Total Maximum Daily Loads for Indicator Bacteria in the Houston Metropolitan Area

Contract No. 582-6-70860
Work Orders No. 582-6-70860-04 and 582-6-70860-07

Final Quarterly Report No. 3

Prepared by
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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

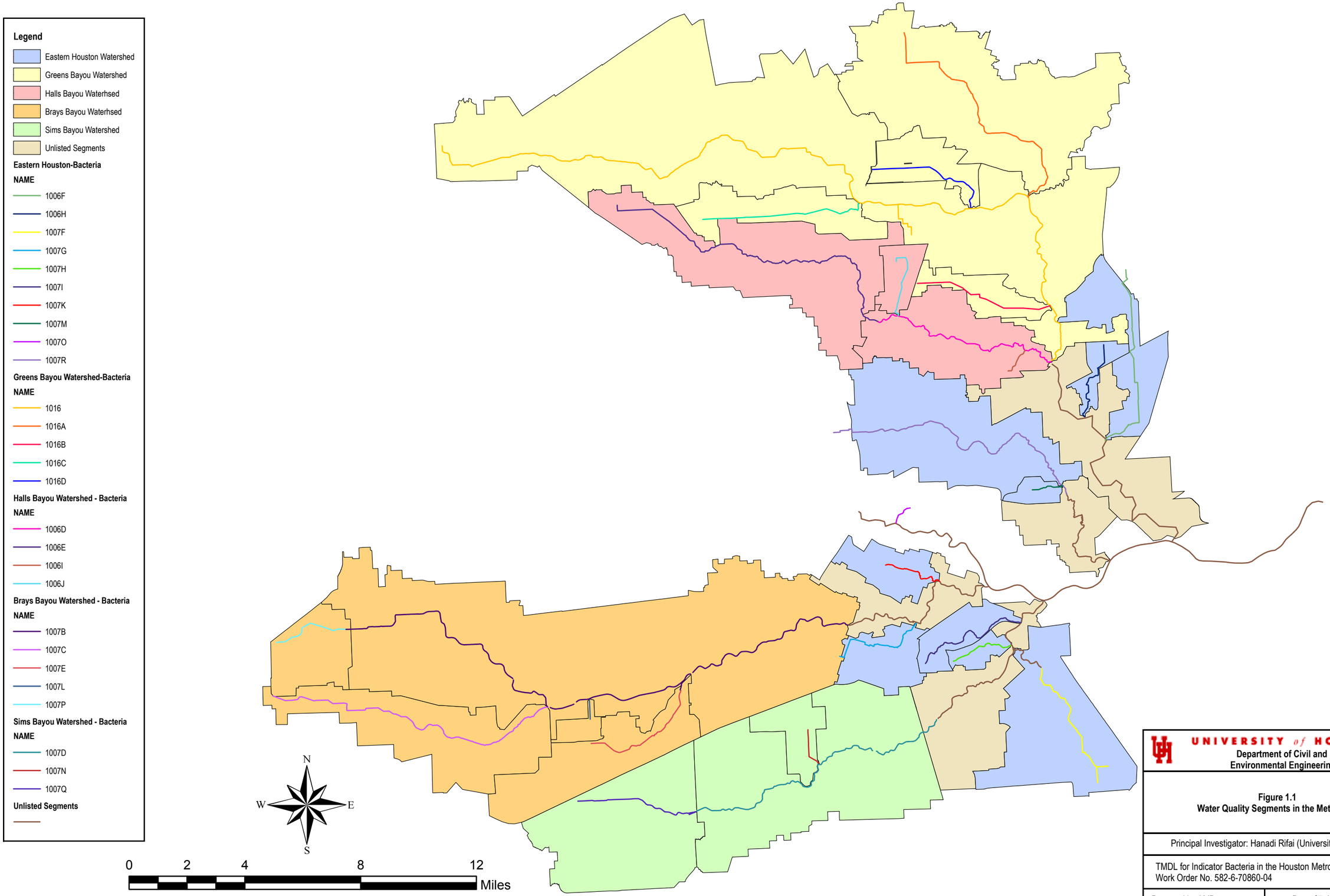
In Texas, pathogen contamination was the primary cause of impairments on the 2000-303(d) list. The 303(d) list identifies water bodies that do not meet the water quality standards established by the state of Texas. In response to the violations of water quality standards, under the Clean Water Act, the Texas Commission on Environmental Quality (TCEQ) implemented the Total Maximum Daily Loads (TMDLs) Program to evaluate the steps necessary to restore the recreational quality of these waters.

The Houston Metropolitan Area project includes 27 segments (see Table 1.1) that are listed on the Texas 2004 303(d) List for not meeting the contact recreation standard for indicator bacteria. These segments are in a number of watersheds in the San Jacinto River basin including, Greens Bayou Watershed, Halls Bayou Watershed, Hunting Bayou Watershed, Brays Bayou Watershed, Sims Bayou Watershed, and the general Houston Ship Channel Watershed. For the purpose of TMDL development, the project has been subdivided into five sub-projects; Greens Bayou Watershed – Bacteria, Halls Bayou Watershed – Bacteria, Brays Bayou Watershed – Bacteria, Sims Bayou Watershed, and Eastern Houston – Bacteria (Figure 1.1). The Eastern Houston project contains all of the segments in the Houston Ship Channel and Houston Ship Channel/Buffalo Bayou watersheds. All of these segments are fresh water and *Escherichia coli* (*E. coli*) is the indicator bacteria for contact recreation.

Table 1.1 Water Quality Segments in the Metro area

TMDL Project Name	Segment Number	Segment Name
Eastern Houston - Bacteria	1006F	Big Gulch Above Tidal
	1006H	Spring Gully Above Tidal
	1007F	Berry Bayou Above Tidal
	1007G	Kuhlman Gully Above Tidal
	1007H	Pine Gully Above Tidal
	1007I	Plum Creek Above Tidal
	1007K	Country Club Bayou
	1007M	Unnamed Non-Tidal Tributary of Hunting Bayou
	1007O	Unnamed Non-Tidal Tributary of Buffalo Bayou
	1007R	Hunting Bayou Above Tidal
Greens Bayou Watershed - Bacteria	1016	Greens Bayou Above Tidal
	1016A	Garners Bayou
	1016B	Unnamed Tributary of Greens Bayou
	1016C	Unnamed Tributary of Greens Bayou
	1016D	Unnamed Tributary of Greens Bayou
Halls Bayou Watershed - Bacteria	1006D	Halls Bayou below US 59
	1006E	Halls Bayou above US 59
	1006I	Unnamed Tributary of Halls Bayou
	1006J	Unnamed Tributary of Halls Bayou
Brays Bayou Watershed - Bacteria	1007B	Brays Bayou Above Tidal
	1007C	Keegans Bayou above tidal
	1007E	Willow Waterhole Bayou Above Tidal
	1007L	Unnamed Non-Tidal Tributary of Brays Bayou
	1007P	Brays Bayou Above Tidal
Sims Bayou Watershed - Bacteria	1007D	Sims Bayou Above Tidal
	1007N	Unnamed Non-Tidal Tributary of Sims Bayou
	1007Q	Sims Bayou Above Tidal

In 2000, the State of Texas adopted new bacteria standards for contact recreation. The *E. coli* indicator bacteria standard was adopted for contact recreation in place of the existing fecal coliform indicator bacteria. For fecal coliform, no sample should exceed 400 colony-forming units (cfu) per 100 mL for contact recreation. In addition, the geometric mean should be less than 200 cfu/100 mL to meet contact recreation criteria.



UNIVERSITY of HOUSTON
Department of Civil and Environmental Engineering

Figure 1.1
Water Quality Segments in the Metro area

Principal Investigator: Hanadi Rifai (University of Houston)

TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04

Prepared by AMD | Date: 07-17-2006

For *E. coli*, no sample should exceed 394 cfu/ 100 mL and the geometric mean should be less than 126 cfu/100 mL (30 Texas Administrative Code 307.7(b)(A)).

The overall objective of this project is to establish the TMDL allocation equation for the segments listed above.

There are four main tasks to be completed for WO 582-6-70860-07:

1. Administer project;
2. Participate in stakeholder process;
3. QAPP/Sampling Plan/Data Management; and
4. Data Collection

This quarterly report summarizes the results from load duration curve analysis applied to select stations within the Metro area. In addition, this report also documents the preliminary results from sampling conducted in May 2006.

1.2 DESCRIPTION OF THE REPORT

This document constitutes the third quarterly report for Work Orders No. 582-6-70860-04/582-6-70860-07 of the Bacteria in the Houston Metropolitan Area TMDL Project and summarizes the activities undertaken by the University of Houston during the period March 2006 to May 2006.

This report reflects the progress made towards the following subtasks delineated in the Project Work Plans:

<u>Subtask 3.4.2/WO4</u> - Prepare an inventory of major sources and fate and transport of E. coli and fecal contamination in the target water bodies based on historical data.

Subtask 3.2/WO7 – Prepare and submit for approval a draft and final QAPP prior to the first scheduled monitoring event.

Subtask 4.1/WO7 – Conduct data collection activities to complete an assessment of the fecal pathogen and *E. coli* levels and trends in the project watersheds.

Chapter 2 of the report will present the load duration curve analysis of the historical data while Chapter 3 presents the results from sampling activities to date. In the past quarter, the QAPP was submitted on March 7, 2006 to the TCEQ. Comments were received and the QAPP was revised on April 11 and April 18, 2006. The QAPP was subsequently approved on April 20, 2006.

CHAPTER 2

LOAD DURATION CURVE METHODOLOGY

2.1 Background

TMDLs often have considerable variability (Bonta and Cleland, 2003; Freedman et al. 2004) associated with in stream and watershed processes that directly or indirectly impact pollutant loading. TMDLs typically use modeling tools for assessment of appropriate load allocations. Various approaches are available for load estimation and assessment of water quality criteria. The methods available vary in approach and complexity in dealing with the problem or the watershed processes. Load duration curves are being viewed as an emerging tool for pathogen modeling. Many states have adopted the load duration curve methodology for determining TMDL allocations.

In general duration curves represent the percentage of time that a defined parameter is exceeded. This variable may be flow, in which case the duration curve will be called as a flow duration curve. Flow duration curves have been used since the late 1800s to establish the duration of flows for a watershed (Bonta and Cleland, 2003). The flow duration curves represent a cumulative frequency graph of flow irrespective of the order of occurrence (Leopold, 1994). Load duration curves establish different flow conditions and for each flow condition, a load is calculated assuming that it is predominant over that entire flow period resulting in a load duration curve. The duration curves are based on an average concentration or a load rate. The advantage of the load duration curve is that it characterizes different flow regimes rather than considering a single flow value (Stiles, 2001). This enables a visual interpretation and understanding of the number of times a water quality parameter is exceeded.

2.2 Steps to Construct a Load Duration Curve

a) Select the flow gage to be used for establishing the flow conditions.

b) Determine the stream location for which the curve is to be established. If flow data are not available for the desired location within the stream, for analysis purposes, data from the nearest USGS gage can be used for establishing flow conditions.

c) With the historical flow data, a flow duration curve is constructed to characterize the hydrologic conditions. The flow duration curve is a graphical plot of flow duration interval versus flow (Fig. 2.1).

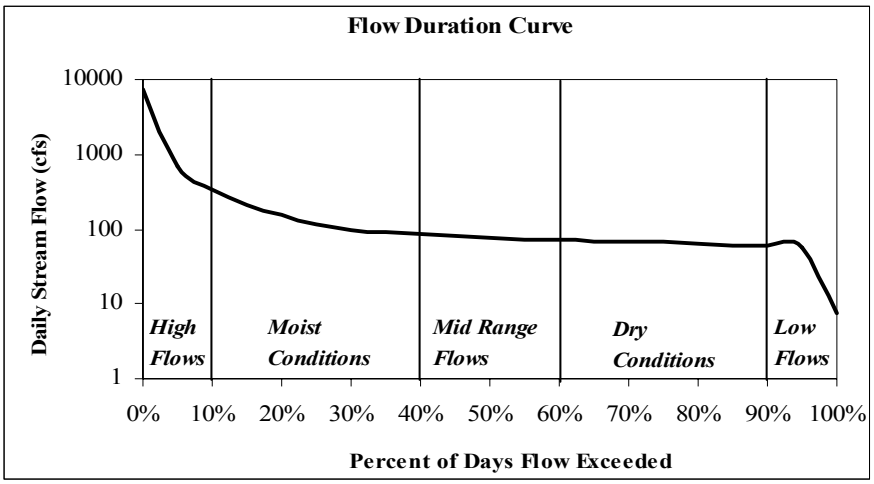


Fig. 2.1 Flow Duration Curve

d) Once a flow duration curve is established, different flow regimes are determined on a percentile exceedance basis. The flow regimes established are (Cleland, 2003):

Flow Duration Interval	Condition
0 - 10%	High Flows
10 - 40%	Moist Conditions
40 - 60%	Mid Range Flows
60 - 90%	Dry Conditions
90 - 100%	Low Flows

e) The target load curve is determined by multiplying the flow and concentration and then expressing the load as MPN or cfu per day. The target loads are estimated based on the current standard for *E.coli* (single sample criterion = 394 MPN/100mL) and fecal coliform (400 MPN/100/mL). The target load serves as a baseline for water quality assessment (Fig. 2.2).

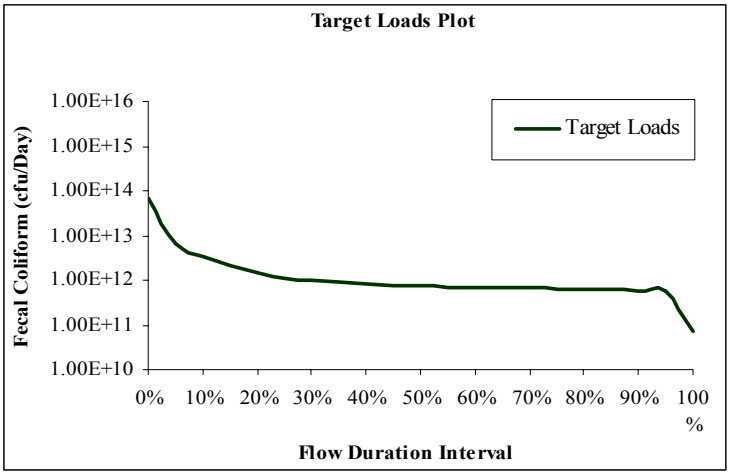


Fig. 2.2 Graphical plot depicting the target loads for Fecal coliform

f) Subsequently, loads are calculated using the available flow data and observed concentrations at a particular location in the stream. The load is typically expressed as mass/time depending on the water quality parameter (Fig. 2.3). Load duration curves may also be constructed for total suspended solids, nutrients, dissolved oxygen etc.

g) The load duration curve serves as an interpretation tool for assessment of water quality generally correlated to flow conditions.

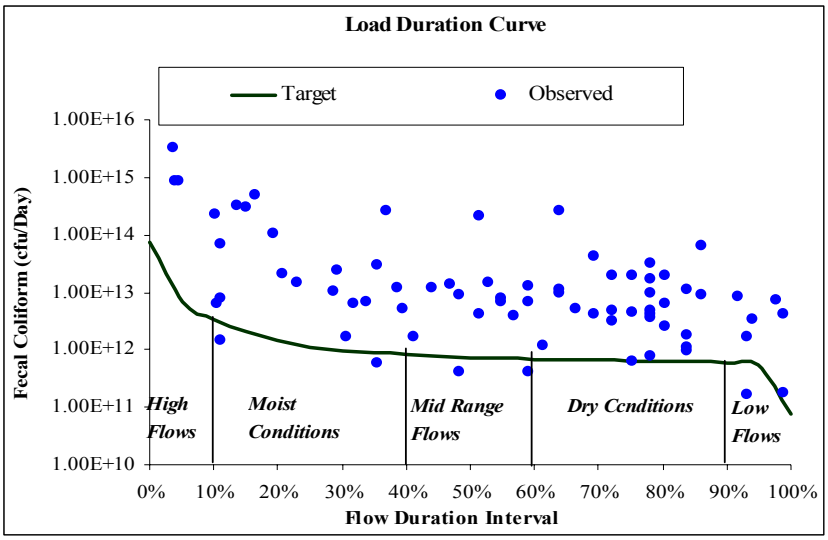


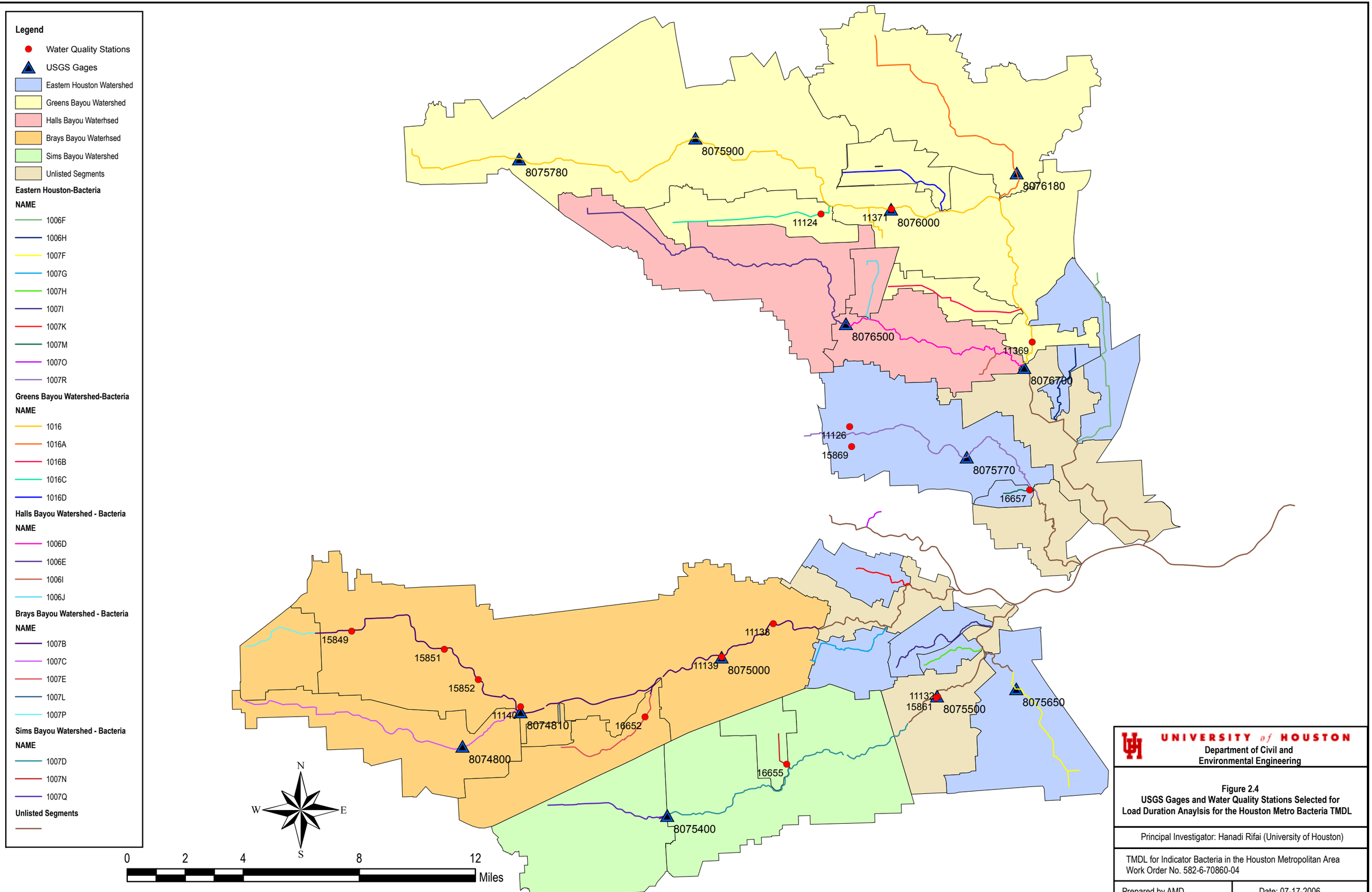
Fig. 2.3 Load Duration Curve for Fecal coliform

2.3 Load Duration Curves Analysis for Selected Stations

Segment 1007

Load duration curves were established for select stations within this segment. The first step involved selection of a USGS gage located sufficiently close to the station for which duration curves would be constructed. Fig. 2.4 shows the USGS gages in the Metro Area along with the water quality stations selected for load duration analysis.

A flow duration curve for gage 8074810 was constructed and is shown in Fig. 2.5. Accordingly, the five flow regimes have been established for this gage. The median flow for this gage for the entire flow period is 76 cfs. Based on the flow data available at this gage, a load duration curve is constructed to observe the effect of different flow regimes on indicator concentrations. For all the load duration analyses, all the existing historical data from the TCEQ (http://www.tceq.state.tx.us/compliance/monitoring/crp/data/samplequery.html) website were used.


Legend
Water Quality Stations
USGS Gages
Eastern Houston Watershed
Greens Bayou Watershed
Halls Bayou Waterhsed
Brays Bayou Waterhsed
Sims Bayou Watershed
Unlisted Segments
Eastern Houston-Bacteria
NAME
1006F
1006H
1007F
1007G
1007H
1007I
1007K
1007M
1007O
1007R
Greens Bayou Watershed-Bacteria
NAME
1016
1016A
1016B
1016C
1016D
Halls Bayou Watershed - Bacteria
NAME
1006D
1006E
1006I
1006J
Brays Bayou Watershed - Bacteria
NAME
1007B
1007C
1007E
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1007P
Sims Bayou Watershed - Bacteria
NAME
1007D
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Unlisted Segments
8075780
8075900
8076180
11124
11371
8076000
8076500
11369
8076700
11126
15869
8075770
16657
15849
15851
15852
11140
8074810
8074800
16652
11138
11139
8075000
11132
15861
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8075400
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Miles
UNIVERSITY of HOUSTON
Department of Civil and
Environmental Engineering
Figure 2.4
USGS Gages and Water Quality Stations Selected for
Load Duration Anaylsis for the Houston Metro Bacteria TMDL
Principal Investigator: Hanadi Rifai (University of Houston)
TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04
Prepared by AMD
Date: 07-17-2006

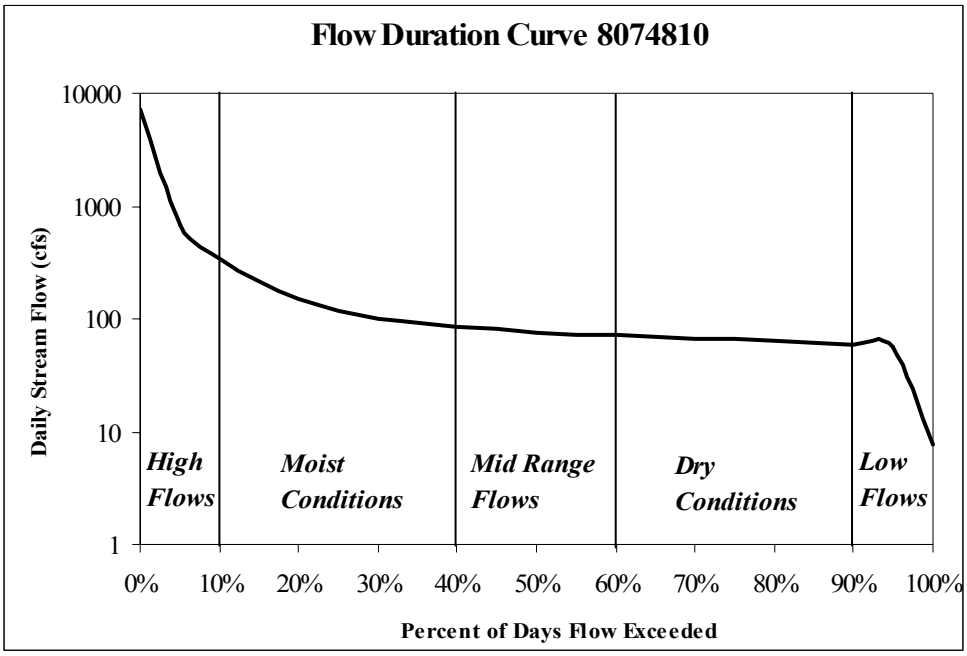


Fig. 2.5 Flow Duration Curve for USGS Gage 8074810

Flow data from USGS gage 8074810 were used for constructing load duration curves for stations 11138, 11139, 15851, 11140, 15849, and 15852 located within segment 1007B. These stations were selected since adequate flow data were available. The flow conditions at each of the stations are tabulated in Table 2.1.

Table 2.1 Flow Conditions and Indicators for Select Stations in Segment 1007

Station	Flow Conditions	Indicator/Target Used
11138	High Flows to Moist	*E.coli*./394 MPN/100mL
11139	High Flows to Moist	*E.coli*./394 MPN/100mL
11140	Range from High to Low Flows	Fecal coliform/400 MPN/100mL
15851	Range from High to Low Flows	*E.coli*./394 MPN/100mL
15852	Range from High to Low Flows	*E.coli*./394 MPN/100mL
15849	Range from High to Low Flows	*E.coli*./394 MPN/100mL

Fig. 2.6 depicts the load duration curve for station 11138. The results indicate that sampling took place mostly under high and moist flow conditions and there is no sampling information available for the other flows. The presence of the high flow conditions does not preclude the possibility of other flow conditions since it is possible that data at low conditions are not available. For station 11138, the water quality standard for *E.coli* is exceeded at all times during high flow and moist conditions. During periods of high flow, non point sources are identified as potential contributors of fecal bacteria to the receiving water bodies since run off events or thunderstorms result in increased delivery of pollutants (Cleland, 2003).

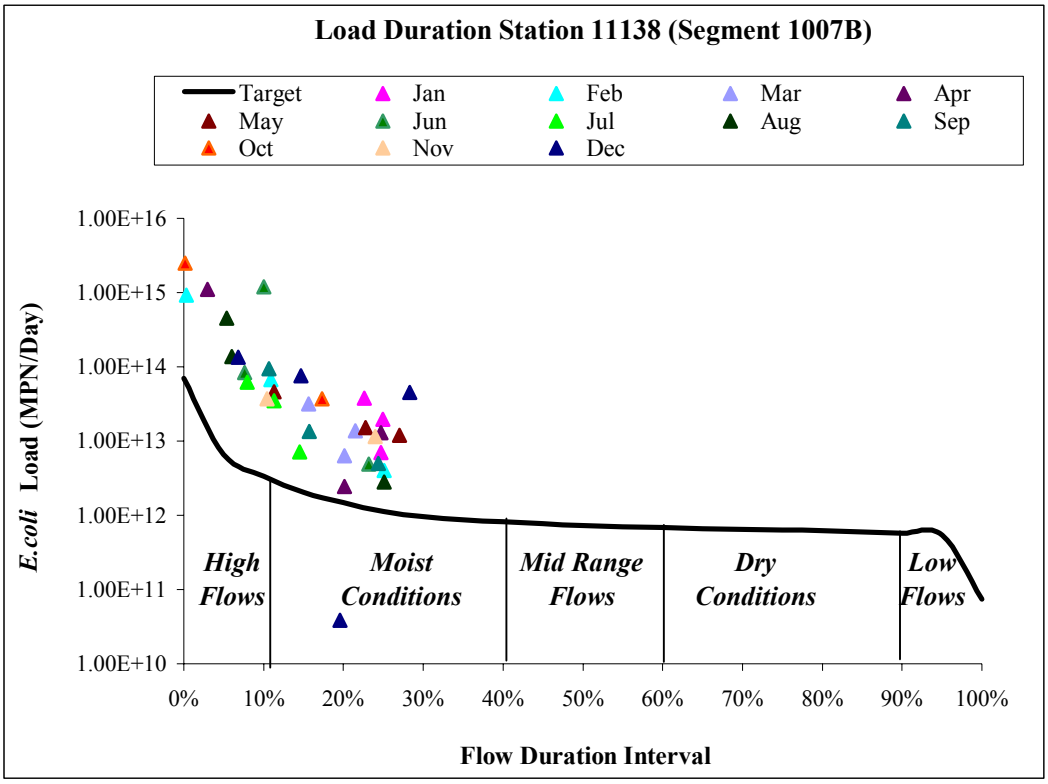


Fig. 2.6 Load Duration Curve for *E.coli* for Station 11138

For station 11139, flow data from USGS gage 8075000 were used for evaluating the load duration curve (Fig. 2.7). For station 11139, the water quality is exceeded during high flows to moist conditions indicating that non point sources dominate this flow period. A load duration curve plotted for fecal coliform data (Fig. 2.7) reveals that sources of fecal bacteria prevail not only during high flow and moist conditions but mid range and low flows also represent potential periods under which fecal bacteria are delivered to the streams. The graph suggests that there are not enough data to characterize the nature of sources resulting in the bacteria loading. However, the graph shows that different sources may be contributing over a wide variety of flows.

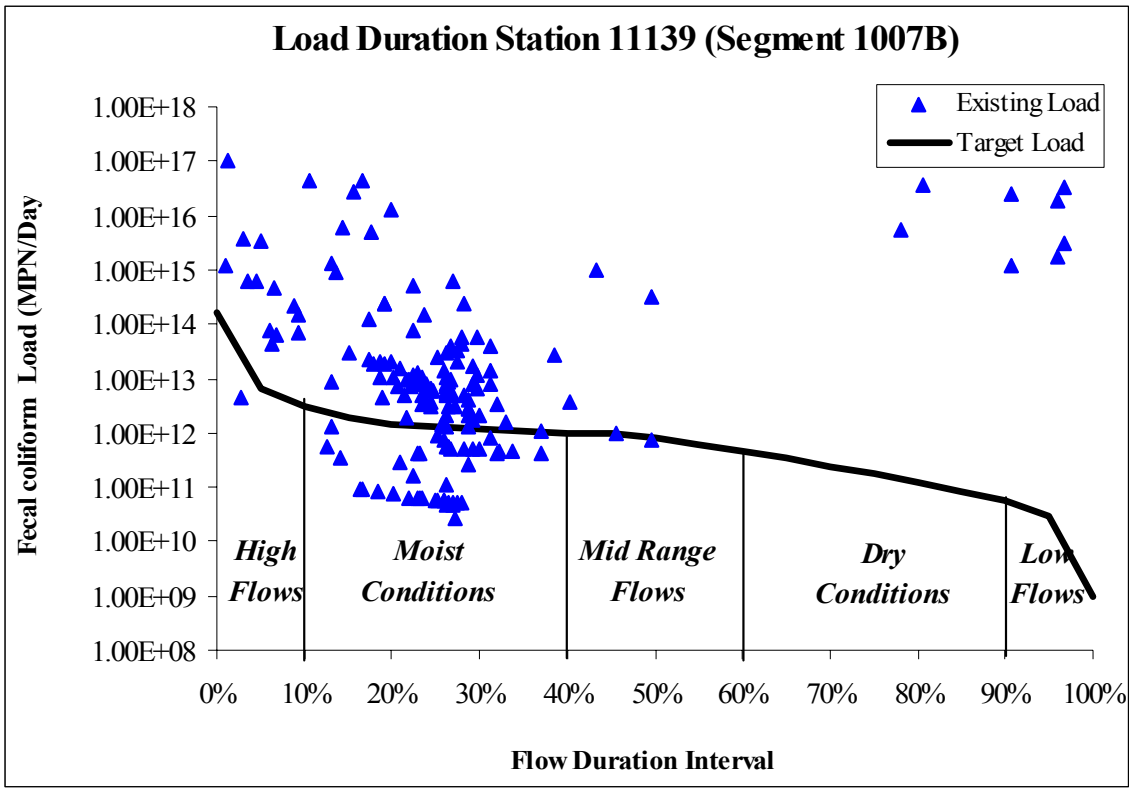


Fig. 2.7 Load Duration for Fecal coliform for Station 11139

The load duration curve for station 11140 is constructed for fecal coliform (Fig. 2.8). The location of this station overlaps with USGS gage 8074810 and thus this station reasonably represents the flow conditions at the particular location in the stream. The graph indicates that for most of the period during the year, the water quality is exceeded based on the fecal coliform standards. The data are exceeded throughout the entire flow regime suggesting that rainfall and run off events along with other sources represent potential sources for bacteria loading to the stream (Cleland 2003). In cases where the water quality is exceeded during the entire flow period, the prevalence of point and non point sources is likely.

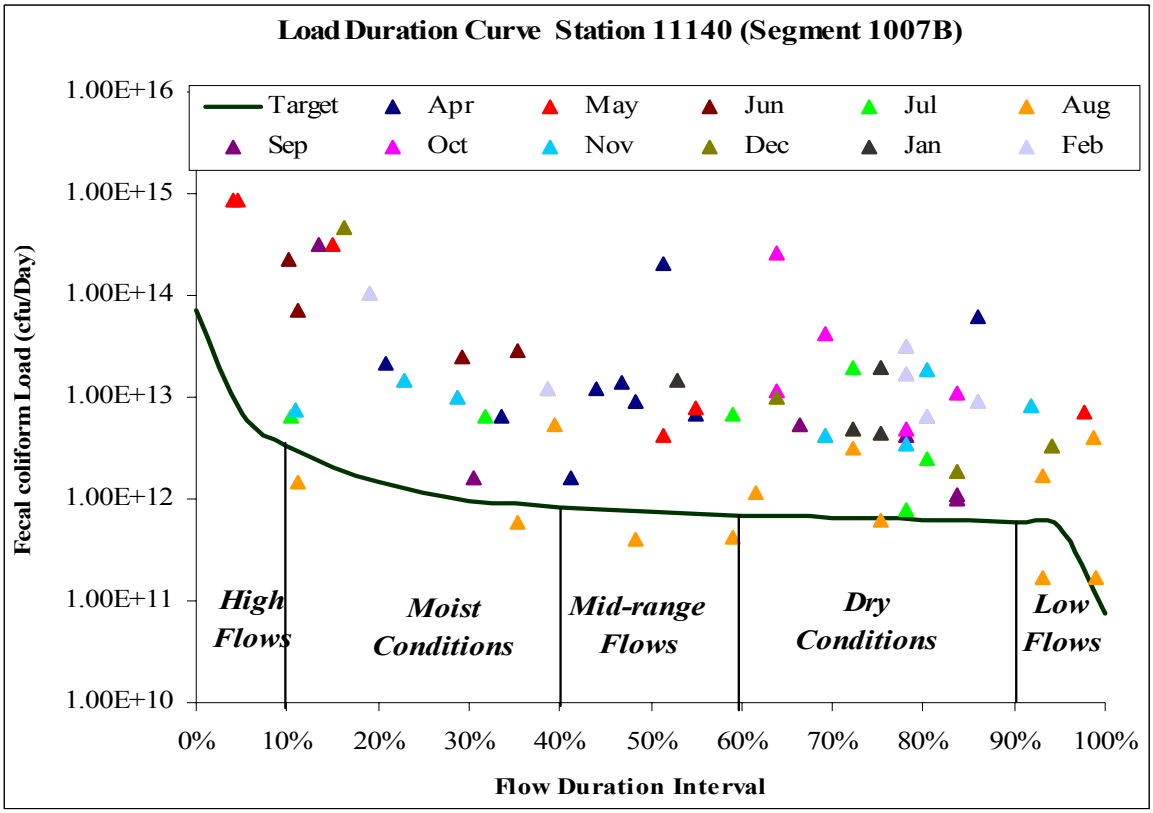


Fig. 2.8 Load Duration Curve for Fecal coliform for Station 11140

For station 15851, there are not much data available for *E.coli* to sufficiently establish a correlation between hydrologic conditions and indicator concentrations (Fig. 2.9). The available data show that generally, bacteria loads are exceeded in all flows by a large amount. This indicates that all sources may be contributing to the exceedances

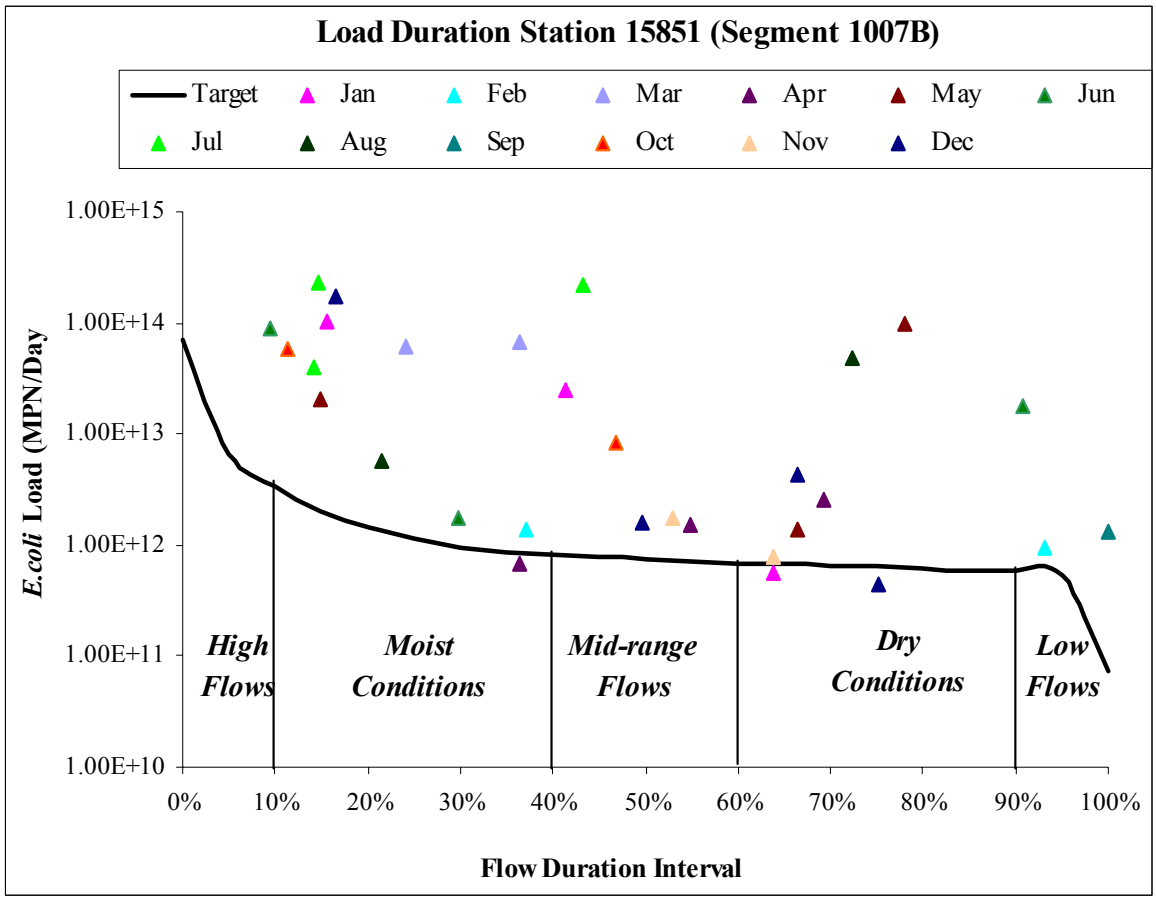


Fig. 2.9 Load Duration Curve for *E.coli* for Station 15851

Similarly for stations 15852 and 15849, the observed loads exceed the target loads for the entire flow period (Fig. 2.10 and Fig. 2.11) with the inherent limitation of a small data set. For both the stations 15852 and 15849, the graph suggests that different sources prevail over a variety of flow conditions with the exceedances occurring for the entire flow period with the exception for station 15849.

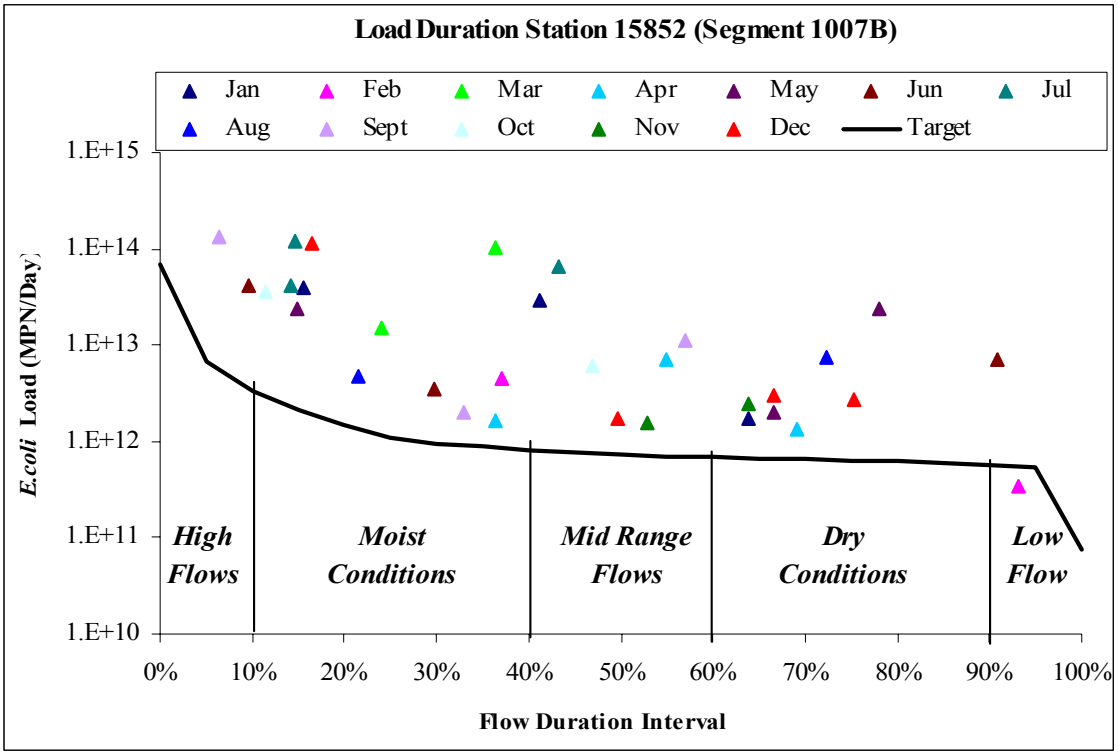


Fig. 2.10 Load Duration Curve for *E.coli* for Station 15852

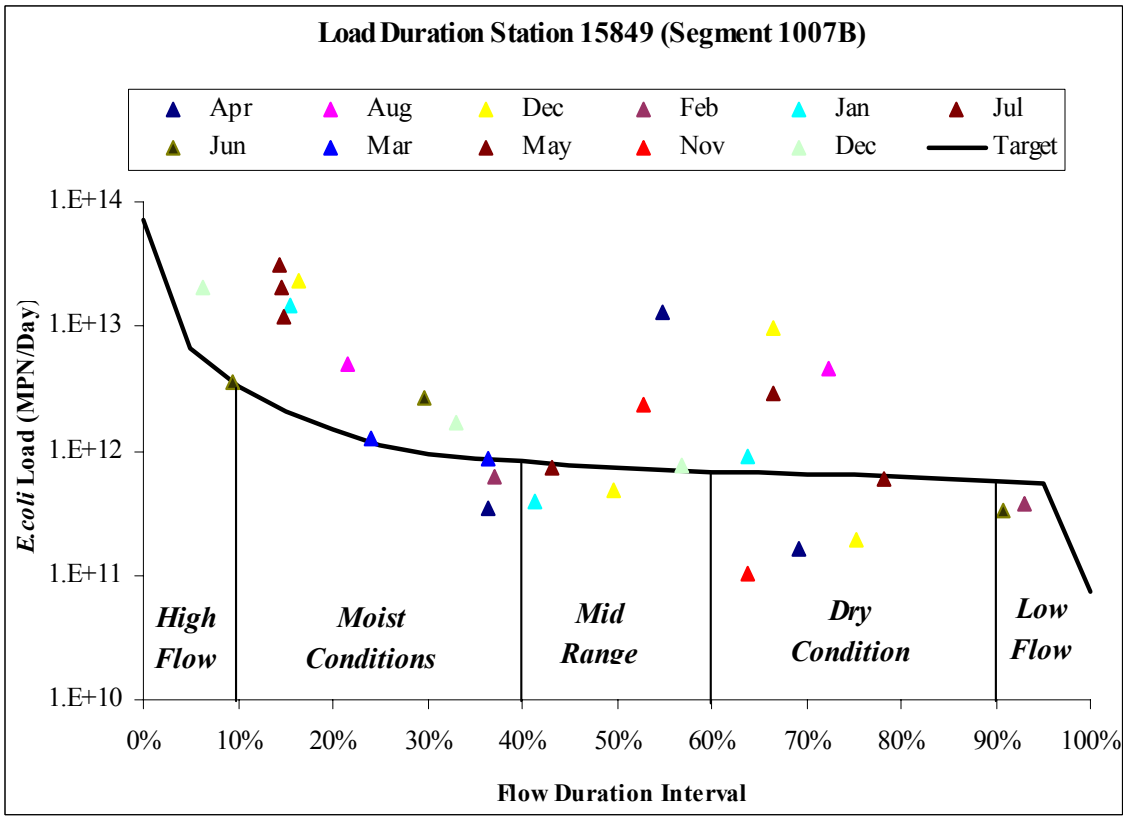


Fig. 2.11 Load Duration Curve for *E.coli* for Station 15849

Segment 1007D

For this segment, the load duration analysis was performed only for station 11132 (Fig. 2.12) since adequate flow data were not available for other stations (11133 and 15877) within this segment. At this station, fecal bacteria loads were consistently high from April though December under mid range to low flow conditions. Fecal coliform data are not available for high flows to mid range flows however, existing data reveal point sources as potential contributors of fecal bacteria.

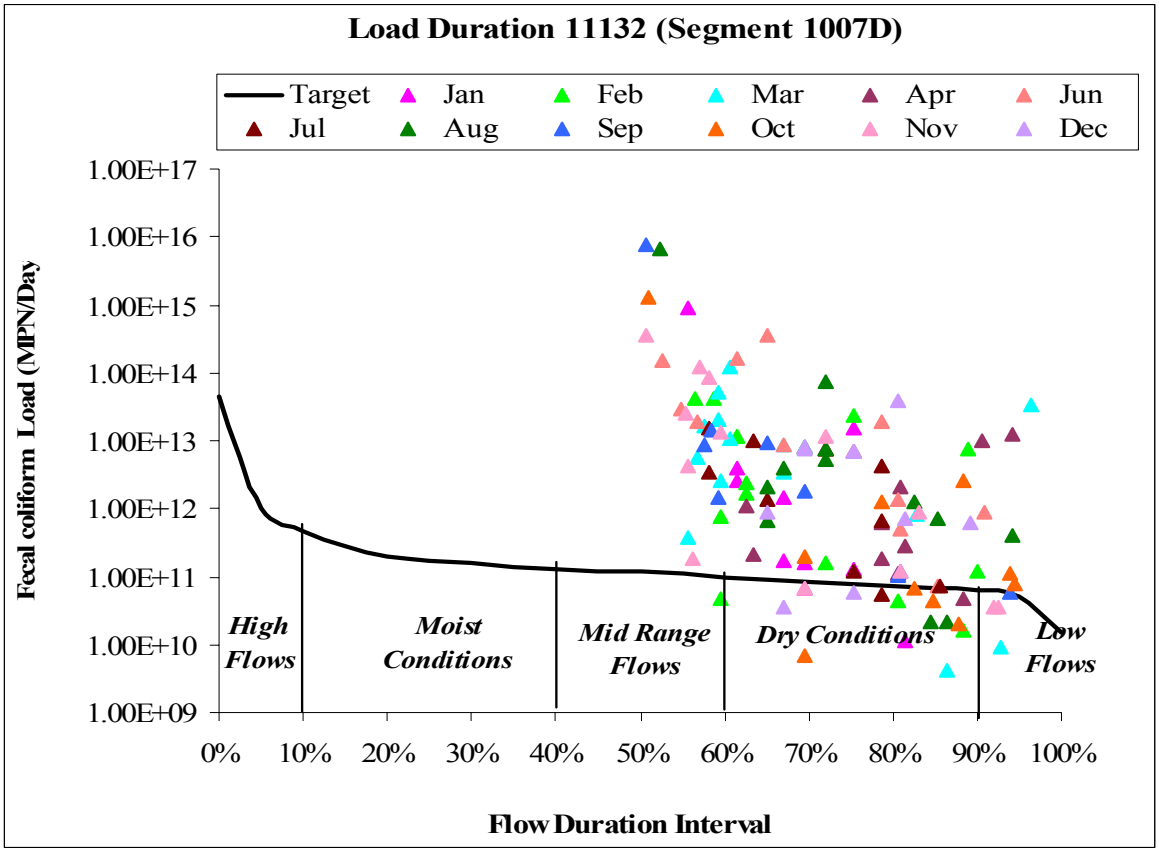


Fig. 2.12 Load Duration Curve for Fecal coliform for Station 11132

Segment 1007E

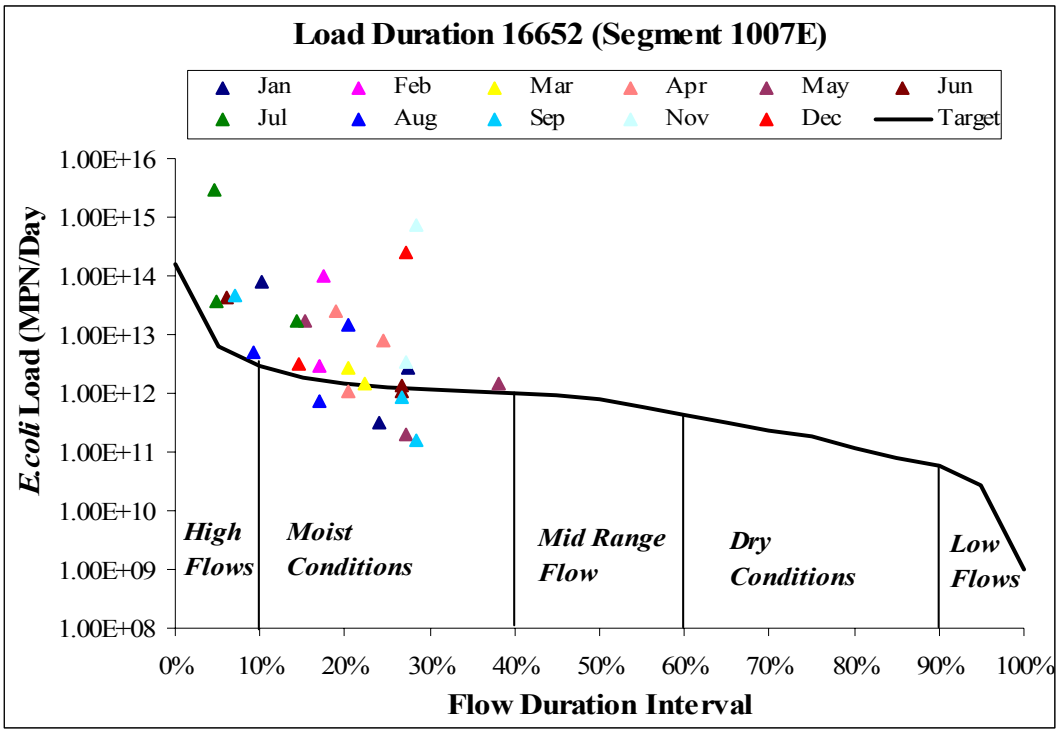


Fig. 2.13 Load Duration Curve for *E.coli* for Station 16652

For segment 1007E, a load duration curve for *E.coli* was constructed only for station 16652 (Fig. 2.13). Due to the absence of a USGS gage in this segment, flow was evaluated against gage 8075000. The graph suggests that the observed loads are out of compliance generally for the entire period with the exception of a few days during the months of January, April, June, August, September, and November. Available data are for high and moist flow conditions only. Although nothing can be said about point sources under lower flow conditions, the available data indicate that non-point sources may be contributing to the bacteria loads.

Segment 1007N

For segment 1007N, USGS gage 8075400 was used for flow calculations. A flow analysis included in the second quarterly report for this project revealed that both low flow and high flow data were available at station 16655 and thus a load duration curve was constructed for this station (Fig. 2.14). Relatively few data are available for this station as evident from the graph. In addition, since the exceedances are observed during the entire flow period, the existence of both point and non point sources is likely.

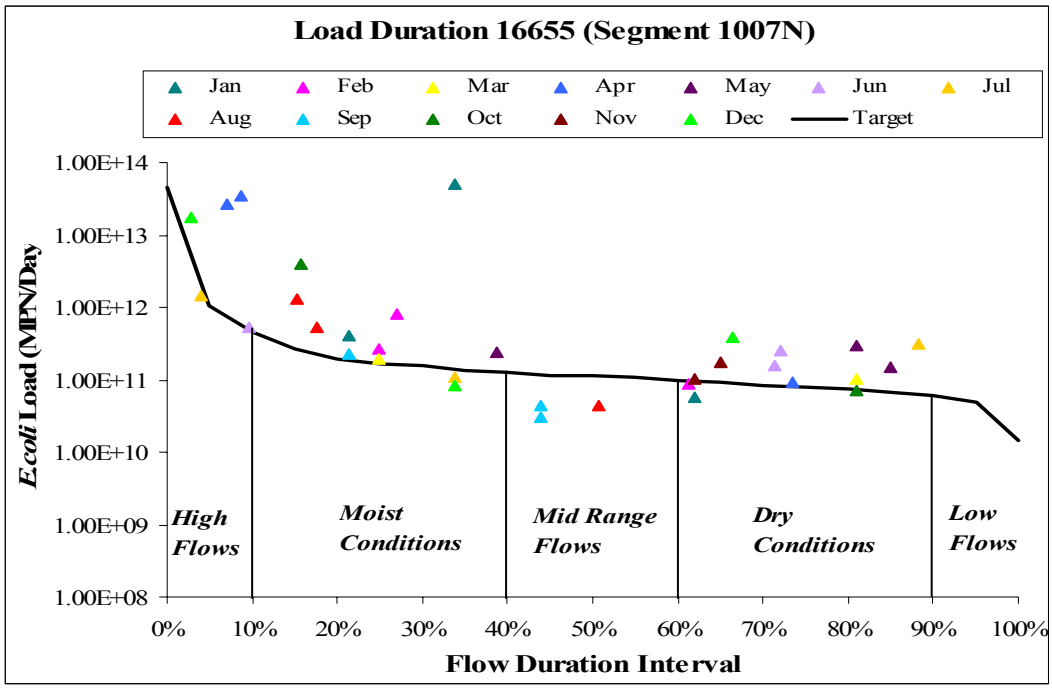


Fig. 2.14 Load Duration Curve for *E.coli* for Station 16655

Segment 1007R

For segment 1007R, stations 16657 and 15869 were selected based on the flow analysis included in the second quarterly report for the Metro area. The existence of high flow and low flow conditions at both stations (Fig. 2.15 & Fig. 2.16) suggest that both

point and non point inputs represent potential sources of fecal bacteria. However, for station 16657, the non-exceedance observed during the dry conditions and low flow periods indicated that point sources may not be contributing.

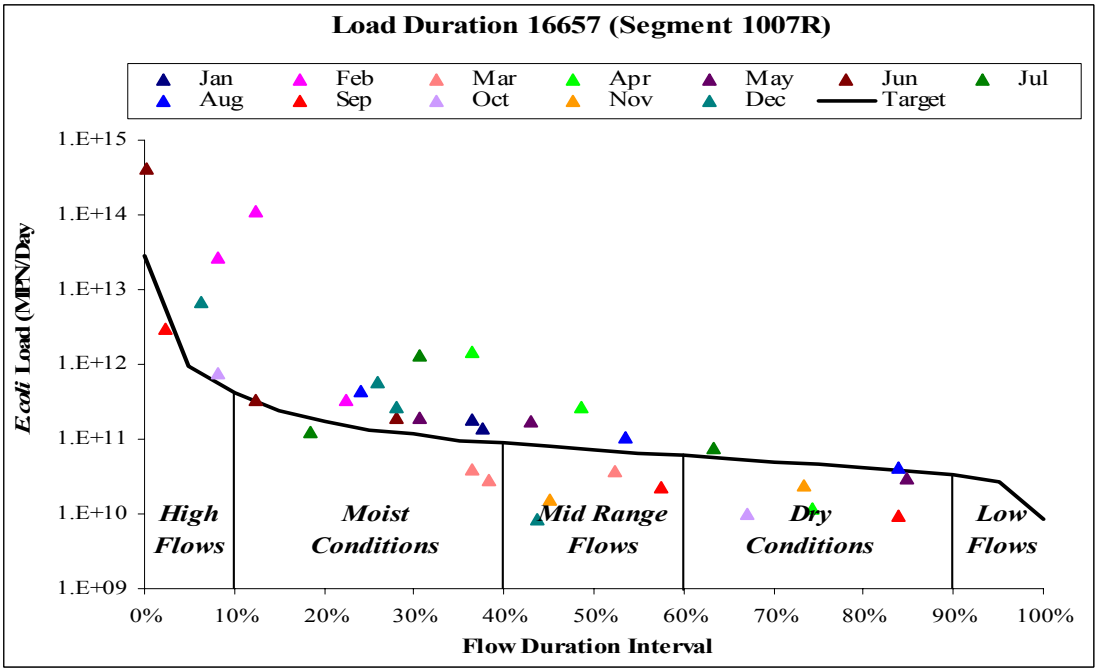


Fig. 2.15 Load Duration Curve for *E.coli* for Station 16657

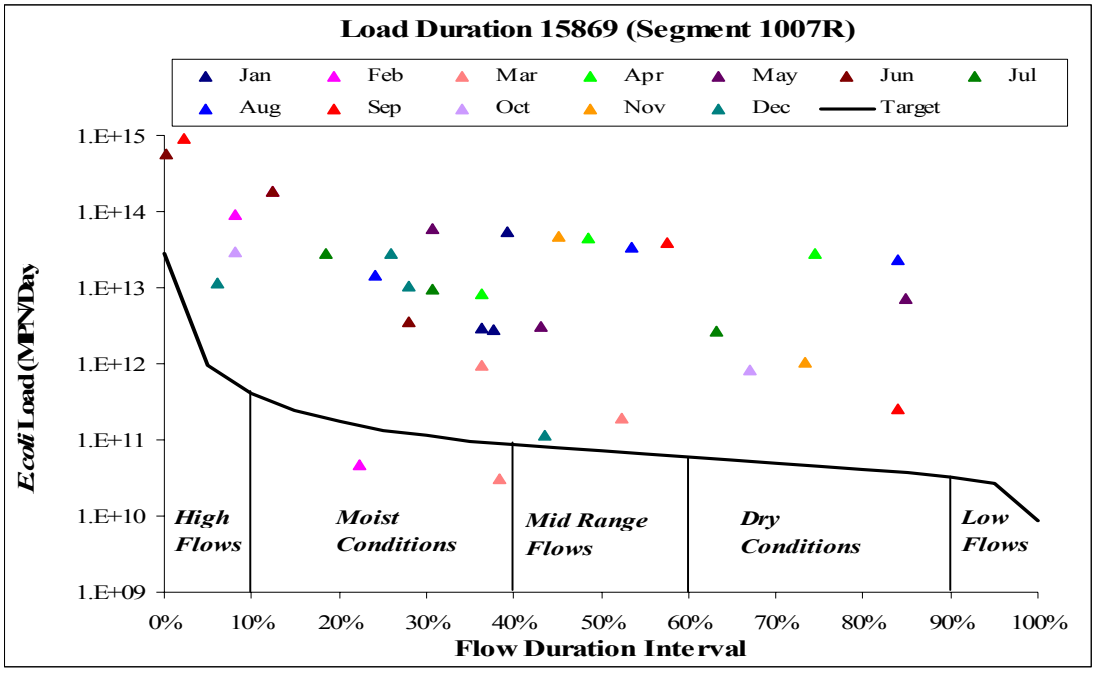


Fig. 2.16 Load Duration Curve for *E.coli* for Station 15869

Segment 1016

For this segment, stations 11371, 11124, and 11369 were selected for analysis. The observed loads violate the target loads generally for the entire period for which the analysis is conducted. Fecal bacteria loads were calculated for stations where sufficient *E.coli* data were not available (Fig. 2.17, 2.18, 2.19). For all the stations analyzed for this segment, similar observations are made as far as the exceedance during different flow conditions is concerned.

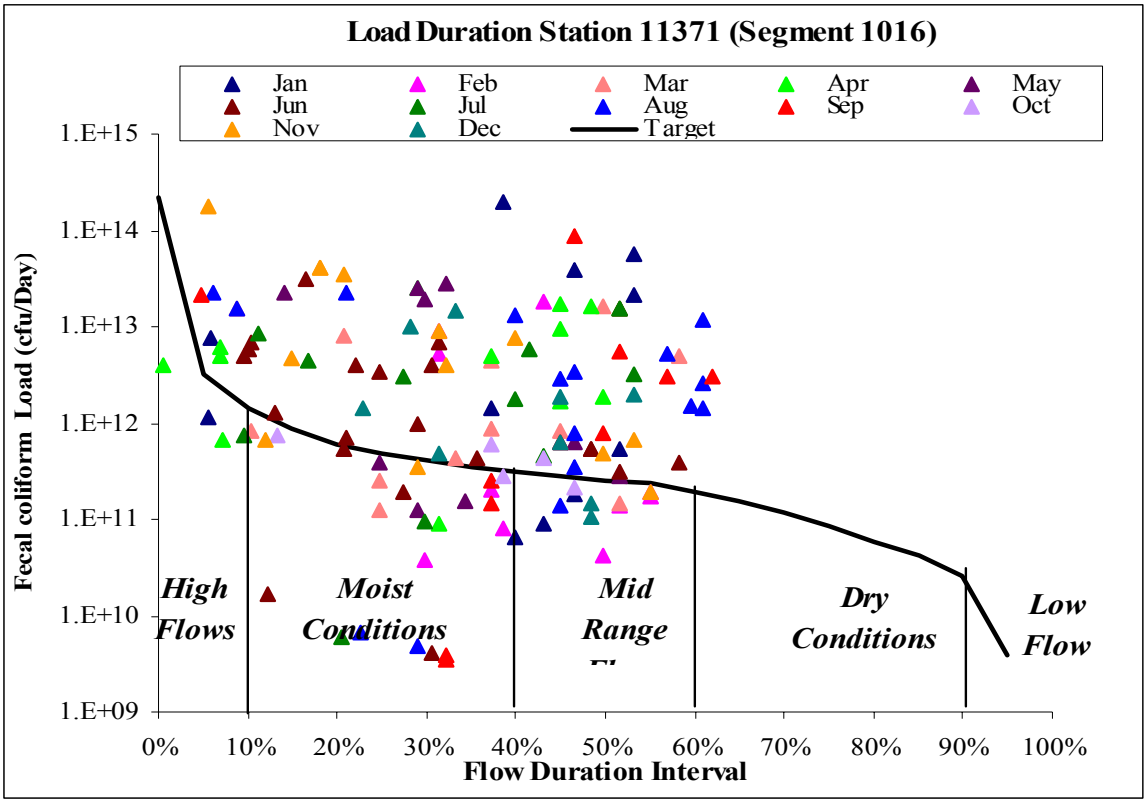


Fig. 2.17 Load Duration Curve for Fecal coliform for Station 11371

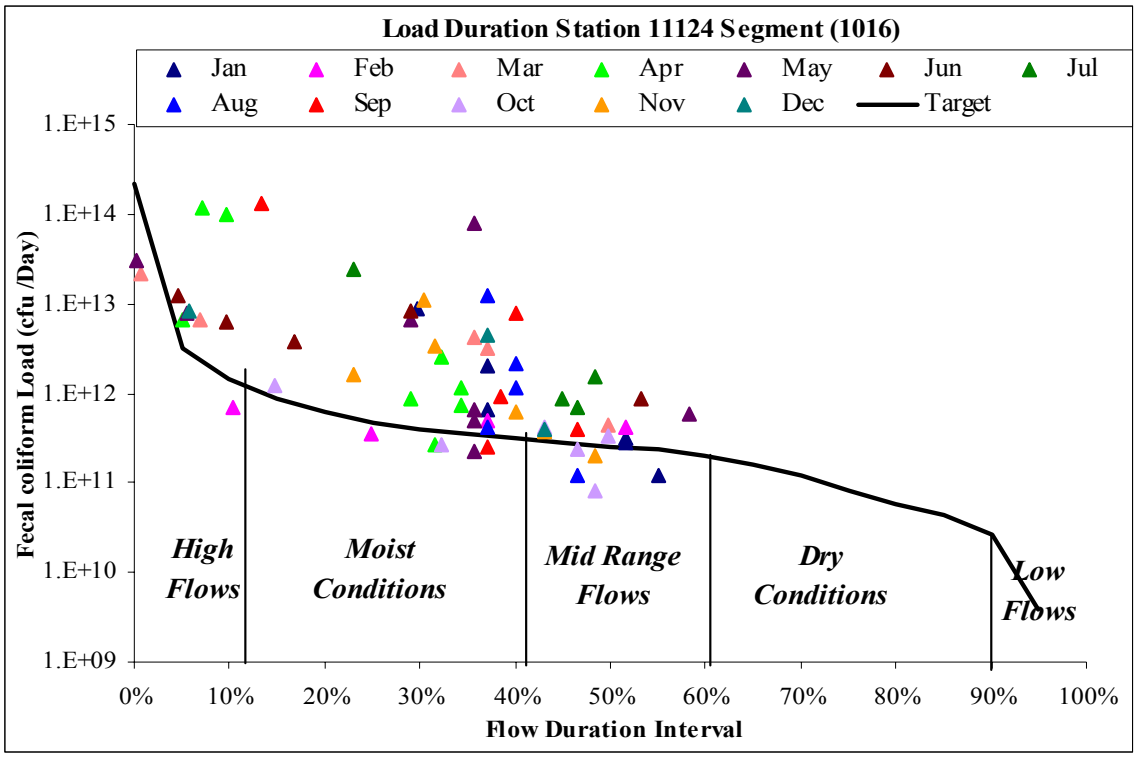


Fig. 2.18 Load Duration Curve for Fecal coliform for Station 11124

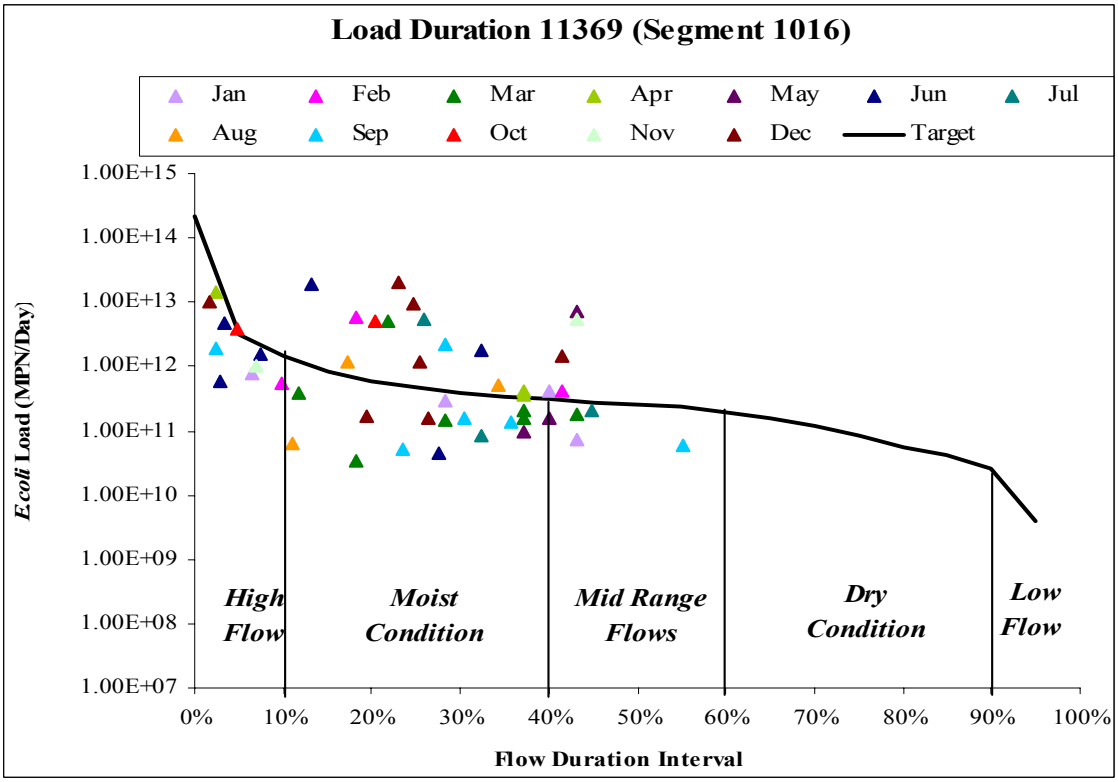


Fig. 2.19 Load Duration Curve for *E.coli* for Station 11369

For segment 1016, for all the stations selected for load duration analyses, it is observed that fecal bacteria data are available mostly for high flows to mid range flows. The observed loads exceed the target load most of the times, for example for station 11371 (Fig. 2.17), the observed loads exceed the target load 70% of the times during high flow to mid range flow conditions. The available data suggest that non point sources may be potential contributors to the observed loads.

Segment 1006

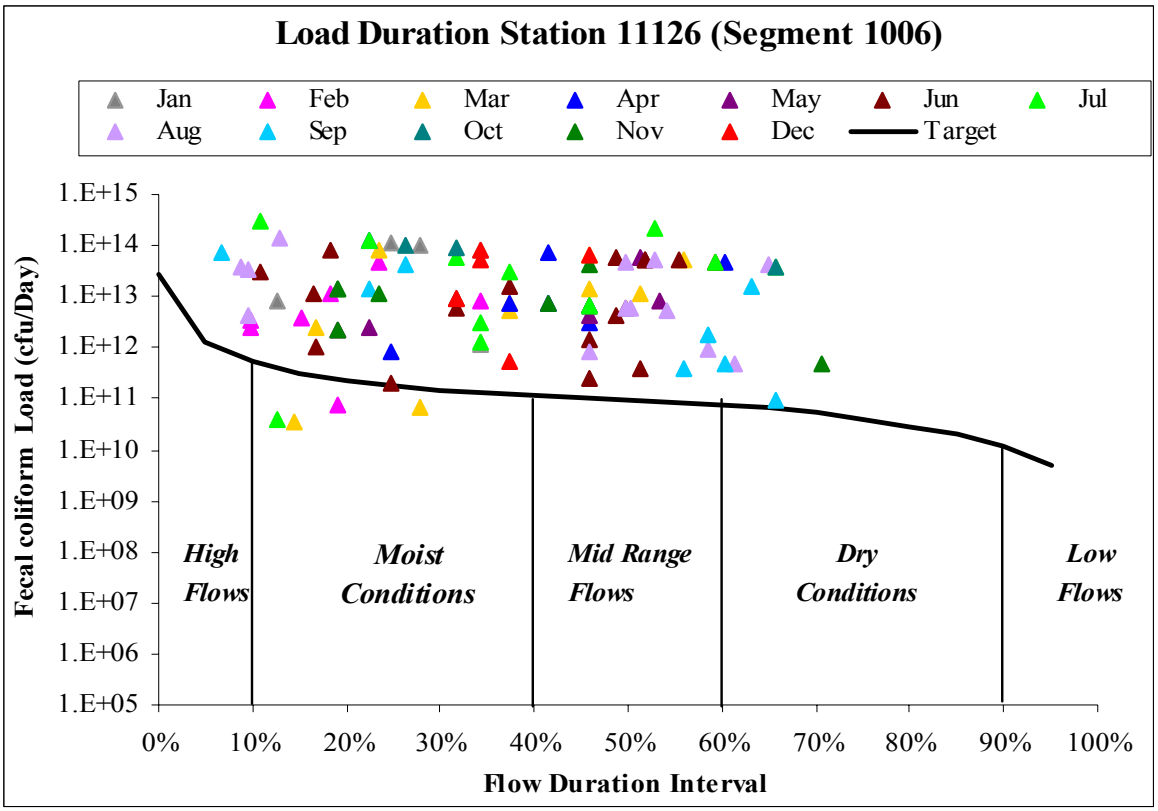


Fig. 2.20 Load Duration Curve for Fecal coliform for Station 11126

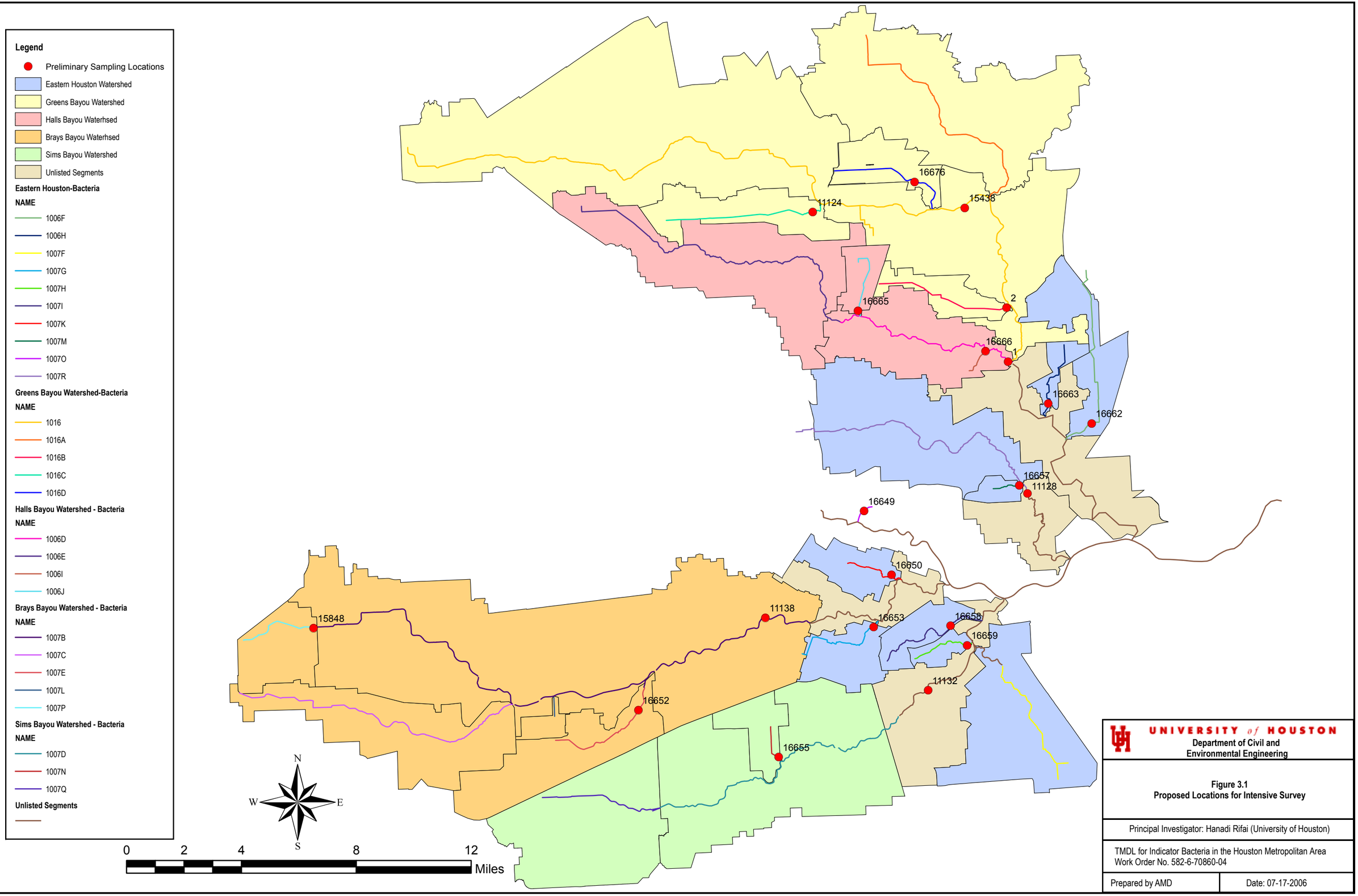
For this particular segment, only station 11126 was selected for constructing the load duration curve (Fig. 2.20). Generally, the bacteria load is exceeded at all flow conditions where data is available. Information is not available for dry conditions and low flows. The existing data indicate that all potential bacteria sources are contributing to the exceedances.

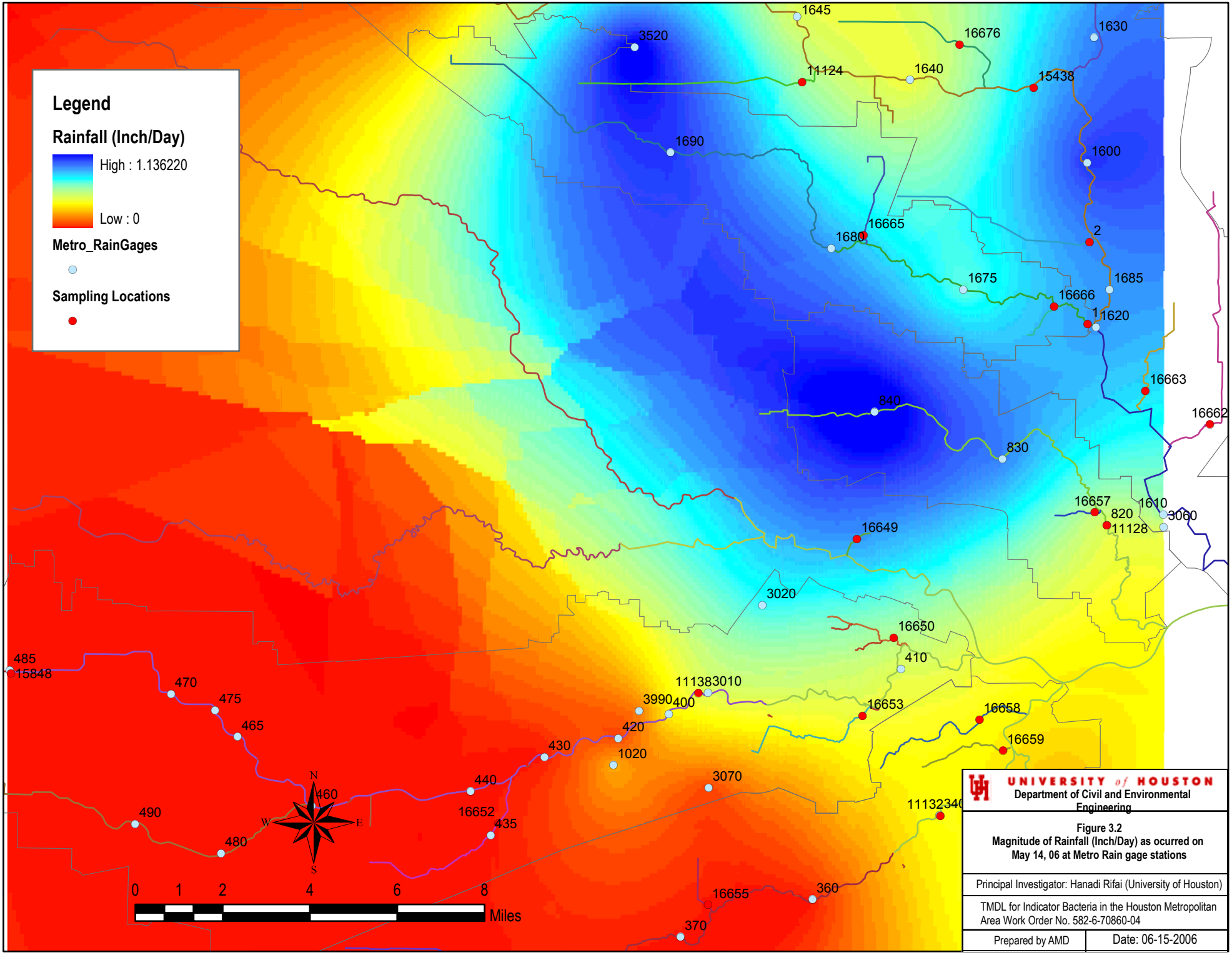
CHAPTER 3

PRELIMINARY SAMPLING RESULTS

3.1 Introduction

Sampling was conducted on May 15, 06 through May 19, 06 to collect flow and *E.coli* at the 21 locations shown on Fig. 3.1. The preliminary results for *E.coli* are summarized in Table 3.1. The sampling conducted was a dry weather sampling event; however a rainfall event prior to the sampling may have resulted in the elevated concentrations observed at the sampling locations. The rainfall event occurred on May 14, 06. The magnitude and distribution of rainfall over a period of one day at each of the rain gage stations obtained by krigging rainfall data is depicted in Fig. 3.2. The accumulation of rainfall on the subsequent days was approximately zero. As observed, most of the rain was experienced by parts of the Eastern Houston, Greens Bayou, and the Halls Bayou watersheds. Thus, bacteria stations in these watersheds exhibited high *E.coli* concentrations as compared to the sampling locations in Brays and Sims Bayou where the rainfall intensity ranged mostly from 0 to 0.55 inch/day with a few exceptions. Graphical plots indicate the temporal nature of the indicator concentrations (Fig. 3.3, 3.4, 3.5 and 3.6) at the sampled locations. A decline in *E.coli* concentrations can be seen based on the data in the plots, especially at stations 16676, 16663, 16657, 16662, 11371 and site # 1 where concentrations decrease to below the single sample exceedance criteria for *E.coli*. The concentrations drop to values below the single sample exceedance criteria in approximately 5 days following the rainfall event.


Legend
Preliminary Sampling Locations
Eastern Houston Watershed
Greens Bayou Watershed
Halls Bayou Waterhsed
Brays Bayou Waterhsed
Sims Bayou Watershed
Unlisted Segments
Eastern Houston-Bacteria
NAME
1006F
1006H
1007F
1007G
1007H
1007I
1007K
1007M
1007O
1007R
Greens Bayou Watershed-Bacteria
NAME
1016
1016A
1016B
1016C
1016D
Halls Bayou Watershed - Bacteria
NAME
1006D
1006E
1006I
1006J
Brays Bayou Watershed - Bacteria
NAME
1007B
1007C
1007E
1007L
1007P
Sims Bayou Watershed - Bacteria
NAME
1007D
1007N
1007Q
Unlisted Segments
16676
15438
11124
16665
2
16666
1
16663
16662
16657
11128
16649
16650
15848
11138
16653
16658
16659
11132
16652
16655
N
W
E
S
0
2
4
8
12
Miles
UNIVERSITY of HOUSTON
Department of Civil and
Environmental Engineering
Figure 3.1
Proposed Locations for Intensive Survey
Principal Investigator: Hanadi Rifai (University of Houston)
TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04
Prepared by AMD
Date: 07-17-2006


Legend
Rainfall (Inch/Day)
High : 1.136220
Low : 0
Metro_RainGages
Sampling Locations
1645
3520
16676
1630
11124
1640
15438
1690
1600
16665
1680
2
1675
1685
16666
1620
16663
840
16662
830
16657
1610
820
3060
11128
16649
3020
16650
410
485
15848
470
475
465
111383010
3990
400
16653
16658
420
16659
430
1020
440
3070
460
490
16652
435
11132340
480
16655
360
370
N
W
E
S
0
1
2
4
6
8
Miles
UNIVERSITY of HOUSTON
Department of Civil and Environmental Engineering
Figure 3.2
Magnitude of Rainfall (Inch/Day) as ocurred on May 14, 06 at Metro Rain gage stations
Principal Investigator: Hanadi Rifai (University of Houston)
TMDL for Indicator Bacteria in the Houston Metropolitan Area Work Order No. 582-6-70860-04
Prepared by AMD
Date: 06-15-2006

The *E.coli* concentrations at most of the sampling locations exhibited a decreasing trend in bacteria concentrations except at stations 16652, 11132, 16655, 11138, 11128, and 16650 where the variation in concentrations appeared to be independent of the time period sampled. At stations 16653 and 16659, the concentrations decline from greater than a log value of 100000 MPN/100mL on day 0 to below the single sample exceedance limit on day 4. However, at station 16658, the concentration of *E.coli* on day 0 was greater than 242000 MPN/100mL and decreased to 5310 MPN/100mL on day 4. Thus, the effects of rainfall on bacteria concentrations are evident and these effects may be observed for at least 3 to 5 days following the rainfall event.

Table 3.1 Results from Preliminary Sampling Conducted in May 06

Station ID	Day	Date	*E.coli* Conc (MPN/100mL)	CI (95%) MPN/100mL
11124	0	5/15/2006	13905	1715
	1	5/16/2006	1519	325
	2	5/17/2006	1497	0
	3	5/18/2006	1523	119
	3.2	5/18/2006	1877	205
	4	5/19/2006	1195	37
TBD # 2	0	5/15/2006	46390	11947
	1	5/16/2006	702	24
	1.3	05/16/2006	495	54
	2	5/17/2006	475	31
	3	5/18/2006	140	32
	4	5/19/2006	144	64
16676	0	5/15/2006	12640	1188
	1	5/16/2006	4413	1701
	2	5/17/2006	1316	558
	3	5/18/2006	196	117
	3.2	5/18/2006	155	15
	4	5/19/2006	118	3
16665	0	5/15/2006	42895	7206
	1	5/16/2006	1235	54
	2	5/17/2006	1440	773
	3	5/18/2006	670	120
	4	5/19/2006	1009	231
16666	0	5/15/2006	98350	14054
	1	5/16/2006	1537	703
	2	5/17/2006	1035	230
	3	5/18/2006	1194	196
	4	5/19/2006	384	172
11371	0	5/15/2006	24385	10546
	1	5/16/2006	20435	1222
	2	5/17/2006	562	118
	3	5/18/2006	398	83
	4	5/19/2006	340	347
	4.1	5/19/2006	95	9
11132	0	5/15/2006	809	340
	1	5/16/2006	346	29
	2	5/17/2006	463	58
	2.3	5/17/2006	366	48
	3	5/18/2006	466	116
	3.2	5/18/2006	436	28

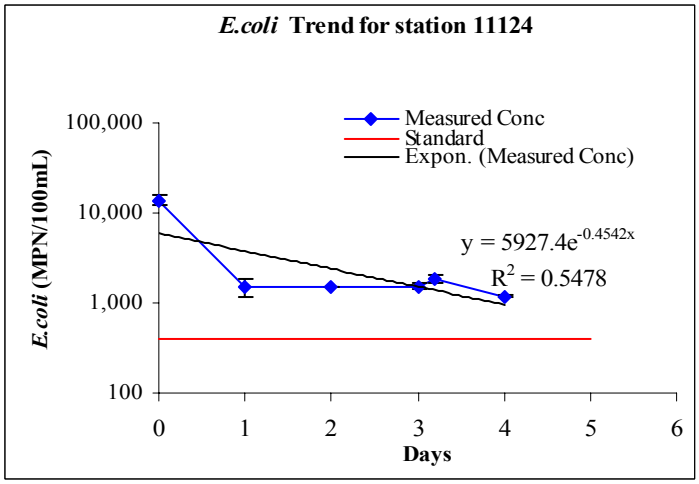
MPN: Most Probable Number, Conc: Concentration, CI: Confidence Interval

Table 3.1 Results from Preliminary Sampling Conducted in May 06

Station ID	Day	Date	*E.coli* Conc (MPN/100mL)	CI (95%) MPN/100mL
16659	0	5/15/2006	92080	0
	1	5/16/2006	1106	141
	2	5/17/2006	947	92
	2.3	5/17/2006	613	112
	3	5/18/2006	626	113
	4	5/19/2006	411	54
16652	0	5/15/2006	986	556
	1	5/16/2006	2795	430
	2	5/17/2006	690	208
	3	5/18/2006	655	132
	4	5/19/2006	1636	343
16655	0	5/15/2006	556	90
	1	5/16/2006	380	182
	2	5/17/2006	453	61
	3	5/18/2006	71	13
	4	5/19/2006	278	106
15848	0	5/15/2006	649	90
	1	5/16/2006	411	153
	2	5/17/2006	157	48
	3	5/18/2006	106	27
	3.1	5/18/2006	323	143
	4	5/19/2006	511	59
16662	0	5/15/2006	7580	1816
	1	5/16/2006	536	104
	2	5/17/2006	269	264
	2.3	5/17/2006	472	302
	3	5/18/2006	51	1
	4	5/19/2006	80	4
16663	0	5/15/2006	10430	3026
	1	5/16/2006	407	183
	2	5/17/2006	151	35
	3	5/18/2006	97	9
	4	5/19/2006	96	48
16653	0	5/15/2006	141360	0
	1	5/16/2006	7685	1154
	1.1	05/16/2006	5334	832
	2	5/17/2006	600	310
	3	5/18/2006	411	0
	4	5/19/2006	436	57

Table 3.1 Results from Preliminary Sampling Conducted in May 06

Station ID	Day	Date	*E.coli* Conc (MPN/100mL)	CI (95%) MPN/100mL
16658	0	5/15/2006	>242000	-
	1	5/16/2006	>242000	-
	1.2	5/16/2006	30745	1087
	2	5/17/2006	13115	2813
	3	5/18/2006	6665	4315
	4	5/19/2006	5310	605
16650	0	5/15/2006	>242000	-
	1	5/16/2006	8190	964
	2	5/17/2006	2274	760
	3	5/18/2006	5675	684
	4	5/19/2006	10960	3653
16657	0	5/15/2006	1656	158
	1	5/16/2006	112	17
	2	5/17/2006	169	7
	2.3	5/17/2006	56	0
	3	5/18/2006	21	11
	4	5/19/2006	16	5
16649	0	5/15/2006	>242000	-
	1	5/16/2006	26845	6780
	2	5/17/2006	13450	695
	3	5/18/2006	2503	494
	4	5/19/2006	4300	973
	4.08	5/19/2006	3880	507
11128	0	5/15/2006	71	10
	1	5/16/2006	4	2
	2	5/17/2006	15	11
	3	5/18/2006	3	2
	4	5/19/2006	9	3
11138	0	5/15/2006	4748	306
	1	5/16/2006	1029	517
	1.2	5/16/2006	1096	309
	2	5/17/2006	2004	623
	3	5/18/2006	720	123
	4	5/19/2006	4310	1932
TBD # 1	0	5/15/2006	89840	18380
	1	5/16/2006	1646	182
	1.33	05/16/2006	811	332
	2	5/17/2006	1045	137
	3	5/18/2006	112	10
	4	5/19/2006	88	41
11132	0	5/15/2006	809	340
	1	5/16/2006	613	0
	2	5/17/2006	463	58
	3	5/18/2006	517	0
	3.1	5/18/2006	445	37



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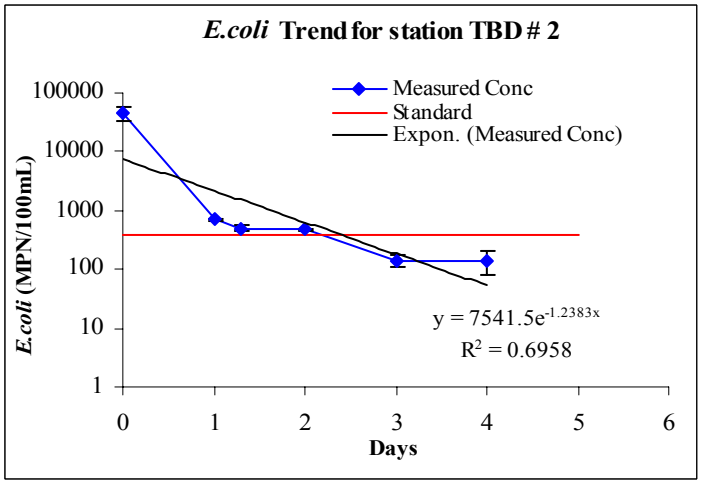

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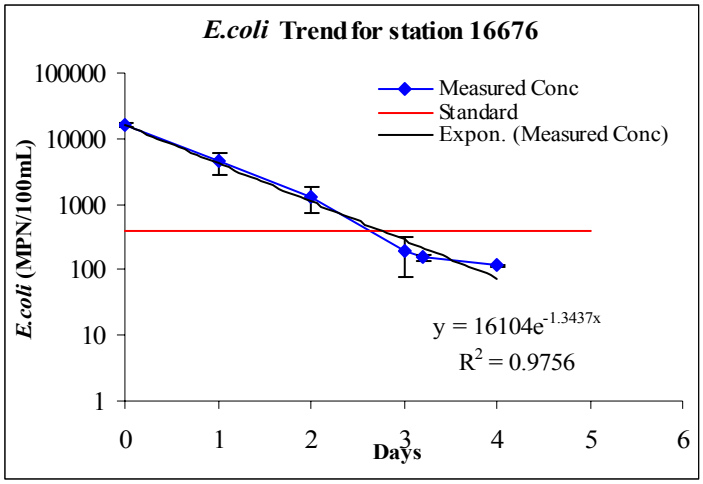

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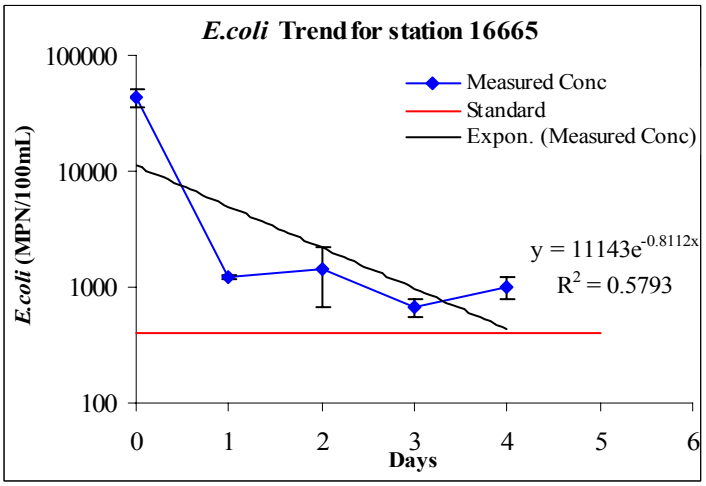

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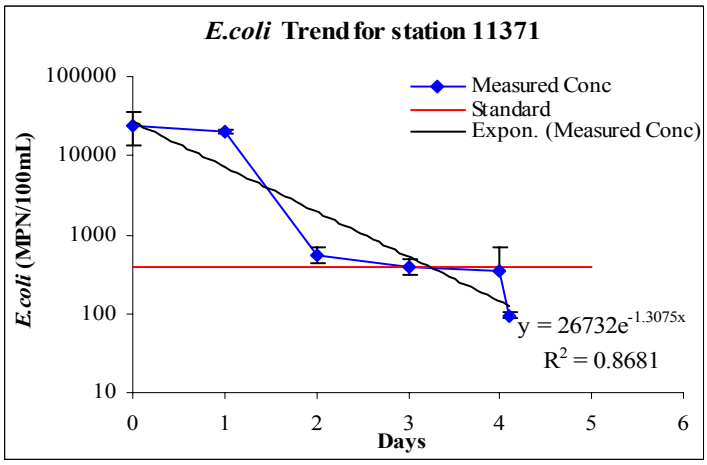

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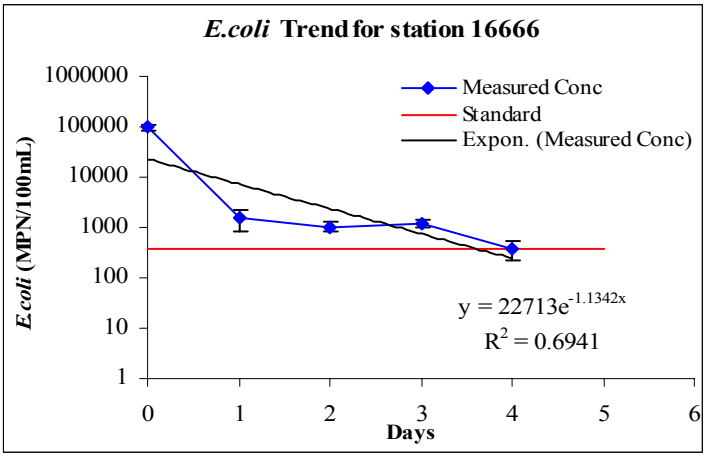

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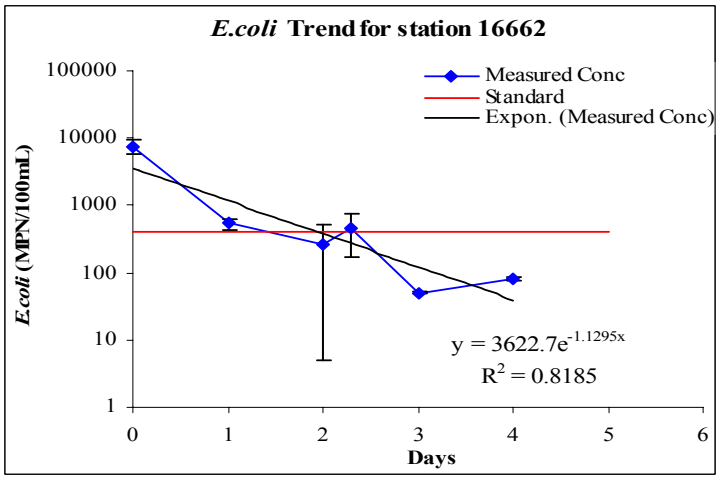
Fig.3.3 Indicator Concentration Trends During May 06 Sampling



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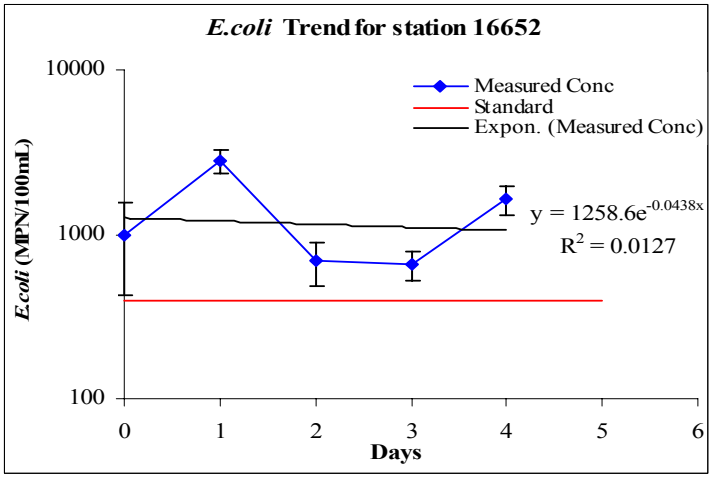

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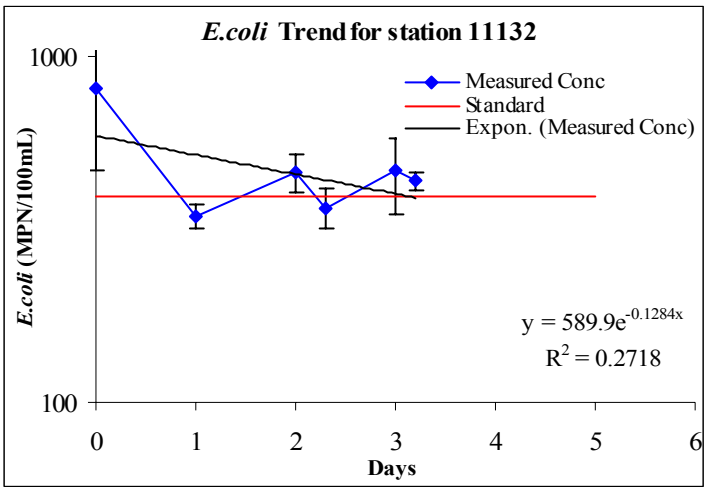

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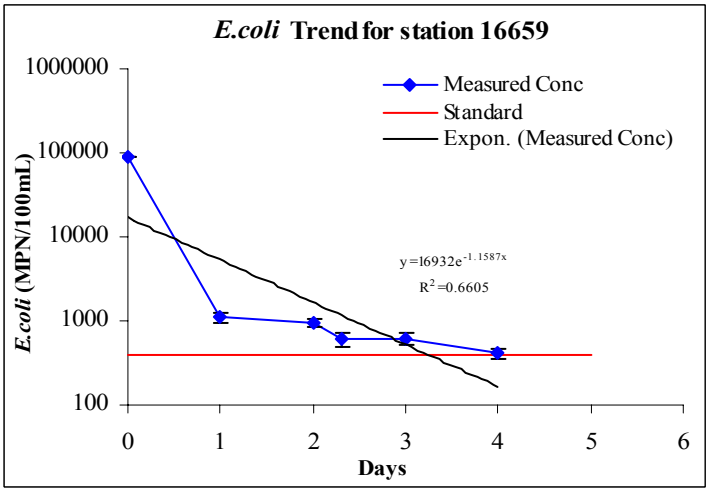

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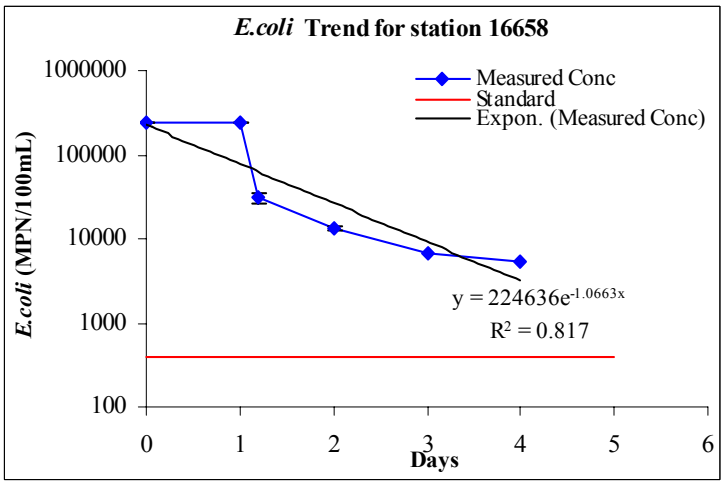

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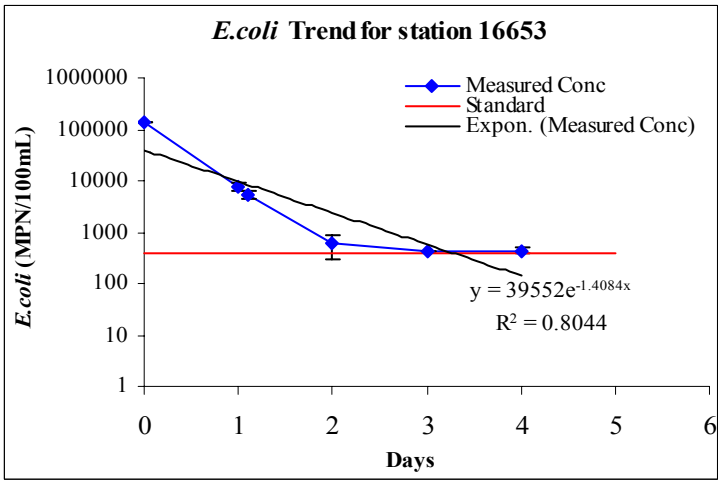

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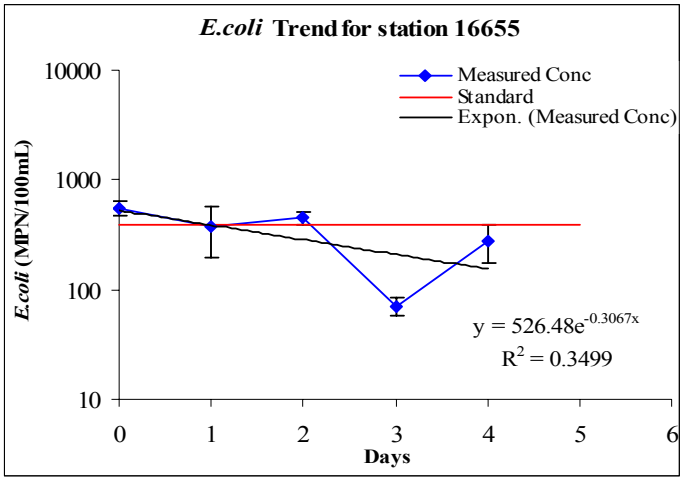
Fig.3.4 Indicator Concentration Trends During May 06 Sampling



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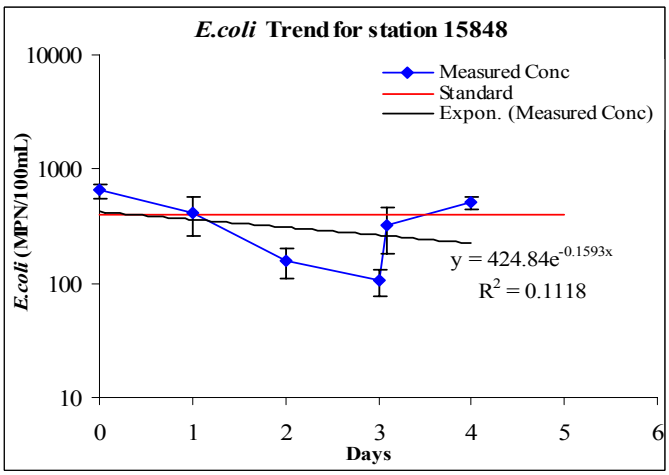

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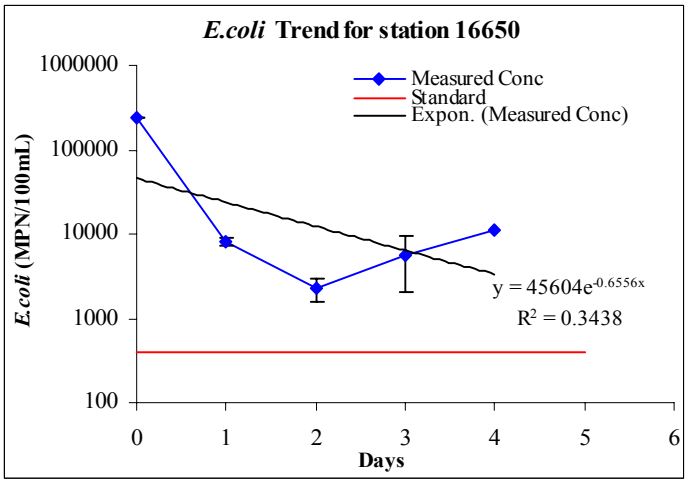

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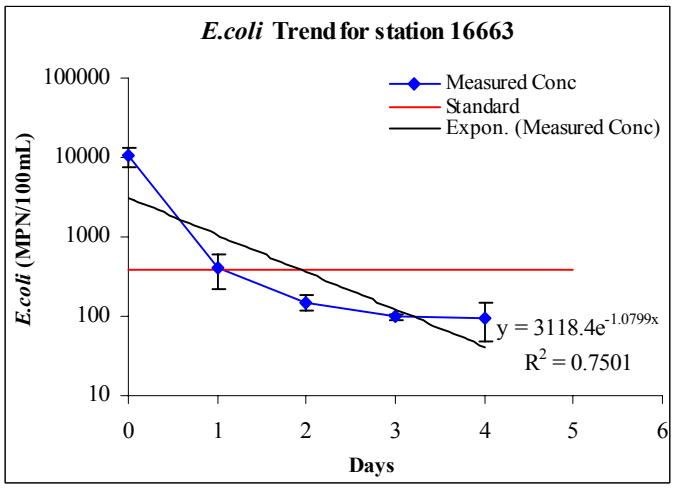

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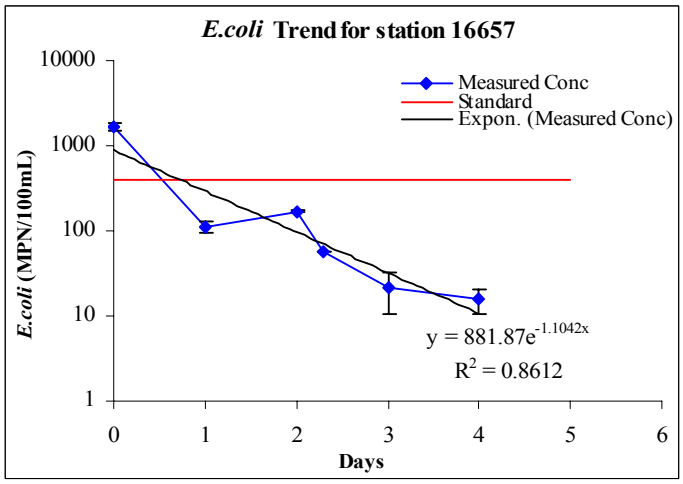

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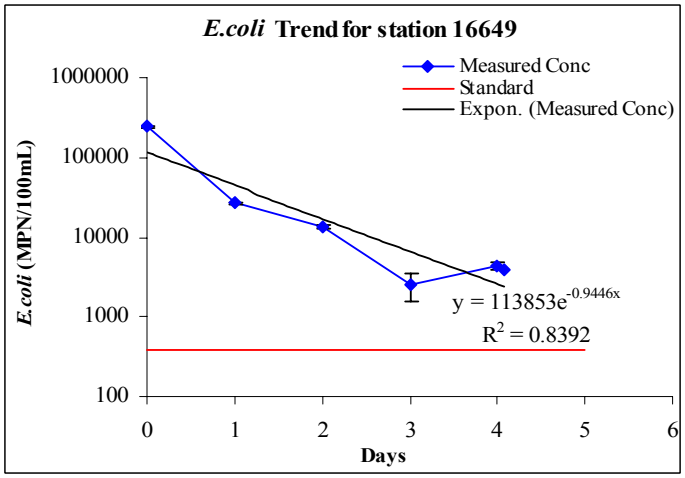
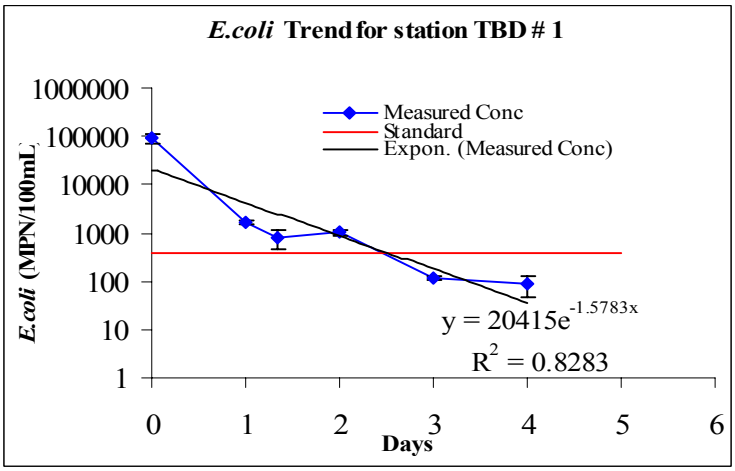


(f)

Fig.3.5 Indicator Concentration Trends During May 06 Sampling



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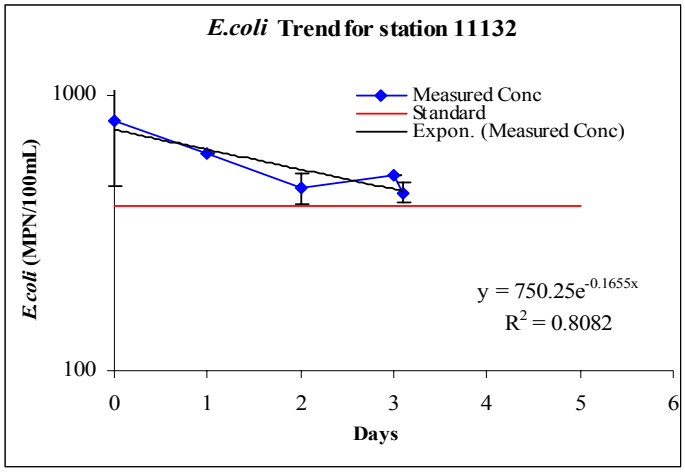

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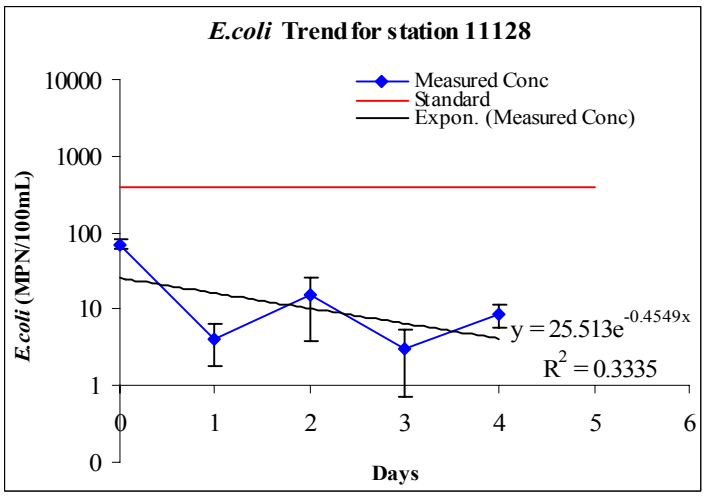

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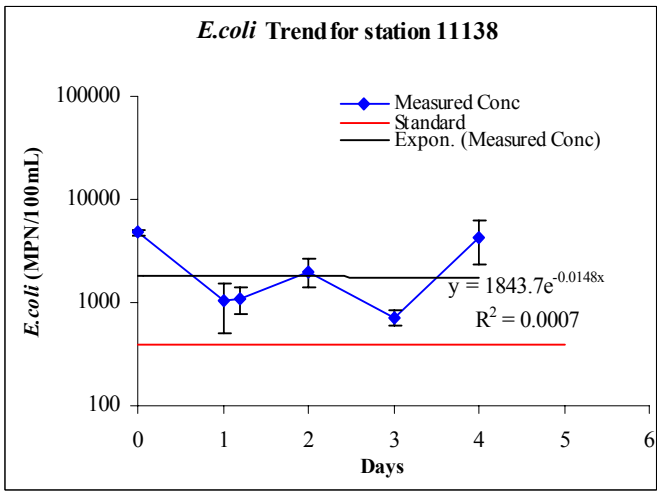

(d)

Fig.3.6 Indicator Concentration Trends During May 06 Sampling

CHAPTER 4

SUMMARY AND FUTURE ACTIVITIES

4.1 SUMMARY

During the third quarter of this TMDL project, the historical data were used for developing load duration curves for select stations in the Metro area. The analysis yielded mixed results indicating that both point and non-point sources as potential causes of the observed impairments. Sampling was initiated and conducted at the 21 locations proposed in the QAPP for this project.

4.2 PLANNED ACTIVITIES FOR THE FOURTH QUARTER OF THE PROJECT TIME FRAME

During the period June 1 to August 31, 2006, the project team will be focusing on the following activities (numbered as they appear in the Work Plans for WO# 582-6-70860-04 and 07):

Subtask 3.4.2/WO4 - Prepare an inventory of major sources and fate and transport of *E. coli* and fecal contamination in the target waterbodies based on historical data.

Subtask 4.1/WO7 - Conduct sample collecting in accordance with the approved QAPP.

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