# Guadalupe Blanco River Authority
# And
# Upper Guadalupe River Authority
# Clean Rivers Program
# FY 2002-03

## Investigation of elevated sulfate concentrations in the Upper Blanco River

## Report

Prepared in Cooperation with the Guadalupe-Blanco River Authority and the Texas Commission on Environmental Quality Under the Authorization of the Texas Clean Rivers Act


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| | |
|---|---|
| **AWRL** | **Ambient Water Reporting Limits** |
| **CFR** | **Code of Federal Regulations** |
| **CRP** | **Clean Rivers Program** |
| **DQO** | **Data Quality Objective** |
| **EPA** | **US Environmental Protection Agency** |
| **FY** | **Fiscal Year** |
| **GBRA** | **Guadalupe-Blanco River Authority** |
| **QA** | **Quality Assurance** |
| **QAPP** | **Quality Assurance Project Plan** |
| **SOP** | **Standard Operating Procedure** |
| **SWQM** | **Surface Water Quality Monitoring** |
| **TCEQ** | **Texas Natural Resource Conservation Commission** |
| **TSWQS** | **Texas Surface Water Quality Standards** |
| **TWDB** | **Texas Water Development Board** |

## EXECUTIVE SUMMARY

A special study on the sub-watersheds of the upper Blanco River was conducted to investigate the occurrence of elevated sulfate concentrations observed during routine monitoring at the site located on the Blanco River at FM 165 in Blanco County in stream segment 1813. Between September 1999 and November 2000, eight of the thirteen possible sampling events conducted at the GBRA routine monitoring site had sulfate concentrations that were greater than the stream standard of 50 milligrams per liter (mg/L) and all thirteen were greater than the previous standard of 25 mg/L. Whereas, TCEQ would not be concerned about one site within the segment that exhibited impairment if it did not impact the segment as a whole, GBRA was concerned, based on the historical data, about the future impact the site could have on the categorization of the segment. GBRA felt that if a source of elevated sulfate could be identified prior to the listing of the segment as impaired, any subsequent intensive study or TMDL could be eliminated or minimized.

The study was divided into two phases. The first phase consisted of monthly monitoring at 12 locations for one year, mixed between main stem and tributaries, in addition to the current monitoring location on the Blanco River at FM 165. These sites were included to identify possible sources of sulfate or the watershed contributing elevated sulfate concentrations, while investigating the relationship between flow and sulfate in the Blanco River. Data was collected for flow, sulfate, temperature and conductivity. The sub-watersheds that were included are: Falls Creek, Crabapple Creek, Big Creek, McKinney Creek, Cottonwood Creek, and Koch Creek. The effluent from the Blanco wastewater treatment facility was monitored for sulfate and discharge volume.

A sub-watershed, Big Creek, was identified as a potential source of sulfate concentrations in Phase 1 of the study. Phase 2 was conducted in the second year of the biennium and was developed to focus monitoring efforts in that sub-watershed. The Phase 2 sites included the original site on Big Creek, an unnamed tributary to Big Creek, the East Prong of Big Creek and the West Prong of Big Creek.

During Phase 1, samples were collected from January 2002 through December 2002. During the monitoring conducted in this phase, one tributary, Big Creek, had a range of sulfate concentrations from 21.2 and 129 mg/L, with a mean sulfate concentration of 54.4 mg/L, 2.2 times greater than the mean sulfate concentration observed at the Blanco River at FM 165 site during the study period. The City of Blanco disposes of treated effluent by irrigating coastal bermuda. Only during times of the cutting of the hay does the city discharge its effluent to the Blanco River. There was no discharge of effluent to the Blanco River on the days that the river was being sampled.

It was observed at the main stem sites that there is an inverse relationship between flow and sulfate concentrations. As flow increases the sulfate concentration is diluted in the stream. The reduction of flow has less of an impact in five of the six tributaries; as the flow fluctuates the concentration of sulfate stays relatively stable. The one exception to this trend is in the Big Creek data. During low flow conditions, there was a marked increase in sulfate concentration.

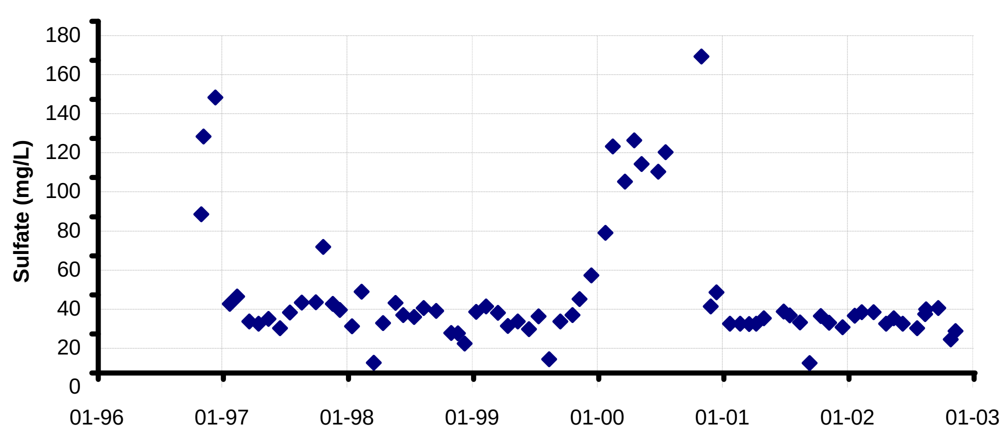
One possible explanation for the elevated sulfate could be a contribution of groundwater to Big Creek. Groundwater in the area of the Big Creek watershed is very high in sulfate concentration. Because of the apparent link between the sulfate concentrations and low flow or drought conditions, further research into land practices and water usage should be done on the Big Creek watershed to determine if there are any discharges of groundwater into the stream during these periods of dry conditions.

## INTRODUCTION

A special study on the sub-watersheds of the upper Blanco River was conducted to investigate the occurrence of elevated sulfate concentrations observed during routine monitoring at the site located on the Blanco River at FM 165 in Blanco County. The monitoring location is in Segment Number 1813, The Upper Blanco River. Segment 1813 is 71 miles in length and extends from a point 0.2 miles upstream of Limekiln Road in Hays County to the confluence of Meier Creek in Kendall County. Data collected at the Blanco River at FM 165, along with three additional monitoring locations, were included in the TCEQ assessment performed on the Upper Blanco River. For sulfate, TCEQ compares the annual average concentration of all of the stations in the segment to the stream standard for that segment.

Between September 1999 and November 2000, eight of the thirteen possible sampling events conducted at the GBRA routine monitoring site had sulfate concentrations that were greater than the stream standard of 50 milligrams per liter (mg/L) and all thirteen were greater than the previous standard of 25 mg/L (Appendix A). However, this did not result in the listing of the stream segment on the 303d list of impaired water bodies because the historical average sulfate concentration of the routine site as well as the stream segment remained below the stream standard (Figure 1) (PBS&J, 2003). Whereas, TCEQ would not be concerned about one site within the segment that exhibited impairment if it did not impact the segment as a whole, GBRA was concerned, based on the historical data, about the future impact the site could have on the categorization of the segment. GBRA felt that if a source of elevated sulfate could be identified prior to the listing of the segment as impaired, any subsequent intensive study or TMDL could be eliminated or minimized and save the state and river authority time and money.

**Figure 1. Historical sulfate concentrations at Blanco River at FM 165**




## PROJECT SIGNIFICANCE AND BACKGROUND

The Blanco River basin has 355 square miles of drainage basin. The area is prone to flash floods and high runoff rates. The average annual precipitation ranges from 32 to 36 inches and the evapotranspiration rate exceeds the annual precipitation. The area is dominated by limestone formations, with gravel, silt and clay strata. The basin lies on the Edwards Plateau, is a part of the Great Plains Province and overlies the Trinity Aquifer system (Engelke, 2002). The land use of the region includes recreation, including deer hunting, mining activities, and livestock grazing.

According to the Texas Water Development Board's Report 174, Ground-Water Resources of Blanco County, Texas, 1973, the ground water in the area is primarily used for rural-domestic and stock needs and to a lesser extent for municipal supply and irrigation. Because irrigation in the area is practiced only during periods of deficient rainfall, use of ground water for irrigation is considered safe. The sodium hazard is mostly low, but the salinity hazard ranges from medium to very high. The Blanco River watershed lies over Glen Rose Limestone which is made up of two layers, the first yielding small quantities of fresh to moderately saline water and the second yielding small to moderate amounts of fresh to slightly saline water. The report states that wells from the upper layer yield water having a high content of sulfate due to the poor quality water associated with gypsum deposits.

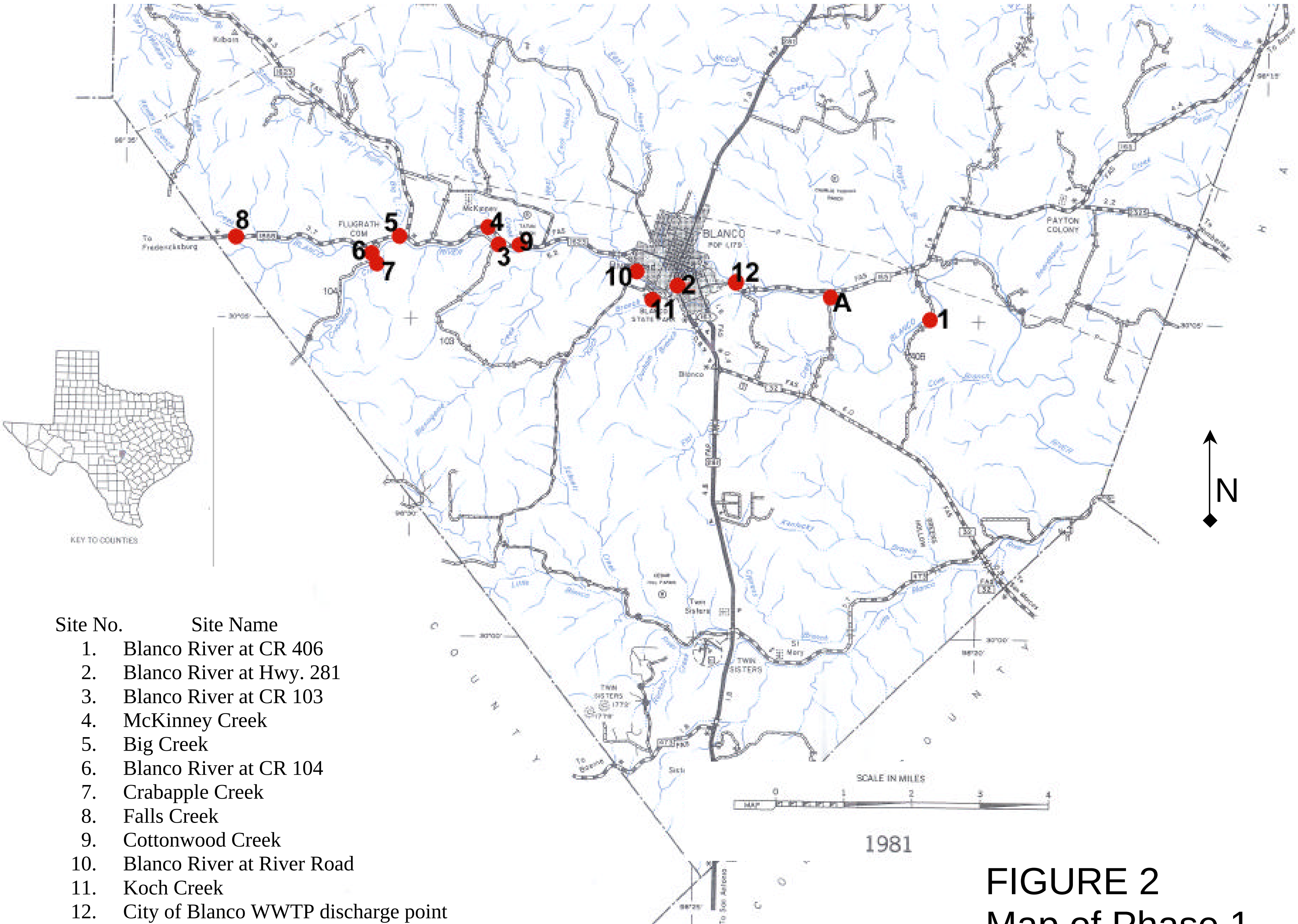
The city of Blanco treats surface water for its potable water supply. The sulfate concentration of the city's potable water published in the Texas Department of Health Chemical Analyses of Public Water Systems (1990) was 82 mg/L. The city's wastewater effluent is routinely disposed of by irrigating fields of coastal bermuda. Only during times when the hay is being harvested does the city discharge to the Blanco River. The city's discharge point is located approximately 2 miles upstream of the Blanco River at FM 165 monitoring location.

The study was divided into two phases. The first phase consisted of monthly monitoring at 12 locations for one year, mixed between main stem and tributaries, in addition to the current monitoring location on the Blanco River at FM 165. These sites were included to identify possible sources of sulfate or the watershed contributing elevated sulfate concentrations, while investigating the relationship between flow and sulfate in the Blanco River. Figure 2 is a map of the Phase 1 study area, with monitoring sites labeled. Data was collected for flow, sulfate, temperature and conductivity. The sites were located at county roads and state highways for accessibility. The sub-watersheds that were included are: Falls Creek, Crabapple Creek, Big Creek, McKinney Creek, Cottonwood Creek, and Koch Creek. In Phase 2, additional monitoring was conducted on the stream found to be exhibiting elevated sulfate concentrations relative to the other monitoring locations over the Phase 1 study period. The effluent from the Blanco wastewater treatment facility was monitored for sulfate and discharge volume.

Figure 3, Upper Blanco River Watersheds, is a map delineating the sub-watersheds monitored in the project. Those sub-watersheds not monitored in the study were intermittent or dry at the time of the project development.

A sub-watershed, Big Creek, was identified as a potential source of sulfate concentrations in Phase 1 of the study. Phase 2 was conducted in the second year of the biennium and was developed to focus monitoring efforts in that sub-watershed. Figure 4, Big Creek Watershed Study Sites, is a map of the Phase 2 study area, with monitoring sites labeled. The Phase 2 sites included the original site on Big Creek, an unnamed tributary to Big Creek, the East Prong of Big Creek and the West Prong of Big Creek.

Figure 5 is a land use map of Blanco River watershed. The study sub-watersheds are dominated by pasture, small grain and row croplands, and grasslands, with some forested areas. The Big Creek watershed, in addition to croplands, has bare rock outcroppings.




Site No. Site Name

1. Blanco River at CR 406
2. Blanco River at Hwy. 281
3. Blanco River at CR 103
4. McKinney Creek
5. Big Creek
6. Blanco River at CR 104
7. Crabapple Creek
8. Falls Creek
9. Cottonwood Creek
10. Blanco River at River Road
11. Koch Creek
12. City of Blanco WWTP discharge point

A. Blanco River at FM 165

FIGURE 2
Map of Phase 1
Study Area

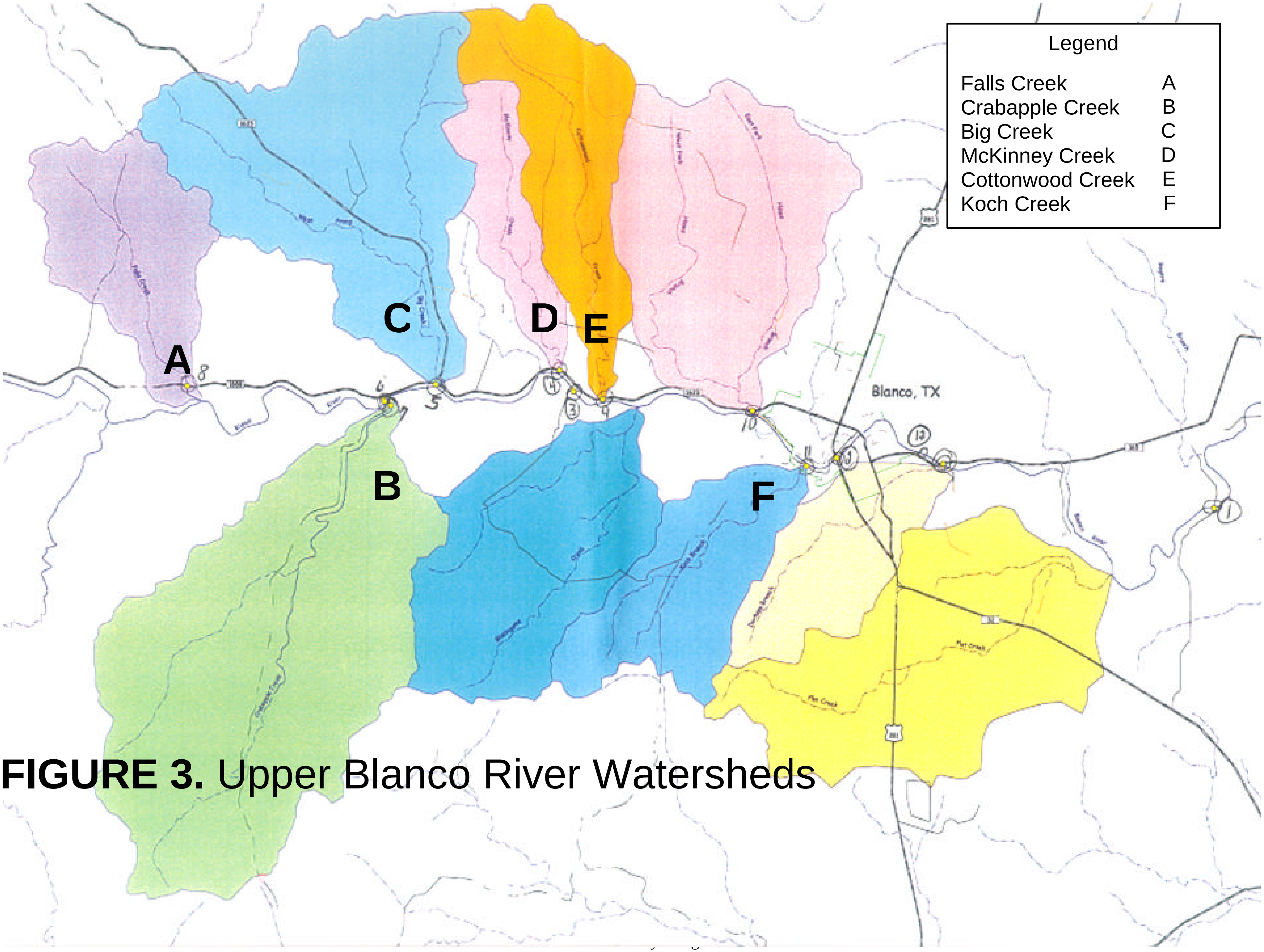
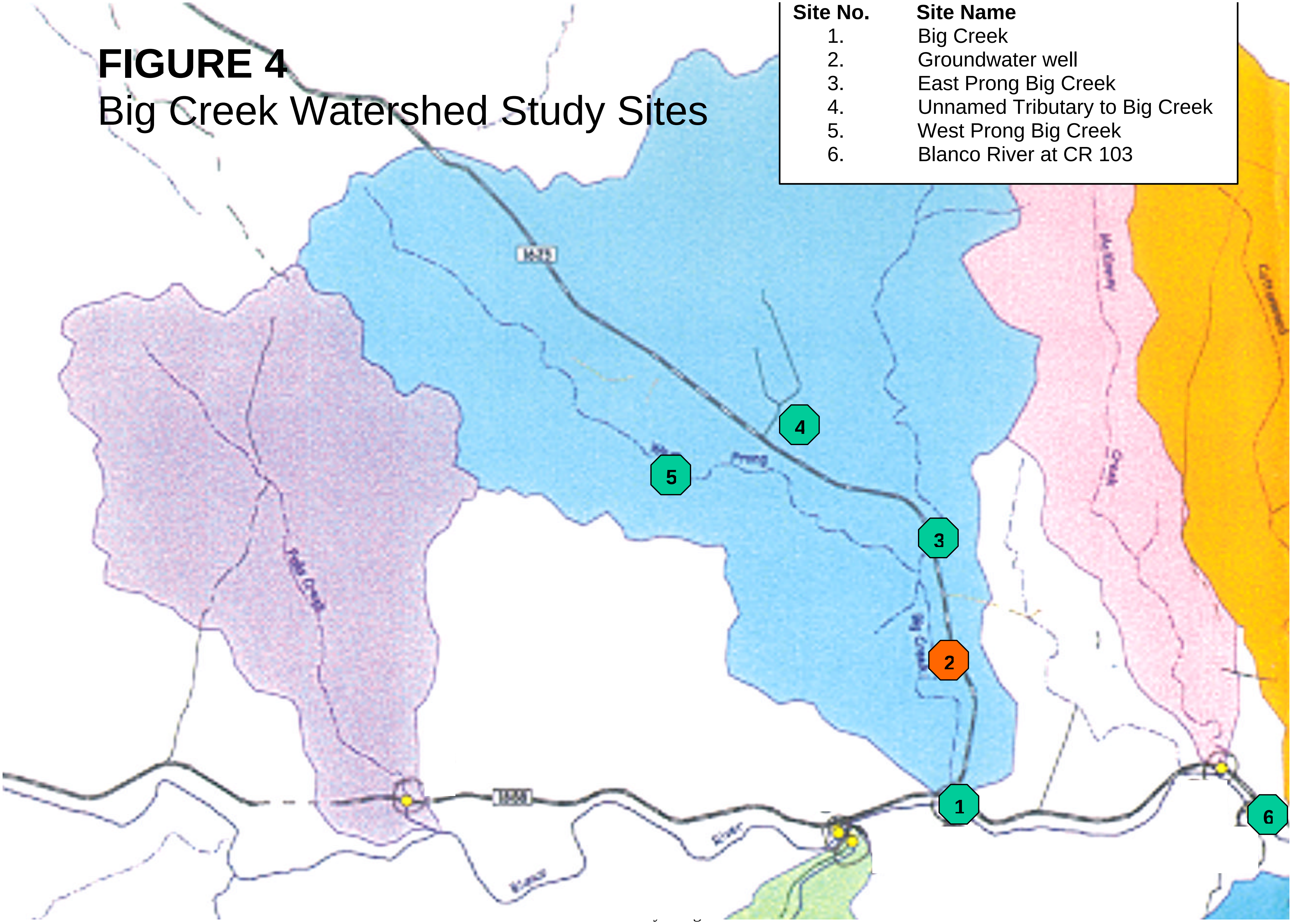



**FIGURE 3.** Upper Blanco River Watersheds

# FIGURE 4
Big Creek Watershed Study Sites




| Site No. | Site Name |
|---|---|
| 1. | Big Creek |
| 2. | Groundwater well |
| 3. | East Prong Big Creek |
| 4. | Unnamed Tributary to Big Creek |
| 5. | West Prong Big Creek |
| 6. | Blanco River at CR 103 |

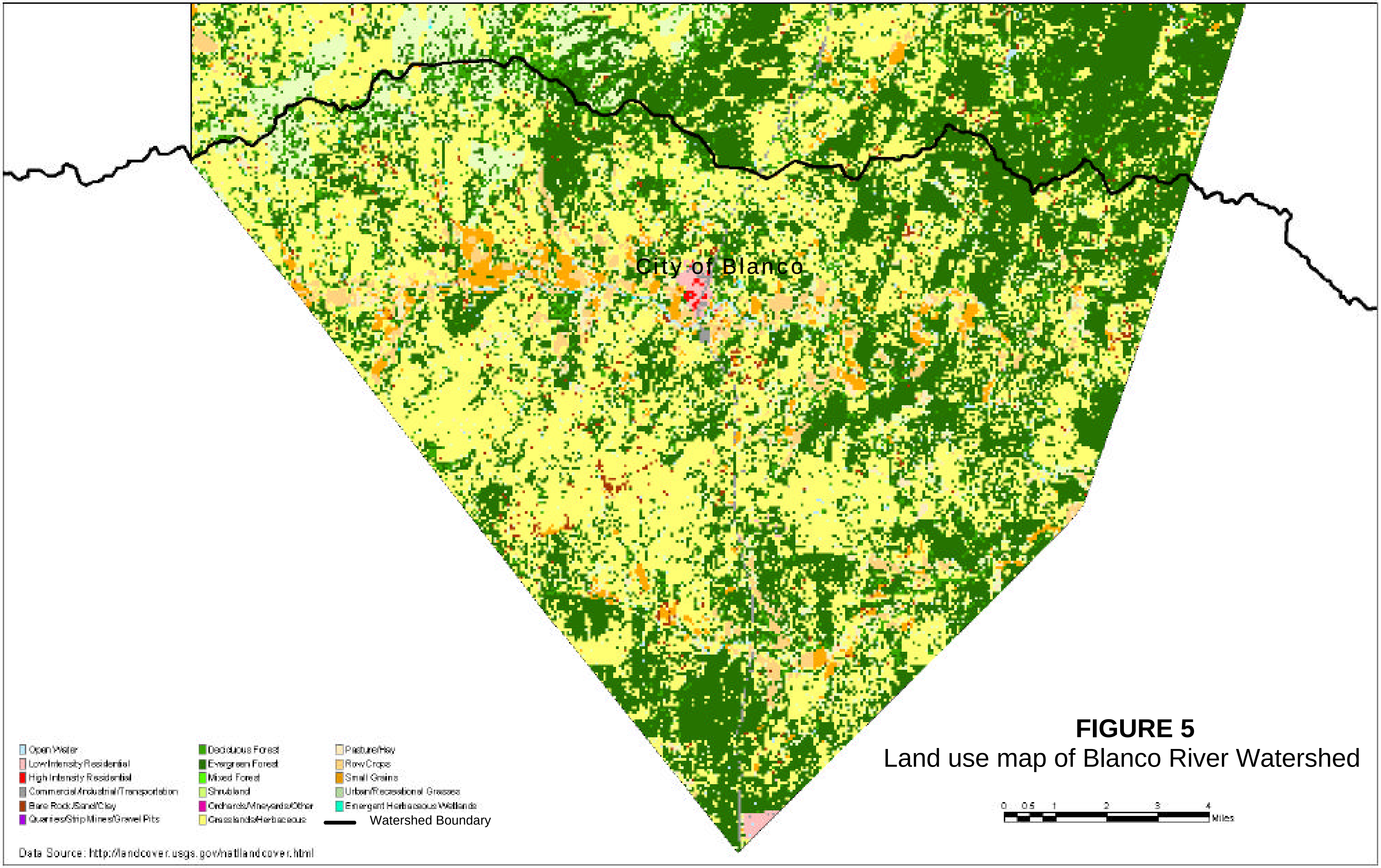



**FIGURE 5**
Land use map of Blanco River Watershed

## METHODS AND MATERIALS

The purpose of the project was to investigate the elevated sulfate concentrations found in the Upper Blanco River. The measurement performance criteria to support the project objectives are specified in Table 1. Sulfate concentrations and flow measurements at the special study sampling sites were compared to concentrations and flow measured at the existing monitoring location as well as to the stream standard. The following decision process was used to assess study findings:

<u>Question 1:</u> Does the monitoring site upstream of the existing monitoring site exhibit similar levels of sulfate as the existing monitoring site?

<u>Decision Rule 1:</u> If the concentration of flow-corrected sulfate in mg/L at the existing monitoring site is greater than 25% of the closest upstream site on average over the period of the study, then there may be a significant source of sulfate in that reach of the stream.

<u>Question 2:</u> Do any of the monitoring sites exhibit significant levels of sulfate and cause levels in the Blanco River to become elevated downstream?

<u>Decision Rule 2</u>: If, after one year of monthly sampling, one or more upstream sites are found to have significantly higher (approximately 25% or greater) concentrations of sulfate than the others on an event basis (at least 50% of the time), then additional monitoring will take place in that (those) sub-watersheds in an attempt to locate the source of the elevated sulfate concentrations. If none of the special study sampling sites shows significantly greater concentrations of sulfate than the other sites, then no additional monitoring will take place. Based on decision rule 2, Phase 2 was developed to focus monitoring efforts on the Big Creek watershed. During Phase 1, 42% of the sulfate concentrations measured at the Big Creek monitoring location exceeded the stream standard of 50 mg/L. None of sulfate concentrations measured at the other subwatershed sites exceeded the stream standard at any time during the study period.

**Table 1. Data Quality Objectives for the Blanco River Sulfate Study**

| PARAMETER | UNITS | MATRIX | METHOD | STORET | AWRL | PRECISION of laboratory duplicates (RPD) | ACCURACY at AWRLS (%Rec.) | ACCURACY of lab matrix spikes (%Rec.) | LABORATORY PERFORMING ANALYSIS |
|---|---|---|---|---|---|---|---|---|---|
| ***Field Parameters*** | | | | | | | | | |
| Conductivity | umhos/cm | water | SM 2510 and TNRCC SOP | 00094 | NA[1] | NA | NA | NA | GBRA |
| Temperature | $^{o}$ C | water | SM 2550 B. and TNRCC SOP | 00010 | NA[1] | NA | NA | NA | GBRA |
| Flow | cfs | water | TNRCC SOP | 00061 | NA[1] | NA | NA | NA | GBRA |
| Flow measurement method | 1- gage 2-electric | water | TNRCC SOP | 89835 | NA[1] | NA | NA | NA | GBRA |
| ***Conventional Parameters*** | | | | | | | | | |
| Sulfate | mg/L | water | EPA 300 | 00945 | 10 | 10 | 75-125 | 80-120 | GBRA |
| Sulfate[2] | mg/L | water | SM 4500-$SO_4$ E. | 00945 | 10 | 10 | 75-125 | 80-120 | GBRA |

1 Reporting to be consistent with SWQM guidance and based on measurement capability.
2 Secondary method listed. To be used in the event that the primary method cannot be used or needs to be confirmed, i.e. automated method cannot be used due to instrument failure.

The field sampling procedures are documented in the TCEQ *Surface Water Quality Monitoring Procedures Manual* (1999, or subsequent editions). Samples for sulfate analysis were collected and stored on ice as described above and delivered by lab personnel, along with the chain of custody, to the GBRA Regional Laboratory in Seguin, Texas. The analytical methods, and associated matrices are listed in Table 1. The authority for analysis methodologies under the Clean Rivers Program is derived from the TSWQS (307.1-307.10) in that data generally are generated for comparison to those standards and/or criteria. The Standards state that a procedure for laboratory analysis will be in accordance with the most recently published edition of *Standard Methods for the Examination of Water and Wastewater*, the latest version of the TCEQ *Surface Water Quality Monitoring Procedures Manual*, 40 CFR 136 or other reliable procedures acceptable to the executive director. Copies of laboratory SOPs are retained by GBRA and are available for review by the TCEQ. Laboratory SOPs are consistent with EPA requirements as specified in the method. The quality control practices were prescribed in the 2002-03 QAPP, Section B5.

## RESULTS AND OBSERVATIONS

Data collected during the project is tabulated in Appendix B. Samples were collected from January 2002 through December 2002. All samples were collected during mid-day. There was a broad range of flow conditions in the Upper Blanco River during the study period, ranging between 2.4 (low) and 300 (high) cubic feet per second (cfs). There was one flood event that occurred in July. During that event, flows at the Blanco River sites ranged between 250 to 300 cfs. As expected, flows in the sub-watersheds were considerably lower than the main stem sites throughout the study period. There were periods of dry conditions in two of the tributaries (see Appendix B).

Mean concentrations for the parameters measured are given in Table 2. The sulfate concentrations at the main stem sites ranged from 15.6 to 33.7 mg/L. Five of the six tributaries monitored in Phase 1 of the study had sulfate concentrations that ranged from 12.6 to 38.3 mg/L. During the monitoring conducted in Phase 1, one tributary, Big Creek, had a range of sulfate concentrations from 21.2 and 129 mg/L, with a mean sulfate concentration of 54.4 mg/L. This mean concentration is 2.2 times greater than the mean sulfate concentration observed at the Blanco River at FM 165 site during the study period.

Data collected in Phase 2 of the study is in Appendix C. Over the six months in Phase 2, the sulfate concentration was increasing at the Big Creek site. The trend was also observed in the East Prong of Big Creek. The concentration of sulfate more than doubled in the six-month period in the two tributaries. The trend was not as obvious in the unnamed tributary to Big Creek or the West Prong of Big Creek.

The City of Blanco disposes of treated effluent by irrigating coastal bermuda. Only during times of the cutting of the hay does the city discharge its effluent to the Blanco River. The effluent volumes discharged during the study period are noted in Appendix B, but there was no discharge of effluent to the Blanco River on the days that the river was being sampled.

It was observed at the main stem sites that there is an inverse relationship between flow and sulfate concentrations (Figures 6.a.-l.). As flow increases the sulfate concentration is diluted in the stream. The reduction of flow has less of an impact in five of the six tributaries; as the flow fluctuates the concentration of sulfate stays relatively stable. The one exception to this trend is in the Big Creek data. During low flow conditions, there was a marked increase in sulfate concentration.

Table 2. Mean concentrations observed at each monitoring site in Phase 1 (sub-watersheds shaded).

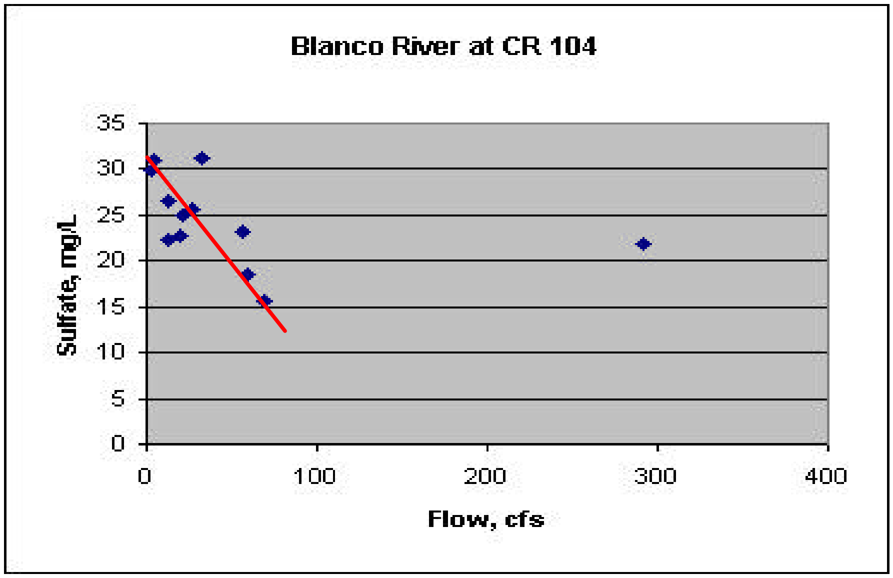
| **Parameter** | **Falls Creek** | **Blanco at CR 104** | **Crabapple Creek** | **Big Creek** | **McKinney Creek** | **Blanco at CR 103** | **Cotton-wood Creek** | **Blanco at River Rd.** | **Koch Creek** | **Blanco at Hwy 281** | **City of Blanco effluent** | **Blanco at CR 406** | **Blanco at FM 165** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow, cfs | 1.5 | 50.6 | 10.2 | 3.1 | 0.7 | 62.3 | 1.7 | 62.3 | 2.1 | 62.6 | | 63 | 64.9 |
| | | | | | | | | | | | | | |
| Temperature, °C | 19.3 | 20 | 19.8 | 20.3 | 19.3 | 21.8 | 18.6 | 21.2 | 20.8 | 21.6 | | 21.6 | 21.9 |
| Conductivity, umhos/cm | 605 | 502 | 477 | 607 | 551 | 491 | 593 | 512 | 564 | 512 | | 499 | 488 |
| Sulfate, mg/L | 25.9 | 24.4 | 16.4 | 54.4 | 28.6 | 25.5 | 30.8 | 26.4 | 15.5 | 25.2 | 57.8 | 27.6 | 25.1 |

**Figure 6 (a-l). Comparison of flow to sulfate concentration at monitoring sites in Phase 1.**

**a. Blanco River at CR 104**

| flow | sulfate |
|---|---|
| 26.9 | 25.7 |
| 20.6 | 24.9 |
| 12.9 | 26.5 |
| 13.1 | 22.2 |
| 4.47 | 30.9 |
| 2.43 | 29.8 |
| 292 | 21.9 |
| 33 | 31.2 |
| 19.1 | 22.7 |
| 68.6 | 15.6 |
| 58.8 | 18.4 |
| 55.8 | 23.2 |

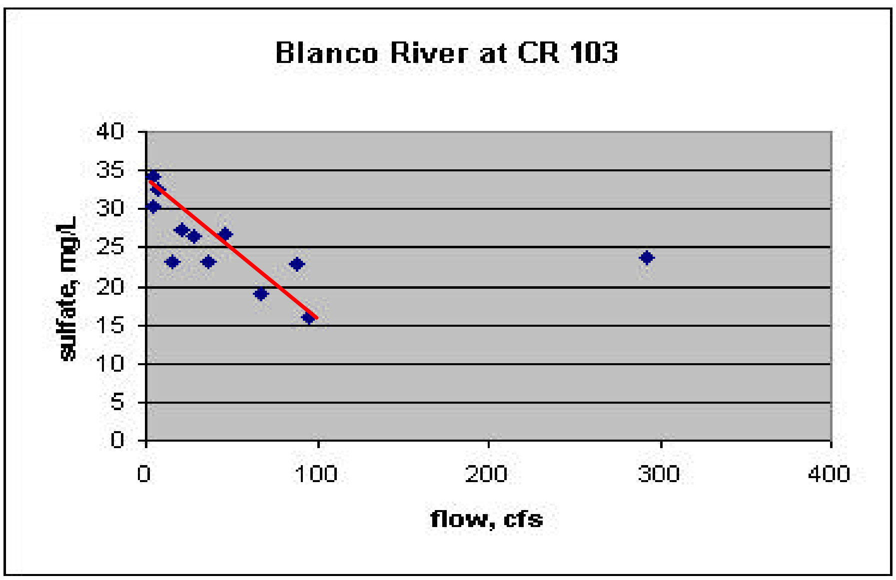
$r^2$=-0.36




**b. Blanco River at CR 103**

| flow | sulfate |
|---|---|
| 46 | 26.8 |
| 28.6 | 26.4 |
| 20.8 | 27.3 |
| 16 | 23.2 |
| 6.6 | 32.5 |
| 3.7 | 30.4 |
| 292 | 23.6 |
| 4.7 | 34.2 |
| 36.8 | 23.2 |
| 95 | 15.9 |
| 66.7 | 19.1 |
| 87.6 | 23 |

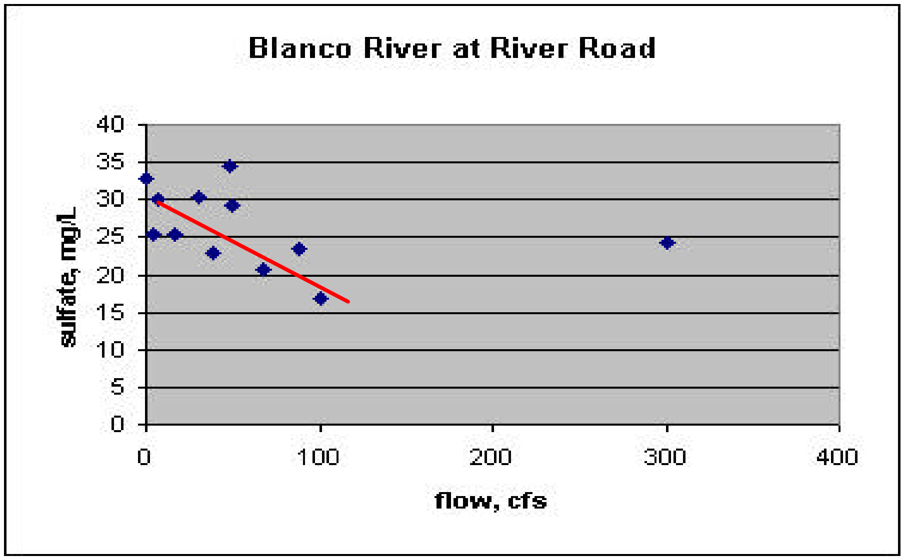
$r^2$=-0.43



**c. Blanco River at River Road**

| flow | sulfate |
|---|---|
| 50 | 29.3 |
| 30 | 30.4 |
| 0.1 | 32.9 |
| 16 | 25.4 |
| 7 | 30.2 |
| 4 | 25.4 |
| 300 | 24.3 |
| 48 | 34.6 |
| 38 | 22.8 |
| 100 | 16.9 |
| 67 | 20.8 |
| 88 | 23.4 |

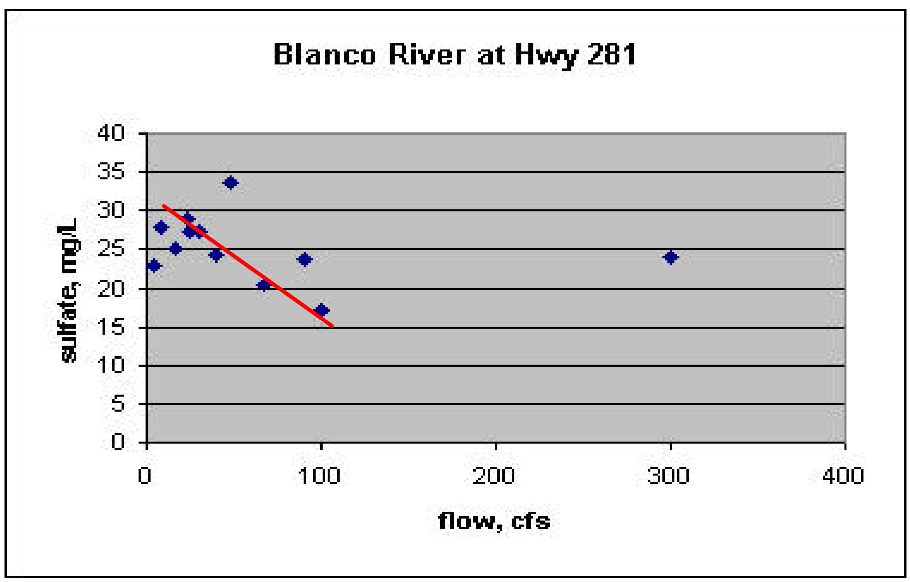
$r^2$=-0.36




**d. Blanco River at Hwy 281**

| flow | sulfate |
|---|---|
| 25 | 27.3 |
| 30 | 27.3 |
| 23 | 29.1 |
| 16 | 25 |
| 8 | 27.8 |
| 4 | 22.9 |
| 300 | 24 |
| 48 | 33.7 |
| 40 | 24.3 |
| 100 | 17 |
| 67 | 20.5 |
| 90 | 23.7 |

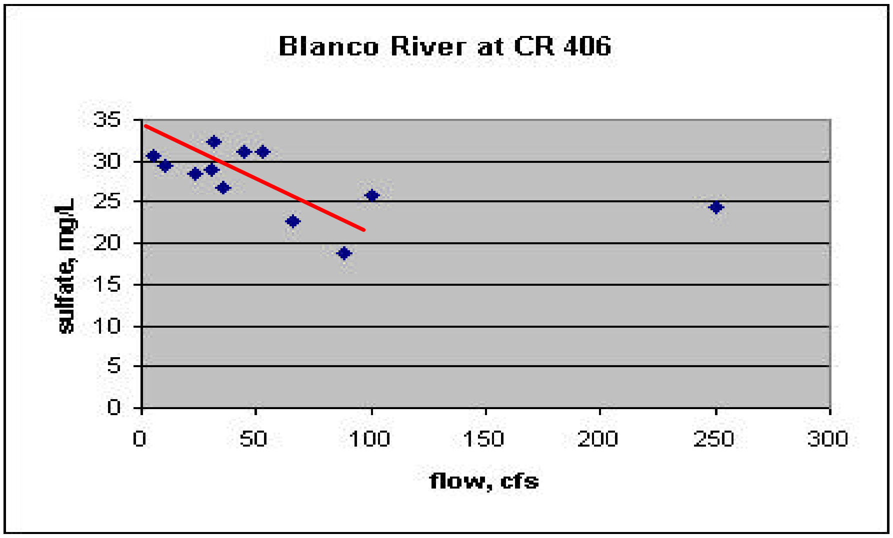
$r^2$=-0.28



**e. Blanco River at CR 406**

| flow | sulfate |
|---|---|
| 30 | 29 |
| 23 | 28.6 |
| 45 | 31.2 |
| 35 | 26.8 |
| 9.8 | 29.4 |
| 4.7 | 30.7 |
| 250 | 24.4 |
| 31.5 | 32.4 |
| 53 | 31.2 |
| 88 | 18.8 |
| 65.9 | 22.8 |
| 100 | 25.9 |

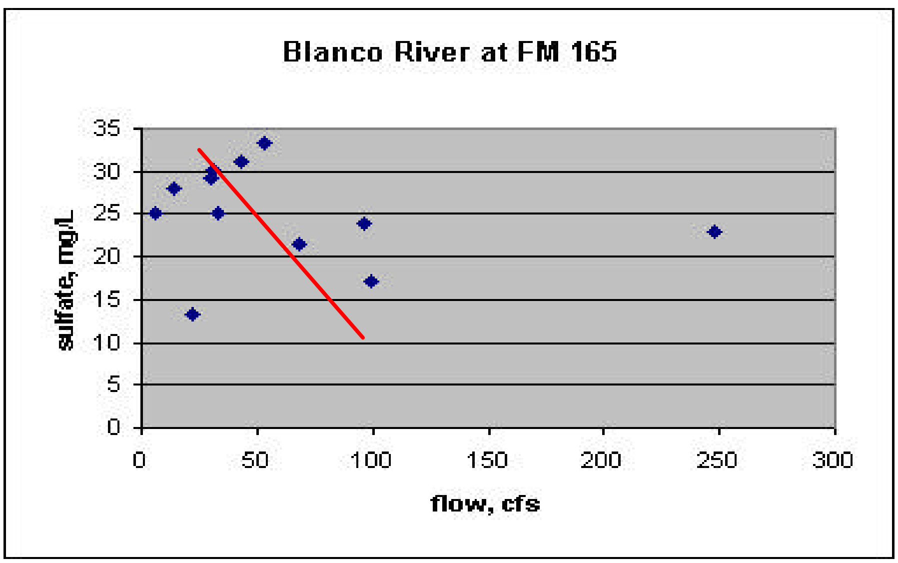
$r^2$=-0.51




**f. Blanco River at FM 165**

| flow | sulfate |
|---|---|
| 30.4 | 29.3 |
| 21.7 | 13.2 |
| 42.7 | 31.1 |
| 33 | 25.2 |
| 14.5 | 28 |
| 6.28 | 25.2 |
| 248 | 22.9 |
| 31.5 | 30.2 |
| 53 | 33.2 |
| 99 | 17.2 |
| 68.6 | 21.4 |
| 96.7 | 23.8 |

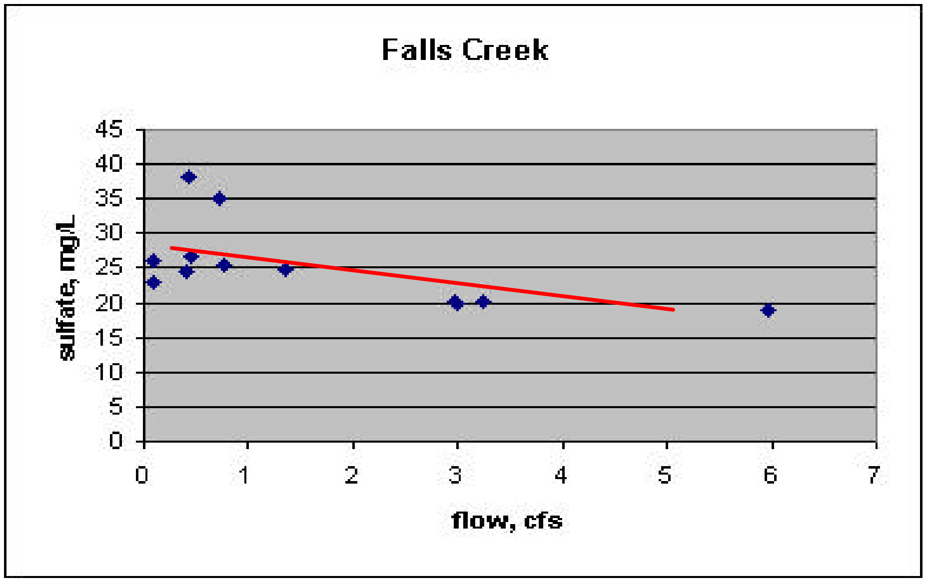
$r^2$=-0.22



**g. Falls Creek**

| flow | sulfate |
|---|---|
| 1.36 | 24.9 |
| 0.77 | 25.6 |
| 0.45 | 26.6 |
| 0.4 | 24.5 |
| 0.1 | 26 |
| 0.1 | 22.9 |
| 5.97 | 18.8 |
| 0.71 | 35.2 |
| 0.42 | 38.3 |
| 3 | 20 |
| 2.98 | 20.2 |
| 3.25 | 20.2 |

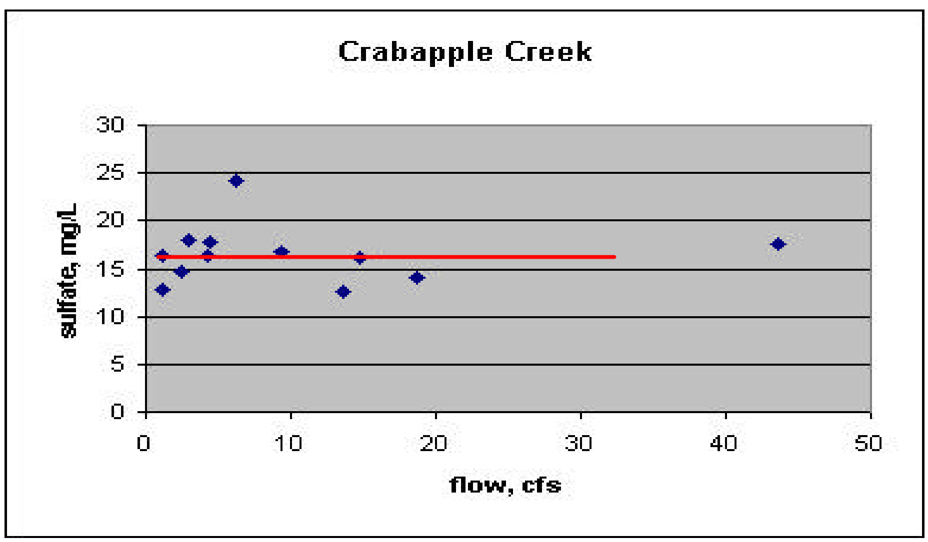
$r^2$=-0.58




**h. Crabapple Creek**

| flow | sulfate |
|---|---|
| 9.34 | 16.7 |
| 4.36 | 17.7 |
| 3 | 17.9 |
| 2.5 | 14.6 |
| 1.1 | 16.4 |
| 1.1 | 12.9 |
| 43.6 | 17.5 |
| 6.26 | 24.2 |
| 4.26 | 16.4 |
| 13.6 | 12.6 |
| 18.7 | 14.1 |
| 14.8 | 16.1 |

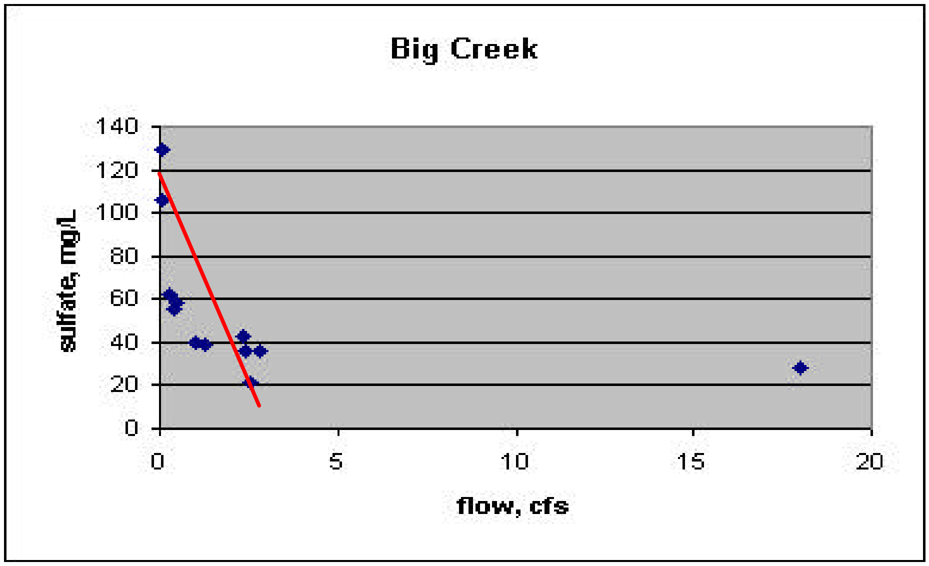
$r^2$=-0.00



### i. Big Creek

| flow | sulfate |
|---|---|
| 2.54 | 21.2 |
| 0.98 | 39.6 |
| 0.44 | 58 |
| 0.24 | 62.3 |
| 0.1 | 106 |
| 0.1 | 129 |
| 18 | 28.5 |
| 2.36 | 43 |
| 0.41 | 55.1 |
| 1.24 | 38.7 |
| 2.44 | 36.2 |
| 2.81 | 35.6 |

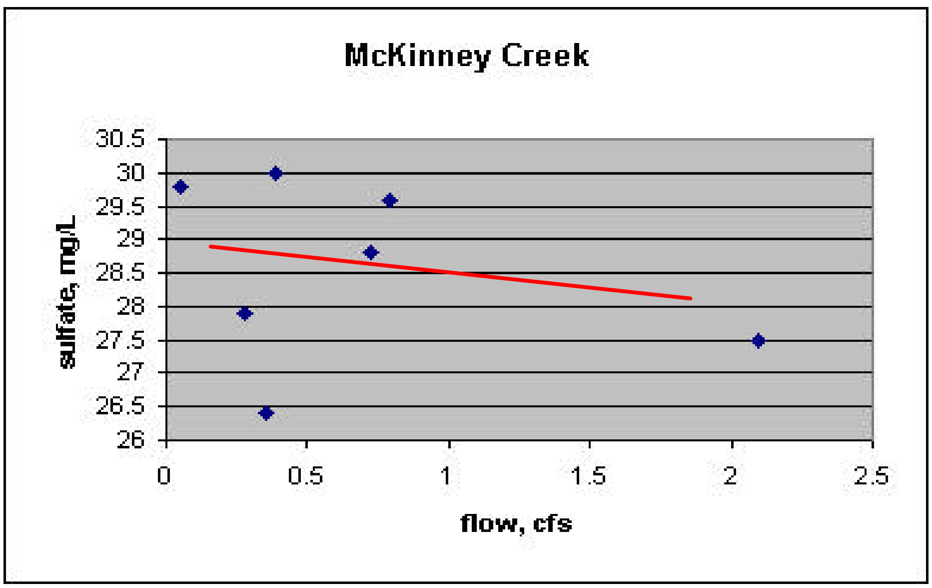
$r^2$=-0.40




### j. McKinney Creek

| flow | sulfate |
|---|---|
| 0.35 | 26.4 |
| 0.05 | 29.8 |
| | |
| 2.1 | 27.5 |
| 0.72 | 28.8 |
| | |
| 0.28 | 27.9 |
| 0.39 | 30 |
| 0.79 | 29.6 |

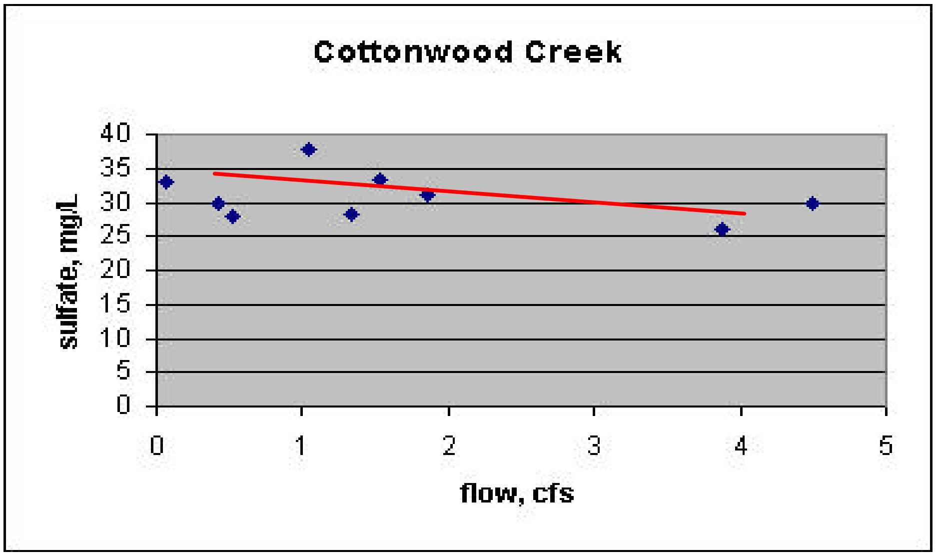
$r^2$=-0.29



**k. Cottonwood Creek**

| flow | sulfate |
|---|---|
| 1.53 | 33.2 |
| 0.52 | 28 |
| 0.06 | 32.9 |
| | |
| | |
| | |
| 4.5 | 29.9 |
| 1.05 | 37.8 |
| 0.42 | 30 |
| 3.87 | 25.9 |
| 1.85 | 31.1 |
| 1.33 | 28.4 |

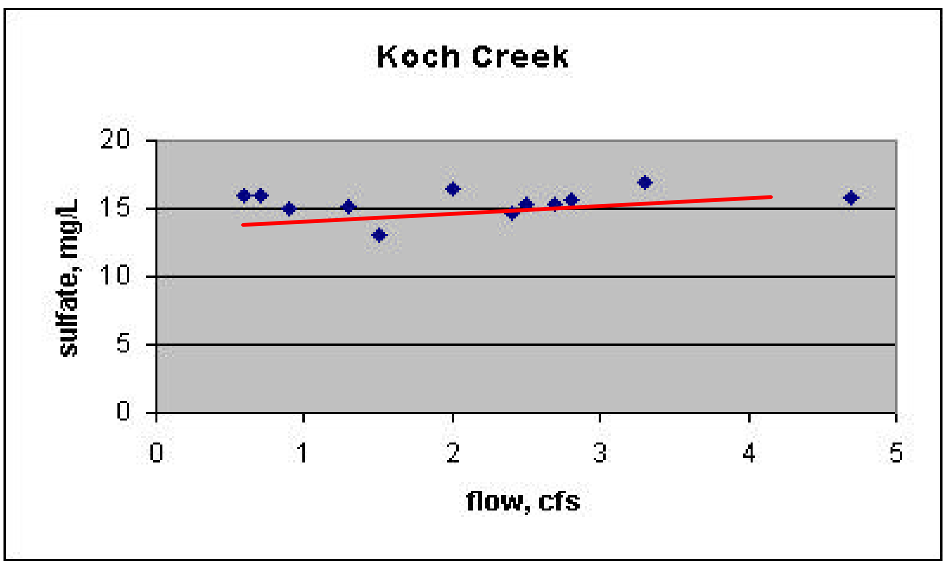
$r^2$=-0.38




**l. Koch Creek**

| flow | sulfate |
|---|---|
| 2.7 | 15.4 |
| 2.4 | 14.7 |
| 1.3 | 15.2 |
| 0.9 | 15 |
| 0.7 | 16 |
| 0.6 | 15.9 |
| 4.7 | 15.8 |
| 2 | 16.4 |
| 1.5 | 13 |
| 2.8 | 15.7 |
| 2.5 | 15.4 |
| 3.3 | 16.9 |

$r^2$=0.46



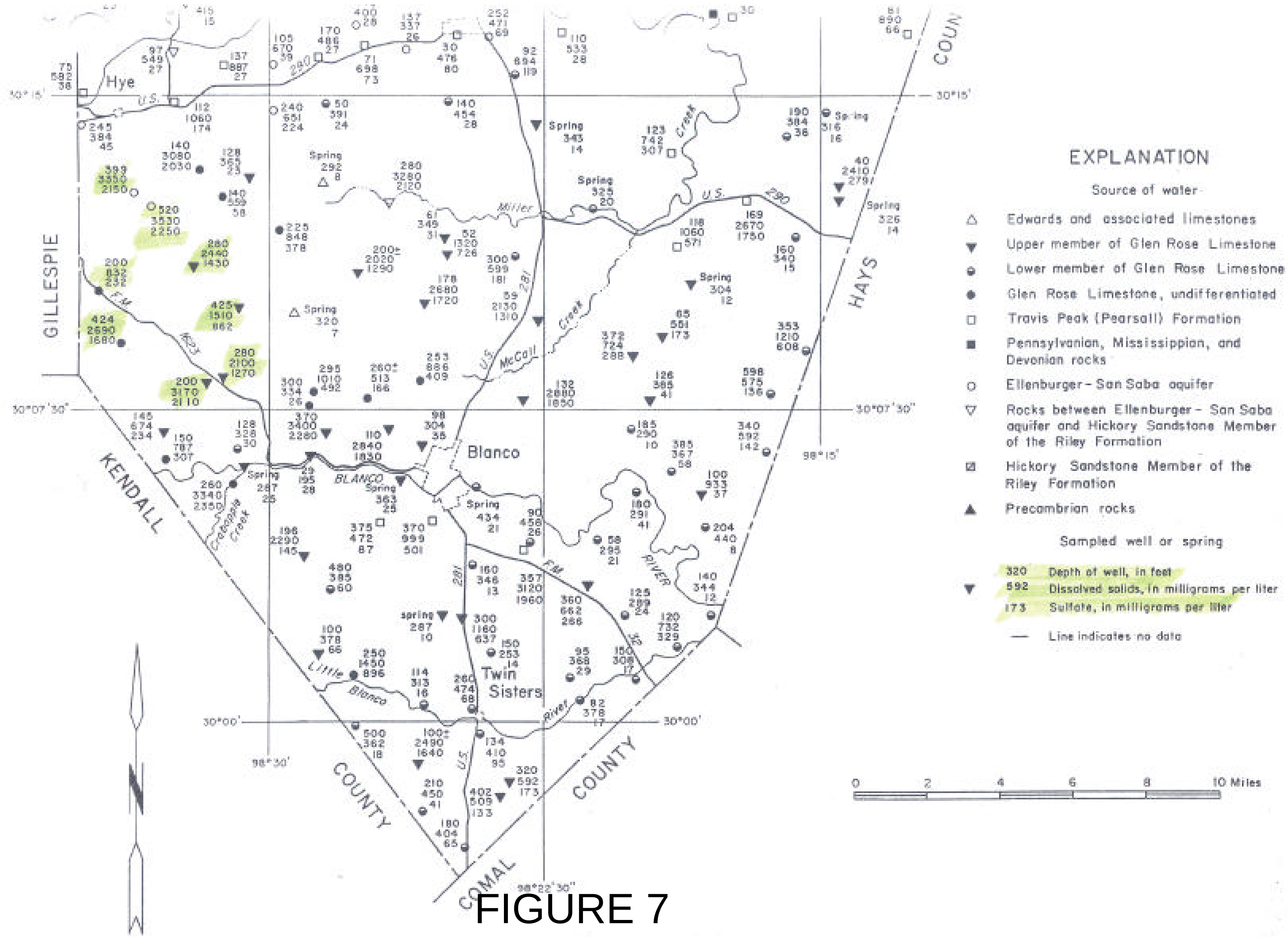
## DISCUSSION

One possible explanation for the elevated sulfate could be a contribution of groundwater to Big Creek. Groundwater in the area of the Big Creek watershed is very high in sulfate concentration. Figure 7, Sulfate and Dissolved Solids Content of Water From Wells and Springs, is a map taken from the TWDB report 174 with the wells in the Big Creek watershed highlighted. Wells in this part of the county have sulfate concentrations as high as 2250 mg/L. There could be an artesian source upstream of the confluence of the Big Creek with the Blanco River, although according to the TWDB report the wells in Blanco County that are known to occur under artesian conditions are low in sulfate concentration. A more likely scenario is that there may be the operation of a well that is contributing to the flow of the stream during low flow conditions. The historical data at the routine monitoring site supports this explanation in that it was during low river flow conditions that the spike in sulfate concentrations occurred. Although not as high as the wells highlighted in Figure 7, the well monitored in the sub-watershed had a sulfate concentration of 77.3 mg/L which is over 50 percent greater than the stream standard of 50 mg/L.

The City of Blanco intermittently discharges its treated wastewater to the stream. In most cases, it irrigates with its effluent. The city was not discharging to the Blanco River during the time when the original spikes in sulfate occurred. It is unlikely that the city's effluent was the source of the sulfate.

## CONCLUSIONS

It is felt that the watershed contributing elevated sulfates to the Upper Blanco River has been identified by this data collection and further research into land practices and water usage should be done on the Big Creek watershed. The Texas Agricultural Extension Agent located in Blanco County should be contacted to learn of businesses or agricultural practices in the sub-watershed. It appears that there is a link between the sulfate concentrations and low flow or drought conditions. If it is learned that there are businesses that use groundwater high in sulfates during times of drought, there should be discussions with the business manager of the impacts their discharge of groundwater to the surface water is having. Another possible remedy to these impacts during times of drought may be an increase in availability of surface water to Blanco County from other sources that will make the use of groundwater less advantageous.




# FIGURE 7

Sulfate and Dissolved-Solids Content of Water From Wells and Springs

## REFERENCES

Engelke, Drew. 2000. Blanco River Basin at Wimberley, Texas. SWT Geography 5334 Water Resource Management.

Guadalupe-Blanco River Authority. 2001. Quality Assurance Project Plan. Surface Water Quality Monitoring Project for the Guadalupe River Basin.

Land use map: http://landcover.usgs.gov/natllandcover.html

PBS&J. 2003. Basin Summary Report. Guadalupe River and Lavaca-Guadalupe Coastal Basin.

Texas Department of Health. 1990. Chemical Analyses of Public Water Systems.

Texas Water Development Board. 1973. Report 174. Ground-Water Resources of Blanco County, Texas