

**BACTERIOLOGICAL ASSESSMENT
OF THE
LOWER SAN ANTONIO RIVER
SEGMENT 1901**

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EXECUTIVE SUMMARY

The lower portion of the San Antonio River (Segment 1901) encompasses the area from the confluence with the Guadalupe River in Refugio and Victoria Counties to a point approximately 600 meters downstream of FM 791 near Falls City, Texas in Karnes County. Fecal coliform bacteria have been found to occasionally exceed the stream standards for contact recreation in Segment 1901. The segment has been placed on the Texas 2002 Clean Water Act Section 303(d) list of impaired waters due to these exceedances.

Large volumes of water are discharged from the wastewater treatment plants in the City of San Antonio, which is located upstream of the study reach in Segment 1911. Because of the large volume, and because of poor quality effluent discharged by the City in the past, it has been assumed by many that the source of the current bacterial problem in Segment 1901 is primarily the City of San Antonio. However, limited water quality data has shown that the sites immediately below the City have generally been in compliance with the contact recreation standard. Since the completion of the new Dos Rios wastewater treatment plant and the major renovations of several other large treatment facilities in the late 1980's, all permitted point sources are meeting their discharge permit requirements. Previous monitoring data (Texas Clean Rivers Program) from the reach of the San Antonio River below the Medina River confluence in Bexar County to FM 791 in Karnes County, indicate that on the occasions where bacteria levels were above the State stream standard they were associated with rainfall events, or nonpoint source in origin.

The two objectives of this study were to determine what areas of Segment 1901 are, or are not meeting the State stream standard for contact recreation and secondly, determine what might be the source(s) of the bacterial contamination in those areas where the stream standard is not met.

Thirteen sites on the lower portion of the San Antonio River were selected to bracket tributaries and municipalities that could possibly be contributors of bacterial pollutants to this segment. During the twelve month study, from May 2003 through April 2004, these thirteen sites on the lower San Antonio River were sampled five times per month for *Escherichia coli* (*E. coli*), fecal coliform and fecal streptococcus bacteria. Field parameters for dissolved oxygen, conductivity, pH, and temperature were measured at the same frequency. Once each month additional samples were collected for turbidity and total suspended solids analyses. This was an intensive monitoring effort that collected and analyzed hundreds of samples (Table 1).

Assessment of the *E. coli* data (the current bacterial indicator organism used in Texas to determine support of contact recreation in fresh water) revealed that most of Segment 1901 was not meeting the contact recreation criterion during the twelve months of the study. Of the thirteen sites in the study only three (FM 791, Old Runge Road (CR 326), and US 77) met both the criteria for the long term geometric average (twelve months) and the criteria for individual samples. Further examination of the data showed that during dry weather with low to average flows most of the sites met the standard for contact recreation. However, during rainfall events, and for several days after, bacterial concentrations were greatly increased and typically all sites were found to exceed the stream standard. This is the result of storm water flows washing across roof tops, streets, and soil picking up fecal matter from wild and domestic animals and depositing these pollutants into streams. An increase in

bacterial concentration during and after a storm water event would indicate that the principle source(s) of the bacterial pollutants are not point sources (such as the discharge from wastewater treatment plants) but are non-point sources.

The ratios of fecal coliform to fecal streptococcus bacteria were calculated to indicate the host origin of the bacterial pollutants. The resulting ratios indicated that the host origin for most of the bacteria was probably non-human. Only a small percentage (1.6%) of the ratios indicated a probable human source. These ratios, though not considered accurate for identifying the sources (geographic) of bacterial pollutants, are considered useful as general indicators of human vs. non-human origins. The fecal coliform to fecal streptococcus ratios at all sites, combined with the results showing low bacterial counts under dry weather conditions and high numbers during and after rain events, indicate that the source(s) contributing the highest percent of bacterial pollutants in Segment 1901 are nonpoint sources, most likely from wildlife and domestic animals.

The ranking of E. coli values show that the sites having the highest E. coli concentrations the greatest number of times are located in the area around Goliad, Texas. The sites having the lowest E. coli counts the greatest number of times are the most upstream sites. This ranking showed a general increase in concentration from upstream to downstream for all three bacteria assessed, which would suggest that the source(s) of these bacterial pollutants in Segment 1901 are from other than upstream point and nonpoint sources.

It was not possible to determine the sources of the bacterial pollutants in Segment 1901, however three reaches were identified where bacterial concentrations peaked. The area near Goliad, Texas had the highest concentrations for E. coli during the study period. However, to determine the source(s) of the bacteria will require additional intensive monitoring of this reach of the San Antonio River. The site immediately upstream of City of Goliad had the highest geometric mean values for fecal coliform bacteria. There are several tributaries to the San Antonio River in this reach which may be contributing bacterial pollutants. The three largest of these tributaries have been added as monitoring sites under the Texas Clean Rivers Program as a result of this study. The two remaining reaches where both E. coli and fecal coliform concentrations peaked were in the area of SH 72 and FM 81. These two sites have been added to the San Antonio River Authority's stream monitoring program, and are currently being monitored monthly for E.coli and fecal coliform. At this time no intensive monitoring efforts have been planned to try to identify the sources of the bacterial pollutants identified in this study.

It is hoped that within the next few years genetic source tracking will be available to help identify the origin(s) of the fecal bacteria in the San Antonio River. The work to catalog the different species is presently being done by Texas A&M University at El Paso as part of a Total Maximum Daily Load (TMDL) project for bacteria currently being done on Segment 1901. When this tool is available it should be possible to differentiate not only human from non-human sources, but identify wildlife vs. domestic livestock sources and even identify components such as cattle, goats, poultry etc. When ready, this technology should be part of an intensive monitoring effort in Segment 1901. Such an effort could produce the data needed to develop Best Management Practices to reduce bacterial loading in the reaches identified by this study.

INTRODUCTION

Citizens in the lower portion of the San Antonio River Watershed have expressed concerns about bacteria levels in the San Antonio River and asked that the San Antonio River Authority address their concerns. Many felt that the City of San Antonio was the principle source of the bacterial concerns on the lower San Antonio River (Segment 1901). However, since water quality data showed that the stream standard for contact recreation was generally being met at sites on the San Antonio River from I-37 in Bexar County to FM 791 in Karnes County, it was likely that the concerns identified in the lower portion of the River had other sources. Therefore, this study was designed to concentrate its limited resources on Segment 1901.

Segment 1901 encompasses the area from the confluence with the Guadalupe River in Refugio and Victoria Counties to a point approximately 600 meters downstream of the FM 791 bridge near Falls City, Texas in Karnes County. Limited fecal coliform bacteria data has identified several areas where the State stream standard for contact recreation has occasionally not been met in this segment, and the segment has been placed on the Texas 2002 Clean Water Act Section 303(d) List of impaired water bodies.

This study was designed to collect and analyze surface water samples from the lower San Antonio River in order to identify reaches that may, or may not, be meeting the State stream standard for contact recreation, and attempt to identify the source(s) of bacterial contamination.

METHODS AND MATERIALS

Field personnel from the Environmental Services Department of the San Antonio River Authority collected all samples used in the analysis of fecal coliform, E. coli, fecal streptococcus, turbidity, and total suspended solids. Standard field parameters (dissolved oxygen, temperature, conductivity and pH) were recorded by the field personnel at the time of sample collection. Bacterial samples and field parameters were collected five times per month for twelve months, while turbidity and total suspended solids were sampled once per month. At this sampling rate 780 bacterial samples and field parameters would be collected if no problems were encountered. A total of 156 turbidity and total dissolved solids were expected to be collected (Table 1).

Table 1: Quantity of Samples Collected

PARAMETER	GOAL	COLLECTED
E. coli	780	780
Fecal coliform	780	775
Fecal streptococcus	780	764
Turbidity	156	155
Total Dissolved Solids	156	156
Dissolved Oxygen	780	773
Temperature	780	786
Conductivity	780	786
pH	780	786

Samples were collected from bridges using a 1-gallon polyethylene bucket fastened to the end of a rope. The bucket was lowered, filled with water from the site, and rinsed with the ambient water. After rinsing twice, the bucket was lowered to a depth of approximately four inches below the water surface where the sample was taken. The grab sample was hoisted to the bridge where it was transferred to polyethylene plastic bags and ice preserved for bacterial analyses. A 1-gallon polyethylene cubitainer was filled and ice preserved for turbidity and total suspended solids analyses.

Samples were generally returned to the SARA laboratory within six hours of collection. Fecal coliform and fecal streptococcus samples were set up within 8 hours from the time of collection utilizing Standard Methods, 20th Edition, methods 9222-D and 9230-C respectively. *Escherichia coli* counts were determined using Standard Methods, 20th Edition 9222-G. Turbidity was determined within forty-eight hours of collection by EPA method 180.1. Total Suspended Solids analysis was done within seven days using EPA method 160.2.

RESULTS AND OBSERVATIONS

Contact recreation standards were developed to protect the public from bacteria, viruses, and other disease causing organisms that could be harmful to people using surface water for swimming or other activities that involve direct contact with water. The current organism used to estimate the relative risk for contact recreation is the bacteria *E. coli*. The presence of *E. coli* in a water body indicates pollution from human and animal feces. The contact recreation standard is not met if the geometric mean value for *E. coli* is greater than 126 colonies/100 ml of the sampled water, or if the individual samples exceed 394 colonies/100 ml for more than 25% of the samples.

The geometric mean (*E. coli*) for all twelve months of the sampling period was computed and only four sites (FM 791, Old Runge Road – CR 326, SH 239, and US 77) were found to meet the contact recreation standard based on this criterion. These sites had geometric mean values of 126 colonies/100 mL or less. However, the site at SH 239 exceeded the criteria for individual samples (394 colonies/100mL) greater than 25 percent of the time and therefore did not meet the stream standard.

The correlation between *E. coli*, fecal coliform, and fecal streptococcus geometric means were fairly consistent for each month and for all months combined (Figure 1, 2, and 3). The reaches with the two highest peaks for all three bacteria were in the Goliad, Texas area and the area around SH 72 between the Cities of Kenedy and Runge, Texas.

Figure 1: Twelve Month Geometric Mean and Stream Standard for E. coli

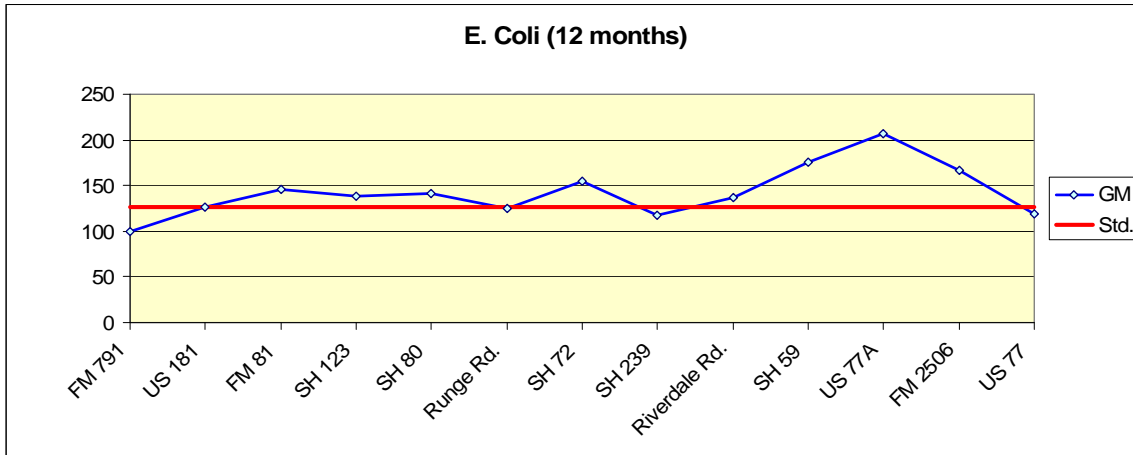


Figure 2: Twelve Month Geometric Mean and Stream Standard for Fecal Coliform

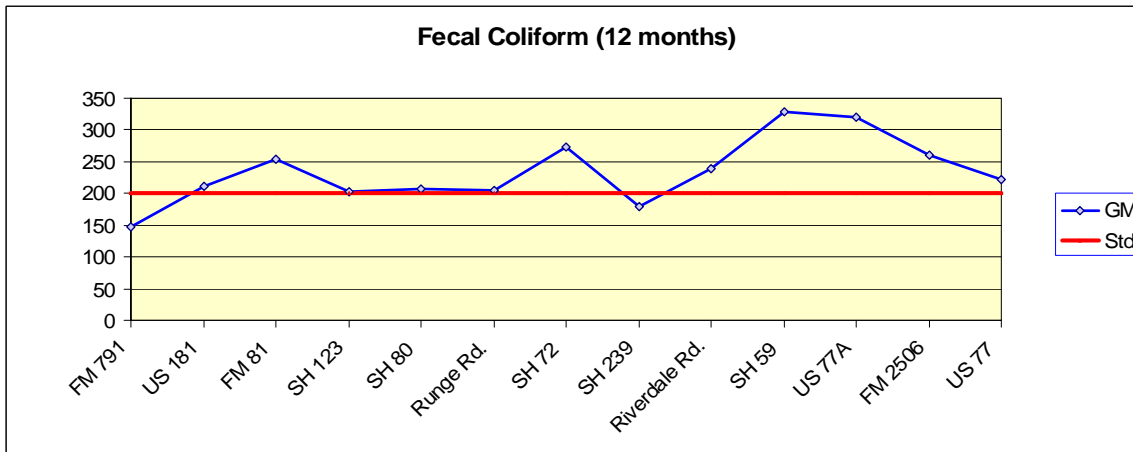
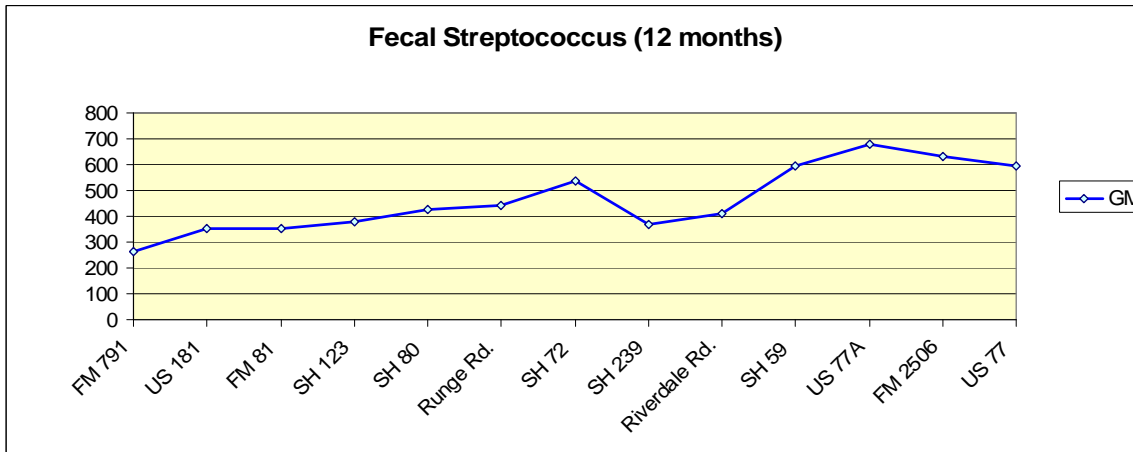


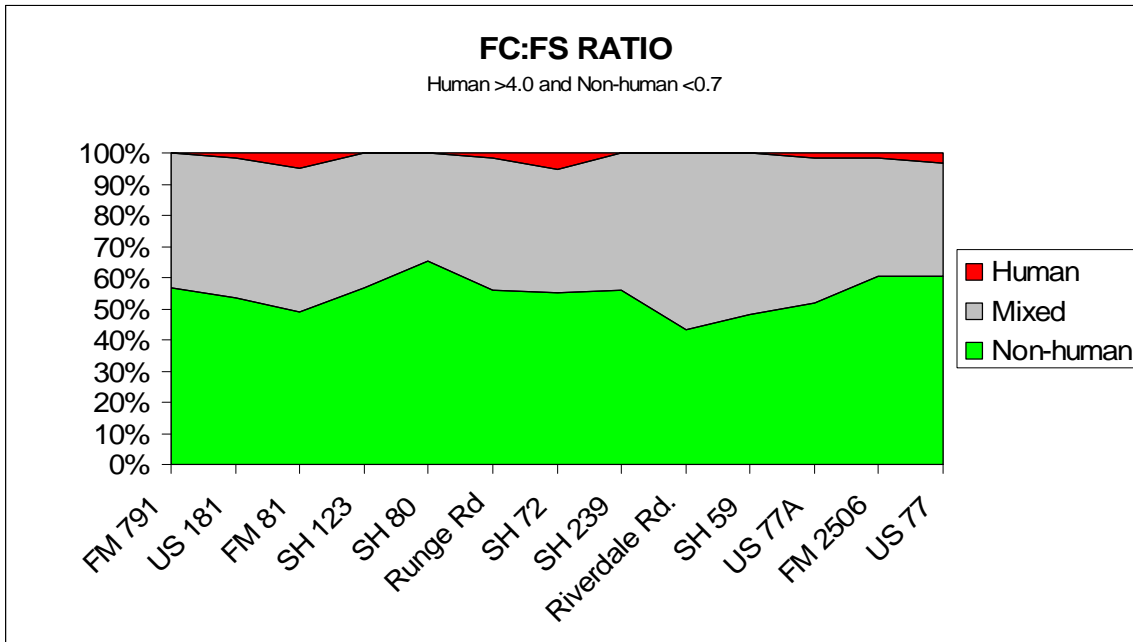
Figure 3: Twelve Month Geometric Mean for Fecal Streptococcus



The ratio of fecal coliform to fecal streptococcus bacteria was calculated to try and obtain some indication of the host origin of the bacteria. A ratio of 0.7 or less would indicate the origin as being non-human, and a ratio of 4.0 and higher would indicate a human origin. More than fifty-four percent of the ratios were below 0.7 indicating a non-human source.

Only 1.6 percent of the ratios were above 4.0 which indicate a human source. The remaining ratios indicate a mixed origin (Figure 4).

Figure 4: Percentage of Fecal Coliform / Fecal Streptococcus Ratios (12 months)



E. coli values were ranked to see if some sites were consistently producing higher values. For each sampling event the stations were ranked from one to thirteen, with the 1st rank representing the highest E. coli value in a sampling run and 13th representing the lowest value. During the ranking process there were times when one or more sites had the same E. coli value. In these cases the rank was shared (for example a sample run could have more than one site ranking 5th). The number of times a site received a certain ranking was totaled, and the highest number for each ranking was highlighted (Table 2). The group of sites which consistently had higher E. coli levels, relative to the other sites, were those located in the Goliad, Texas area (as indicated by the red box in Table 2).

Table 2: Ranking of E.coli (rank 1 has the highest frequency and rank 13 has lowest)

Rank	FM 791	US 181	FM 81	SH 123	SH 80	Runge Road	SH 72	SH 239	Riverdale Road	SH 59	US 77A	FM 2506	US 77
1 st	1	4	3	7	3	3	3	3	8	6	9	9	6
2 nd	1	3	6	3	4	3	5	3	2	7	13	9	5
3 rd	4	2	9	5	8	7	6	3	5	9	2	8	2
4 th	5	6	2	2	5	0	6	5	7	5	10	6	2
5 th	2	8	6	6	6	8	9	3	3	6	5	5	6
6 th	3	3	6	4	6	10	7	6	4	5	9	2	6
7 th	4	6	8	2	7	8	10	3	4	6	0	6	5
8 th	7	11	5	8	11	7	6	4	5	4	3	3	1
9 th	5	6	3	6	3	9	3	7	6	3	1	4	7
10 th	8	5	5	5	2	0	1	5	5	3	4	3	6
11 th	5	3	5	7	2	4	0	3	3	3	1	3	6
12 th	10	1	0	2	1	0	2	5	4	0	0	0	5
13 th	2	0	0	1	1	1	0	3	0	0	0	1	1

Bacterial concentrations were seen to increase during rainfall events and for a period of time after the events. Listed in Table 3 are some examples of high flow events with elevated E. coli concentrations and the associated “low” flow values just prior to the rain events. However, increases in bacterial concentration could not be associated with the amount and duration of precipitation due to a lack of recording rain gages. A comparison of E. coli concentration to flow (log transformed) from all sampling events at the two sites associated with USGA flow gages, show that bacterial levels typically rise with flows (Figure 5 and 6). This relationship was observed at all sites. An increase of bacterial pollutants associated with storm water is a common occurrence, not only in the lower San Antonio River, but in a large number of Texas watersheds. The Environmental Protection Agency (EPA) has stated that storm water runoff, can carry high levels of pollutants, including pathogens, and “is a major cause of water quality impairment” (EPA, 2003 Storm Water Compliance and Water Quality Impairment).

Table 3: E.coli Concentrations/Rain Events and Flow (at sites with USGS flow gages)

SITE	DATE	E. COLI COUNT	FLOW	DATE	E. COLI COUNT	FLOW
		RAIN EVENT GREATER THAN 7 DAYS PRIOR TO SAMPLING			RAIN EVENT LESS THAN 3 DAYS PRIOR TO SAMPLING	
Site 1 (12879)	6/26/2003	66	379	7/10/2003	4,000	1,550
Site 11 (12791)	6/25/2003	97	508	7/9/2003	1,000	2,180
Site 1 (12879)	8/28/2003	28	310	9/4/2003	800	454
Site 11 (12791)	8/27/2003	100	349	9/3/2003	186	481
Site 1 (12879)	11/13/2003	77	335	11/20/2003	115	407
Site 11 (12791)	11/12/2003	140	499	11/19/2003	767	584

Note: Site 1 – FM 791
Site 11 – US 77A

Figure 5: Log Transformed E. coli Concentrations and Flows at FM 791 (12879)

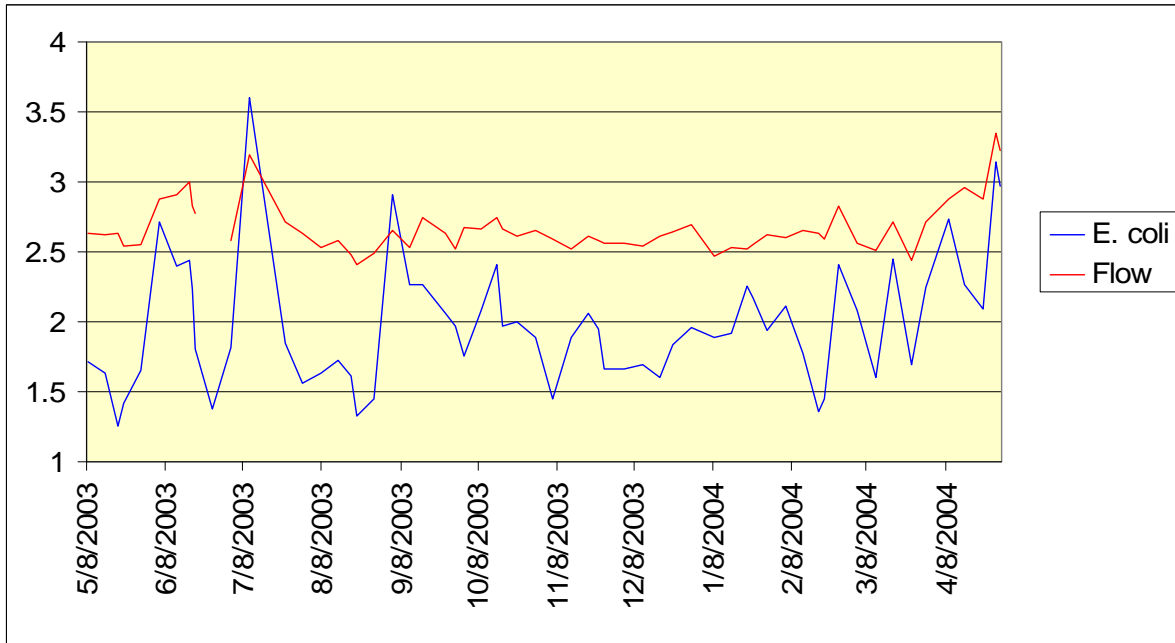
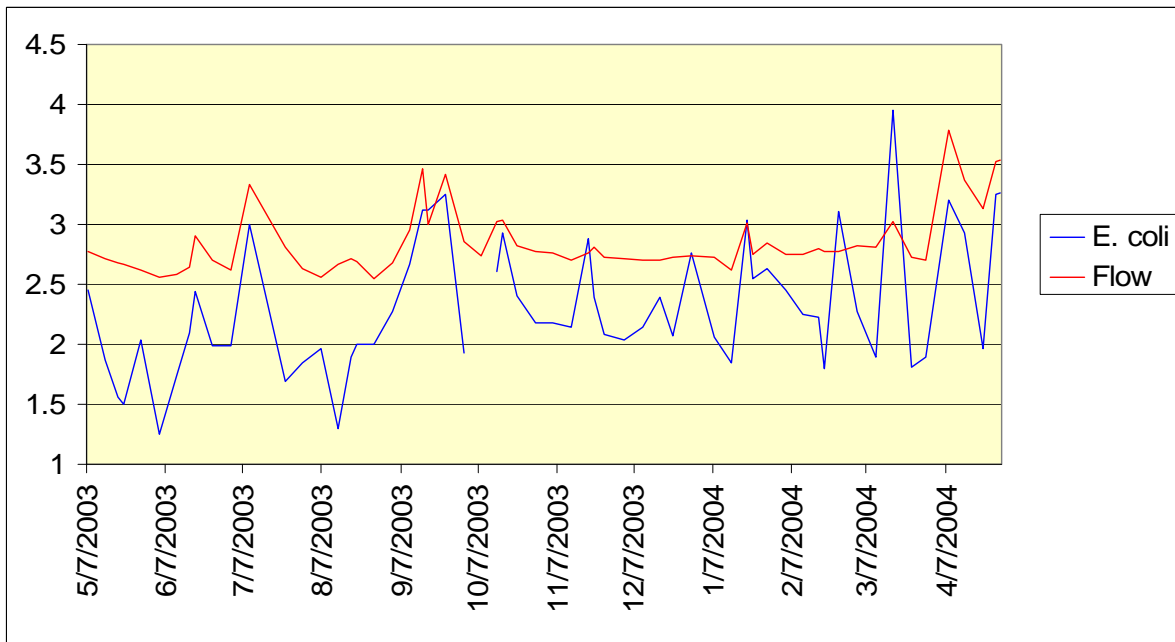


Figure 6: Log Transformed E. coli Concentrations and Flows at US 77-A (12791)



DISCUSSION

Of the thirteen sites examined in this study only three sites (FM 791, Old Runge Road, and US 77) meet the contact recreation standards when looking at all twelve months of data. Analysis did indicate that the State stream standard for contact recreation was generally being met at all sites when there had not been a rainfall event in the previous 2 to 5 days (depending on such factors as rain intensity and duration). However, any rainfall event sufficient to produce an increase in stream flow typically produced bacterial counts in excess of the stream standard. In months where only one rain event occurred most sites were found

to meet the stream standard based on the geometric mean of five samples. When two or more rain events occurred per month most sites were found to exceed the standard based on a five sample mean. The months of May and August 2003 were the only two months where the contact recreation standard was met at all sites. In May there were no rain events and August produced just one minor rain event that only minimally increased stream flow.

To try and identify the origin of the bacterial pollution, a fecal coliform / fecal streptococcus ratio (FC:FS) was calculated. This ratio is not considered to be a very reliable method for source tracking, however it can be useful as a general indicator of human versus non-human fecal bacteria contamination. The results of the FC:FS ratio indicated that greater than fifty-four percent of the bacteria was from a non-human source while approximately forty-four percent was of mixed origin and only 1.6 percent was from a human source. This would indicate a non-point source of bacterial contamination, which relates well with the data showing bacterial concentrations generally low in dry weather and under low to average flows, and high bacterial concentrations during and after rainfall events.

A ranking of *E. coli* concentrations was performed to see if any particular sites were producing high counts at a greater frequency than the other sites. The results of the ranking showed that the site at US 77A, just downstream of Goliad, Texas was producing higher counts more frequently than the other sites. This ranking also showed that the FM 791 site had the lowest frequency of high *E. coli* counts. In general the ranking showed that the sites having higher frequencies of elevated *E. coli* counts increased from upstream to downstream in the study area.

Bacteria (*E. coli*, fecal coliform, and fecal streptococcus) concentrations generally showed an increase from upstream to downstream. The peak concentrations of *E. coli* occurred at the US 77A site. Two smaller peaks were often observed at the SH 72 and FM 81 sites.

In this study turbidity and total suspended solids were sampled once each month. While there was a good correlation between these two parameters there does not appear to be a good relationship between either of these parameters and bacterial concentration. No relationship was found between any of the field parameters (conductivity, pH, dissolved oxygen, and temperature) and bacterial concentration.

SUMMARY

The objective of this study was to collect bacteriological data needed to make two determinations. First, what areas of the lower San Antonio River (Segment 1901) are or are not currently meeting the State stream standard for contact recreation and secondly, what might be the source(s) of the bacterial contamination in those areas where the stream standard was not met.

It is clear that during this twelve month study the majority of Segment 1901 was not meeting the contact recreation criteria. It is also clear that when looking at bacterial concentrations and rainfall events, the majority of the bacterial pollutants are from non-point sources.

Bacterial concentrations above and below the City of Goliad, Texas indicate that the area may be one of the significant contributors of coliform bacteria to the lower San Antonio

River. However, to determine the source(s) of these bacteria would require additional intensive monitoring beyond the scope of this study.

Geometric mean values for fecal coliform bacteria peaked at the site (US 59) upstream of the City of Goliad. In this area there are several small tributaries to the San Antonio River that may be contributing. As a result of this study, the three largest of these tributaries have been added to the monitoring sites under the Texas Clean Rivers Program to assess their bacterial loads as a possible source.

Two other areas (near SH 72 and FM 81) which showed geometric mean peak values for both *E. coli* and fecal coliform, that were the second and third highest for this study, are being monitored monthly under the San Antonio River Authority's stream monitoring program, in part due to data developed by this investigation.

A TMDL project is currently underway in Segment 1901 and the data generated from this bacteriological study will be used as a calibration component in the water quality model developed in that (TMDL) undertaking. This survey, in conjunction with the TMDL effort, will give us a better understanding of bacterial loading in the lower San Antonio River.

APPENDIX

MAPS OF STUDY AREA

