collected by the Harris County Stormwater Quality sampling and the University of Houston and TCEQ sampling may be related to the sample collection point, variability in effluent quality or sampling and analysis protocols.

Loads at each WWTP were calculated as shown in Table 3.2 for the University of Houston, TCEQ and Harris County Storm Water Quality Section sampling data. The total calculated load for all plants ranged between $3.5E+11$ to $6.56E+12$ MPN/day, and is generally dominated by the plant with the highest loading. The highest overall loading was observed in the samples collected by the TCEQ in summer 2006, while the lowest overall load was for the off-peak sampling by UH.

3.2 MASS BALANCE RESULTS

The concentrations measured during the TCEQ and Harris County sampling were input into the BLEST mass balance tool and the results are shown in Tables 3.3, 3.4 and 3.5. In addition, a summary of the WWTP load along with the percent reduction for the WLA and LA required to meet the contact recreation standard is shown in Table 3.6. As shown in the tables, the WWTP load varies considerably depending upon which WWTP data are used as input. The loads range from 1.35 billion MPN/day in Segment 1014 during dry weather using baseline conditions to 5,718 billion MPN/day for intermediate and wet conditions in the Reservoir watershed using TCEQ sampling data.

It should be noted that although the WWTP loads discussed above vary significantly, loads input to BLEST must be appropriately quantified with respect to other loads in the system since BLEST is fundamentally a mass balance model that simulates observed in-stream loads.

The estimated total loads for each watershed should be consistent with the observed loads in the bayou.

Table 3.2. Summary of Bacteria Loads from WWTPs

Permit #	Sub basin	Water shed	E. coli load (MPN/day)				
			Peak Summer (2000) UH	Off-Peak Summer (2000) UH	Summer (2006) TCEQ	Summer (2006) - Harris County Round 1	Summer (2006) -Harris County Round 2
02731-000	27	BB	-	-	-	-	-
10495-030	33	BB	-	-	3.50E+09	-	-
10495-135	35	BB	2.51E+08	1.86E+08	3.78E+07	-	-
12346-001	35	BB	3.73E+06	-	8.17E+09	-	-
12427-001	35	BB	-	4.13E+05	-	-	-
12682-001	35	BB	1.97E+06	2.35E+06	-	-	-
13021-001	35	BB	-	-	-	-	-
13228-001	35	BB	-	-	-	-	-
14182-001	35	BB	-	-	-	-	-
12233-001	44	BB	-	-	4.75E+06	-	-
10584-001	53	BB	-	-	1.65E+10	-	-
10495-109	55	BB	-	-	-	-	-
12355-001	56	BB	-	-	8.18E+04	-	-
12830-001	56	BB	-	-	-	-	-
14070-001	56	BB	4.91E+04	7.09E+04	6.76E+05	-	-
14117-001	56	BB	-	-	3.45E+06	-	-
03153-000	104	BB	5.44E+05	3.27E+06	-	-	-
12466-001	105	BB	8.51E+07	7.37E+05	-	-	-
13484-001	105	BB	5.49E+05	1.06E+06	1.77E+05	-	-
10932-001	106	BB	-	-	2.74E+01	-	-
11290-001	106	BB	-	-	4.00E+12	-	-
11523-001	108	BB	6.94E+08	1.42E+09	8.90E+07	-	-
12124-001	108	BB	-	-	3.64E+06	-	-
12474-001	108	BB	-	-	1.56E+07	-	-
12927-001	108	BB	-	-	1.38E+07	-	-
13778-001	108	BB	-	-	2.23E+05	-	-
11836-001	109	BB	-	-	1.10E+12	-	-
11935-001	109	BB	3.66E+06	0.00E+00	2.72E+06	-	-
11486-001	110	BB	-	-	1.99E+07	-	-
11682-001	110	BB	-	-	5.95E+07	-	-
11414-001	113	BB	2.18E+05	2.51E+05	2.09E+05	-	-
11472-001	113	BB	1.04E+07	9.66E+06	6.21E+06	-	-
11947-001	113	BB	-	-	6.17E+08	-	-
12128-001	113	BB	2.34E+08	6.46E+08	2.13E+07	-	-
12304-001	113	BB	7.20E+07	1.13E+07	-	-	-
12310-001	113	BB	1.45E+05	1.20E+05	1.12E+06	-	-
12685-001	113	BB	1.79E+06	1.57E+06	1.16E+06	-	-
12223-001	114	BB	1.24E+08	1.23E+07	3.97E+04	-	-
12726-001	115	BB	1.64E+08	-	7.51E+06	-	-
12447-001	116	BB	-	-	4.77E+07	-	-
13328-001	116	BB	-	-	9.55E+08	-	-
11906-001	117	BB	6.06E+06	5.87E+06	4.46E+10	-	-

Abbreviations: BB - Buffalo Bayou, dL - deciliter, MPN - most probable number, NPDES - national pollutant discharge elimination system, TCEQ - Texas Commission on Environmental Quality, UH - University of Houston, WOB - Whiteoak Bayou

Table 3.2. Summary of Bacteria Loads from WWTPs, continued

Permit #	Sub basin	Water shed	E. coli load (MPN/day)				
			Peak Summer (2000) UH	Off-Peak Summer (2000) UH	Summer (2006) TCEQ	Summer (2006) - Harris County Round 1	Summer (2006) -Harris County Round 2
12209-001	119	BB	-	-	1.39E+07	-	-
12834-001	119	BB	9.09E+04	7.95E+04	3.08E+06	-	-
12841-001	119	BB	-	-	1.77E+05	-	-
12949-001	119	BB	1.05E+05	-	2.49E+07	-	-
11792-002	120	BB	4.22E+07	6.12E+07	3.82E+08	-	-
13921-001	122	BB	3.41E+05	3.41E+05	2.17E+01	-	-
11696-002	123	BB	2.09E+06	4.09E+07	1.98E+06	-	-
12516-001	123	BB	-	-	-	-	-
11969-001	124	BB	7.94E+07	6.82E+07	1.41E+08	-	-
12140-001	125	BB	3.01E+06	-	5.42E+06	-	-
12858-001	133	BB	-	-	-	-	-
13172-002	133	BB	-	-	-	-	-
13245-001	133	BB	-	-	-	-	-
13558-001	133	BB	-	-	-	-	-
12370-001	135	BB	-	-	-	-	-
14011-001	135	BB	-	-	-	-	-
10706-001	136	BB	-	-	-	-	-
02229-000	144	BB	-	-	-	-	-
12356-001	146	BB	-	-	-	-	-
12479-001	147	BB	9.11E+08	-	-	-	-
12289-001	148	BB	4.66E+08	-	6.23E+08	-	-
11883-001	149	BB	1.16E+07	8.88E+06	-	-	-
11598-001	150	BB	1.37E+09	1.56E+09	-	-	-
14109-001	151	BB	-	-	-	-	-
11152-001	153	BB	-	-	2.55E+07	-	-
11893-001	155	BB	-	-	9.11E+08	-	-
13674-001	155	BB	-	-	3.13E+09	-	-
13775-001	171	BB	-	-	-	-	-
14134-001	171	BB	-	-	-	-	-
12298-001	178	BB	3.98E+05	9.72E+05	-	-	-
10495-139	1	WOB	3.39E+07	1.70E+06	9.41E+09	-	-
10495-076	2	WOB	-	-	4.39E+08	7.27E+09	4.56E+10
11193-001	2	WOB	7.12E+10	4.57E+09	1.11E+07	1.53E+09	9.72E+07
12139-001	2	WOB	5.13E+08	5.83E+02	7.90E+06	2.03E+06	1.01E+06
12222-001	2	WOB	3.75E+12	3.40E+11	3.31E+04	-	-
13996-001	2	WOB	-	-	8.18E+04	1.01E+06	1.92E+06
02710-000	4	WOB	-	-	-	-	-
04760-000	4	WOB	-	-	-	-	-
11051-001	4	WOB	4.97E+07	5.33E+07	7.80E+06	1.25E+07	8.30E+09
11188-001	4	WOB	9.70E+06	4.75E+06	7.99E+06	7.43E+07	7.04E+07
11273-001	4	WOB	1.25E+07	4.03E+06	5.98E+06	4.50E+09	4.00E+07
11375-001	4	WOB	1.91E+08	1.43E+07	7.84E+05	-	-

Abbreviations: BB - Buffalo Bayou, dL - deciliter, MPN - most probable number, NPDES - national pollutant discharge elimination system, TCEQ - Texas Commission on Environmental Quality, UH - University of Houston, WOB - Whiteoak Bayou

Table 3.2. Summary of Bacteria Loads from WWTPs, continued

Permit #	Sub basin	Water shed	E. coli load (MPN/day)				
			Peak Summer (2000) UH	Off-Peak Summer (2000) UH	Summer (2006) TCEQ	Summer (2006) - Harris County Round 1	Summer (2006) -Harris County Round 2
11389-001	4	WOB	1.73E+05	1.34E+06	1.32E+05	-	-
11485-001	4	WOB	8.56E+06	1.09E+07	3.45E+06	5.12E+07	5.36E+07
11538-001	4	WOB	-	-	4.10E+08	3.39E+10	1.50E+11
11670-001	4	WOB	2.90E+08	2.10E+08	7.45E+06	1.01E+08	6.03E+07
12342-001	4	WOB	1.74E+06	1.99E+05	2.07E+05	-	-
12443-001	4	WOB	2.34E+04	7.29E+05	5.20E+06	-	-
12552-001	4	WOB	-	-	3.05E+08	-	-
12552-002	4	WOB	-	-	7.50E+04	-	-
13433-001	4	WOB	4.47E+04	3.09E+02	1.33E+07	-	-
13509-001	4	WOB	6.46E+06	9.05E+06	2.09E+05	-	-
13578-001	4	WOB	4.55E+04	8.90E+04	8.90E+04	-	-
13623-001	4	WOB	7.58E+06	6.25E+06	6.19E+05	1.10E+09	1.74E+08
13689-001	4	WOB	1.55E+09	3.60E+08	9.94E+08	4.69E+10	3.09E+10
13727-001	4	WOB	3.64E+05	1.04E+05	1.53E+05	-	-
13807-001	4	WOB	0.00E+00	6.65E+04	2.42E+06	-	-
13939-001	4	WOB	-	-	7.58E+04	-	-
13983-001	4	WOB	-	-	0.00E+00	-	-
14316-001	4	WOB	-	-	-	-	-
10495-099	7	WOB	-	-	4.73E+07	7.10E+09	1.26E+11
12573-001	9	WOB	2.88E+05	2.88E+05	-	-	-
12714-001	9	WOB	1.79E+07	2.31E+06	3.37E+07	2.69E+09	1.21E+07
14359-001	9	WOB	-	-	-	-	-
14506-001	9	WOB	-	-	1.36E+12	1.45E+06	1.69E+06
14538-001	9	WOB	-	-	2.92E+07	1.98E+10	3.49E+09
11563-001	10	WOB	4.34E+08	3.10E+08	1.82E+09	7.10E+09	1.38E+11
11979-002	10	WOB	5.15E+06	4.36E+06	6.23E+06	1.41E+07	1.74E+07
12397-001	10	WOB	-	-	1.48E+08	-	-
12574-001	10	WOB	3.11E+06	1.11E+07	4.37E+06	-	-
12681-001	10	WOB	-	-	3.45E+06	2.65E+07	2.90E+07
14072-001	10	WOB	9.98E+08	2.46E+07	6.80E+07	7.08E+09	9.34E+10
12121-001	11	WOB	9.55E+08	2.11E+08	3.87E+07	1.99E+09	2.41E+10
12795-001	11	WOB	3.36E+08	2.56E+08	1.51E+09	1.63E+09	2.91E+07
10876-001	13	WOB	1.43E+08	2.59E+08	1.04E+08	3.59E+11	2.55E+11
10876-002	13	WOB	3.86E+08	2.75E+07	1.79E+09	7.22E+11	1.06E+12
12465-001	13	WOB	9.89E+04	2.57E+07	5.53E+05	-	-
11005-001	17	WOB	7.56E+06	4.13E+06	1.98E+06	2.43E+07	1.81E+07
12132-001	40	WOB	3.58E+05	0.00E+00	4.51E+06	-	-
13764-001	42	WOB	-	-	1.75E+07	-	-
11284-001	181	WOB	2.18E+08	1.86E+08	8.01E+08	-	-
12110-001	181	WOB	2.66E+06	3.46E+06	3.89E+06	-	-
12802-001	181	WOB	3.87E+07	1.55E+06	6.09E+07	-	-
11989-001	183	WOB	9.94E+06	4.36E+06	5.42E+06	-	-

Abbreviations: BB - Buffalo Bayou, dL - deciliter, MPN - most probable number, NPDES - national pollutant discharge elimination system, TCEQ - Texas Commission on Environmental Quality, UH - University of Houston, WOB - Whiteoak Bayou

Table 3.2. Summary of Bacteria Loads from WWTPs, continued

Permit #	Sub basin	Water shed	E. coli load (MPN/day)				
			Peak Summer (2000) UH	Off-Peak Summer (2000) UH	Summer (2006) TCEQ	Summer (2006) - Harris County Round 1	Summer (2006) -Harris County Round 2
12189-001	183	WOB	-	-	3.20E+06	-	-
12247-001	183	WOB	1.14E+05	1.16E+05	7.12E+07	-	-
11917-001	185	WOB	1.10E+07	4.73E+06	6.71E+04	-	-
11986-001	-	Outside	-	-	-	-	-
14259-001	-	Outside	-	-	2.81E+06	-	-
13727-002	-	Outside	-	-	1.51E+08	-	-
12561-001	-	Outside	-	-	4.94E+04	-	-
13770-001	-	Outside	-	-	7.28E+07	1.27E+08	3.90E+06
Total			3.84E+12	3.50E+11	6.56E+12	1.22E+12	1.94E+12
Minimum			0.00E+00	0.00E+00	0.00E+00	1.01E+06	1.01E+06
Maximum			3.75E+12	3.40E+11	4.00E+12	7.22E+11	1.06E+12

Notes:

1. Samples less than detection limit assigned value of 1/2 detection limit
 2. Duplicates, if available, were averaged
- data not available/not collected

Abbreviations: BB - Buffalo Bayou, dL - deciliter, MPN - most probable number, NPDES - national pollutant discharge elimination system, TCEQ - Texas Commission on Environmental Quality, UH - University of Houston, WOB - Whiteoak Bayou

Table 3.3(A) Load Analysis for Mouth of Segment 1014

Scenario: TCEQ E. coli

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		6.46		1,516.22
<u>WWTPs</u>						
WWTP Discharges	18.00	19.16	18.93	20.15	18.93	20.15
WWTP Biosolid Releases	-	-	-	-	1.13	111.55
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	0.62	272.84	0.62	272.84	-	-
<u>Wet Weather Storm Sewer Discharges</u>			0.50	805.42	333.18	539,159.82
<u>SSO</u>						
SSO - All Conditions	2.17E-04	38.62	2.17E-04	38.62	3.29E-04	53.43
Load Allocation		84.36		84.36		84.36
<u>OSSF</u>	3.86E-03	439.43	3.86E-03	439.43	3.86E-03	439.43
<u>Bed Sediment</u>	-	-	-	-	-	4,036.32
<u>Direct Deposition</u>	-	49.17	-	49.17	-	49.17
Upstream Input		93.44		299.23		2211.19
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Margin of Safety (MOS)		9.36		20.53		200.62
Margin of Safety (5% of Target Load)		9.36		20.53		200.62
Final Load Calculation						
Estimated Current Load	39.24	922.01	86.08	1,945.38	841.24	546,281.69
Contact Recreation Target (126 MPN/dL)	39.24	187.16	86.08	410.58	841.24	4,012.39
Non-contact Recreation Target (605 MPN/dL)	39.24	898.67	86.08	1,971.43	841.24	19,265.86
TMDL Target		187.16		410.58		4,012.39
Percent Reduction (Contact Recreation)	WLA	100%		99%		100%
	LA	83%		83%		98%
Percent Reduction (Non-contact Recreation)	All	3%		0%		96%

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 3.3(B) Load Analysis for Mouth of Segment 1013

Scenario: TCEQ E. coli

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		0.00		764.10
<u>WWTPs</u>						
WWTP Discharges	0.00	0.00	0.00	0.00	0.00	0.00
WWTP Biosolid Releases	-	-	-	-	0.00	0.00
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	5.36E-04	0.01	5.36E-04	0.01	-	-
<u>Wet Weather Storm Sewer Discharges</u>			6.84	11,377.44	175.48	291,700.00
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.56E-04	42.18
Load Allocation		0.00		31.02		31.02
<u>OSSF</u>	2.44E-04	27.81	2.44E-04	27.81	2.44E-04	27.81
<u>Bed Sediment</u>	-	-	-	-	-	1,271.26
<u>Direct Deposition</u>	-	16.07	-	16.07	-	16.07
Upstream Input		177.80		390.05		3811.78
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Segment 1014	18.62	84.36	20.04	90.82	353.24	1,600.59
Margin of Safety (MOS)		9.36		22.16		242.47
Margin of Safety (5% of Target Load)		9.36		22.16		242.47
Final Load Calculation						
Estimated Current Load	39.24	263.37	92.93	11,865.86	1016.72	297,111.57
Contact Recreation Target (126 MPN/dL)	39.24	187.16	92.93	443.23	1016.72	4,849.36
Non-contact Recreation Target (605 MPN/dL)	39.24	898.69	92.93	2,128.20	1016.72	23,284.62
TMDL Target		187.16		443.23		4,849.36
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	100%		29%		98%
Percent Reduction (Non-contact Recreation)	All	0%		82%		92%

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 3.3(C) Load Analysis for Mouth of Watersheds Draining Reservoirs

Scenario: TCEQ E. coli

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		205.79		2,117.75
WWTPs						
WWTP Discharges	20.58	5,438.22	21.64	5,718.43	21.64	5,718.43
WWTP Biosolid Releases	-	-	-	-	1.29	127.55
MS4s						
Dry Weather Storm Sewer Discharges	0.00	0.00	0.00	0.00	-	-
Wet Weather Storm Sewer Discharges			44.36	50,673.93	465.03	531,253.65
SSO						
SSO - All Conditions	1.15E-04	20.40	1.15E-04	20.40	1.99E-04	31.64
Load Allocation		93.44		93.44		93.44
OSSF	4.32E-02	4,922.75	4.32E-02	4,922.75	4.32E-02	4,922.75
Bed Sediment	-	-	-	-	-	9,535.55
Direct Deposition	-	139.39	-	139.39	-	139.39
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)		4.92		15.75		116.38
Margin of Safety (5% of Target Load)		4.92		15.75		116.38
Final Load Calculation						
Estimated Current Load	20.62	10,525.68	66.04	61,490.66	488.00	551,845.35
Contact Recreation Target (126 MPN/dL)	20.62	98.36	66.04	314.98	488.00	2,327.57
Non-contact Recreation Target (605 MPN/dL)	20.62	472.27	66.04	1,512.40	488.00	11,176.02
TMDL Target		98.36		314.98		2,327.57
Percent Reduction (Contact Recreation)	WLA LA	100% 98%		100% 98%		100% 99%
Percent Reduction (Non-contact Recreation)	All	96%		98%		98%

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 3.3(D) Load Analysis for Mouth of Segment 1017

Scenario: TCEQ E. coli

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		61.03		1,648.74
<u>WWTPs</u>						
WWTP Discharges	20.03	8.97	21.06	9.43	21.06	9.43
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	0.76	250.09	0.76	250.09	-	-
<u>Wet Weather Storm Sewer Discharges</u>			12.44	19,928.55	362.34	580,640.16
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.00E-04	34.73
Load Allocation		94.32		94.32		94.32
<u>OSSF</u>	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
<u>Bed Sediment</u>	-	-	-	-	-	1,949.07
<u>Direct Deposition</u>	-	35.87	-	35.87	-	35.87
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	3,486.10	34.28	23,418.32	384.69	586,039.07
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Non-contact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Percent Reduction (Non-contact Recreation)	All	86%		97%		98%

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 3.4 Load Analysis for Mouth of Segment 1017

Scenario: Harris County Round 1

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		61.03		1,648.74
<u>WWTPs</u>						
WWTP Discharges	20.03	416.16	21.06	437.60	21.06	437.60
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.76	250.09	0.76	250.09	-	-
<u>Wet Weather Storm Sewer Discharges</u>			12.44	19,928.55	362.34	580,640.16
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.00E-04	34.73
Load Allocation		94.32		94.32		94.32
<u>OSSF</u>	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
<u>Bed Sediment</u>	-	-	-	-	-	1,949.07
<u>Direct Deposition</u>	-	35.87	-	35.87	-	35.87
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	3,893.30	34.28	23,846.50	384.69	586,467.24
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Non-contact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Percent Reduction (Non-contact Recreation)	All	88%		97%		98%

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 3.5 Load Analysis for Mouth of Segment 1017

Scenario: Harris County Round 2

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		61.03		1,648.74
<u>WWTPs</u>						
WWTP Discharges	20.03	643.94	21.06	677.12	21.06	677.12
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.76	250.09	0.76	250.09	-	-
<u>Wet Weather Storm Sewer Discharges</u>			12.44	19,928.55	362.34	580,640.16
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.00E-04	34.73
Load Allocation		94.32		94.32		94.32
<u>OSSF</u>	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
<u>Bed Sediment</u>	-	-	-	-	-	1,949.07
<u>Direct Deposition</u>	-	35.87	-	35.87	-	35.87
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	4,121.08	34.28	24,086.02	384.69	586,706.76
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Non-contact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Percent Reduction (Non-contact Recreation)	All	88%		97%		98%

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 3.6. Summary of BLEST Results using New WWTP Data

		1014			1013			Reservoirs			1017		
		Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet
WWTP Load (billion MPN/day)	Baseline	1.35	1.42	1.42	0	0	0	6.46	6.8	6.8	59.39	62.45	62.48
	TCEQ	19.16	20.15	20.15	0	0	0	5438.22	5718.43	5718.43	8.97	9.43	9.43
	Harris County Rnd 1	-	-	-	-	-	-	-	-	-	416.16	437.6	437.6
	Harris County Rnd 2	-	-	-	-	-	-	-	-	-	643.941	677.12	677.12
Reduction in WLA	Baseline	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	TCEQ	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Harris County Rnd 1	-	-	-	-	-	-	-	-	-	100%	100%	100%
	Harris County Rnd 2	-	-	-	-	-	-	-	-	-	100%	100%	100%
Reduction in LA	Baseline	83%	83%	98%	100%	29%	98%	98%	98%	99%	97%	97%	98%
	TCEQ	83%	83%	98%	100%	29%	98%	98%	98%	99%	97%	97%	98%
	Harris County Rnd 1	-	-	-	-	-	-	-	-	-	97%	97%	98%
	Harris County Rnd 2	-	-	-	-	-	-	-	-	-	97%	97%	98%

CHAPTER 4

OTHER ALLOCATION ISSUES

During the past quarter, several load allocation issues were examined. These included a comparison of load reductions computed using several different methods, an evaluation of regrowth and sludge banks on the BLEST mass balance results and a detailed sensitivity analysis of BLEST. The results of these analyses are presented in the following sections.

4.1 LOAD REDUCTION COMPARISON

Load reductions were assessed using several different methodologies including existing data, load duration curves and the Hydrologic Simulation Program – Fortran (HSPF). These assessments will be described in this section and the resulting reductions are compared with those estimated using the BLEST mass balance method.

4.1.1 REDUCTIONS USING EXISTING WATER QUALITY DATA

Existing data available in the TCEQ Texas Regulatory Activities and Compliance System (TRACS) database were evaluated to estimate the percentage reduction required to lower in-stream E. coli concentrations to the water quality standards. As shown in Table 4.1, a total of 45 stations were evaluated. Fourteen were excluded from this analysis because they had less than 15 E. coli samples, too few to calculate the reduction statistics. The table demonstrates that the number of samples exceeding the single sample standard (394 MPN/dL) is significant, typically more than 86%. Meeting the long-term geometric mean standard (126

Table 4.1
Summary of E. coli stations and % Reductions Required to Meet Contact Recreation Standards

Station ID	Segment	Sampling Date		No. of Samples	E. coli (MPN/dL)		% Exceeding 394 MPN/dL	E. coli (MPN/dL) Geometric Mean	% Reductions to Achieve Geomean Standard of 126 MPN/dL
		Initial	Final		Minimum	Maximum			
11148	1013	12/10/01	2/16/05	38	750	240,000	100%	12,983	0.99
11345	1013	12/6/01	11/15/04	37	120	69,000	97%	2,105	0.94
11347	1013	12/6/01	11/15/04	36	140	170,000	94%	3,248	0.96
11351	1013	6/13/01	11/15/04	38	76	140,000	84%	1,807	0.93
15825	1013	12/10/01	2/16/05	38	1,200	240,000	100%	6,839	0.98
15843	1013	12/6/01	11/15/04	36	130	200,000	94%	3,018	0.96
16648	1013	12/10/01	2/16/05	38	180	190,000	97%	6,330	0.98
16675	1013	12/6/01	2/4/05	38	230	240,000	89%	5,024	0.97
11158	1014	7/24/04	8/28/04	15	150	20,000	0.87	2,573	0.95
11163	1014	12/5/01	2/21/05	38	15	25,000	0.50	455	0.72
11164	1014	7/24/04	8/28/04	16	6	28,000	0.88	4,015	0.97
11166	1014	7/24/04	8/28/04	15	120	94,000	0.87	3,878	0.97
11188	1014	12/5/01	2/21/05	37	20	98,000	0.89	3,440	0.96
11353	1014	12/4/01	2/3/05	38	160	37,000	0.76	1,671	0.92
11354	1014	11/14/00	2/8/06	20	52	24,192	0.65	1,376	0.91
11356	1014	12/4/01	2/3/05	38	52	22,000	0.84	1,392	0.91
11360	1014	12/5/01	2/3/05	38	240	10,000	0.87	1,378	0.91
11361	1014	12/5/01	2/21/05	38	10	46,000	0.71	802	0.84
11362	1014	11/14/00	2/8/06	74	10	110,000	0.76	1,422	0.91
11363	1014	12/5/01	2/21/05	38	10	44,000	0.71	671	0.81
11364	1014	12/5/01	2/21/05	39	10	24,000	0.49	412	0.69
15845	1014	12/4/01	2/3/05	38	140	36,000	0.82	1,721	0.93
15846	1014	12/4/01	2/3/05	38	150	30,000	0.89	1,489	0.92
15847	1014	12/5/01	2/21/05	38	41	240,000	0.68	844	0.85
16592	1014	12/4/01	2/3/05	36	170	240,000	0.89	3,034	0.96
16597	1014	12/4/01	2/3/05	38	10	240,000	0.53	617	0.80
17482	1014	1/29/02	2/22/05	36	10	61,000	0.61	1,122	0.89
17483	1014	1/29/02	2/22/05	36	85	65,000	0.75	1,597	0.92
17484	1014	1/17/02	2/22/05	36	10	15,000	0.42	324	0.61
17492	1014	1/9/02	2/22/05	36	57	19,000	0.44	570	0.78
17493	1014	1/17/02	2/22/05	35	10	31,000	0.31	417	0.70
17494	1014	1/17/02	2/22/05	36	63	34,000	0.67	1,149	0.89

Table 4.1, continued

Summary of E. coli stations and % Reductions Required to Meet Contact Recreation Standards

Station ID	Segment	Sampling Date		No. of Samples	E. coli (MPN/dL)		% Exceeding 394 MPN/dL	E. coli (MPN/dL) Geometric Mean	Geometric Mean to 126 MPN/dL
		Initial	Final		Minimum	Maximum			
11155	1017	9/25/03	2/21/05	16	47	9,600	0.44	531	0.76
11387	1017	11/14/00	2/8/06	50	272	240,000	0.96	4,481	0.97
11390	1017	12/4/01	2/21/05	38	150	55,000	0.92	2,560	0.95
11396	1017	9/25/03	2/21/05	16	74	6,100	0.56	504	0.75
15826	1017	12/10/01	2/16/05	38	520	240,000	1.00	6,461	0.98
15827	1017	12/10/01	2/16/05	38	750	240,000	1.00	5,139	0.98
15829	1017	12/4/01	2/21/05	38	170	34,000	0.84	1,556	0.92
15831	1017	12/4/01	2/21/05	38	170	58,000	0.89	1,748	0.93
16593	1017	12/4/01	2/21/05	38	150	240,000	0.95	2,845	0.96
16594	1017	12/4/01	2/21/05	38	10	65,000	0.95	3,333	0.96
16595	1017	12/4/01	2/21/05	38	20	240,000	0.92	11,886	0.99
16596	1017	12/10/01	2/16/05	38	240	160,000	0.92	3,234	0.96
16637	1017	12/4/01	2/8/06	34	130	65,000	0.97	4,584	0.97

Abbreviations: dL - deciliter, MPN - most probable number,

(MPN/dL) standard requires high levels of reductions; more than half the sites require over 92% reductions in concentration to meet the standard.

4.1.2 LOAD REDUCTIONS USING LOAD DURATION CURVES (LDC)

Load duration curves were constructed for all sites in Buffalo and Whiteoak Bayous with USGS flow gauges using available E. coli data. Because some flow gauges did not have co-located bacteria sampling stations, the closest sampling site to the flow gauge was used in these calculations as shown in Figure 4.1.

The developed LDCs are presented in Figure 4.2. As can be seen, the observed data (presented as triangles) are typically above the load duration curve under wet, intermediate and dry conditions. For locations above the Addicks and Barker Reservoirs, exceedances of the LDC were less than those observed below the reservoir.

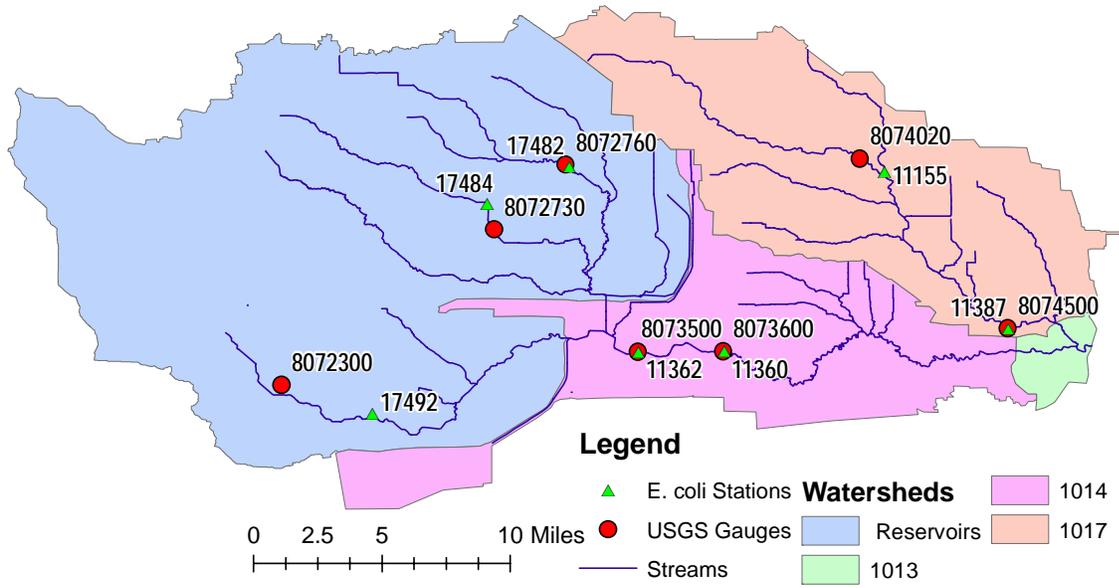


Figure 4.1 USGS Flow Gauges and E. coli Sampling Sites used for Load Duration Curves

Buffalo Bayou Above the Reservoir

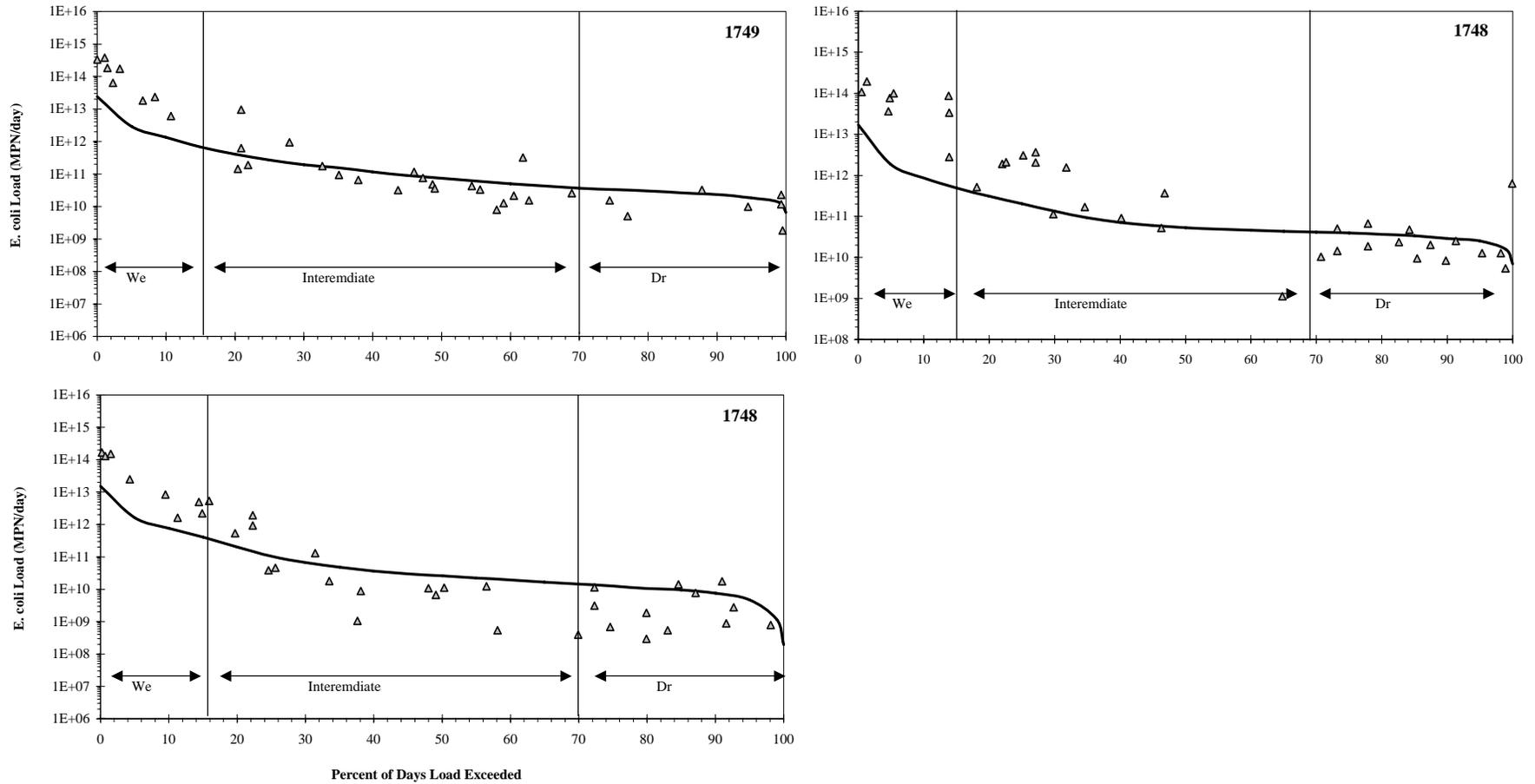
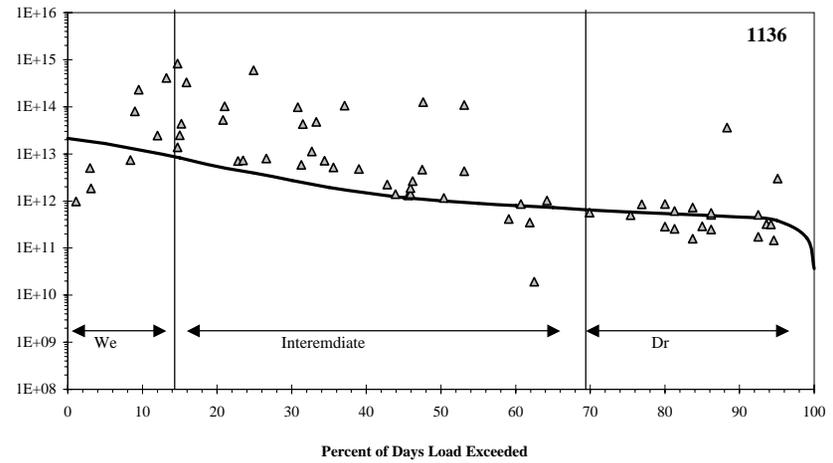
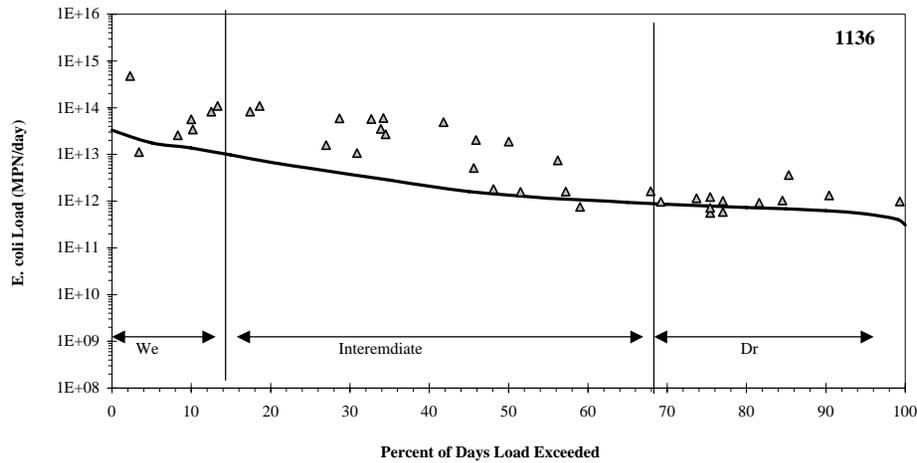


Figure 4.2. Load Duration Curves

Buffalo Bayou Below the Reservoir



Whiteoak Bayou

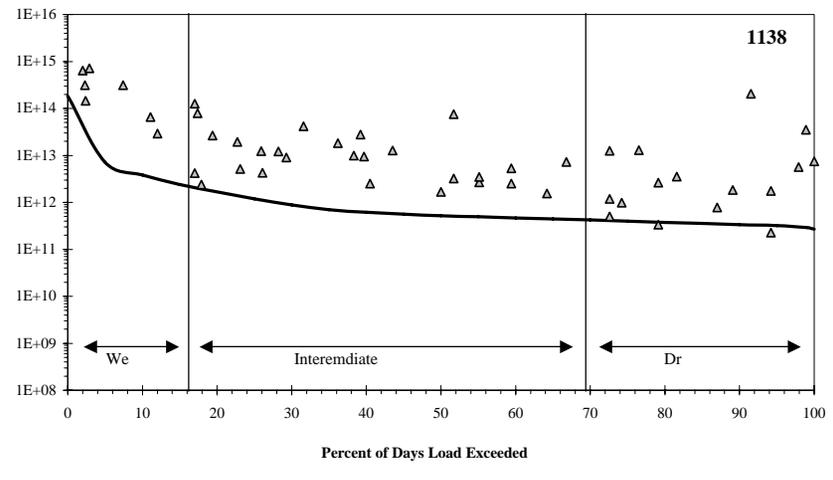
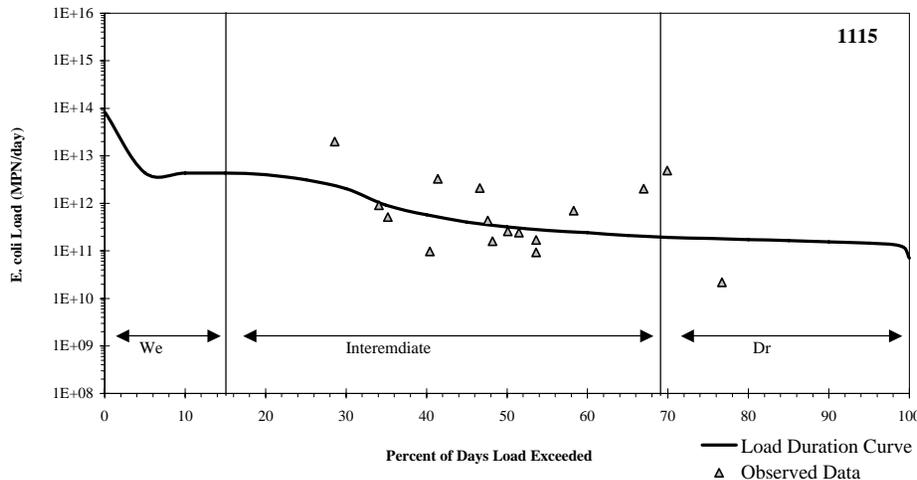


Figure 4.2, continued. Load Duration Curves

Although LDCs can be developed for all flow gauges in Buffalo Bayou, load reductions for segments 1013 and 1014 could not be determined because the Addicks and Barker reservoirs exert influence on the flow regime. Therefore, load reductions based upon the LDCs were only developed for segment 1017 and are shown in **Table 4.2**.

As can be seen from the table, load reductions ranged from 88% under dry weather conditions to almost 100% under wet weather conditions. These loads are comparable to those listed in Table 4.1, where load reductions between 76% and 99% were needed for the Whiteoak Bayou watershed.

4.1.3 LOAD REDUCTIONS USING HSPF

Previously, required load reductions were presented for Buffalo and Whiteoak Bayous based upon the HSPF model (see Work Order 5 Report). Table 4.3 shows the estimated reductions for storm water using HSPF and does not include the estimated reductions for WWTPs. This is because the reduction scenario modeled in HSPF assumed that WWTPs discharge a concentration of 126 MPN/dL. As can be seen, median load reductions computed using HSPF are quite high, between 95 to 99% for the stream segments of interest.

4.1.4 COMPARISON OF ESTIMATED LOAD REDUCTIONS WITH MASS BALANCE

The calculated load reductions in Sections 4.1.1 to 4.1.3 were compared with those estimated using the BLEST mass balance method. As load duration curves can only be used on Segment 1017, this comparison will only be completed for this stream segment. Load reductions

estimated in BLEST are quite high for Whiteoak Bayou, with WLA reductions of more than 99% for dry, intermediate, and wet conditions. In addition, the load allocation load reductions are also

Table 4.2 Load Reductions Computed from LDC for Segment 1017

Percentile Range	Load Duration Curve		
	Dry	Intermediate	Wet
Observed	2.20E+12	9.00E+12	1.40E+14
TMDL	8.60E+10	8.60E+10	8.60E+10
Overall % Reduction	88%	98%	100%

Table 4.3 Load Reductions Computed Using HSPF

End of Segment	1014 & 1013	1017
Median HSPF Reductions	95%	99%

quite high, with reductions between 97% and 98% also required for dry, intermediate and wet conditions. These percent reductions compare favorably to the estimated loads determined using existing data, load duration curves and HSPF.

4.2 EXAMINATION OF REGROWTH USING THE BLEST MASS BALANCE METHOD

The Harris County Stormwater Quality Section undertook a study entitled “Regrowth Potential of Water Pathogens in Sediment and Sewage Treatment Plant Effluent and Affinity of Water Pathogens to Attach to Soil Fractions.” A total of four individual studies were performed as part of this study:

- Study 1: Evaluation of Regrowth Potential of E. coli and other waterborne pathogens in WWTP effluent
- Study 2: Evaluation of Regrowth Potential of E. coli and other waterborne pathogens in Buffered water and Sterilized Sediment
- Study 3: Evaluation of affinity of E. coli and other waterborne pathogens to attach to sand and silt from Harris County detention basin while in WWTP effluent
- Study 4: Evaluation of affinity of E. coli and other waterborne pathogens to attaché to soil fractions of soil collected from Harris County detention basin.

This section of the report will discuss the regrowth rates as determined from Studies 1 and 2 and their impact on BLEST results.

The regrowth data contained in Study 1 were entered into a spreadsheet, plotted versus

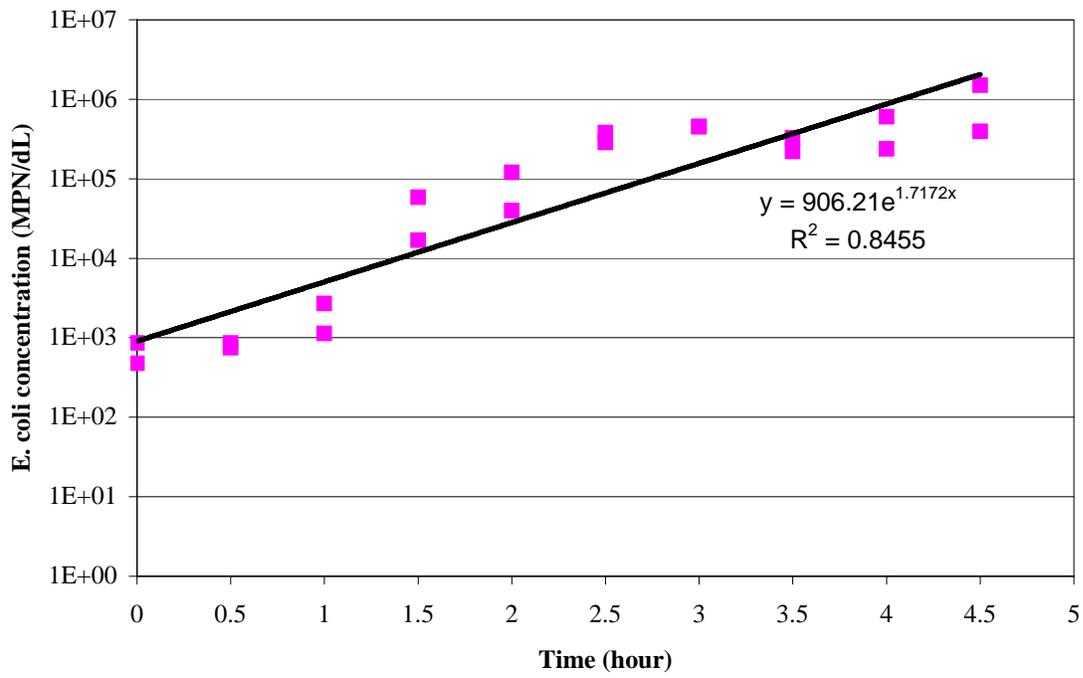


Figure 4.3 Determination of Regrowth Rate from Harris County Stormwater Quality Section Study

time and the regrowth rate determined. It was found that the regrowth rate achieved in the study was around 1.71 hour^{-1} , or 41 day^{-1} . The daily regrowth rate was implemented into BLEST as part of the LA as shown in **Table 4.4** and the percent reductions for the WLA and LA are summarized in Table 4.5. The required reductions in the WLA did not change, while the percent reductions for the LA increased by 1 to 2 percent for Segment 1014 and 1017. An increase in loading from regrowth diminishes the load capacity (LC) of the water body and would need to be counterbalanced by reductions in other load estimates since BLEST is a mass-balance model.

4.3 EXAMINATION OF SLUDGE BANKS USING BLEST

As part of the Harris County Stormwater Quality Section study that was conducted during the Summer of 2006, sediment sampling was conducted in and around WWTPs. The County study report discussed the presence of sludge banks downstream of WWTPs and they sampled these banks during round 1.

Sediment sampling in and around WWTPs was undertaken in this TMDL in 2004 and 2005. In 2004, sediment sampling was conducted in several streams with and without WWTPs discharging to them. In 2005, the TMDL project team conducted sediment sampling near 7 WWTPs with samples being collected upstream of the plant as well as downstream and at the point of effluent discharge. Both of these sampling efforts were inconclusive with regard to the impact of WWTPs on sediment. A wide range of concentrations was noted in and around the plants, and because of the variability, no statistical differences could be found.

To account for sludge banks, however, loading was estimated by developing a ratio of the

Table 4.4(A) Load Analysis for Mouth of Segment 1014

Scenario: Regrowth

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		6.46		1,516.22
<u>WWTPs</u>						
WWTP Discharges	18.00	1.35	18.93	1.42	18.93	1.42
WWTP Biosolid Releases	-	-	-	-	1.13	111.55
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.62	272.84	0.62	272.84	-	-
<u>Wet Weather Storm Sewer Discharges</u>			0.50	805.42	333.18	539,159.82
<u>SSO</u>						
SSO - All Conditions	2.17E-04	38.62	2.17E-04	38.62	3.29E-04	53.43
Load Allocation		84.36		84.36		84.36
<u>OSSF</u>	3.86E-03	439.43	3.86E-03	439.43	3.86E-03	439.43
<u>Bed Sediment</u>	-	-	-	-	-	4,036.32
<u>Direct Deposition</u>	-	49.17	-	49.17	-	49.17
Regrowth	-	55.35	-	58.21	-	58.21
Upstream Input		93.44		299.23		2211.19
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Margin of Safety (MOS)		9.36		20.53		200.62
Margin of Safety (5% of Target Load)		9.36		20.53		200.62
Final Load Calculation						
Estimated Current Load	39.24	904.20	86.08	1,926.66	841.24	546,321.17
Contact Recreation Target (126 MPN/dL)	39.24	187.16	86.08	410.58	841.24	4,012.39
Non-contact Recreation Target (605 MPN/dL)	39.24	898.67	86.08	1,971.43	841.24	19,265.86
TMDL Target		187.16		410.58		4,012.39
Percent Reduction (Contact Recreation)	WLA	100%		99%		100%
	LA	84%		85%		98%
Baseline - no regrowth	LA	83%		83%		98%
Percent Reduction (Non-contact Recreation)	All	1%		0%		96%

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 4.4(B) Load Analysis for Mouth of Segment 1013

Scenario: Regrowth

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		0.00		764.10
<u>WWTPs</u>						
WWTP Discharges	0.00	0.00	0.00	0.00	0.00	0.00
WWTP Biosolid Releases	-	-	-	-	0.00	0.00
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	5.36E-04	0.01	5.36E-04	0.01	-	-
<u>Wet Weather Storm Sewer Discharges</u>			6.84	11,377.44	175.48	291,700.00
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.56E-04	42.18
Load Allocation		0.00		31.02		31.02
<u>OSSF</u>	2.44E-04	27.81	2.44E-04	27.81	2.44E-04	27.81
<u>Bed Sediment</u>	-	-	-	-	-	1,271.26
<u>Direct Deposition</u>	-	16.07	-	16.07	-	16.07
Regrowth		0.00	-	0.00	-	0.00
Upstream Input		177.80		390.05		3811.78
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Segment 1014	18.62	84.36	20.04	90.82	353.24	1,600.59
Margin of Safety (MOS)		9.36		22.16		242.47
Margin of Safety (5% of Target Load)		9.36		22.16		242.47
Final Load Calculation						
Estimated Current Load	39.24	263.37	92.93	11,865.86	1016.72	297,111.57
Contact Recreation Target (126 MPN/dL)	39.24	187.16	92.93	443.23	1016.72	4,849.36
Non-contact Recreation Target (605 MPN/dL)	39.24	898.69	92.93	2,128.20	1016.72	23,284.62
TMDL Target		187.16		443.23		4,849.36
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	100%		29%		98%
Percent Reduction (Non-contact Recreation)	All	0%		82%		92%

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 4.4(C) Load Analysis for Mouth of Watersheds Draining Reservoirs

Scenario: Regrowth

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion)	Q (MGD)	Load (billion)	Q (MGD)	Load (billion)
Waste Load Allocation		0.00		205.79		2,117.75
<u>WWTPs</u>						
WWTP Discharges	20.58	6.46	21.64	6.80	21.64	6.80
WWTP Biosolid Releases	-	-	-	-	1.29	127.55
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.00	0.00	0.00	0.00	-	-
<u>Wet Weather Storm Sewer Discharges</u>			44.36	50,673.93	465.03	531,253.65
<u>SSO</u>						
SSO - All Conditions	1.15E-04	20.40	1.15E-04	20.40	1.99E-04	31.64
Load Allocation		93.44		93.44		93.44
<u>OSSF</u>	4.32E-02	4,922.75	4.32E-02	4,922.75	4.32E-02	4,922.75
<u>Bed Sediment</u>	-	-	-	-	-	9,535.55
<u>Direct Deposition</u>	-	139.39	-	139.39	-	139.39
Regrowth		264.98	-	278.64	-	278.64
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)		4.92		15.75		116.38
Margin of Safety (5% of Target Load)		4.92		15.75		116.38
Final Load Calculation						
Estimated Current Load	20.62	5,093.93	66.04	55,779.02	488.00	546,133.71
Contact Recreation Target (126 MPN/dL)	20.62	98.36	66.04	314.98	488.00	2,327.57
Non-contact Recreation Target (605 MPN/dL)	20.62	472.27	66.04	1,512.40	488.00	11,176.02
TMDL Target		98.36		314.98		2,327.57
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	98%		98%		99%
Percent Reduction (Non-contact Recreation)	All	91%		97%		98%

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 4.4(D) Load Analysis for Mouth of Segment 1017

Scenario: Regrowth

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		61.03		1,648.74
<u>WWTPs</u>						
WWTP Discharges	20.03	59.39	21.06	62.45	21.06	62.45
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	0.76	250.09	0.76	250.09	-	-
<u>Wet Weather Storm Sewer Discharges</u>			12.44	19,928.55	362.34	580,640.16
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.00E-04	34.73
Load Allocation		94.32		94.32		94.32
<u>OSSF</u>	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
<u>Bed Sediment</u>	-	-	-	-	-	1,949.07
<u>Direct Deposition</u>	-	35.87	-	35.87	-	35.87
Regrowth		2435.12	-	2560.59	-	2,560.59
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	5,971.65	34.28	26,031.94	384.69	588,652.68
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Non-contact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	98%		98%		99%
Baseline - no regrowth	LA	97%		97%		98%
Percent Reduction (Non-contact Recreation)	All	92%		97%		99%

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 4.5 Summary of BLEST Results with Regrowth

		1014			1013			Reservoirs			1017		
		Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet
Reduction in WLA	Baseline	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Regrowth	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Reduction in LA	Baseline	83%	83%	98%	100%	29%	98%	98%	98%	99%	97%	97%	98%
	Regrowth	84%	85%	98%	100%	29%	98%	98%	98%	99%	98%	98%	99%

Table 4.6(A) Load Analysis for Mouth of Segment 1014

Scenario: Sludge Banks

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		6.46		1,516.22
<u>WWTPs</u>						
WWTP Discharges	18.00	1.35	18.93	1.42	18.93	1.42
WWTP Biosolid Releases	-	-	-	-	1.13	111.55
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.62	272.84	0.62	272.84	-	-
<u>Wet Weather Storm Sewer Discharges</u>			0.50	805.42	333.18	539,159.82
<u>SSO</u>						
SSO - All Conditions	2.17E-04	38.62	2.17E-04	38.62	3.29E-04	53.43
Load Allocation		84.36		84.36		84.36
<u>OSSF</u>	3.86E-03	439.43	3.86E-03	439.43	3.86E-03	439.43
<u>Bed Sediment</u>	-	-	-	-	-	4,036.32
<u>Direct Deposition</u>	-	49.17	-	49.17	-	49.17
WWTP Sludge banks	-	-	-	-	-	0.38
Upstream Input		93.44		299.23		2211.19
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Margin of Safety (MOS)		9.36		20.53		200.62
Margin of Safety (5% of Target Load)		9.36		20.53		200.62
Final Load Calculation						
Estimated Current Load	39.24	904.20	86.08	1,926.66	841.24	546,263.34
Contact Recreation Target (126 MPN/dL)	39.24	187.16	86.08	410.58	841.24	4,012.39
Non-contact Recreation Target (605 MPN/dL)	39.24	898.67	86.08	1,971.43	841.24	19,265.86
TMDL Target		187.16		410.58		4,012.39
Percent Reduction (Contact Recreation)	WLA	100%		99%		100%
	LA	83%		83%		98%
Baseline - no regrowth	LA	83%		83%		98%
Percent Reduction (Non-contact Recreation)	All	1%		0%		96%

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 4.6(B) Load Analysis for Mouth of Segment 1013

Scenario: Sludge Banks

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		0.00		764.10
<u>WWTPs</u>						
WWTP Discharges	0.00	0.00	0.00	0.00	0.00	0.00
WWTP Biosolid Releases	-	-	-	-	0.00	0.00
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	5.36E-04	0.01	5.36E-04	0.01	-	-
<u>Wet Weather Storm Sewer Discharges</u>			6.84	11,377.44	175.48	291,700.00
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.56E-04	42.18
Load Allocation		0.00		31.02		31.02
<u>OSSF</u>	2.44E-04	27.81	2.44E-04	27.81	2.44E-04	27.81
<u>Bed Sediment</u>	-	-	-	-	-	1,271.26
<u>Direct Deposition</u>	-	16.07	-	16.07	-	16.07
Sludge Banks	-	-	-	-	-	0.00
Upstream Input		177.80		390.05		3811.78
Upstream of Segment 1014	20.62	93.44	66.04	299.23	488.00	2,211.19
Segment 1014	18.62	84.36	20.04	90.82	353.24	1,600.59
Margin of Safety (MOS)		9.36		22.16		242.47
Margin of Safety (5% of Target Load)		9.36		22.16		242.47
Final Load Calculation						
Estimated Current Load	39.24	263.37	92.93	11,865.86	1016.72	297,111.57
Contact Recreation Target (126 MPN/dL)	39.24	187.16	92.93	443.23	1016.72	4,849.36
Non-contact Recreation Target (605 MPN/dL)	39.24	898.69	92.93	2,128.20	1016.72	23,284.62
TMDL Target		187.16		443.23		4,849.36
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	100%		29%		98%
Percent Reduction (Non-contact Recreation)	All	0%		82%		92%

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 4.6(C) Load Analysis for Mouth of Watersheds Draining Reservoirs

Scenario: Sludge Banks

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion)	Q (MGD)	Load (billion)	Q (MGD)	Load (billion)
Waste Load Allocation		0.00		205.79		2,117.75
<u>WWTPs</u>						
WWTP Discharges	20.58	6.46	21.64	6.80	21.64	6.80
WWTP Biosolid Releases	-	-	-	-	1.29	127.55
<u>MS4s</u>						
<u>Dry Weather Storm Sewer Discharges</u>	0.00	0.00	0.00	0.00	-	-
<u>Wet Weather Storm Sewer Discharges</u>			44.36	50,673.93	465.03	531,253.65
<u>SSO</u>						
SSO - All Conditions	1.15E-04	20.40	1.15E-04	20.40	1.99E-04	31.64
Load Allocation		93.44		93.44		93.44
<u>OSSF</u>	4.32E-02	4,922.75	4.32E-02	4,922.75	4.32E-02	4,922.75
<u>Bed Sediment</u>	-	-	-	-	-	9,535.55
<u>Direct Deposition</u>	-	139.39	-	139.39	-	139.39
Sludge Banks	-	-	-	-	-	1.50
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)		4.92		15.75		116.38
Margin of Safety (5% of Target Load)		4.92		15.75		116.38
Final Load Calculation						
Estimated Current Load	20.62	5,093.93	66.04	55,779.02	488.00	546,133.71
Contact Recreation Target (126 MPN/dL)	20.62	98.36	66.04	314.98	488.00	2,327.57
Non-contact Recreation Target (605 MPN/dL)	20.62	472.27	66.04	1,512.40	488.00	11,176.02
TMDL Target		98.36		314.98		2,327.57
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	98%		98%		99%
Percent Reduction (Non-contact Recreation)	All	91%		97%		98%

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 4.6(D) Load Analysis for Mouth of Segment 1017

Scenario: Sludge Banks

<i>E. coli</i> Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Waste Load Allocation		0.00		61.03		1,648.74
<u>WWTPs</u>						
WWTP Discharges	20.03	59.39	21.06	62.45	21.06	62.45
WWTP Biosolid Releases	-	-	-	-	1.26	124.16
MS4s						
<u>Dry Weather Storm Sewer Discharges</u>	0.76	250.09	0.76	250.09	-	-
<u>Wet Weather Storm Sewer Discharges</u>			12.44	19,928.55	362.34	580,640.16
<u>SSO</u>						
SSO - All Conditions	1.82E-04	32.31	1.82E-04	32.31	2.00E-04	34.73
Load Allocation		94.32		94.32		94.32
<u>OSSF</u>	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
<u>Bed Sediment</u>	-	-	-	-	-	1,949.07
<u>Direct Deposition</u>	-	35.87	-	35.87	-	35.87
Sludge Banks	-	-	-	-	-	1.31
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	3,536.53	34.28	23,471.35	384.69	586,093.40
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Non-contact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Baseline - no sludge banks	LA	97%		97%		98%
Percent Reduction (Non-contact Recreation)	All	87%		97%		98%

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 4.7 Summary of BLEST Results with Sludge Banks

		1014			1013			Reservoirs			1017		
		Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet	Dry	Intermediate	Wet
Reduction in WLA	Baseline	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Sludge Banks	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Reduction in LA	Baseline	83%	83%	98%	100%	29%	98%	98%	98%	99%	97%	97%	98%
	Sludge Banks	83%	83%	98%	100%	29%	98%	98%	98%	99%	97%	97%	98%

maximum concentration (1,000 MPN/g) observed in the Jamieson et al. (2005) study to the *E. coli* re-suspension rate found in that same study. The maximum concentration observed in sediment of 60,000 MPN/dL was then converted using a typical density of sediment as 2.65 g/mL to a mass-based concentration of 226 MPN/g. This value was multiplied by the Jamieson ratio to arrive at a re-suspension rate of 1,900 MPN/m²/s. This re-suspension rate was applied to a 100ft² area downstream of all WWTPs in the model and the resulting sludge bank loads in BLEST are presented in Table 4.6 and the required reductions are summarized in Table 4.7.

As can be seen from Table 4.7, the percent reductions for the WLA and LA do not change significantly with the addition of sludge banks to the BLEST mass balance method based on the assumptions above.

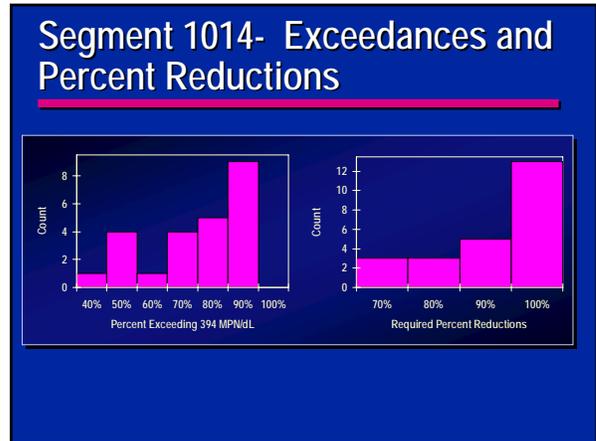
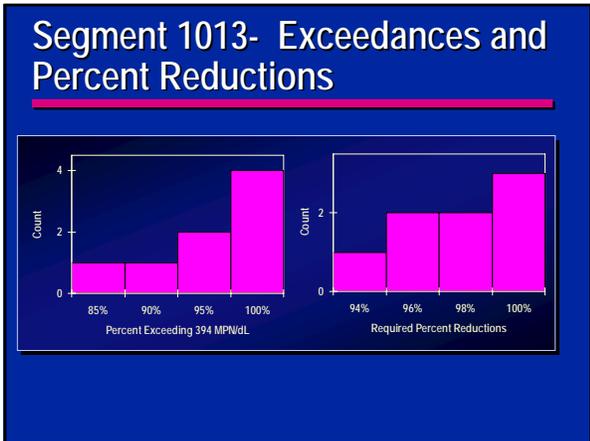
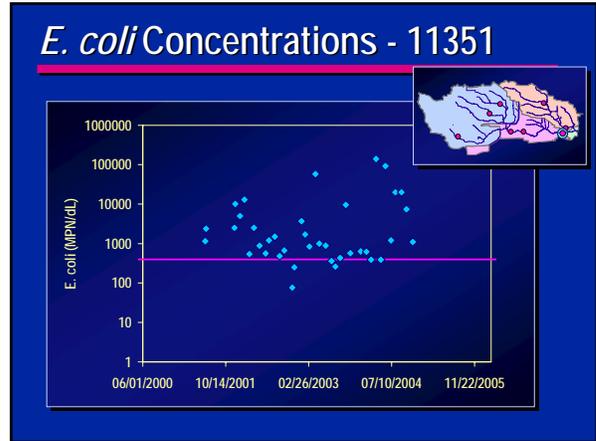
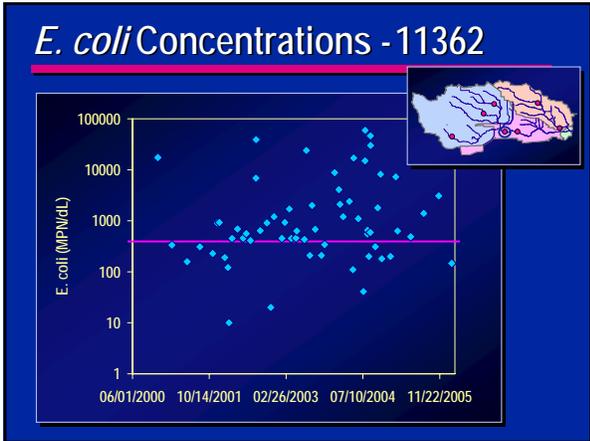
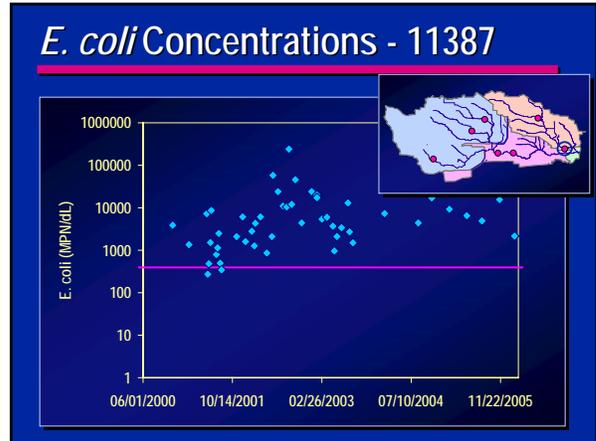
CHAPTER 5

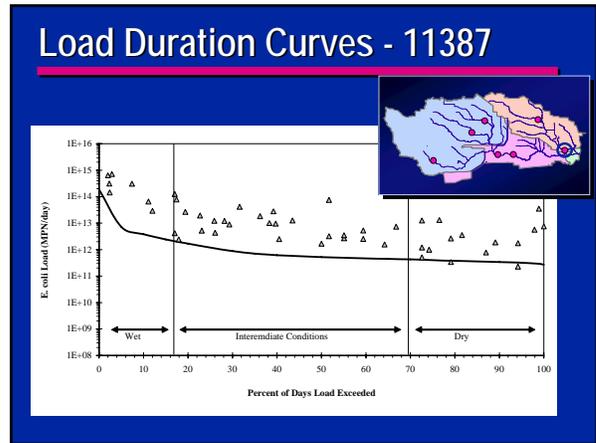
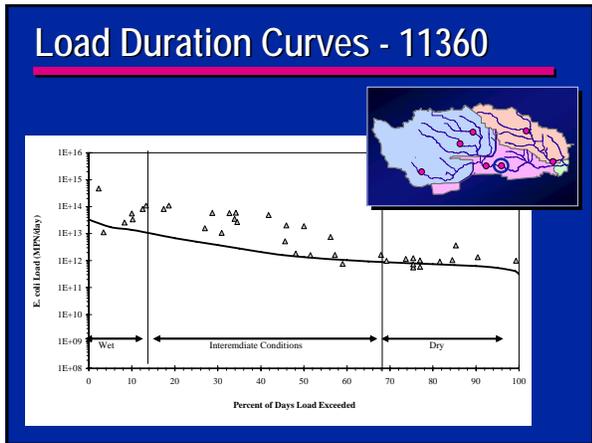
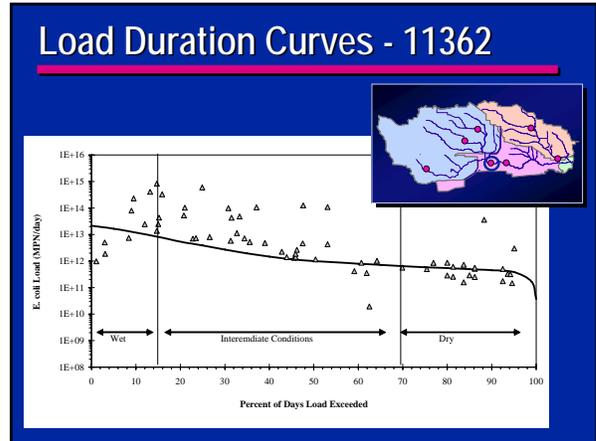
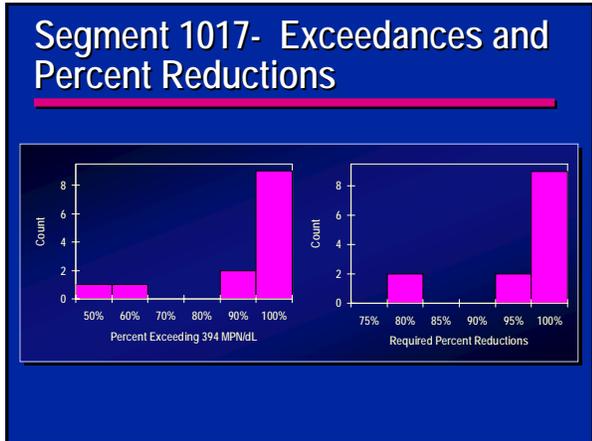
NEXT QUARTER

The work to be completed in the next quarter will be focused on completing the TMDL and addressing stakeholder comments as needed.

APPENDIX A
SLIDES FROM STAKEHOLDER MEETING
FEBRUARY 8, 2007

**Total Maximum Daily Load for
 Fecal Pathogens in Buffalo and
 Whiteoak Bayous**
Stakeholder Meeting
February 8, 2006





Comparison of LDC and BLEST at 11387 (billion MPN/day)

Percentile Range	Load Duration Curve			BLEST		
	Low	Interm.	High	Low	Interm.	High
Observed	2.2E+12	9.0E+12	1.4E+14	3.5E+12	2.3E+13	5.8E+14
TMDL	8.6E+10	8.6E+10	8.6E+10	9.8E+10	1.6E+11	1.8E+12
Overall % Reduction	88%	98%	100%	97%	99%	100%

Overall Percent Reductions

Segment End	Load Duration Curve			BLEST		
	Low	Interm.	High	Low	Interm.	High
1013	nc	nc	nc	29%	96%	98%
1014	nc	nc	nc	79%	79%	99%
1017	88%	98%	100%	97%	99%	100%

nc – could not calculate because of lack of data and upstream control from reservoirs

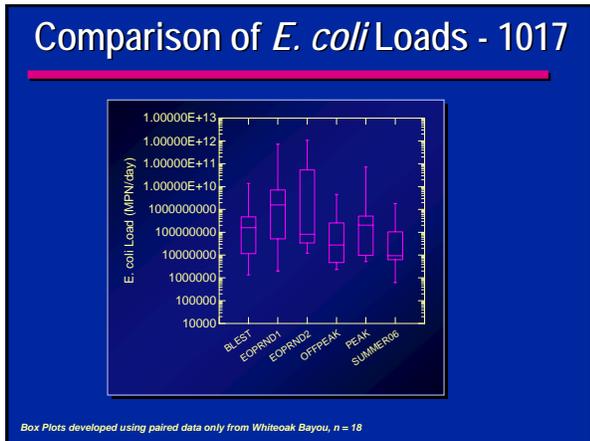
Comparison of WO5 HSPF Wet Weather Reductions to BLEST

Model	End of Segment		
	1014	1013	1017
BLEST	99%	98%	100%
Median HSPF Reductions	95%		99%

**Total Maximum Daily Load for
Fecal Pathogens in Buffalo and
Whiteoak Bayous**
Stakeholder Meeting
February 8, 2007

WWTP Sampling

	Summer 2000	Summer 2006	End of Pipe 2006
Organization	UH	TCEQ	Harris Cty
# of plants	64	99	26
Targeted Watersheds	BB/ WOB	BB/WOB	WOB
Type of Sampling	Weir	Weir	End of Pipe to bayou



BLEST Results using all WWTP data sources – Segment 1017

	WWTP and Biosolid Load (billion MPN/day)			Waste Load % Reduction		
	Dry	Interm.	Wet	Low	Interm.	High
BLEST v1.0	59.39	62.45	186.61	100%	100%	100%
Summer (2006)	8.97	9.43	133.59	100%	100%	100%
End of Pipe Rnd 1, 2 (2006)	416.16	437.60	561.76	100%	100%	100%

BLEST Results using all WWTP data sources - Segment 1014

	WWTP and Biosolid Load (billion MPN/day)	Waste Load % Reduction				
	Dry	Interm.	Wet	Low	Interm.	High
BLEST v1.0	1.3					
Summer (2006)	19.					
End of Pipe Rnd 1, 2 (2006)	n/a					

DO NOT USE THIS SLIDE

n/a – data were not collected for Buffalo Bayou

BLEST Results using all WWTP data sources– Mouth of Reservoirs

	WWTP and Biosolid Load (billion MPN/day)			Waste Load % Reduction		
	Dry	Interm.	Wet	Low	Interm.	High
BLEST v1.0	6.46	6.80	134.35	100%	100%	100%
TCEQ	5,438	5,718	5,846	100%	100%	100%
Harris County	n/a	n/a	n/a	n/a	n/a	n/a

n/a – data were not collected for Buffalo Bayou

Sensitivity of BLEST Model – Segment 1013

	Wasteload Allocation % Reduction			Load Allocation % Reduction		
	Dry	Interm.	Wet	Low	Interm.	High
OSSF between 1% and 35%	100%	99%	100%	100%	0%-44%	98%
High Intensity EMC (10,658-66,260 MPN/dL)	100%	100%	99%-100%	100%	29%	98%
Baseline	100%	100%	100%	100%	29%	98%

Sensitivity of BLEST Model – Segment 1017

	Wasteload Allocation % Reduction			Load Allocation % Reduction		
	Dry	Interm.	Wet	Low	Interm.	High
OSSF between 1% and 35%	100%	100%	100%	42%	42%	96%
High Intensity EMC (10,658-66,260 MPN/dL)	100%	99%-100%	99%-100%	97%	97%	98%
Baseline	100%	100%	100%	97%	97%	98%

Regrowth Evaluation for Whiteoak

E. coli Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (Billion MPN/day)	Q (MGD)	Load (Billion MPN/day)	Q (MGD)	Load (Billion MPN/day)
Load Allocation		94.32		94.32		94.32
OSSF	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
Bed Sediment	-	-	-	-	-	1,949.07
Direct Deposition	-	35.87	-	35.87	-	35.87
Regrowth		59.39		62.45		62.45
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	3,595.92	34.28	23,533.80	384.69	596,154.54
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
Noncontact Recreation Target (605 MPN/dL)	20.82	476.74	34.28	785.18	384.69	8,809.98
TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Baseline - no regrowth	LA	97%		97%		98%

Die-off?

Regrowth load assumed to double existing WWTP concentration

Regrowth Evaluation

Die-off Rate Measured in Work Order 2	Die-off Rate Measured in Work Order 8	Estimated Regrowth Rate from NSF Study
1.3 – 3 per day	0.52 – 1.36 per day	1.6 – 2 per day

E. coli in sediment downstream of WWTPs

Work Order 6 (2004)	Work Order 8 (2005)	End of Pipe study (2006) ¹
4,700 – 230,000 MPN/100 g	35 – 610,000 MPN/100 g	400 – 60,000 MPN/dL – 150 – 23,000 MPN/100 g

¹ Concentrations in MPN/dL were converted to MPN/100 g by using sediment density of 2.65 g/mL

Effect of WWTP sludge banks

- Assuming 100 ft² of sludge bank downstream of every WWTP
- 57 WWTPs in Whiteoak Bayou
- Resuspension rate calculated for sludge banks with maximum sediment concentration observed in End of Pipe study (60,000 MPN/dL)
- Resuspension rate in BLEST: 2,740,000 MPN/ft²/hr
- Resuspension rate for Sludge Banks: 621,000 MPN/ft²/hr

Effect of WWTP sludge banks – Whiteoak Bayou

E. coli Sources	Dry Condition		Intermediate Condition		Wet Condition	
	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)	Q (MGD)	Load (billion MPN/day)
Load Allocation		94.32		94.32		94.32
CSSP	2.77E-02	3,153.90	2.77E-02	3,153.90	2.77E-02	3,153.90
Bed Sediment	-	-	-	-	-	1,949.07
Direct Deposition	-	35.87	-	35.87	-	35.87
Sludge Banks	-	-	-	-	-	1.36
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		8.18		91.74
Margin of Safety (5% of Target Load)		4.96		8.18		91.74
Final Load Calculation						
Estimated Current Load	20.82	3,536.53	34.28	23,471.35	384.69	586,003.45
Contact Recreation Target (126 MPN/dL)	20.82	99.29	34.28	163.53	384.69	1,834.81
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TMDL Target		99.29		163.53		1,834.81
Percent Reduction (Contact Recreation)	WLA	100%		100%		100%
	LA	97%		97%		98%
Baseline - no sludge banks	LA	97%		97%		98%