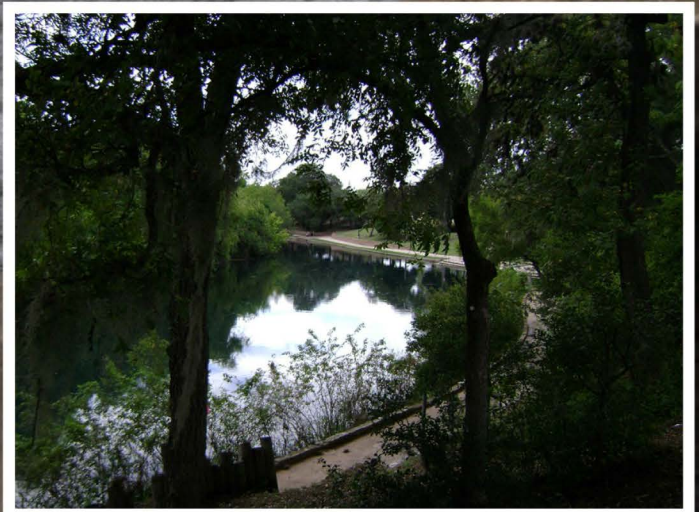


# Initial Study on the Recreational Impacts to Protected Species and Habitats in the Comal and San Marcos Springs Ecosystems

## Part 2







**10. What are the positive aspects of recreation on the river?**

- *Economic benefits: liquor sales, restaurants, employment, tourism*
- *Wellness, health, quality of life*

**11. What are the negative aspects of recreation on the river?**

- *Environmental degradation: pollution, litter, erosion*
- *Parking issues/ traffic congestion*
- *Water safety issues*
- *Crowding issues*

**12. How important are river-based recreational activities to the local economy?**

- *Hard to determine exactly*
- *Important but does not drive the economy*
  - a) **What are its contributions: i.e. sales tax, property taxes, other taxes/fees, spin-off businesses (related revenue sources for the city)?**
    - *Tourism & entertainment businesses*
  - b) **How much does recreation activity contribute to the local economy? (in \$ or % of city revenue)**
    - *Lions Club tube rentals returns between \$110k-\$125k/yr to local charities*
    - *Unknown. Check with Michael Ravel & Richard Earl of TSU geography department for studies*

**13. What is your perception of the level of enforcement on the river? Too much, not enough? Why?**

- *Enforcement is not an issue, but more is better*

**14. Is the amount of regulation with regards to activities on the river acceptable? Should there be more? Or less?**

- *Need regulation to protect wild rice and prevent overcrowding issues*
  - a) **Are there certain things that should be regulated that aren't currently?**
    - *More stringent litter laws including restrictions on food and beverage containers (glass & Styrofoam)*
    - *Ban or limit alcohol from the river (4x)*
    - *Crowding issues & river access points to disperse crowds*
  - b) **Are there certain things that are currently regulated that shouldn't be?**
    - *No*

**15. What is your perception of the level of maintenance? Too much, not enough? Why?**

- *With regards to litter: there is never enough trash maintenance*
- *Sentiment that the river should be dredged annually as in previous years*

**16. Are there operational issues with regards to emergency flood situations?**

- *Well prepared: dams control many of the severe floods*





### **OTHER COMMENTS**

- *Much degradation over last 8 years*
- *People feel conflicted over the alcohol consumption on the river/parks*
- *The revenue from the river helps maintain the river*
- *Though the city parks are closed after dark, canoeists and kayakers operate during this time and the city is tolerant of canoeists and kayakers moving through the parks at this time; there seems to be a general understanding that daytime (summer) is for tubers and all else times are best for canoeists and kayakers*
- *There is only 1 tube vendor for San Marcos: Lions Club; they run the shuttle*
- *Richard Earl, Geography Dept. at Texas State has studies regarding number of users and revenue generated from river activities*

### **OTHER CONTRIBUTORS TO THE ECONOMY:**

- *Outlet malls: 25-30% sales tax revenue (over 11 million visitors /yr, 3rd highest visitor attraction in Texas)*
- *University Conference Center*
- *River in general is a draw; people attend TSU because of the setting, people move here because of the setting*

### **OPERATIONAL ISSUES**

- *Not enough restrooms & drinking fountains to support the peak capacities*
- *Need to disseminate information about the river as a natural entity so users can more fully understand what the experience of tubing on the river will be*
- *The Lions Club contributes between \$110k-\$120k/year to local charities*
- *There is abuse of the Domestic Water Rights in that certain land owners have been drawing water to stock their ponds for uses other than agriculture (TCEQ permits 200 acre/ft / year)*
- *Cummings Dam at the confluence of the Blanco has had a possible effect on Fountain Darter population as it stagnated a 3 mi. length and the population has shown decline (Tom Goynes article)*
- *San Marcos's water supply is 73-74% surface drawn, city has made effort to minimize their draw on the aquifer*





## V. WATER QUALITY DATA

Water quality in the San Marcos and Comal Rivers is a measurable parameter that is being monitored on a regular basis by the TCEQ Clean Rivers Program. The data obtained through monthly sampling at specific locations can be a useful tool to assess the current health of the protected species in the two river systems, and possibly draw correlations between the frequency/type of recreation that contribute to measurable changes in water quality, and how these changes could affect protected species.

Initially for this study, it was proposed that aquatic specialists would review existing water quality data trends and identify potential spatial and temporal correlations between water quality data, recreational use, and protected species habitat. However through recreational research for this study, it was realized that there is not a comprehensive monitoring program to count the number of recreational users, or reliable user counts readily available. Data for protected species was limited and thus this initial recreational study was limited to only providing the available historical water quality data in the GIS geodatabase to build a framework for future analysis. No correlations were made during this process due to lack of data for recreation and limited data for protected species.

GIS analysts obtained data from the TCEQ Water Data Management & Analysis, Water Quality Planning division. This information is considered to be the most recognized, comprehensive scientific data for this area that is readily available in GIS format. The TCEQ surface water quality monitoring program coordinates the monitoring and assessment of surface water resources and oversees the statewide network of monitoring sites. The Texas Clean Rivers Program (CRP) is a state fee-funded program for water quality monitoring, assessment, and public outreach. The CRP is a collaboration of 15 partner agencies and the TCEQ. The TCEQ monitors the quality of surface water to evaluate physical, chemical, and biological characteristics of aquatic systems. Water quality is monitored in relation to human health concerns, ecological condition, and designated uses. (TCEQ website, 2010)

During this study, additional water quality data sources were identified. These studies are either in progress or have just recently been published. For example, the contracted study between TCEQ and Guadalupe-Blanco River Authority (2009 and 2010) to collect water quality samples is a newer ongoing study. The results of this study are scheduled to be incorporated into the future published TCEQ Clean Rivers Program.

Tables 9 and 10 list the TCEQ Clean Rivers Program monitoring stations within the study area identified on map exhibits A-1 to A-25. The Comal River section of the study area consists of 18 surface water monitoring sites. The San Marcos River section consists of 8 surface water quality monitoring sites. Of these 26 sampling locations, monitoring data presented in the GIS geodatabase spans various months over a nineteen year period from 1990 to 2009.





Table 9	
TCEQ Clean Rivers Program Monitoring Stations: Comal River	
15412	COMAL RIVER AT MULBERRY AVE UPSTREAM OF LANDA PARK
13510	COMAL RIVER AT ISLAND AT END OF BOONEVILLE AVENUE IN LANDA ESTATES IN NEW BRAUNFELS
12574	COMAL SPRINGS AT FOOTBRIDGE NEAR GAZEBO IN LANDA PARK IN NEW BRAUNFELS
18525	PANTHER CANYON IMMEDIATELY UPSTREAM OF LANDA PARK DR NEAR COMAL SPRINGS IN NEW BRAUNFELS TX
15413	COMAL RIVER AT LANDA LAKE IMMEDIATELY WEST OF LANDA PARK IN NEW BRAUNFELS .25 KM DIRECTLY EAST OF CALIFORNIA RD
12572	COMAL SPRINGS AT CALIFORNIA BLVD IN NEW BRAUNFELS
12573	COMAL SPRINGS DOWNSTREAM PANTHER CANYON IN NEW BRAUNFELS
15204	COMAL RIVER/LANDA LAKE AT BOATHOUSE IN LANDA PARK
12654	COMAL RIVER AT MINIATURE TRAIN DEPOT IN LANDA PARK IN NEW BRAUNFELS
15082	COMAL RIVER AT LANDA PARK AREA 16 2.45 MI UPSTREAM FROM CONFLUENCE WITH GUADALUPE RIVER IN NEW BRAUNFELS
15146	COMAL RIVER AT HINMAN ISLAND 2.1 MI UPSTREAM OF CONFLUENCE WITH GUADALUPE RIVER
14933	DRY COMAL CREEK AT SEGUIN ST NEW BRAUNFELS
12570	DRY COMAL CREEK AT MISSOURI-KANSAS-TEXAS RAILROAD CROSSING IN NEW BRAUNFELS
12652	COMAL RIVER DOWNSTREAM STEINKE FALLS BETWEEN CONCRETE STAIRWAYS BEHIND COTTAGE NO. 13 IN NEW BRAUNFELS
15401	COMAL RIVER IMMEDIATELY SOUTH OF UNION BLVD 0.2 KM UPSTREAM OF THE GUADALUPE RIVER IN NEW BRAUNFELS
12651	COMAL RIVER NEAR GUADA COMA/UNION BLVD COMAL RIVER 50 M UPSTREAM OF END OF GUADA COMA DR WEST/UNION BLVD BRIDGE IN NEW BRAUNFELS
12657	GUADALUPE RIVER 1.1 MI UPSTREAM FROM COMAL RIVER IN NEW BRAUNFELS
12656	GUADALUPE RIVER AT THE BEGINNING OF CYPRESS BEND PARK IN NEW BRAUNFELS

Table 10	
TCEQ Clean Rivers Program Monitoring Stations: San Marcos River	
15496	SPRING LAKE AT AQUARENA SPRINGS BRIDGE IN SAN MARCOS
15497	SPRING LAKE AT DAM .10 MI UPSTREAM FROM LOOP 82 IN SAN MARCOS
15498	UPPER SAN MARCOS RIVER AT CONFLUENCE OF SESSOM CREEK AT LOOP 82 IN SAN MARCOS
15499	UPPER SAN MARCOS RIVER AT CONFLUENCE OF PURGATORY CREEK AT CITY PARK .10 MI DOWNSTREAM OF SH 12 IN SAN MARCOS
15500	UPPER SAN MARCOS RIVER AT RIO VISTA PARK FOOTBRIDGE .20 MI DOWNSTREAM OF SH 12 IN SAN MARCOS
12672	UPPER SAN MARCOS RIVER IMMEDIATELY UPSTREAM OF IH 35 BRIDGE AT SAN MARCOS
14153	SAN MARCOS/A.E. WOODS TPWD FISH HATCHERY DISCHARGE POINT TO SAN MARCOS RIVER
12671	UPPER SAN MARCOS RIVER 0.7 MILE DOWNSTREAM FROM IH 35

Future investigations can utilize the GIS geodatabase created during this study, and update it with the most current readily available data from the TCEQ Clean Rivers Program. Once numerical recreation use data becomes available, it can be compared to the water quality data to ascertain any correlations between the frequency and intensity of recreational use and water quality. Then layering any protected species mapping data may allow analysis of any potential relationship between species sustainability or proliferation and recreation use. Two recognizable studies conducted by the USGS in the 1990's can be used as a model for future studies (See Appendix D). The GIS geodatabase of TCEQ data includes the parameters that the





USGS used: pH, temperature, dissolved oxygen, major ions, nutrients, trace elements, selected organic compounds, and stream flow. A list of all of the parameters monitored by TCEQ are illustrated in Table 11.

TABLE 11.	
TCEQ WATER QUALITY SAMPLING PARAMETERS	
00060	FLOW, STREAM, MEAN DAILY (CUBIC FEET PER SEC)
00061	FLOW STREAM, INSTANTANEOUS (CUBIC FEET PER SEC)
00078	TRANSPARENCY, SECCHI DISC (METERS)
00090	OXIDATION REDUCTION POTENTIAL (MILLIVOLTS)
00094	SPECIFIC CONDUCTANCE, FIELD (UMHOS/CM @ 25C)
00095	SPECIFIC CONDUCTANCE, LAB (UMHOS/CM @ 25C)
00300	OXYGEN, DISSOLVED (MG/L)
00301	OXYGEN, DISSOLVED (PERCENT OF SATURATION)
00400	PH (STANDARD UNITS)
00403	PH (STANDARD UNITS) LAB
00410	ALKALINITY, TOTAL (MG/L AS CaCO <sub>3</sub> )
00480	SALINITY - PARTS PER THOUSAND
00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)
00535	RESIDUE, VOLATILE NONFILTRABLE (MG/L)
00593	NO <sub>2</sub> PLUS NO <sub>3</sub> -N, TOTAL, WHATMAN GF/F FILT (MG/L)
00608	NITROGEN, AMMONIA, DISSOLVED (MG/L AS N)
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)
00613	NITRITE, DISSOLVED (MG/L AS N)
00615	NITRITE NITROGEN, TOTAL (MG/L AS N)
00620	NITRATE NITROGEN, TOTAL (MG/L AS N)
00623	NITROGEN, KJELDAHL, DISSOLVED (MG/L AS N)
00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

00630 NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)
00631 NITRITE PLUS NITRATE, DISS 1 DET. (MG/L AS N)
00665 PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)
00666 PHOSPHORUS, DISSOLVED (MG/L AS P)
00671 ORTHOPHOSPHATE PHOSPHORUS, DISS, MG/L, FLDFILT<15MIN
00680 CARBON, TOTAL ORGANIC, NPOC (TOC), MG/L
00681 CARBON, DISSOLVED ORGANIC, DNPC (DOC), MG/L
00689 CARBON, SUSPENDED ORGANIC - POC (MG/L)
00900 HARDNESS, TOTAL (MG/L AS CaCO <sub>3</sub> )
00915 CALCIUM, DISSOLVED (MG/L AS Ca)
00925 MAGNESIUM, DISSOLVED (MG/L AS Mg)
00930 SODIUM, DISSOLVED (MG/L AS Na)
00935 POTASSIUM, DISSOLVED (MG/L AS K)
00940 CHLORIDE (MG/L AS Cl)
00945 SULFATE (MG/L AS SO <sub>4</sub> )
00950 FLUORIDE, DISSOLVED (MG/L AS F)
00955 SILICA, DISSOLVED (MG/L AS SiO <sub>2</sub> )
01000 ARSENIC, DISSOLVED (UG/L AS As)
01005 BARIUM, DISSOLVED (UG/L AS Ba)
01010 BERYLLIUM, DISSOLVED (UG/L AS Be)
01025 CADMIUM, DISSOLVED (UG/L AS Cd)
01030 CHROMIUM, DISSOLVED (UG/L AS Cr)
01035 COBALT, DISSOLVED (UG/L AS Co)
01040 COPPER, DISSOLVED (UG/L AS Cu)





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

01046 IRON, DISSOLVED (UG/L)
01049 LEAD, DISSOLVED (UG/L AS PB)
01056 MANGANESE, DISSOLVED (UG/L AS MN)
01060 MOLYBDENUM, DISSOLVED (UG/L AS MO)
01065 NICKEL, DISSOLVED (UG/L AS NI)
01075 SILVER, DISSOLVED (UG/L AS AG)
01090 ZINC, DISSOLVED (UG/L AS ZN)
01095 ANTIMONY, DISSOLVED (UG/L AS SB)
01106 ALUMINUM, DISSOLVED (UG/L AS AL)
01145 SELENIUM, DISSOLVED (UG/L AS SE)
01351 FLOW:1=No Flow,2=Low,3=Normal,4=Flood,5=High,6=Dry
22703 URANIUM, NATURAL, DISSOLVED
31616 FECAL COLIFORM, MEMBR FILTER, M-FC BROTH, #/100ML
31648 E. COLI, MTEC, MF, #/100 ML
31673 FECAL STREPTOCOCCI, MBR FILT, KF AGAR, 35C, 48HR
31699 E. COLI, COLILERT, IDEXX METHOD, MPN/100ML
32211 CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH
32218 PHEOPHYTIN-A UG/L SPECTROPHOTOMETRIC ACID. METH.
32764 7,12-DIMETHYLBENZ(A)ANTHRACENE, SED, DRY WT
32772 DIBENZ(AJ)ACRIDINE, SEDIMENT, DRY WT, UG/KG
32778 M,P-CRESOL, SEDIMENT, DRY WT, UG/KG
34203 ACENAPHTHYLENE, DRY WT, BOTTOM (UG/KG)
34208 ACENAPHTHENE, DRY WT, BOTTOM (UG/KG)
34223 ANTHRACENE DRY WT BOTUG/KG





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

34233 BENZO(B)FLUORANTHENE,SEDIMENTS, DRY WT,UG/KG
34245 BENZO(K)FLUORANTHENE DRY WTBOT UG/KG
34250 BENZO-A-PYRENE DRY WTBOTUG/KG
34276 BIS (2-CHLOROETHYL) ETHER DRY WTBOTUG/KG
34281 BIS (2-CHLOROETHOXY) METHANE DRY WTBOTUG/KG
34286 BIS (2-CHLOROISOPROPYL) ETHER DRY WTBOTUG/KG
34295 N-BUTYL BENZYL PHTHALATE, SEDIMENTS,DRY WT,UG/K
34323 CHRYSENE DRY WTBOTUG/KG
34339 DIETHYL PHTHALATE DRY WTBOTUG/KG
34344 DIMETHYL PHTHALATE DRY WTBOTUG/KG
34349 1,2-DIPHENYLHYDRAZINE, DRY WT, BOTTOM (UG/KG)
34379 FLUORANTHENE DRY WTBOTUG/KG
34384 FLUORENE DRY WTBOTUG/KG
34389 HEXACHLOROCYCLOPENTADIENE DRY WTBOTUG/KG
34399 HEXACHLOROETHANE DRY WTBOTUG/KG
34406 INDENO (1,2,3-CD) PYRENE DRY WTBOTUG/KG
34411 ISOPHORONE DRY WTBOTUG/KG
34431 N-NITROSODI-N-PROPYLAMINE DRY WTBOTUG/KG
34436 N-NITROSODIPHENYLAMINE DRY WTBOTUG/KG
34441 N-NITROSODIMETHYLAMINE DRY WTBOTUG/KG
34445 NAPHTHALENE DRY WTBOTUG/KG
34450 NITROBENZENE DRY WTBOTUG/KG
34455 PARACHLOROMETA CRESOL DRY WTBOTUG/KG
34464 PHENANTHRENE DRY WTBOTUG/KG





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

34472 PYRENE DRY WTBOTUG/KG
34524 BENZO(GHI)PERYLENE1,12-BENZOPERYLENDRYWTBOTUG/KG
34529 BENZO(A)ANTHRACENE1,2-BENZANTHRACENDRYWTBOTUG/KG
34539 1,2-DICHLOROBENZENE DRY WT, BOTTOM (UG/KG)
34554 1,2,4-TRICHLOROBENZENE DRY WTBOTUG/KG
34559 1,2,5,6-DIBENZANTHRACENE DRY WTBOTUG/KG
34569 1,3-DICHLOROBENZENE, DRY WT, BOTTOM (UG/KG)
34574 1,4-DICHLOROBENZENE, DRY WT, BOTTOM (UG/KG)
34589 2-CHLOROPHENOL, DRY WT, BOTTOM (UG/KG)
34594 2-NITROPHENOL DRY WTBOTUG/KG
34599 DI-N-OCTYL PHTHALATE DRY WTBOTUG/KG
34604 2,4-DICHLOROPHENOL DRY WT, BOTTOM (UG/KG)
34609 2,4-DIMETHYLPHENOL DRY WT, BOTTOM (UG/KG)
34614 2,4-DINITROTOLUENE DRY WT, BOTTOM (UG/KG)
34619 2,4-DINITROPHENOL DRY WT, BOTTOM (UG/KG)
34624 2,4,6-TRICHLOROPHENOL ,DRY WT, BOTTOM (UG/KG)
34629 2,6-DINITROTOLUENE DRY WT, BOTTOM (UG/KG)
34634 3,3'-DICHLOROBENZIDINE, DRY WT BOTTOM (UG/KG)
34639 4-BROMOPHENYL PHENYL ETHER, DRY WT, BOT (UG/KG)
34644 4-CHLOROPHENYL PHENYL ETHER, DRY WT, BOT (UG/KG)
34649 4-NITROPHENOL ,DRY WT, BOTTOM (UG/KG)
34660 DNOC (4,6-DINITRO-ORTHO-CRESOL) DRY WTBOTUG/KG
34695 PHENOL(C <sub>6</sub> H <sub>5</sub> OH)-SINGLE COMPOUND DRY WTUG/KG
34721 2,3,4,6-TETRACHLOROPHENOL SEDIMENT, DRYWT(UG/KG)





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

39036 ALKALINITY, FILTERED SAMPLE AS CaCO <sub>3</sub> MG/L
39061 PCP (PENTACHLOROPHENOL ) IN BOT DEPOS DRY UG/KG
39102 BIS(2-ETHYLHEXYL) PHTHALATE SED, DRY WT,UG/KG
39112 DI-N-BUTYL PHTHALATE, SEDIMENTS,DRY WT,UG/KG
39118 PENTACHLOROBENZENE IN SEDIMENT UG/KG
39121 BENZIDINE IN BOTTOM DEPOS (UG/KG DRY SOLIDS)
39191 TOTAL CHLORONAPHTHALENE (1AND 2) IN SED, UG/KG
39631 ATRAZINE IN BOTTOM DEPOS (UG/KG DRY SOLIDS)
39701 HEXACHLOROBENZENE IN BOT DEPOS (UG/KG DRY SOLIDS
39705 HEXACHLOROBUTADIENE BOT. DEPOS. (UG/KG DRY WT)
70300 RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)
70507 ORTHOPHOSPHATE PHOSPHORUS,DISS,MG/L,FILTER >15MIN
72053 DAYS SINCE PRECIPITATION EVENT (DAYS)
73031 PRONAMIDE IN SEDIMENT, DRY WEIGHT (UG/KG)
73116 P-DIMETHYLAMINOAZOBENZENE, SED, DRY WT, UG/KG
73117 PHENACETIN IN SEDIMENT, DRY WEIGHT (UG/KG)
73118 ETHYLMETHANSULFONATE IN SEDIMENT, DRY WT (UG/KG)
73119 METHYLMETHANESULFONATE IN SEDIMENT, DRY WT (UG/K
73122 2,6-DICHLOROPHENOL IN SEDIMENT, DRY WT (UG/KG)
73124 2-NAPHTHYLAMINE IN SEDIMENT, DRY WEIGHT (UG/KG)
73125 4-AMINOBIPHENYL, SEDIMENT, DRY WT (UG/KG)
73129 N-NITROSOPIPERIDINE IN SEDIMENT, DRY WT (UG/KG)
73143 1-NAPHTHYLAMINE IN SEDIMENT, DRY WT (UG/KG)
73156 3-METHYLCHLORANTHRENE, SEDIMENT, DRY WT(UG/KG)





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

73158 2-METHYLPYRIDINE IN SEDIMENT, DRY WEIGHT (UG/KG)
73159 N-NITROSO-DI-N-BUTYLAMINE, DRY WT,SEDIMENT (UG/K
74069 STREAM FLOW ESTIMATE (CFS)
75212 BENZYL ALCOHOL IN SEDIMENT, DRY WEIGHT (UG/KG)
75315 BENZOIC ACID IN SEDIMENT, DRY WEIGHT (UG/KG)
75647 DIBENZOFURAN, SEDIMENT, DRY WT (UG/KG)
78299 2-NITROANILINE IN SEDIMENT, DRY WEIGHT (UG/KG)
78401 2,4,5-TRICHLOROPHENOL IN SEDIMENT,DRY WT (UG/KG)
78543 CARBAZOLE IN SEDIMENT, DRY WEIGHT (UG/KG)
78755 ACETOPHENONE, SEDIMENT, DRY WT (UG/KG)
78866 ANILINE IN SEDIMENT, DRY WEIGHT (UG/KG)
78867 4-CHLOROANILINE, SEDIMENT, DRY WT (UG/KG)
78868 2-METHYLNAPHTHALENE IN SEDIMENT, DRY WEIGHT (UG/K
78869 3-NITROANILINE, SEDIMENT, DRY WEIGHT (UG/KG)
78870 4-NITROANILINE, SEDIMENT, DRY WT (UG/KG)
78872 2-METHYLPHENOL(O-CRESOL) SEDIMENT DRY WT. (UG/KG
80154 SUSP. SEDIMENT CONCENTRATION-EVAP AT 110C (MG/L)
80256 SEDIMENT PRTCL.SIZE CLASS >2.0MM GRAVEL %DRY WT
81373 SOLIDS IN SEDIMENT, PERCENT BY WEIGHT (DRY)
81808 PENTACHLORONITROBENZENE IN SEDIMENT, DRYWT (UG/K
81818 SEVIN IN SEDIMENT DRY WEIGHT (UG/KG)
81951 TOTAL ORGANIC CARBON,NPOC(TOC), SED DRY WT,MG/KG
82003 MOISTURE CONTENT IN SEDIMENT (%)
82008 SEDIMENT PRTL.SIZE CLASS.0039-.0625 SILT %DRY W





**TABLE 11.**

**TCEQ WATER QUALITY SAMPLING PARAMETERS**

82009 SEDIMENT PRCTL.SIZE CLASS <.0039 CLAY %DRY WT
82079 TURBIDITY,LAB NEPHELOMETRIC TURBIDITY UNITS, NTU
88811 CRESOL IN SEDIMENT, DRY WEIGHT, (UG/KG)
88817 N-NITROSODIETHYLAMINE, SED DRY WT (UG/KG)
88823 PYRIDINE SEDIMENT DRY WEIGHT (UG/KG)
88826 1,2,4,5-TETRACHLOROBENZENE SEDIMENT DRY WT (UG/K
89835 FLOW MTH 1=GAGE 2=ELEC 3=MECH 4=WEIR/FLU 5=DOPPL
89991 SEDIMENT PRCTL.SIZE CLASS,SAND .0625-2MM %DRYWT

In addition to data collection, the TCEQ assesses water quality throughout the state. Formerly called the "Texas Water Quality Inventory and 303(d) List," the Integrated Report evaluates the quality of surface waters in Texas, and provides resource managers with a tool for making informed decisions when directing agency programs. The Texas Integrated Report describes the status of Texas' natural waters based on historical data. It identifies water bodies that are not meeting standards set for their use on the 303(d) list. The Texas Integrated Report satisfies the requirements of federal Clean Water Act Sections 305(b) and 303(d). The TCEQ produces a new report every two years in even-numbered years, as required by law. The 303(d) List must be approved by the EPA before it is final. The TCEQ monitoring program also reports the status of water quality in the biennial Texas Water Quality Inventory and 303(d) List of Impaired Waters. The Texas Water Quality Inventory and 303(d) List reports the information on Texas' surface waters, including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources (TCEQ website, 2010).

Table 12 lists the stream segments within the study area. According to the 2008 Texas Water Quality Inventory and 303(d) List of Impaired Waters, no segments (1811, 1812, and 1814) within the study area were considered impaired. See Appendix D for the results of this analysis.





**TABLE 12**

**2008 TEXAS WATER QUALITY INVENTORY STREAM SEGMENTS IN STUDY AREA**

1811 – Comal River	From the confluence with the Guadalupe River in Comal County to Klingemann Street in New Braunfels in Comal County (4 miles)
1811A – Dry Comal Creek  Unclassified (Not assessed in 2008)	From the confluence of the Comal River in New Braunfels in Comal County to the upstream perennial portion of the stream southwest of New Braunfels in Comal County (30 miles)
1814 – Upper San Marcos River	From a point 1.0 km (0.6 miles) upstream of the confluence of the Blanco River in Hays County to a  point 0.7 km (0.4 miles) upstream of Loop 82 in San Marcos in Hays County (5 miles)





## VI. PERTINENT SCIENTIFIC STUDIES

Sources for the following studies come from the City of San Marcos, the City of New Braunfels, and River Systems Institute. Halff is aware there are relevant studies beyond what has been summarized in this document, however those relevant studies were either not accessible or not made available at the time of this report. It would likely be of benefit for the EARIP to take into consideration the results of those complementary studies.

The studies reviewed include habitat conservation plans, academic theses, articles and books and provide insight into the management of rivers for the sake of habitat and/or the physical and chemical affects on rivers from human activity, including recreation. Of greatest relevance is the current on-going study of Texas State University student Jenna Winters; although methodologies were not specifically revealed, her data on the San Marcos River is the most site specific and significant of information gathered.

### A. Pertinent Studies

#### **Doctoral Study of San Marcos River between Sewell Park and Rio Vista falls by Jenna Winters, unpublished data from 2007-2009**

Geographical points of study of San Marco River from upstream to downstream order:

Last bridge  
Just before City Park  
Just after City Park  
Hopkins St. Bridge  
Bicentennial Park  
Beginning of Rio Vista Park  
Dam at Rio vista Park

Turbidity:

- Measurements of turbidity were taken at 6' from each bank and center of current channel
- Correlation was found between number of people and turbidity levels.
- Levels of turbidity in San Marcos River between Sept and April: mostly recorded at 2.00 NTUs and under, rarely more than 3.00 NTUs. Spikes in turbidity during this time correlated with rainfall events. Turbidity increased with summer months. The correlation was found to be consistently 0.72 in both 2008 and 2009.





- Years when flow of the river was low, turbidity was higher and vice versa.

Peak days were summer season (Memorial Day weekend – Labor Day) Saturdays and Sundays, with greater amount of people on Saturdays. Holiday Mondays showed higher numbers as well and in general, Thursdays and Fridays averaged greater numbers than Tuesdays and Wednesdays. In one counting survey performed during a July 4 weekend taken between 12pm and 2pm, 1756 people (swimming or tubing) and 6 dogs were counted to be in the river. On June 5, 2009 (a Friday), a count was documented at 706 people and 4 dogs. In her 2008 survey of 717 people, the following information was revealed:

- Reported primary activity of visitors to the San Marcos River:
- 33% swim
- 28% socialize
- 16% tube
- 6% boat
- 2% fish
- Mean age of user: 34
- 53% were from San Marcos area
- 76% were from the Austin- San Antonio IH 35 corridor
- 98% were Texas residents
- 98% reported they would return
- 87% were repeat visitors
- Average duration of stay at the river: 4 hours
- This duration does not vary with weekend or weekday days
- 50% brought their own tubes

For that particular visit:

- 75% spent less than \$25
- 13% spent between \$25-\$50
- 6% spent between \$50-\$75
- 7% spent >\$100
- 6% were overnight guests
- 24% advised that fuel prices would affect their decision to visit

Awareness of listed species in the San Marcos River:

- 59% advised they were aware
- 27% advised they learned this from school programs



- 18% advised they learned this from friends
- 13% advised they learned this from signage
- 67% of Caucasians were aware
- 44% of Hispanics were aware

#### Cleanliness of the River:

- 29% perceived the water as very clean
- 50% perceived the water is mostly clean

#### Perception of crowding

- 82% reported to have no issues with levels of crowd
- 94% reported to not feel crowded or only slightly crowded

#### Ethnicity

Percentage of Hispanic and Caucasian visitors proportionately mirrored the San Marcos city demographic

#### ***USFWS, Summary of 2009 sampling efforts related to Edwards Aquifer Authority Variable Flow Study under USFWS permit number TE037155-0, 2009***

Methods and findings of federally listed species in specific locations of the Comal and San Marcos Rivers were explained.

This report provides current and specific information of where and in what kinds of densities each of the Fountain Darters, San Marcos Salamander, Texas Wild Rice, Comal Spring Riffle Beetle was found, along with other fish and crustaceans, arachnids and insects. Information regarding current flow, time of year and water quality was also provided, as well as findings from previous years for comparison.

This report is useful in ascertaining information about population fluctuations and habitat conditions and may provide clues as to where recreation use could be altered to accommodate for these habitats.

#### **Owens, Chetta S., John D. Madsen, R. Michael Smart and Michael Stewart** ***Dispersal of Native and Nonnative Aquatic Plant Species in the San Marcos River, Texas***

Five sites were sampled 5 times each on a quarterly schedule reflecting seasonal trends for introduced and native vegetation types. The article focuses on the proliferation of hydrilla and East Indian hygrophylla and their effects on the native listed species Texas Wild Rice. References to other sources noted times and season of recreation use and the finding that recreation negatively impacts





Texas wild rice, additionally that recreation users disturb, tear and uproot native species allowing more aggressive nonnative species to proliferate.

**Bussemey, Michelle, *Analysis of Landscape Change of the Rio Vista Dam in San***

***Marcos, Texas. MS Thesis, Texas State University, San Marcos, Texas, 2007***

Repeat photography documents the changes of the river and adjacent banks at the location of the current day Rio Vista Dam dating back from 1917. A cultural and physical history is documented and concludes the landscape changes which include opening this part of the river to the community (for recreation use) and the reconstruction of the dam and construction of step pools has resulted in congestion, increased turbidity and trash in and around the river. The author also warns the alterations in the dams and the introduction of pools will also result in sediment bars and ultimately could alter the channel and the flow of the river.

**City of San Marcos Habitat Conservation Plan (Draft – not yet implemented)**

This report outlines options in strategies in which to protect and minimize disturbance and limit take (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct) of federally listed aquatic species found in the San Marcos River during the course of maintenance and construction projects and activities for the next twenty (20) years. Those species include the fountain darter, the Comal Springs riffle beetle, the San Marcos salamander and Texas wild-rice.

Requirements under the take permit, known as a Section 10(a)(1)(B) permit, issued by US Fisheries and Wildlife Service (USFWS) include biological data, impact assessments, geographical area, activities of listed species within the project area, provisions to monitor, minimize, and mitigate impacts and procedures to deal with unforeseen circumstances.

This report aims to support a comprehensive watershed management plan for the San Marcos River within the city limits which includes the city's Recreation Master Plan as well as the Environmental Protection Agency Phase II Storm Water Management Program.

The projects and activities that apply to this study are those surrounding the San Marcos River corridor between the springs at Spring Lake and Rio Vista Falls.

This draft publication describes the physical attributes of the affected area, including hydrology, climate, water quality, existing land use, vegetation and wildlife including the listed species. The draft publication also makes an assessment of threats which include sedimentation, increased pollution, increased nutrient levels, expanding population of non-natives and recreational activity, on which this report focuses.





River recreation activities cited include scuba, swimming, tubing, canoeing/kayaking, fishing, wading, dog playing, snorkeling and boat touring. Recreation causes disturbance to the river bottom and vegetation, streamside issues include erosion, litter and pollution, while fishing specifically can introduce non-native bait species.

Maintenance is performed to maintain a clear corridor for water recreation; this includes clearing vegetation from the central 5 meters of the current channel to a depth of 12". The city will manage a strategically timed incremental removal of high growth and non-native vegetative species while replacing with low growth native species, in addition to sediment removal.

The proximity of Texas State University golf course incurs strict regulations by USFWS on use of fertilizers and pesticides, as well as watering regimes.

In addition to outlining on-going maintenance activities within the area, this draft publication also lists future projects by Texas State University, including construction of a new hike/bike trail and an expanded academic curriculum of water activities (at Spring Lake) by Texas State University. City projects include bank stabilization projects and provision of controlled river access points taking care to remediate with native rock and riparian vegetation.

**Edwards Aquifer Authority. 'Comprehensive and Critical Period Monitoring Program to Evaluate the Effects of Variable Flow on Biological Resources in the Comal Springs/River Aquatic Ecosystem Final 2009 Annual Report' . BIO-WEST Inc. March 2010**

This report was made known to the Halff team late in the process of producing this report and was thus not thoroughly reviewed. Relevant information found in this document includes monitoring efforts by the Master Naturalist volunteers who collected data on river users (numbers, types/activities) and water quality (pH, carbon dioxide) on a weekly basis in the years 2006 through 2009. Five (5) sites were visited regularly at roughly the same time for the same duration at each of the five locations. Tubing was found to be the dominant recreation activity, with emphasis between May and September of each year and 2009 showed a higher number of users at four of the five locations over 2007 and 2008. With regards to water quality, pH levels were shown to be consistently lower nearer the springs than downstream and carbon dioxide concentrations showed higher levels nearer the springs and less downstream.

**Edwards Aquifer Authority. 'Comprehensive and Critical Period Monitoring Program to Evaluate the Effects of Variable Flow on Biological Resources in the San Marcos Springs/River Aquatic Ecosystem Final 2009 Annual Report' . BIO-WEST Inc. March 2010**





This report was made known to the Halff team late in the process of producing this report and was thus not thoroughly reviewed. This document summarizes the methodology and findings of two comprehensive monitoring events and three critical period low-flow events. These samplings examined water chemistry, current flow, water levels, water temperature, aquatic vegetation and changes in channel morphology. This type of detailed investigation found correlations between the establishment of Texas wild rice with water levels and current flow and subsequently, recreation use as a result of water levels and their impact on the establishment of Texas wild rice. The report cites mechanical disturbance on river banks and bottom and fragmentation of wild rice stands from recreationists. Quantitative data comes from mapping of wild rice stands and measurement of current flows, water levels, and changes in channel morphology. Observed recreation use (areas and activities) correlated with accessibility of the river and water depths. Similarly, fountain darter found locations correlated with stands of aquatic vegetation and was thus also found to be affected by recreationists.

**Edwards Aquifer Area Expert Science Subcommittee for the Edwards Aquifer Recovery Implementation Program. 'Analysis of Species Requirements in Relation to Spring Discharge Rates and Associated Withdrawal Reductions and Stages for Critical Period Management of the Edwards Aquifer'. Report to Steering Committee for the Edwards Aquifer Implementation Program. December 28, 2009.**

This report was made known to the Halff team late in the process of producing this report and was thus not thoroughly reviewed. Quantitative documentation of water flow and physical changes to vegetation and stream channel were provided for the three (3) years of this study. Information regarding population size and locations of the various species at various times of the year were also provided and qualitative observations were made regarding the context of each sampling period, including human (recreation) activity. The report provides information on which and how listed species are affected by flow rates and the various factors flow rates affect (that ultimately affect the habitat for listed species): turbidity (sunlight), scouring effects (establishment of Texas wild rice and opportunities for more aggressive (competitive) non-native aquatic vegetation), sedimentation, recreation (opportunities for greater human contact with banks and river bottoms, accessibility of shallow depth stream areas). The report clearly indicates recreation has a direct and indirect effect on fountain darters and a direct effect on Texas wild rice but cites such factors as sedimentation, turbidity, presence of exotic species are also variables in their populations. Populations of the Texas blind salamander and listed beetle species are noted to be physically found closer to or within the spring sources and are thus much less affected by recreation but more so by water table depth (draw), water flow rates (draw and drought) and water quality (pollution within recharge zones). The San Marcos blind salamander riverbed habitat was found to be





impacted near Spring Lake Dam by siltation (allowing extensive vegetation growth) and (accessibility of water) recreation during low discharge years of 2006 and 2009. The report makes conclusions about minimum flow rates for species survival.

**Bradsby, D.D. 1994. *A Recreational Use Survey of the San Marcos River*. MS Thesis, Southwest Texas State University, San Marcos, Tx 82pp.**

This study was not accessible but was referred to by several sources.

**Breslin, S.L. 1997. *The impact of recreation on Texas wild rice*. MS Thesis, Southwest Texas State University, San Marcos, Tx. 69pp.**

This study was not accessible but was referred to by several sources. One reference found stated Texas wild rice is found only in the upper 2.5 km of the San Marcos River. Recreation visibly causes considerable damage to Texas wild rice stands with highest occurrence during peak recreational months in the hours between 2-3pm.

**Earl, Richard A. and Wood, Charles R. 'Upstream Changes and Downstream Effects of the San Marcos River of Central Texas'. The Texas Journal of Science February 2002**

The San Marcos River is recognized as a unique resource; it is attracting a growing population to the city as well as Texas State University. It is documented to have the potential to produce a floodflow of 247 square kilometers. The flood of May 15, 1970 which resulted in a discharge of 76,600 cubic feet per second was the impetus for the formation of the Upper San Marcos Watershed Reclamation and Flood Control District. Another flood on June 13, 1981 prompted the funding for a series of five (5) control dams upstream San Marcos River, the last of which was completed in 1991. These dams have a combined capacity of 23 million cubic meters (19,000acre feet) and consequently reduced the uncontrolled drainage area from 247 square km to 47 square km. Although effective in controlling flood damage (as evidenced by larger than 100 year flood event of October 1998, which produced a peak discharge of what would have been a 25 year event), the construction of the dams have resulted in decreased scouring action (reduced flow), and consequently, increased sedimentation of the river, by as much as 0.5 meters depth in the main channel. The changes have caused issue with the increases in exotic riparian and aquatic vegetation, and thereby affecting the natural habitats of the four (fountain darter, texas wild rice, san marcos salamander, comal springs riffle beetle)US Fish and Wildlife Services aquatic species. While flooding control measures are effective, they have brought on a new set of management issues. The Texas Parks and Wildlife Department and the City of San Marcos Parks and Recreation Department since 1990 have been closely monitoring the river for critical habitat and for protection of the river as an aesthetic and tourism resource.





**Comal County, Texas and Comal County Commissioners Court. Comal County Regional Habitat Conservation Plan. April 2010**

The rate of growth in Comal County has induced a desire for a strategy in which to ensure the protection and preservation of open space for the benefit of the County's citizens, to conserve the County's endangered species and to help landowners comply with Endangered Species Act (ESA) compliance efficiently and cost effectively. Participation in the County's process by landowners is voluntary, although compliance with the Endangered Species Act is not.

A Habitat Conservation Plan (HCP) by Comal County would help establish a 30 year regional permit that would allow authorization under the ESA for land development activities that could affect the 'take' (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct) of federally listed or endangered wildlife species listed under the ESA. This type of regional plan specifies the conservation measures that would be implemented in exchange for a US Fisheries and Wildlife Service section 10(a)(1)(B) permit. The Regional HCP addresses habitats for the golden cheeked warbler and the black capped vireo. (Federally) Listed species not addressed in this HCP are aquatic species associated with Edwards Aquifer: the fountain darter, Peck's cave amphipod, Comal Springs riffle beetle, and the Comal Springs dryopid beetle.

**Comal County, Texas and Comal County Commissioners Court. Comal County Regional Habitat Conservation Plan Environmental Impact Statement. April 2010**

This report describes the potential impacts of the 'take' permit described in the Comal County Regional Habitat Conservation Plan (RHCP) of April 2010. Although the aforementioned plan addresses only the take of the golden cheeked warbler and the black capped vireo, this environmental impact statement describes the affect on habitats of other species as a result of land development; the report provides three (3) scenarios for Comal County: no regional permit (alternative A), regional permit granted (alternative B), reduced take regional permit (alternative C, does not cover habitats of the black capped vireo). Each scenario is described in terms of the direct, indirect and cumulative effects of take and mitigation as proposed by the RHCP.

The proposed action, as the favored scenario is referred to, is alternative B: to obtain a regional permit that would allow Comal County to process and monitor land development in terms of take and to ensure that the RHCP is adhered to in terms of mitigating environments and allocating habitat in perpetuity for the survival of the golden cheeked warbler and the black capped vireo.

A regional permit would require a commitment of resources, including revenue, to monitor and support the RHCP. This direction is described as most strategic in that it





is projected to least hinder the pace of economic growth in the area while also yielding the greatest potential for preservation.

A detailed analysis of various topics is part of this environmental impact assessment: water resources, vegetation, general wildlife, covered species, socioeconomic resources. Of the covered species, the listed species of interest in our river recreation study are identified as other protected species (other = those negligibly or minor affected by land (woodland) development as outlined in the RHCP): San Marcos salamander (*Eurycea nana*), Texas blind salamander (*Typhlomolge rathbuni*), Fountain Darter (*Etheostoma fonticola*), San Marcos gambusia (*Gambusia georgei*), Comal Springs Dryopid Beetle (*Stygoparnus comalensis*), Comal Springs Riffle Beetle (*heterelmis comalensis*), Texas wild-rice (*Zizania texana*). It should also be noted that The San Marcos salamander, Texas blind salamander, San Marcos gambusia and Texas wild rice are not evident in Comal County.

The consequential impacts from land development that may affect our species of interest would be any affects to the Edwards Aquifer (development will not be permitted to draw from this aquifer) such as any draw/reduction in flow and any sedimentation or toxic deposits in surface waters as a result of development and the reduction of pervious ground (unfiltered recharge). Changes in water levels, temperature and toxicity would be the largest threat, but because there are strict regulations on aquifer withdrawal, water quality control and development over the Edwards Aquifer recharge zone, and with the development of the Edwards Aquifer Recovery Implementation Program (EARIP), our three species of interest in Comal County (Comal Springs Riffle beetle, Comal Springs dryopid beetle and the fountain darter) would be minor to negligible. It is also stated that developing programs such as the EARIP, of which this study is a part, could be beneficial to such species. The primary focus of this RHCP is the take of black capped vireo and golden cheeked warbler habitat, which is woodland and is thus theoretically unlikely to affect the habitats of our species of interest.

The following ongoing or planned authorities, rules and regulations are expected to minimize the impacts on water resources and aquatic species:

- Edwards Aquifer Authority Rules
- Texas Pollutant Discharge Elimination System regulations
- Environmental Protection Agency and Army Corps of Engineers wetlands program
- Texas Commission on Environmental Quality total maximum daily load program
- Groundwater pumping regulation of the Edwards Aquifer Authority
- Texas House Bill 1763: requiring groups of Groundwater Districts to plan for the desired future condition of the groundwater resources in their Groundwater Management Area





- Texas Senate Bill 3: process leading to establishment of minimum environmental flow standards for each river basin in the state
- Water quality regulations of the city of San Antonio
- Edwards Aquifer Recovery Implementation Program
- Creation of a groundwater district over parts of the Trinity Aquifer occurring over Comal County

This environmental impact statement states the maintenance of water levels within the Edwards Aquifer area as established and regulated by the Edwards Aquifer Authority is the strongest measure in protecting the aquatic listed species so much so that it concludes that the RHCP measures proposed would minimally reduce cumulative adverse impacts on such species.

The report lastly discusses the possibility of climate change and other unavoidable adverse impacts and that they would be offset by the preservation of larger blocks of unfragmented habitat.

#### **B. Related Studies:**

**Bowles, David E., and Arsuffi , Thomas L. *Karst aquatic ecosystems of the Edwards Plateau region of central Texas, USA: A consideration of their importance, threats to their existence, and efforts for their conservation.* 28 Jun 2006 (on-line publication), from Aquatic Conservation: Marine and Freshwater Ecosystems: Special Issue: Endangered Aquatic Habitats - A Symposium of the Entomological Society of America December 1992 Volume 3, Issue 4, pages 317-329, December 1993 John Wiley & Sons, Ltd 1993**

This article identifies the endangered species within the Edwards Aquifer, along with the endemic and unique aquatic biota of the Edwards Plateau. It identifies specific threats from expanding human population including overpumping of aquifers, agricultural practices, pollution, development, recreational activities, introductions of exotic species and changes in regional and global climatic patterns and means for protection and remediation.

This article is most relevant to our focus of study by means of its discussion of water conservation, development of alternative water sources and land management and stewardship programmes.

**Newsome, David. Moore, Susan A.. Dowling, Ross Kingston. Natural Area Tourism, ecology, impacts and management. Channel View Publications, 2002.**

A book that looks at the evolution of natural area tourism, creation of national parks, preservations areas globally and the means by which





environmental consciousness is leading us to find more comprehensive means of planning and managing the impacts of environmental tourism in such a way that not only heightens the experience of the tourist but also benefits the environment simultaneously. The book has many examples of monitoring and surveying techniques used globally to measure various physical and social aspects to first establish a baseline of use and secondly, direction in which to maximize benefits to both users and the environment. Of particular interest in this document related to our study of the San Marcos and Comal systems are the physical variables that are measured with regards to soil compaction and bank stabilization/erosion. It also lists some effects that have not been discussed previously: noise levels, changes in nutrient availability and distribution caused by disturbing river bottoms as well as disturbance of mating rituals and deposited eggs of various species. This book is a wealth of examples of how and what could be sampled to help monitor the effects of recreation for further study.

***GCAGS Transactions Volume 48 (1998)***

Barton Creek watershed and springs located under the Glen Rose Formation : found differences in chemistry of shallow ground water between urban and rural settings, including nutrient levels, pH, temperatures, nitrates, ammonia, Kjeldahl nitrogen, specific conductance and total dissolved solids and potential sources of increased nitrogen levels.

**Edwards Aquifer Authority. 'Variable Flow Study: Seven Years of Monitoring & Applied Research' . BIO-WEST Inc. August 2007.**

This report was made known to the Halff team late in the process of producing this report and was thus not thoroughly reviewed. Over the course of seven years, multiple studies by various academic and government agencies have helped contribute to the findings of variable flows on aquatic habitat with a focus on the federal list of endangered species, the population dynamics and their habitat conditions. Water flow (rates), water quality, water levels, temperature, chemistry, aquatic vegetation, stream morphology were all studied with a focus on the effects on the biological communities. One of the major findings is the importance of aquatic vegetation to the biological community whose changes are measurable and relevant with spring discharge/current flow. The findings include an expanded range of habitat for the Comal Spring riffle beetle, stable populations for the San Marcos and Comal Springs salamanders as well as the fountain darter (but found to correlate with establishment of aquatic vegetation) and that the greatest threats to these species include recreation as well as sedimentation, introduction of exotic species and





aquatic vegetation mats. As so much of water quality is a factor for biological species, such is the importance of aquatic vegetation and Texas wild rice which are most greatly impacted by recreation activities. The document cites direct impacts from recreation on Texas wild rice stands indirectly affect the habitat availability and quality for fountain darters. The study found stable populations in the beetles, salamander species of the endangered species list.

**Gramann, James H. *Toward a behavioral theory of crowding in outdoor recreation: An evaluation and synthesis of research***

This document provides research on physical density versus psychological crowding in outdoor recreation.

**Kuss, FR | Graefe, AR *Effects of recreation trampling on natural area vegetation.***

**Journal of Leisure Research [J. LEISURE RES.]. Vol. 17, no. 3, pp. 165-183. 1985.**

The injurious effects of recreational use on vegetation of natural areas is influenced by not only plant responses to the direct mechanical effects of trampling, but also by stress factors internal to the ecosystem as well as changes in the physical, chemical and, biological nature of the soil medium. These effects are reviewed by tracing the dimensions of impact through selected stages in the life cycle of vascular plants beginning with seed germination and seedling establishment, growth functions after establishment, vigor and biomass production, flowering, seed production, and finally recolonization of impacted areas.

**Sabine River Authority of Texas, Orange, Tx, Sabine River Authority, *Recreation Use and Needs Assessment Study Plan, Revised Study Plan Toledo Bend Relicensing Project FERC Project No. 2305.* State of Louisiana, Many, LA, July 2009**

By use of surveys and site analyses, the study explains a methodology for assessing the recreation facilities around the Toledo Bend Reservoir, the demand and factors to look at for carrying capacity. This study may be useful in providing a list of variables in which to help determine limits on the various recreation activities that currently exist on our rivers of study and for any future land (recreation: camping, sports fields, amphitheaters, picnic sites, trails and the like) developments adjacent.

**Smith, Kellen A. *Providing the best of both worlds: balancing conservation and recreation in a system of protected areas in Texas.***





**MS thesis, Louisiana State University and Agricultural and Mechanical College, August 2007**

Texas Parks and Wildlife Department is charged with the task of providing conservation while offering recreational activities. Using the salient points of the Rio Summit of 1992 on Environment and Biodiversity as a guide, the questions of (a) whether the designated wildlife management areas (WMAs) are successful at providing enough area to adequately represent the various ecoregions of Texas (b) what do visitation rates tell us about what these WMAs offer and (c) do these WMAs adequately fulfill the desires of Texans regarding protection of wildlife and providing outdoor recreation. A list of societal, park management, and individual benefits and goals are presented as well as the variables that limit or attract visitors: proximity to urban areas/highly populated areas, size of WMA, clustering of WMAs, types of recreation activities (consumptive and non-consumptive), existence and number of endangered or threatened species. Though the San Marcos and Comal River systems are not WMAs, it could be asked if they should be treated or managed as such considering their locations in highly populated areas, the benefits they provide and the number of federally listed species within these ecosystems.





## VII. ECONOMIC INFORMATION

### A. New Braunfels

#### **‘The Impact of Tourism in Comal County’, TXP, Inc. December 2007**

This study looks at growth between years 2001 through 2006 in the county in terms of employment, population, single family building permits, and sales tax as indicators of the local economy. The graphs presented in the report express an accelerated growth with time. The report notes that tourism has grown at a slower pace than the local economy and cites probable causes such as 9-11, unusual weather patterns, and loss of shopping outlets.

Under the Bureau of Economic Analysis of the U.S. Department of Commerce, ‘tourism’ is not a distinct industry classification and therefore the numbers in this report are extrapolated from tourist related activity such as restaurant/bar sales and amusement and recreation sales.

Using ratios and adjustments in accordance with statistics of growth in factors like employment, population and building permits, it is estimated the full direct economic impact of tourism for Comal County in year 2002 was \$143.6 million, and by year 2006 had grown to \$224.9 million.

For the year 2006, sales taxes from tourism generated approximately \$5 million for the City of New Braunfels and Comal County, of which river recreation accounted for approximately 20 percent.

#### 2006 River Tourism Calculation:

A survey of 1,046 tubers using the Comal and the Guadalupe entry and exit points at various times in the summer of 2007 yielded the following results:

52 respondents resided in Comal County

48 respondents reported that tubing was not their primary reason for their visit to the area

approximately 486 were day trip visitors

Approximately 460 were overnight visitors

The average dollar expenditure of a day trip visitor was \$27

The average dollar expenditure of an overnight visitor was \$187.64

River tourism spending and calculated numbers were based on the following: In 2006, the City of New Braunfels reported more than 208,000 tubers who paid





the tube fee, of which it is estimated (based on the 2007 survey of percentages of out-of-towners and locals) that there were approximately 199,122 tubers who were not local (overnight guests). TXP estimated a blended average daily expenditure to be \$113, yielding direct river tourism at \$22.5 million for 2006. The full economic impact of river tourism was calculated based on direct spending, indirect spending (such as the additional costs of cleaning supplies for a hotel operator) and the increase in the overall local economy due to the added income by all the above, known as an induced effect. The results of river tourism are expressed in the report as output (equivalent to all sales directly related to recreation users)= \$34.3 million, value-added (describes net revenue by reported firms)= \$19.2 million, earnings (amount paid out to employees)=\$8.3 million and employment = 387 jobs. This output amount represents 12.5% of Comal County's total travel and tourism economic impact for 2006.

In terms of tax revenue, it is based on revenue from categories with a defined tax rate, such as lodging and the additional tax of indirect services and goods, and the spending of local workers who benefit from the need of additional services due to tourism.

For 2006 in Comal County, it was estimated that river recreation users contributed \$630,270 to lodging taxes and \$230,435 to sales taxes, totaling \$860,705.

While the study recognizes the attraction of the rivers and lakes are the driving force behind tourism in Comal County, it also notes that other aspects of tourism have great potential and that all growth will be synergistically beneficial to Comal County as a whole.

**Greater New Braunfels Economic Development Foundation, prepared by  
Impact Data Source.**

**'The Economic Impact of New Braunfels' Hospitality Industry 2009'**

This report is derived from information available from the City of New Braunfels sales tax collections for the year 2009, and US government data sources, including US Census Bureau's Business and Industry Economic Census and NAICS (North American Industry Classification System) standard ratios. It is important to note that taxable sales do not represent the total economic output for the hospitality industry since not all economic output is taxed by the city; this then is adjusted for by analyzing the various tax types (hotel occupancy, mixed beverage). Direct and indirect economic output in terms of employment and earnings is calculated based on census and NAICS ratios.





Based on the information above, the hospitality industry yielded \$469.6 million (direct and indirect sales, induced spending) in 2009. This amount includes various taxes (sales, hotel occupancy , beverage) totaling \$12.8 million to the city of New Braunfels alone, with a total of \$16 million to all local taxing authorities. \$12.8 million represents 19% of the city's total revenue and almost 22% of all sales tax revenue for the city.

\$469.7 million is the total hospitality economic output in New Braunfels which represents almost 20% of the total economic activity in New Braunfels. Of that dollar amount:

- 48% can be attributed to direct economic impacts
- 52% to indirect or spin off economic impacts
- by subcategory:
  - 65% restaurants/ eating establishments
  - 19% entertainment
  - 15% lodging
  - 1% transportation

\$70.3 million was paid in wages to those 5,181 people working directly in the hospitality industry and \$51.5 million was paid to those 1,798 people working in indirect jobs that support the hospitality industry. The number of jobs represents 27% of the employment in New Braunfels.

Similar to hospitality representing approximately 20% of the economic output of New Braunfels, job earnings represented 19% of the total earnings in New Braunfels.

In addition to providing jobs and revenue to the city, the hospitality industry has a philanthropic component and is reported to have contributed more \$722,000 in cash donations, scholarships and in-kind charitable donations in 2009.

#### Growth

The growth in economic output by the hospitality industry showed a steady increase over the years 2005 through 2009, with an annual growth rate of more than 6%.

The growth in workers' earnings grew 37% in the same period of time and employment grew by 32%





### Visitors

The report states over 200,000 people participated in water recreation in the Comal and Guadalupe Rivers in 2009, yielding over \$300,000 in river management fees to the City of New Braunfels.

The civic and convention center expanded in 2007-2008. In 2008, approximately 65,000 people attended more than 380 meetings, celebrations, performances, conferences and trade shows, yielding a \$232,000 in revenue in their fiscal year with projected revenue of \$350,000 for the 2009-2010 fiscal year.

Lodging in the city increased by 4 hotels in 2009, contributing \$2.2 million in hotel occupancy taxes. In addition to this economic contribution, construction jobs were created and local sales taxes were increased; cost of construction projects was estimated at more than \$21 million. Hotel rooms in the city in 2009 increased to 2,400 rooms.

Wurstfest is a fall event that pays homage to the city's German heritage; it had over 100,000 visitors and yielded over \$3 million in 2009. Other events are scheduled at the same time to maximize the draw of visitors to shop, stay and dine.

### **B. San Marcos**

Total number of visitors to San Marcos annually is estimated to be 10 million and is derived from traffic counts from the outlet malls; it is not a scientifically based number but is commonly quoted.

Information from the unpublished dissertation of Texas State University Ph. D candidate Jenna Winters, a 2008 survey of 717 visitors to the San Marcos River was conducted; the following spending was reported:

- 75% spent less than \$25
- 13% spent between \$25-\$50
- 6% spent between \$50-\$75
- 7% spent >\$100

Based on her survey, 16% of visitors were tubing and that approximately 50% of these tubers rented their tubes. From San Marcos Lions Club Tube Rentals numbers of year 2005 (approximately 30,000), we extrapolate the total number of visitors to the river to be in the realm of 375,000 people.





Based on the percentages of dollars spent, we also extrapolate the revenue from river visitors to be in the order of \$12.9 million. (This amount does not account for any change in number of tube users between 2005 and 2008) So although we estimate 375,000, the Greater San Marcos Economic Development Council in year 2000 estimated 500,000 annually visit the San Marcos River for water based recreation and civic activities adjacent to its banks (Earl & Wood art. 'Upstream Changes and Downstream Effects of the San Marcos River of Central Texas, February 2002).

There is no documentation on the number of river visitors during the period from Memorial weekend to Labor Day, nor is there any data available for revenue generated by tourist activity during that same period.

As of July 15, 2010 , The total number of booked/contracted and actual (Jan-July) events for 2010 was 780 events (this includes groups from 3 to 3,000) for an estimated total attendance of 70,393. The average attendance number per event is 90 persons. 84 conferences have been booked between May 2010 and December 2010 with 14,470 rooms dedicated. . (quotation: Ramirez, San Marcos Convention and Visitor Bureau, July, 2010).

Approximately 2,500 canoes and kayaks (TeGrotenhuis, TG canoes and kayaks, June 2010) are rented out annually and almost 30,000 tubes were rented out in the year 2005 (Fairchild, Lions Club). It is estimated from survey information (Winters, TSU, July 2008 data) that tube rentals represent only about 50% of tubers on the river. No other data was provided and there is no data on total number of boats on the river annually;





## VIII. RECREATIONAL IMPACTS & FURTHER STUDY

### A. New Braunfels

From stakeholder interviews, public parks are the predominant locations for access to the Comal River. Landa Park, as expressed by one interviewee, is felt to be at or beyond capacity as evidenced by the compaction and erosion along the banks of Landa Lake from foot traffic as well as from deterioration of vegetation caused by the foot traffic. The sentiment of general wear on the landscape was reported by a majority of the interviewees. Litter and negative behavior were also cited by stakeholders as on going issues due to recreation. In the more active recreation areas of the river, access is concentrated in various locations such as at Landa Falls, and downstream at various points along Hinman Island and Prince Solms Park and the public exit at Union Avenue. The river banks along these parks have mostly been reconstructed so erosion of the banks are not as much an issue in these areas, however, the limited availability of picnicking makes them most vulnerable to both the behavioral and litter issues, as well as overcrowding, which impedes access and egress to the river and continues to damage the vegetation and increases erosion.

In spite of these social issues, stakeholders held the value of the river in high regard, citing environmental stewardship, economics and mental and physical rejuvenation as benefits.

Quantitative information from weekly monitoring activities of the Texas Master Naturalist volunteers between 2006 and 2009 inclusive (Bio-West for Edwards Aquifer Authority, March 2010a) provide insight into optimum habitat variables for the listed species. This report provides a good basis from which to observe how recreation affects these variables.

As for reported direct effects, it appears that paddle boats on Landa Lake contribute to the reduction of both exotic and native vegetation (Bio-West for Edwards Aquifer, August 2007) which would both reduce the physical habitat of fountain darters as well as affect the amount of carbon dioxide in the water. Sedimentation and turbidity, which are both affected by recreation users, may also affect listed species albeit on a short term basis, but most significantly, as a result of low flow and shallow water depths, enabling water recreation enthusiasts to access more of the stream bed (Bio-West for Edwards Aquifer, August 2007) . Tubing is reported to be the most popular activity within the water with swimming, fishing as other common activities and rope jumping and





swift water rescue as seemingly less common activities. Along the banks, picnicking and wading and water lounging are activities that one could expect to affect the river. All these activities have varying degrees of direct physical contact/disturbance to the stream bed/bank and thereby affect the river in terms of turbidity but to what degree these activities affect sedimentation (through erosion of banks) and water quality was not precisely found, although water quality data is available for various parts of the river at various times of the year (Bio-West for Edwards Aquifer Authority, March 2010).

In the Comal Springs system, recreation occurs mostly downstream of the confluence of the Old Channel and Landa Lake, where salamanders and macro invertebrate species populations remain stable (BioWest for Edwards Aquifer Authority, August 2007) and higher quality habitat exists for the fountain darters (Edwards Aquifer Authority, December 2009) and thus the recreation along these downstream stretches are not of great concern (Edwards Aquifer Authority, December 2009). The salamander and macro invertebrate species were mostly found within the springs or near the springs and the fountain darters were found to be most populous in native *Cabomba* vegetation found in the deeper waters in the upper reaches of the Comal Springs system including Landa Lake (Bio-West for Edwards Aquifer Authority, March 2010a). Where more careful monitoring of recreation could take place then is within Landa Lake and all areas upstream as these areas are noted to be quality habitat (Edwards Aquifer Authority, December 2009).

As there are so many variables (nutrient levels, pH level, dissolved oxygen, carbon dioxide, temperature, sediment, flow, water depth, time of year, pollutant infiltration, herbivory, precipitation) that can affect listed species populations, it may be challenging to directly link any one source of species disruption. In so far as water-based recreation is seen as a cause for concern, it may be helpful to more closely examine the quality habitat areas (upper reaches of the Comal Springs system) and document the following at various times of the year for several cycles to augment other data that exists:

- Types of recreation (and direct physical contact with banks and stream channel)
- Number of users
- Documentation of pollutants and non-native species (organisms, plants and vertebrates)
- Water levels within the river channels
- Turbidity levels associated with specific recreation types
- Water quality: temperature, pH, nutrient levels
- Current flow





- Precipitation
- Substrate composition and changes in sedimentation in the riverbed
- Bank condition / geology / vegetation

At the same time, it would be useful to continue to:

- Map locations of species found
- Document habitat conditions
- Document life cycle stage of specimens

## **B. San Marcos**

As reported by stakeholders, recreation activity along the San Marcos River is concentrated between Sewell Park on the Texas State University (TSU) campus and Rio Vista Park. This stretch of river is almost completely lined with public park lands with the exception of one residential area on the north bank. As such, much of this stretch of river is accessible except where riparian vegetation creates an obstacle.

From interviewing stakeholders, prime bank activity occurs at Sewell Park, City Park and Rio Vista Park, where people mostly picnic, socialize and access the river with tubes or for swimming. The banks along Sewell Park and City Park are, for the most part, walled with concrete so access in these areas is by ladder or steps. Erosion of the banks is not necessarily a concern in these parts of the river, but erosion of stream bank vegetation within the parks is a concern, along with a concern about disturbance to the stream bottom (Bio-West for Edwards Aquifer Authority, March 2010b) where people tend to congregate not far from their picnic sites.

Where there are no concrete walls there is evidence of trampled vegetation and eroded ground cover (Winters, 2010, unpublished). City of San Marcos park staff indicated river bank erosion issues. The City currently has begun a river bank stabilization project that occurs between Rio Vista falls and Interstate Highway 35. City representatives reported that their community parks master plan aims to provide controlled access points to the river (by planting native riparian vegetation) in an effort to protect their parks and banks from further erosion.

The overall sentiment from the various stakeholders is that even though these river side parks provide an opportunity for environmental stewardship and education, an economic resource and a source of mental and physical rejuvenation, the parks (and associated river banks) are experiencing a





noticeable degradation of landscape through trampling of vegetation, erosion, pollution and litter by the park users themselves.

An economic study in the year 2000 indicated 500,000 river recreation users come to the City on an annual basis (Greater San Marcos Economic Council, 2000). There was no other published information found in this regard. A doctoral research candidate at Texas State University who is currently studying recreation on the river, provided one account of 1,756 users on/in the river during a peak 2 hour period of time on one summer holiday Monday (peak season, but not necessarily a peak day) in 2007.

Over the course of a 3 year period in which this student has been working, she also documented precipitation rates and dates, turbidity, levels of the water, and also prepared a user survey with more than 700 participants over the course of a three year research project. The survey of park users (along the San Marcos River) indicated that 33% stated swimming as their primary activity and 16% stated tubing as their primary activity with an overall of 57% reporting their primary activity was some type of recreation in or on the water.

Other than this unpublished data, and information gathered from stakeholders, we found no other specific information on numbers, types of users nor specific locations for San Marcos users was identified.

Recreation posed the most direct and indirect effect on Texas wild rice (Bio-West for Edwards Aquifer Authority, March 2010b) with mechanical disturbance (by pulling, walking, wading) and in so doing, indirectly affecting fountain darters by compromising this habitat. Data documenting changes in Texas wild rice stands, along with corresponding flow and water levels quantifies the observation of deterioration and fragmentation of Texas wild rice stands by recreation in the San Marcos River (Bio-West for Edwards Aquifer Authority, August 2007). Correspondingly, population dynamics and habitat conditions were examined for each of the listed species.

The overall conclusions were that salamander species and fountain darter populations were stable while invertebrate populations fluctuated (without conclusive factors) for the period between 2000 and 2007 inclusive, while the range of the Comal Spring riffle beetle expanded (Bio-West for Edwards Aquifer Authority, August 2007). However, in looking more closely at population relationships with recreation activity, drought and corresponding low water levels in year 2006 provided greater opportunities for recreation and physical contact with the riverbed and in so doing, habitats of fountain darters (aquatic





vegetation and namely, Texas wild rice) and salamanders were directly adversely affected by increased recreation activity. Reasons cited for the overall stable trend in listed species populations are due to various factors of spring flow, precipitation events (making the salamander habitat spillway at Spring Lake Dam less accessible) and likely most significantly, the sanctifying and restriction of recreation use of Spring Lake, helping preserve quality habitat (characterized by certain vegetation types and low velocities) for namely fountain darters whose reproductive numbers help offset diminished numbers downstream (Bio-West for Edwards Aquifer Authority, August 2007).

In efforts to more closely examine the correlation between river recreation and listed species habitats, it may be of interest to investigate and document a comparison of river environment and habitat factors between Spring Lake and points between Sewell Park and Rio Vista Park where most recreation occurs. Factors to evaluate include temperature, current Flow, water depth, water quality: pH, nutrient levels, vegetation, bank condition, turbidity levels associated with various activities, substrate composition and changes in the riverbed, numbers and types of recreation users and documentation of pollutants and non-native species (organisms, plants and vertebrates). It would also be prudent to record this data over a course of several seasons and for any critical events (such as flood or high precipitation, hazardous spills etc.).





## CONCLUSION

It is clear that the delicate balance of society's needs for recreating while maintaining a healthy perpetually viable natural environment will become more of a challenge with time as population increases create growing demands on these spring and river resources.

While there are definitive observations that recreational activity is adversely affecting the river environment, there is an apparent lack of raw data that could lead to a conclusive threshold of numbers and types of recreational activities in which populations of endangered and threatened species are critically compromised.

Studies reviewed and data collected suggest recreational activities put great pressure on species habitat. With the exception of the unpublished data of Winters and the inaccessible Breslin and Bradsby studies, very little information was found that specifically evaluated recreation as a source of species habitat disruption. In studies about water flow and its affects on species, recreational activities were observed as a consequential impact. In studies about Texas wild rice, low current flow, resulting recreational activities and opportunities were noted to be factors affecting the wild rice populations.

To be conclusive about the impacts recreational activities have on listed species and habitats, a study that is focused on the effects of recreational activities should be conducted. Using water quality data taken from locations where habitats supported the highest populations as a basis, one could compare the same factors where recreation activity actually occurs or immediately downstream from where recreation activity occurs. Type and intensity of recreation use and physical contact, and resulting changes within the banks and river bed would need to be documented, measured and evaluated. From stakeholder interviews, crowding, litter and alcohol are top issues. Beyond the wear and tear human activities cause on the landscape, including riverbed disruption (and resulting turbidity) from shear numbers, humans contribute all kinds of pollutants to these rivers via food, alcohol (excrement, vomit and urine) and lotions worn on the skin.

These rivers offer unique and highly valued recreation opportunities and as the population of Central Texas grows, recreational users will undoubtedly correspondingly increase. Although the upper reaches of each of these springs are restricted in terms of recreation, it should be determined if these areas are adequate in cultivating the growth or at least stabilizing the listed species populations. The questions of adverse and beneficial attributes (of recreation) and threshold and capacity (of recreation users) remain to be determined.





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## Appendix A: GIS Mapping Exhibits







**EARIP**  
**Recreation Areas**  
**New Braunfels**  
**Comal County, Texas**

**Map Key**

- Recreation Area
- Entry/Exit Area
- Parks
- TCEQ Clean Rivers Water Quality Stations

**Recreation Areas**  
**Tubing**  
**NB.1**

0 550 1,100  
Feet

OCT 2010

AVO 27520





# EARIP

## Recreation Areas

### New Braunfels

### Comal County, Texas

#### Map Key

- Recreation Area
- Entry/Exit Area
- Parks
- TCEQ Clean Rivers Water Quality Stations

## Recreation Areas

### Paddle Boats

### NB.2

05501,100

Feet

OCT 2010

AVO 27520





# EARIP

## Recreation Areas

### New Braunfels

### Comal County, Texas

### Map Key

- Recreation Area
- Entry/Exit Area
- Parks
- TCEQ Clean Rivers Water Quality Stations

## Recreation Areas

### Picnic Areas,

### RV Campgrounds

## NB.9

0

550

1,100

Feet

OCT 2010

AVO 27520





**EARIP**  
**Recreation Areas**  
**New Braunfels**  
**Comal County, Texas**

**Map Key**

-  Recreation Area
-  Entry/Exit Area
-  Parks
-  TCEQ Clean Rivers Water Quality Stations

**Recreation Areas**  
**Swift Water Rescue Training**  
**NB.4**

0 550 1,100  
Feet





OCT 2010 AVO 27520





**EARIP**  
**Recreation Areas**  
**New Braunfels**  
**Comal County, Texas**

**Map Key**

-  Recreation Area
-  Entry/Exit Area
-  Parks
-  TCEQ Clean Rivers Water Quality Stations

**Recreation Areas**  
**Swimming**  
**NB.5**

0 550 1,100  
Feet





AVO 27520  
OCT 2010