NUECES RIVER AUTHORITY

UPPER FRIO RIVER STUDY

FINAL

January 1998

Prepared in Cooperation with the Texas Natural Resource Conservation Commission under authorization of the Clean Rivers Act.

THE TEXAS CLEAN RIVERS PROGRAM

ALAN PLUMMER ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERS • DESIGNERS • SCIENTISTS

TABLE OF CONTENTS

APPENDICES

The appendices are not available online.

For a complete report contact:

Chris Pasch
Alan Plummer Associates, Inc.
6300 La Calam Suite 400
Austin, Texas 78752-3825
Ph: (512)452-5905 Fax: (512)452-2325
E-mail: chris@apaienv.com

LIST OF ABBREVIATIONS

CRP	Clean Rivers Program
DO	dissolved oxygen
MAL	Minimum Analytical Limit
mg/L	milligrams per liter
ml	milliliter
NRA	Nueces River Authority
NTU	nephelometer turbidity units
OP	ortho phosphorus
RBA	Rapid Biological Assessment
TKN	Total Kjehldal Nitrogen
TP	total phosphorus
TSS	total suspended solids
TSWQS	Texas Surface Water Quality Standards
US	United States
USGS	U.S. Geological Survey
VSS	volatile suspended solids

INTRODUCTION

The Upper Frio River has been used extensively for recreation for many years. The intensive usage is expected to continue in the future. The objective of this study was to evaluate the impact of recreational use and land development in the Upper Frio River on the water quality and the aquatic biological community. Impacts were evaluated through the collection and interpretation of information on land uses and historic utilization, and by conducting biological assessments, toxicity testing, and water quality analyses. This study was conducted under a work plan developed as part of the Nueces River Authority's (NRA) participation in the Texas Clean Rivers Program (CRP). The results of the study indicate that recreational uses and the current level of development in the watershed may have a minimal impact on both water quality and the benthic macroinvertebrate community. However, the results may have been affected by the above average flow conditions during the study period.

Location

The 1995 Texas Surface Water Quality Standards (TSWQS) define the geographic extent of the Upper Frio River (Segment 2113) as the reach from a point 100 meters upstream of United States Highway (US) 90 in Uvalde County to the confluence of the West Frio River and the East Frio River in Real County. The extensive recreational use of the Upper Frio River, especially tubing, occurs almost exclusively upstream of Concan, Texas. This study was limited to a reach from about one mile downstream of Concan to the confluence of the West Frio River and the East Frio River as shown in Figure 1 in the complete report. Unless specified otherwise, the reference to the Upper Frio River in this document will refer to the reach above Concan, Texas. The reference to Segment 2113 will refer to the

reach as defined in the TSWQS.

Site-Specific Uses and Criteria

The site-specific uses and criteria for Segment 2113, as identified in the TSWQS, are as follows:

Uses:

- Contact recreation
- Exceptional aquatic life use
- Domestic water supply and aquifer protection

Criteria:

Parameter	Limit	Explanation
Chloride	25 mg/L	annual average
Sulfate	30 mg/L	annual average
Total Dissolved Solids	300 mg/L	annual average
Dissolved Oxygen	6.0 mg/L	minimum 24-hour mean
pH range	6.5 - 9.0	minimum and maximum at any site in the segment
Fecal Coliform	200/100 ml	geometric mean of five samples or more collected over less than 30 days
Temperature	90º(Fahrenheit)	maximum at any site in the segment

---

Historic and Existing Land Uses

Figure 1 (in the complete study) is a map of the Frio River Study area showing current land use coverages. The study watershed area is 395 square miles. Aerial photographs made in January 1995 were used to establish the land use coverages. The study watershed is primarily forest and rangeland with some agricultural activities, mainly orchards and nurseries, and very limited urban land development primarily related to tourist and camping accommodations. Three small mining sites were identified in the watershed. Most development is adjacent to the river from the town of Leakey south to Garner State Park. Leakey is the largest settlement in the watershed with an estimated population of 400. As an indication of the overall watershed population density, about 70 percent of the watershed area is in Real County which has an estimated population of 2,500 over an area of 697 square miles.

Historical Recreational Utilization

Figure 2 (in the complete study) presents Garner State Park monthly visitation data for January through July 1997. Sampling activities for this study were conducted in April, May, June, and July. Usage in June and July was about 2.5 times greater than in April and May. Figure 2 also presents yearly visitation data for the period 1977-1995. The variation in visitation from 1977-1981 was related to a change in camping policy from "camp anywhere" to "campground only". Beginning in 1982, new campgrounds have been opened, and visitation has increased at an average rate of approximately 3.3 percent annually. Visitation in 1997 exceeded 600,000 through July, which is higher than any previous annual total.

(The tables below are included in place of Figure 2):

1997 Monthy Attendance	
Month	**Number of People**
January	23,492
February	25,883
March	125,883
April	62,111
May	59,643
June	129,854
July	173,364

Year

Annual Visitation	
Number of People	
1977	375,349
1978	275,221
1979	215,379
1980	274,037
1981	300,000
1982	356,565
1983	356,330
1984	304,365
1985	321,577
1986	361,208
1987	345,983
1988	363,383
1989	378,769
1990	382,214
1991	412,532
1992	412,710
1993	414,189
1994	463,577
1995	455,143

Population

Over the period 1960 to 1990, Real County population increased from 2,079 to 2,412. This is a very low annual growth rate of 0.5 percent. The Texas Water Development Board population projections for the period 2000 to 2030 are 422 to 576 (1 percent annual growth) for the town of Leakey and 2,534 to 2,706 (0.2 percent annual growth) for Real County. Census data does not provide information about the increasing number of non-residents that own property and visit the area regularly.

SAMPLING PLAN

As specified in the project work plan, four monitoring stations were established at the locations indicated on Figure 3 (in the complete study). These sites were selected based on the following criteria:

Station 1	East Frio at the Burchfield residence	Reference station above the primary recreational use/developed area
Station 2	FM 1120	Mid-point of the primary recreational use/developed area
Station 3	Mager's Crossing below Garner State Park	End of the primary recreational use/developed area
Station 4	Big Tree Ranch below Concan	Below primary recreational use/developed area

The sites were located to provide information about background conditions, conditions at the most extensively used section of the river, and conditions downstream of the extensive use area.

Water quality samples were collected four times in the spring and summer of 1997, in order to characterize impacts during the moderate and high visitation periods of the year (Thursday, April 24, Wednesday-Thursday, May 14-15, Monday, June 16 and Saturday-Sunday, July 5-6). In addition, benthic organisms and samples for toxicity testing were collected during the sample events in May and July.

Conditions During Sample Collections

The flow of the U.S. Geological Survey (USGS) gage at Concan (Station 1) over the period of the study, as shown on Figure 4 (in the complete study)was above long-term averages but within the range observed in the previous ten years. The June sampling event was interrupted by a heavy storm that prevented sample collection at the reference station. All other sampling events were not directly influenced by weather conditions.

(The tables below are included in place of Figure 4):

Day	Average Daily Flow (cfs)				
	April	May	June	July	August
1		190	134	594	189
2		184	133	553	186
3		175	130	528	180
4		170	127	497	174
5		165	126	472	166
6		162	123	445	164
7		162	122	423	162
8		159	139	408	176
9		163	180	393	164
10		158	172	379	156
11		152	196	362	153
12		150	211	345	148
13		166	181	326	144
14		157	164	316	137
15	284	152	236	303	133
16	274	150	1090	290	
17	264	142	775	281	
18	256	132	397	273	
19	256	129	312	263	
20	245	135	281	257	
21	237	134	307	255	
22	228	132	22600	264	
23	221	137	3070	246	
24	216	146	1630	236	
25	219	159	1260	226	
26	237	146	1020	218	
27	230	137	831	211	
28	218	149	747	203	
29	206	146	687	197	
30	197	145	640	193	
31		139		190	

Year	Average Monthly Flow (cfs)				
	March	April	May	June	July
1987	219	175	559	1765	523
1988	81	71	70	227	394
1989	82	72	54	39	25
1990	92	121	296	82	256
1991	69	65	67	57	94
1992	762	499	381	602	256
1993	107	108	101	74	50
1994	149	95	284	126	183
1995	106	99	81	111	89
1996	55	47	38	36	22
1997	157	320	152	1237	349

RAPID BIOASSESSMENTS

To understand the effects of human activities on water resources, biological assessments provide an important supplement to chemical sampling. Biological assessments can reflect current conditions as well as long-term changes in waterways, including the cumulative effects of successive disturbances.

Biological assessments are quantified using numeric values based on metrics such as community structure, taxa richness, variety, dominance, and relative abundance. Metrics are used to describe biological integrity compared to a reference site. The Rapid Biological Assessment (RBA) protocol applied in this study used macroinvertebrate benthic organisms. Macroinvertebrates are visually distinguishable crustaceans, molluscs, insects, and other fairly large aquatic invertebrates that inhabit the stream bed. The benthic community is continually exposed to any changes in water quality; therefore, the composition of the community is a very good indicator of overall water quality.

Benthic macroinvertebrate samples were collected May 15 and July 4 in conjunction with water quality sampling field activities. RBA Protocol II macroinvertebrate metric determinations were calculated using Station 1 as the reference station for the three downstream stations. The metric values were used to assign biological condition categories to each downstream sampling station. The stations were characterized as "non-impaired," "moderately impaired," or "severely impaired" as compared to the reference station. The results are presented in Tables 1 and 2.

Table 1
Rapid Bioassessment Summary for the May 15-16, 1997 Benthic Macroinvertebrate Samples

Metric	Calculated Value (Biological Condition Score)		
	Station 2 FM 1120	**Station 3 Mager's Crossing**	**Station 4 Big Tree Ranch**
Number of Taxa(1)	63% (3)	84% (6)	84% (6)
Family Biotic Index(2)	86% (6)	88% (6)	86% (6)
Scrapers/Filterer + Scraper) Abundances(1)	No Value (0)	No Value (0)	No Value (0)
EPT/(Chronomid + EPT) Abundances (1)	91% (6)	102% (6)	101% (6)
Percent Contribution of Dominant Taxa(3)	46% (3)	33% (3)	48% (3)
EPT Index(1)	67% (0)	133% (6)	117% (6)
Community Loss Index	0.8 (3)	0.4 (6)	0.4 (6)
Biological Condition Point Total	21	33	33
Percent Comparison to Reference Score (4)	50%	78%	78%
Biological Condition Category	Moderately Impaired	Moderately to Non-Impaired	Moderately to Non-Impaired

(1) Ratio of the study site to the reference site (Station 1 - East Frio River at Burchfield residence) expressed as a percentage.

(2) Ratio of the reference site to the study site expressed as a percentage.

(3) Scoring criteria evaluates actual percent contribution, not % comparison to reference.

(4) Interpretation of comparison to reference score.

> 79% Non-impaired

29-72% Moderately Impaired

< 21% Severely Impaired

Table 2
Rapid Bioassessment Summary for the July 4-5, 1997 Benthic Macroinvertebrate Samples

Metric	Calculated Value (Biological Condition Score)		
	Station 2 FM 1120	Station 3 Mager's Crossing	Station 4 Big Tree Ranch
Number of Taxa(1)	88% (6)	82% (6)	94% (6)
Family Biotic Index(2)	99% (6)	100% (6)	111% (6)
Scrapers/Filterer + Scraper) Abundances(1)	28% (3)	0% (0)	0% (0)
EPT/(Chronomid + EPT) Abundances (1)	96% (6)	98% (6)	95% (6)
Percent Contribution of Dominant Taxa(3)	20% (6)	28% (6)	28% (6)
EPT Index(1)	88% (3)	88% (3)	63% (0)
Community Loss Index	0.4 (6)	0.4 (6)	0.3 (6)
Biological Condition Point Total	36	33	30
Percent Comparison to Reference Score (4)	92%	85%	77%
Biological Condition Category	Non-impaired	Non-Impaired	Moderately to Non-Impaired

(1) Ratio of the study site to the reference site (Station 1 - East Frio River at Burchfield residence) expressed as a percentage.

(2) Ratio of the reference site to the study site expressed as a percentage.

(3) Scoring criteria evaluates actual percent contribution, not % comparison to reference.

(4) Interpretation of comparison to reference score.

> 79% Non-impaired

29-72% Moderately Impaired

< 21% Severely Impaired

The results of the two sampling events differed slightly. Compared to the reference station, the three downstream stations showed more impairment in the May sampling than in the July sampling. The most significant impairment was the moderate impairment at Station 2 in May; the station had no impairment in the July sample. Station 4 retained its moderate to non-impaired level for both sampling events. Station 4 had a slight change from not impaired in May to borderline moderately-impaired in July.

The habitat was also evaluated as part of the rapid bioassessment protocol. Habitat classification categories are "optimal," "sub-optimal," "marginal," and "poor" dependent on the physical characteristics of the stream, hydrologic conditions, and riparian vegetation. The four sample locations scored closely between 180 and 188. The scores indicate that the habitats are at the lower end of an "optimal" habitat. The habitat evaluation field data, the macroinvertebrate data, and metric determinations are compiled in Appendix A in the complete report.

WATER QUALITY ANALYSIS AND DATA EVALUATION

Four sampling events were conducted to characterize conditions during spring and summer conditions. Grab samples were collected and analyzed for the following characterization parameters:

- Total Phosphorus
- Ammonia
- Nitrate
- Total Suspended Solids (TSS)
- ortho-Phosphate
- Total Kjehldal Nitrogen (TKN)
- Nitrite
- Volatile Suspended Solids (VSS)

- Turbidity
- Dissolved Oxygen (DO)
- pH
- Ambient Toxicity (Ceriodaphnia dubia).

The results of the sampling and analytical characterization activities are presented graphically in Figures 5, 6, 7, 8, 9, and 10 in the complete report. The laboratory analysis data are summarized in Appendix B in the complete report.

(The tables below are included in place of Figures 5-10):

Total Suspended Solids (TSS) & Volatile Suspended Solids(VSS) (Figure 5)

Date	Station 1		Station 2		Station 3		Station 4	
	TSS(mg/L)	VSS(mg/L)	TSS(mg/L)	VSS(mg/L)	TSS(mg/L)	VSS(mg/L)	TSS(mg/L)	VSS(mg/L)
April 24, 1997	1	2.4	1	2.2	1	2.4	1	2.4
May 14, 1997	1	1			1	1	2.6	1
June 16, 1997	Lost	Lost	1.4	1	1.2	1	1.8	1
July 6, 1997	1	1	1.2	1	1	1	1.4	1

Turbidity & Dissolved Oxygen (Figure 6)

Date	Station 1		Station 2		Station 3		Station 4	
	Turbidity (NTUs)	DO(mg/L)	Turbidity (NTUs)	DO(mg/L)	Turbidity (NTUs)	DO(mg/L)	Turbidity (NTUs)	DO(mg/L)
April 24, 1997	0.61	5.1	0.63	8.8	0.38	5.1	0.79	8.5
May 14, 1997	0.64	8.6		8.1	0.5	4.8	0.8	6.4
June 16, 1997	Lost	Lost	0.92	7.6	0.52	3.8	1.31	6.6
July 4, 1997						4.8		6.3
July 5, 1997		8.3		8				
July 6, 1997	1.59	7.8	1.26	7.6	0.99	4.7	1.62	6.7

Total Phosphorus (TP) & Ortho-Phosphate (O-P) (Figure 7)

Date	Station 1		Station 2		Station 3		Station 4	
	TP(mg/L)	O-P(mg/L)	TP(mg/L)	O-P(mg/L)	TP(mg/L)	O-P(mg/L)	TP(mg/L)	O-P(mg/L)
April 24, 1997	0.01	0.03	0.02	0.03	0.02	0.03	0.01	0.03
May 14, 1997	0.01	0.03			0.01	0.03	0.01	0.03
June 16, 1997	Lost	Lost	0.01	0.06	0.01	0.07	0.01	0.06
July 6, 1997	0.01	0.05	0.01	0.07	0.01	0.06	0.01	0.06

Conductivity and pH (Figure 8)

Date	Station 1		Station 2		Station 3		Station 4	
	Conductivity (uOHMS)	pH(SU)	Conductivity (uOHMS)	pH(SU)	Conductivity (uOHMS)	pH(SU)	Conductivity (uOHMS)	pH(SU)
April 24, 1997	330	8.9	390	8.06	380	7.69	410	8.26
May 14, 1997	350	8.22	410	7.98	410	7.55	420	7.96
June 16, 1997	Lost	Lost	410	8.21	390	7.67	430	8.08
July 4, 1997					470	7.72	465	7.88
July 5, 1997	410	8.22	450	7.99				
July 6, 1997	400	8.18	450	7.99	460	7.58	460	7.9

Nitrate & Nitrite Nitrogen (Figure 9)								
Date	Station 1		Station 2		Station 3		Station 4	
	Nitrate(mg/L)	Nitrite Nitrogen (mg/L)	Nitrate(mg/L)	Nitrite Nitrogen (mg/L)	Nitrate(mg/L)	Nitrite Nitrogen (mg/L)	Nitrate(mg/L)	Nitrite Nitrogen (mg/L)
April 24, 1997	0.05	0.01	0.2	0.01	0.16	0.01	0.2	0.01
May 14, 1997	0.25	0.01			0.31	0.01	0.27	0.01
June 16, 1997	Lost	Lost	0.3	0.01	0.44	0.01	0.27	0.01
July 6, 1997	0.33	0.01	5.84	0.01	0.52	0.01	0.33	0.02

Ammonia & Total Kjeldahl Nitrogen (TKN) (Figure 10)								
Date	Station 1		Station 2		Station 3		Station 4	
	Ammonia(mg/L)	TKN(mg/L)	Ammonia(mg/L)	TKN(mg/L)	Ammonia(mg/L)	TKN(mg/L)	Ammonia(mg/L)	TKN(mg/L)
April 24, 1997	0.02	0.11	0.02	0.15	0.02	0.03	0.03	0.04
May 14, 1997	0.02	0.12			0.02	0.11	0.02	0.07
June 16, 1997	Lost	Lost	0.02	0.1	0.02	0.05	0.02	0.19
July 6, 1997	0.02	0.26	0.02	0.05	0.02	0.09	0.02	0.14

Water Quality Constituent Characterization

The water quality data indicate that water quality was very good at all locations with the exception of one elevated nitrate value [6 milligrams per liter (mg/L)] at Station 2 on July 6. This value is judged to not be representative since the other three nitrate values above and below the Station 2 location on that date were about 0.05 mg/L. Dissolved oxygen determinations exceeded the segment water quality standard of 6.0 mg/L except at Station 3 where values ranged from 3.8 to 5.2 mg/L. Additionally, with the exception of DO at Station 3 and the outlier nitrate value at Station 2, none of the values exceeded the Texas Clean Rivers Program screening criteria for identification of water quality concerns. Evaluation of the water quality data at the four monitoring stations indicates the following:

Overall, constituent parameter values did not vary significantly with respect to location on the river, level of river usage or with time over the four month duration of the sampling program with the following exceptions:

- Turbidity was slightly increased at all locations on the highest usage day July 6
- Ortho phosphorus was higher at all locations during the June 16 and July 6 summer determinations
- Volatile suspended solids were highest on April 24
- Dissolved oxygen was lower at Station 3 on all dates
- TKN exhibited temporal and locational variability but no trends were evident

There are some discrepancies in the suspended solids and phosphorus analytical data which can be attributed to the low concentrations that were near or below the minimum analytical limit (MAL). The MAL is an agreed upon number, and it is assumed that data reported below the MAL are less reliable and have more errors associated criteria values above the MAL. Volatile suspended solids exceeded total suspended solids for four of the sixteen determinations, but all VSS and TSS values were less than 2.6 mg/L, which is below the MAL of 4 mg/L. Ortho phosphorus (OP) exceeded total phosphorus (TP) for all fourteen determinations, which may be attributed to the low concentrations of both parameters.

Forty-eight-hour acute toxicity tests (Ceriodaphnia dubia) were conducted on samples collected at Station 1 (East Frio control

reference) and Station 3 (Garner State Park) on May 14 and July 6. All tests were negative, indicating no acute toxicity. Toxicity testing results are compiled in Appendix C in the complete report.

Data Summary and Analysis

Overall, the chemical and physical water quality of the study reach of the Upper Frio River was very good and was minimally impacted by recreational usage during the April-July study period. Turbidity was slightly increased during the peak usage of the July 4th weekend but remained low at about 1.5 nephelometer turbidity units (NTU).

Based on the biological assessments in May, Station 2 was moderately impaired while Station 3 and Station 4 were non-impaired. In July, all three lower stations were essentially non-impaired indicating minimum impact from recreational activities. As mentioned above, any impairment is relative to the reference station on the East Frio River.

At Station 3, dissolved oxygen values were consistently lower than at the other three locations during all four sampling events. This condition may indicate the presence of a continuous source of oxygen demand such as recreational use refuse or septic tank effluent seepage in the reach from Station 2 to Station 3. Sewage at Garner State Park is treated and disposed by land irrigation with no direct discharge to the river; therefore, park sewage is not a likely source of oxygen demand. No bacteria data were collected as part of this study; these could provide an indication of any septic tank effluent influences.

During the spring-summer 1997 visitation period, recreational use had little impact on river water quality. Summer visitation was approximately 2.5 times greater than spring visitation. The 1997 spring-early summer period, over which this study was conducted, was characterized by higher than average rainfall and river flow rates. Because of the higher than average flows, these conditions may not represent typical water quality conditions.

RECOMMENDATIONS

Sampling During Average Flow Conditions

During this study, flow in the Upper Frio River was higher than long-term averages and could have masked the magnitude of impacts. Repeated sampling during average or below average spring-summer flow conditions may reveal wider temporal and positional variation in water quality and biological impacts.

Dissolved Oxygen

Station 3, below Garner State Park should be investigated to determine the cause of low DO conditions. Monitoring of diurnal DO profile data should be collected with coliform data, nutrient data, and TDS.

Biological Assessments

For future biological assessment activities, it is recommended that the RBA Protocol III sampling protocol be applied in order to obtain a more representative community sample, including the snails, and higher taxonomic resolution by identification of the benthic macroinvertebrates to the lowest possible taxa level. Performing the RBA Protocol III and increasing the taxonomic resolution would allow for a more detailed evaluation of the community structure and impairment levels in this reach of the Frio River.

End of Report