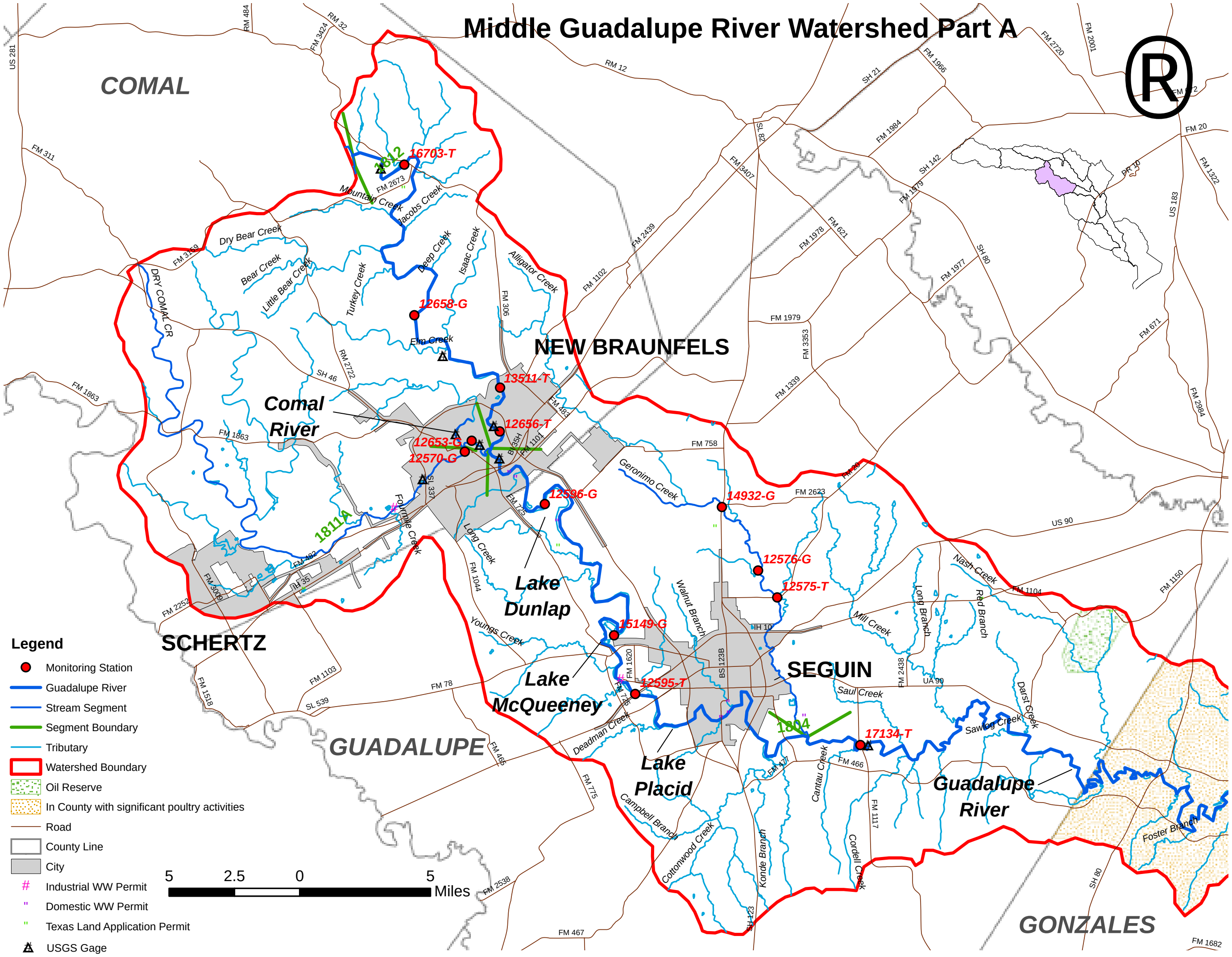


Monitoring Stations – Middle Guadalupe River Watershed Part A

16703-T	Guadalupe River at FM 306, downstream of Horseshoe Falls
12658-G	Guadalupe River at Second Crossing
13511-T	Guadalupe River at Gruene Bridge
12656-T	Guadalupe River at Cypress Bend Park in New Braunfels
12653-G	Comal River downstream Clemons Dam (Hinman Island)
12570-G	Dry Comal Creek at Missouri-Kansas Railroad Crossing
12596-G	Lake Dunlap at AC's Place
15149-G	Lake McQueeney near the dam at Hot Shots
12595-T	Guadalupe River at IH 10 (Lake Placid)
14932-G	Geronimo Creek at SH 123
12576-G	Geronimo Creek at Haberle Road
12575-T	Geronimo Creek at FM 20
17134-T	Guadalupe River at FM 1117

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

Middle Guadalupe Watershed (Part A)

Drainage Area: 939 square miles

Streams and Rivers: Guadalupe River below Canyon Dam, Dry Comal Creek, Comal River, Geronimo Creek

Lakes: Lake Dunlap, Lake McQueeney, Lake Placid

Aquifers: Edwards Trinity, Edwards Balcones Fault Zone, Carrizo Wilcox

River Segments: 1804, 1804A, 1811, 1811A, 1812

Cities: Sattler, New Braunfels, Schertz, Seguin, Geronimo, Kingsbury

Counties: Comal, Guadalupe, Gonzales

EcoRegions: Texas Blackland Prairies, Post Oak Savannah

Vegetation Cover:

Pasture/Hay- 25.5%	Grass/Herbaceous - 15.1%
Evergreen Forest - 18.0%	Shrublands - 12.0%
Deciduous Forest - 15.5%	Row Crops - 8.1%

Climate:

Average annual rainfall: 29 inches

Average annual temperature: January 35° July 95°

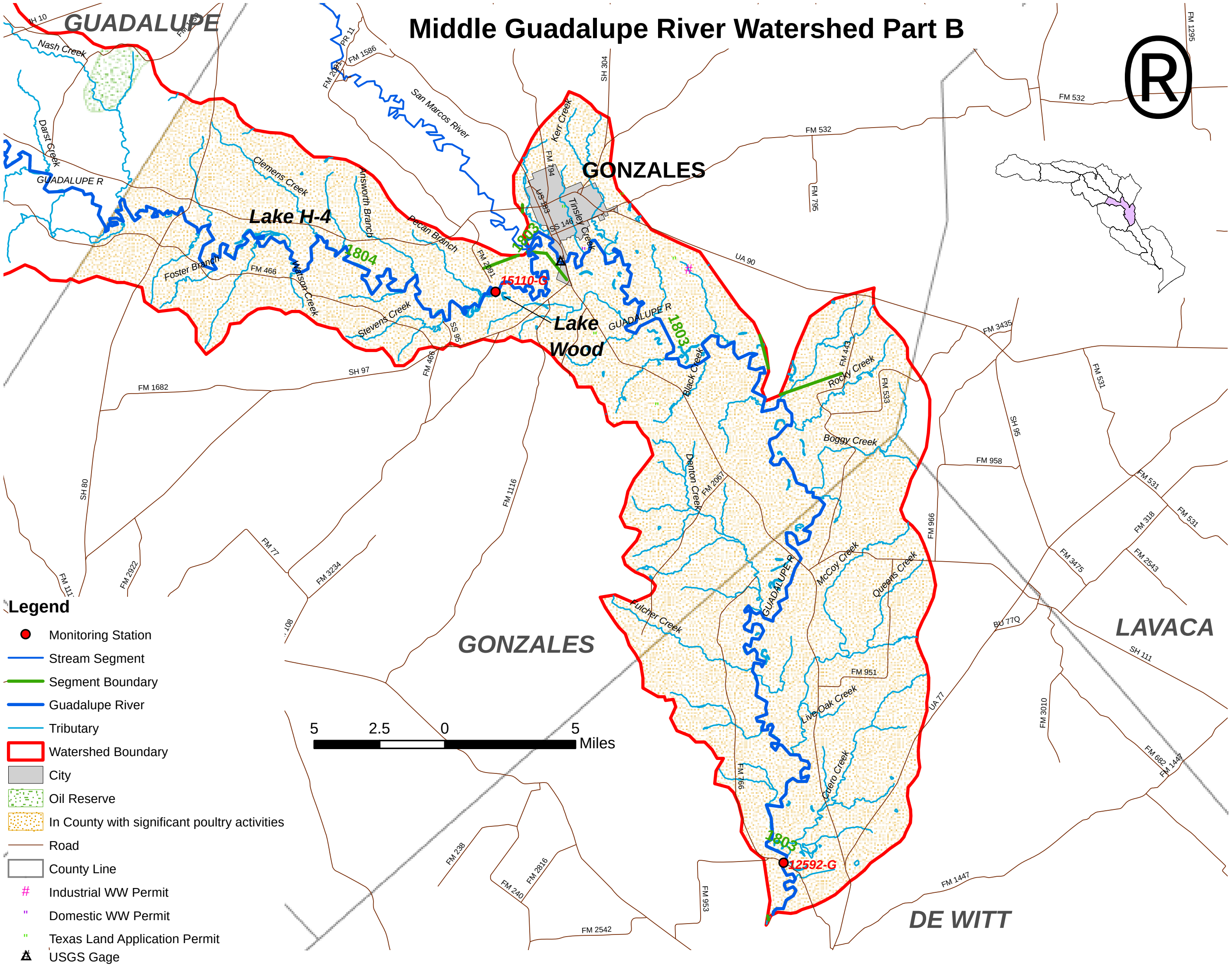
Land Uses: Urban, Light Manufacturing, Heavy Manufacturing, Farming, Cattle Ranching, Poultry, Petroleum Production, Gravel Mining

Water Body Uses: Aquatic Life, Contact Recreation, Fish Consumption, General, Public Water Supply, Hydroelectricity, Agricultural Crops, Industrial

Soils: Dark, calcareous clay, sandy loam, loam with clay subsoils; dark red sandstone, light tan and gray sandstone

Permitted Wastewater Treatment Facilities:

Domestic: 8, Land Application: 5, Industrial: 4



Monitoring Stations – Middle Guadalupe River Watershed Part B

15110-G	Guadalupe River below Lake Wood (H-5) dam
12592-G	Guadalupe River at FM 766

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

Middle Guadalupe Watershed (Part B)

Drainage Area: 939 square miles

Streams and Rivers: Guadalupe River below Canyon Dam, Guadalupe River from confluence with the San Marcos River

Lakes: Lake H-4, Lake Wood

Aquifers: Carrizo Wilcox

River Segments: 1803, 1804

Cities: Gonzales

Counties: Guadalupe, Gonzales, Lavaca, DeWitt

EcoRegions: Texas Blackland Prairies, Post Oak Savannah

Vegetation Cover:

Pasture/Hay- 25.5%	Grass/Herbaceous - 15.1%
Evergreen Forest - 18.0%	Shrublands - 12.0%
Deciduous Forest - 15.5%	Row Crops - 8.1%

Climate:

Average annual rainfall: 29 inches

Average annual temperature: January 35° July 95°

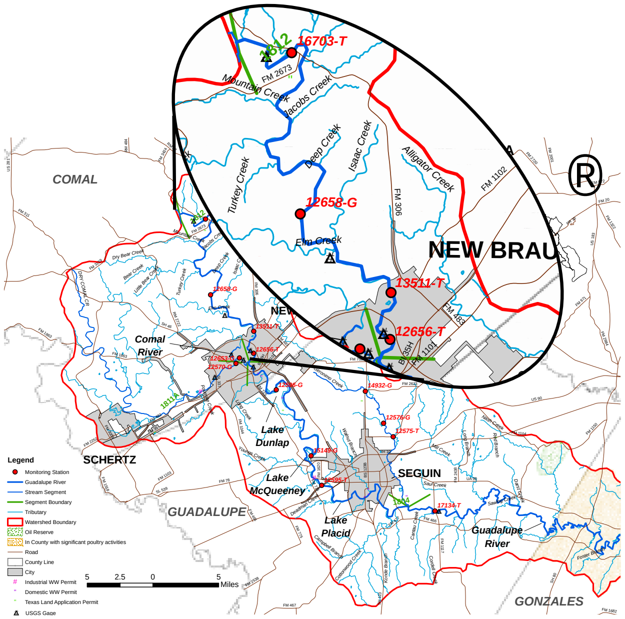
Land Uses: Urban, Light Manufacturing, Heavy Manufacturing, Farming, Cattle Ranching, Poultry, Petroleum Production, Gravel Mining

Water Body Uses: Aquatic Life, Contact Recreation, Fish Consumption, General, Public Water Supply, Hydroelectricity, Agricultural, Industrial

Soils: Dark, calcareous clay, sandy loam, loam with clay subsoils; dark red sandstone, light tan and gray sandstone

Permitted Wastewater Treatment Facilities:

Domestic: 1 Land Application: 4 Industrial: 1



Segment 1812, the **Guadalupe River below Canyon Dam**, extends from the confluence of the Guadalupe and Comal Rivers upstream to the bottom release of Canyon Reservoir. The segment is separated into three assessment units: the lower 4 miles; the upper 9 miles; and, the mid-portion between SH 46 and the confluence with Bear Creek. The entire segment lies within Comal County. GBRA has been monitoring the Guadalupe River at the second crossing (12658) monthly since 1987. The GBRA site is located in the uppermost assessment unit. TCEQ has other historical sites within the segment, one located near the small community of Gruene in the lower portion of the segment, one located in the upper portion near CR 306, one near Horseshoe Falls and one in the city of New Braunfels at Cypress Bend Park. Also, the US Geologic Survey collected water quality data in this segment in the 1990s. The water quality study conducted by New Braunfels Utilities in 2006-07 has monitoring sites within this segment. The study had not been released for public review at the time of this publication.

Land Uses, Discharges and Conditions that Impact Water Quality

There is one wastewater discharge to the segment, operated by New Braunfels Utilities, located at Gruene. For the majority of the period of historical data, the 1.0 million gallon per day wastewater treatment plant was not discharging to the stream, beneficially reusing the treated effluent on a small golf course. In 2006, the golf course closed and the plant began discharging back to the stream.

The land use in the watershed is mostly private homes and campgrounds, with flows and stream conditions conducive for recreation and very little agricultural use due to the rocky and fractured terrain. The stream segment is heavily influenced by the cold water, bottom releases from Canyon Reservoir. The portion of the stream segment immediately downstream of the release is used for a put-and-take trout fishery maintained by Trout Unlimited and the Texas Parks and Wildlife Department. It is important to understand how the operation of the Canyon Reservoir impacts the instream flow of the river downstream. Construction on Canyon Dam began in 1958 and began to impound water in 1964. It is a cooperative project jointly managed by GBRA and the U. S. Army Corp of Engineers (COE). The dual-purpose project provides for the storage of water for water supply and for flood protection. The reservoir operates as two parts. The lower portion from elevation 800 to 908 mean sea level (msl) is operated by GBRA for conservation storage. GBRA was granted the original water right for 50,000 acre-feet of water per year to be made available for customers through water purchase contracts. GBRA releases water from the conservation pool as it is called for by downstream customers.

The upper portion of Canyon Reservoir is referred to as the “flood pool” and is controlled by the COE. This part of the reservoir captures floodwaters that are usually released at rates sufficient to empty the flood pool without contributing to downstream flooding. Rates of releases from the flood pool are approximately 5600 cfs. From elevation 911 to elevation 909 msl, the COE releases range up to 1,500 cfs.

Releases out of Canyon Reservoir are governed by several regulatory or contractual requirements. First, the Federal Regulatory Energy Commission stipulated as part of their license agreement with GBRA for hydropower generation at Canyon Dam that GBRA release a minimum of 120 cfs during the months of February through May and 100 cfs other months of the year, except under drought conditions. Second, TCEQ, as part of the Canyon Amendment process added a flow regime that is protective of the instream flow requirements downstream. Third, GBRA has signed an agreement with Trout Unlimited for higher releases during the period of the year (May through September) that is most critical in maintaining a desired thermal regime for stocked rainbow trout downstream of the reservoir. In May, the Trout Unlimited agreement provides for minimum flows that range from 140 to 170 cfs, and in June, the flows range from 210 to 240 cfs. For the months of July, August and September the minimum flow is 200 cfs. Lastly, the base flow of the Guadalupe River coming into the reservoir which would be the amount released from the reservoir under normal flow conditions can be augmented with additional water that is stored under a temporary agreement with the COE and used to enhance flow conditions downstream for recreation use, such as tubing and rafting. The temporary agreement is renewed each year and, most likely, not available in years of drought. Efforts are underway to make this COE agreement permanent.

Water Quality

The 2008 draft Texas Water Quality Inventory has no impairments or concerns listed for Segment 1812. Looking at the three monitoring locations in the segment with the most consistent data sets, the GBRA station at second crossing (“second crossing site”-12658), the TCEQ site at Gruene (“mid-segment site”-13511), and the TCEQ site at Cypress Bend Park in New Braunfels (“downstream site”-12656), the water quality in the segment is very good. The median concentration for dissolved oxygen at the upstream site was 10 milligrams per liter (mg/L), ranging from a minimum of 6.86 mg/L to a maximum of 13.8 mg/L; at the mid-segment site the median concentration was 9.4 mg/L, ranging from 7.1 to 11.6 mg/L; at the downstream site the median concentration was 9.0 mg/L, ranging from 6.3 to 14 mg/L. At no time in the period of record did the dissolved oxygen drop below the standard for the minimum dissolved oxygen concentration (4.0 mg/L). The temperature varied between 8.52ºC to 30.1ºC, with a median temperature of 18.2ºC at the second crossing site; varied between 10.7 ºC to 30.1 ºC with a median temperature of 18.5 ºC at the mid-segment site; and, varied between 10.6 ºC and 29.6 ºC, with a median temperature of 21.0 ºC at the downstream site. The **specific** conductance at the second crossing site ranged between 263 and 569 micromhos per centimeter (umhos/cm), with a median conductivity of 425 umhos/cm; ranged from 346 to 503 umhos/cm, with a median 441 umhos/cm at the mid-segment site; and, ranged from 187 to 479 umhos/cm with a median conductivity of 409 umhos/cm at the downstream site. The median pH of the second crossing site was 8.11, ranging from 7.0 to 8.6 standard pH units; at the mid-segment site the median pH was 7.8, ranging from 7.2 to 8.4; and, at the downstream site, the median pH was 8.0, ranging from 6 to 9.7, falling outside the lower stream standard range of 6.5 one time and falling outside the upper standard of 9.0 one time. The median concentrations for chloride and sulfate were 14.2 and 20.2 mg/L respectively. At no time did the concentration of these dissolved constituents exceed the stream standard of 50 mg/L.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the GBRA monitoring location at the second crossing. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations at the second crossing for all three cited storet codes were 0.21, 0.20, and 0.26 mg/L, ranging from 0.03 to 1.78 mg/L. At no time did the nitrate nitrogen concentration, regardless of storet citing, exceed the screening criteria of 1.95 mg/L. The median concentration for nitrate nitrogen at the mid-segment and downstream sites were 0.4 and 0.36 mg/L respectively, about 2 times higher than the median concentration at the second crossing site, but the range was much tighter, from 0.15 to 0.42 mg/L. The median flow at TCEQ's mid-segment site was 356 cubic feet per second as compared to the median flow of 254 cfs at the second crossing site, the difference most likely due to contributions of flow from small creeks and springs between the sites. The groundwater coming from the springs is influenced by the nitrate nitrogen that is naturally occurring in the geology of the area. The median ammonia nitrogen concentration was 0.21 mg/L, ranging from 0.03 to 0.54 mg/L. Only one time did the concentration of ammonia nitrogen exceed the screening concentration of 0.33 mg/L. The measurement was taken in the winter and during a low flow period (105 cfs) but low flow is not necessarily an explanation for the high concentration because at other times low flows did not result in elevated ammonia concentrations. The median total phosphorus concentration at the second crossing site was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. Total phosphorus and ammonia nitrogen concentrations had median concentrations below detection at the TCEQ sites and no measurement at either site exceeded the screening concentrations for either constituent.

Segment 1812 is known for its recreational opportunities. Flows create conditions that range from a slow meandering stream to swift rapids, providing excellent conditions for tubing and rafting. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for ***E. coli*** bacteria at the second crossing site was 34 organisms per 100 milliliters. In the period of record only one sample was collected at the GBRA site that exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. Figure 1 shows the historical *E. coli* concentrations, along with flow. Something interesting to note is that where high flow events explain some spikes in *E. coli* concentrations, there are times where the spikes in bacterial numbers are during low flow periods (summer months in 1999 and 2006). Sources of *E. coli,* such as septic tanks, portable johns and recreationists carrying in and contributing bacteria to the stream, have greater impacts during low flows when there is less dilution and more disruption of stream and bank sediments.

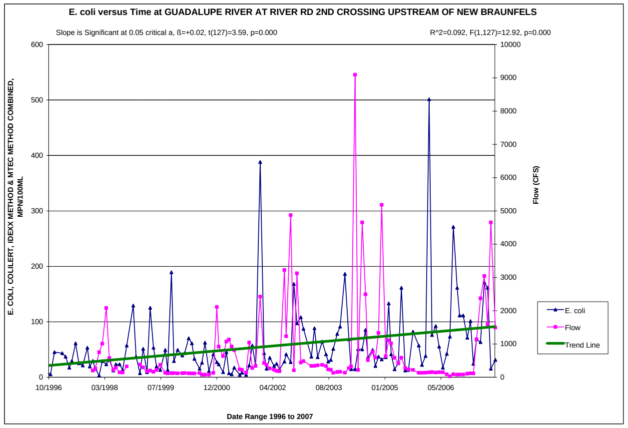


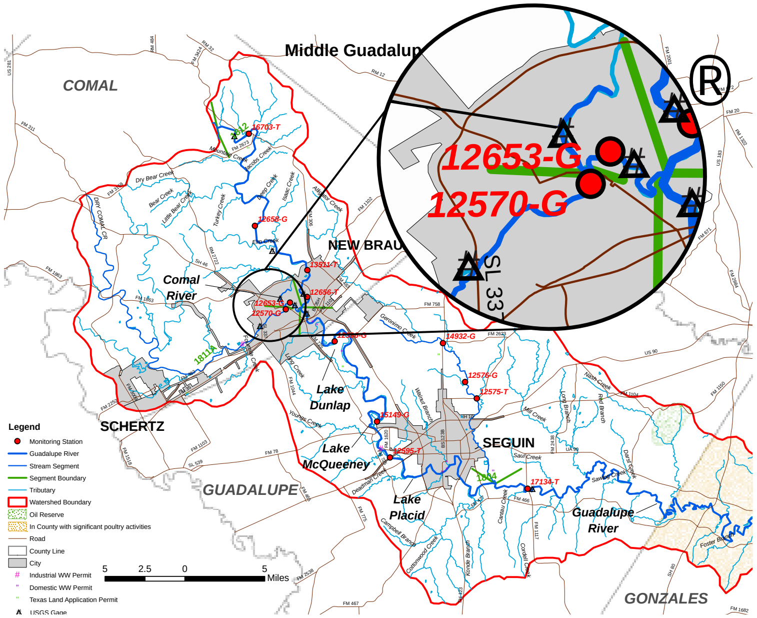
Figure 1. Guadalupe River at 2nd crossing (12658) – *E. coli* verses time all methods.

The substrate at the GBRA monitoring location downstream of Canyon Dam is rocky and the limestone hills that surround the stream segment contribute very little suspended solids during localized rain events. The water is clear and shallow in the majority of locations along the segment, with very few pools. The second crossing sampling site is one of the deepest locations in the segment. The suspended solids ranged from 1 to 87.7 mg/L, with a median of 5.1 mg/L. The TCEQ sites had median concentrations of 5.5 and 5.0 mg/L suspended solids at the mid-segment and downstream sites respectively. The median chlorophyll a concentrations at all three sites was less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.

The historical data from the three monitoring sites was reviewed for trends, comparing constituents over time and flow regimes. Statistically significant trends that were noted, either positive or negative, were not indicative of degrading water quality conditions.

Stakeholder Concerns

Stakeholders have voiced concerns for the impacts from recreational use, such as trash, improper or lack of wastewater treatment and the sheer number of persons in the water, have on the water quality, but these concerns are not supported by routinely high bacteria numbers or poor water quality in this segment.



Segment 1811, the Comal River, extends from the confluence of the Guadalupe River to its headwaters springs coming from the Edwards Aquifer, located in and near Landa Lake. The entire segment lies within the city of New Braunfels. GBRA maintains a monitoring location in the Comal River at Hinman Island (12653) and has been monitoring at this site monthly since late 1994. A major tributary to the Comal River is the Dry Comal Creek. GBRA has maintained a monitoring site located on the Dry Comal very near its confluence with the Comal River in New Braunfels since 1996. TCEQ and the US Geological Survey have monitored the Comal River as well but GBRA assumed consistent monitoring of the Comal River when it joined the Clean Rivers Program in 1996.

Stakeholder Concerns

The Comal River is the shortest river in the State of Texas. It is home to the fountain darter, a federally-listed endangered species. The river is spring-fed, making it a consistent temperature and clarity. Landa Park and its spring-fed pool are located at the headwaters. Landa Lake, located in the park, is the home of ducks, native fish and a healthy stand of rooted, aquatic plants. A concern of stakeholders is the introduction of non-native species such as hygrophila (aquatic plant), ram's horn snail, and loriicarids (aquarium algae eaters) that without natural predators can out-compete the native species and upset the ecological balance in the river. A source of the non-native species is improper disposal of aquarium populations by local residents.

The Comal River is heavily recreated, especially in times when the flow from Canyon Reservoir is reduced due to drought, making the flow in the Guadalupe River too low for tubing and rafting. With increased recreation pressure, comes increased stress and pollution loading (trash) on the Comal River.

Land Use

The land use in the watershed of the river proper is entirely urban. Residential property with manicured lawns and impervious cover associated with urban land uses, including roads, roof tops and parking lots can be sources of pollutant loading to the river. Pollutants that might be captured and bio-degraded by soils are instead readily washed over the cement and pavement and directly into the surface water.

The Dry Comal Creek is a small creek with a mean instantaneous flow of 4 cubic feet per second that flows through a large watershed that is currently more rural than urban. As in other areas in the Austin-San Antonio IH 35 corridor, there are new subdivisions being planned in the watershed that will, over time, reverse the dominance of land use from rural to urban. There are sand and gravel operations in the watershed. There are no wastewater or industrial plants that discharge to either the Comal River or Dry Comal Creek.

Water Quality

The 2008 draft Texas Water Quality Inventory does not list the Comal River or the Dry Comal Creek with any impairments or concerns. Looking at the available historical data on the Comal River (site no. 12653), the temperature varied between 14ºC to 28ºC, with a median temperature of 23.6ºC. The **specific** conductance ranged between 359 and 684 micromhos per centimeter, with a median conductivity of 557 micromhos per centimeter. The median pH of the site was 7.66, ranging from 6.93 to 8.28. The median concentrations for chloride and sulfate in the Comal River were 17 and 24.1 milligrams per liter (mg/L) respectively. All data points for chloride were lower than the stream standard of 50 mg/L except for one point (92.2. mg/L) that appears to be a one-time occurrence. Only three data points for sulfate concentration fell outside of the stream standard of 50 mg/L.

However, in the historical data set for the Dry Comal Creek (site no. 12570), there have been exceedences of the stream standard for sulfate. The Dry Comal Creek is not a classified stream segment so it is assessed using the stream standards of the Comal River. More than half of the samples analyzed for sulfate exceeded the stream standard of 50 mg/L. Figure 1 shows an upward trend in the sulfate concentration over time. Removing the data

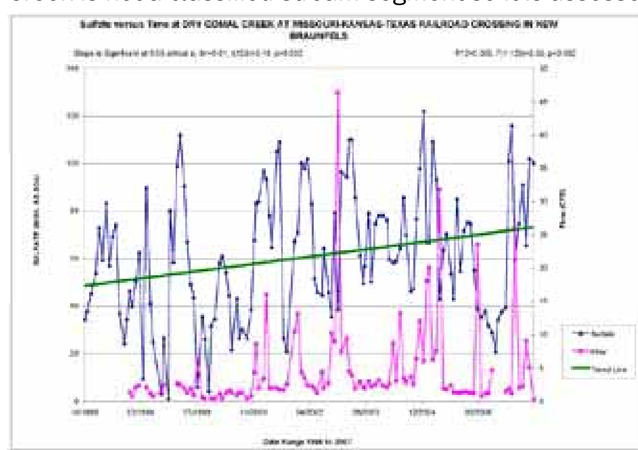


Figure 1. The Dry Comal (12570) is exhibiting a slight upward trend in the monthly concentration of sulfate. The stream standard is 50 mg/L.

associated with high flows, we still see the same upward trend, suggesting that the sulfate is associated with base flows and not rainfall runoff. The source of base flow at the Dry Comal monitoring station are springs located mainly in the city, with no contributions from point source discharges. The majority of the upper watershed is dry a high percentage of the time.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the monitoring locations on both water bodies. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The source of the Comal River is the Edwards Aquifer which has historically exhibited elevated nitrate nitrogen. The median concentration for the locations on the Comal River ranged from 0.02 mg/L to 2.7 mg/L. Looking at the historical data set for the Comal, the nitrate nitrogen concentration exceeded the screening criteria of 1.95 milligrams per liter 20 times out of 215 analyses (9.3%). Figure 2 shows the consistent input of nitrogen from the springs coming from the Edwards Aquifer. The exception was during the period of high flows that contributed flow to the stream as well as recharge to the Edwards Aquifer possibly diluting the naturally-occurring nitrate nitrogen in the base flow.

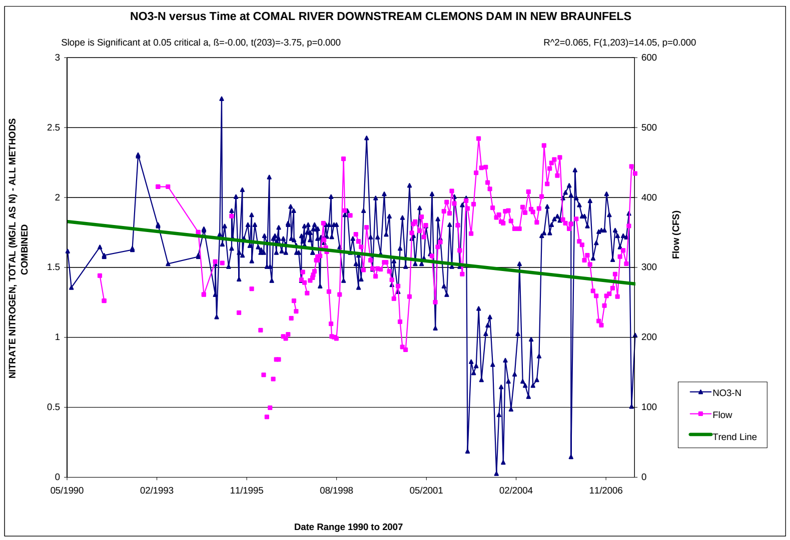


Figure 2. The Hinman Island site (12653) is exhibiting a consistent input of nitrate nitrogen from base flow.

The source of the Dry Comal Creek is primarily ground water and rainfall runoff off of pasture and farmland. The median concentration for nitrate nitrogen in the Dry Comal Creek is lower than the Comal River, ranging from 0.22 mg/L to 0.85 mg/L, and during the period of record, did not exceed the screening concentration. The median ammonia nitrogen concentration for the Comal River was 0.03 mg/L and 0.045 mg/L for the Dry Comal Creek. The median total phosphorus concentration for the Comal River was below the limit of quantification for the method and slightly higher than the limit of quantification in the Dry Comal Creek. When total phosphorus was detected in a sample from either water body it did not exceed the screening concentration of 0.69 milligrams per liter.

Looking at the concentration of nitrate nitrogen over time in the Dry Comal Creek, we see a slight downward trend (Figure 3). In other words, we see a slight decrease in the concentration for the nutrient. Over the same time period, we see an increase in chlorophyll a concentration in the Dry Comal Creek (Figure 4) which could explain the decrease in nitrate concentration as the nutrients are taken up by algae and macrophytes. The median chlorophyll a

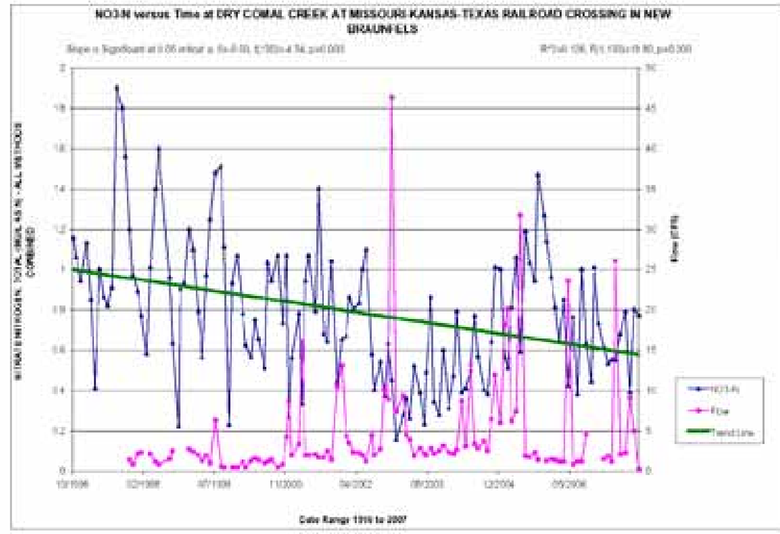


Figure 3. The Dry Comal Creek (12570) is exhibiting a downward trend in nitrate nitrogen.

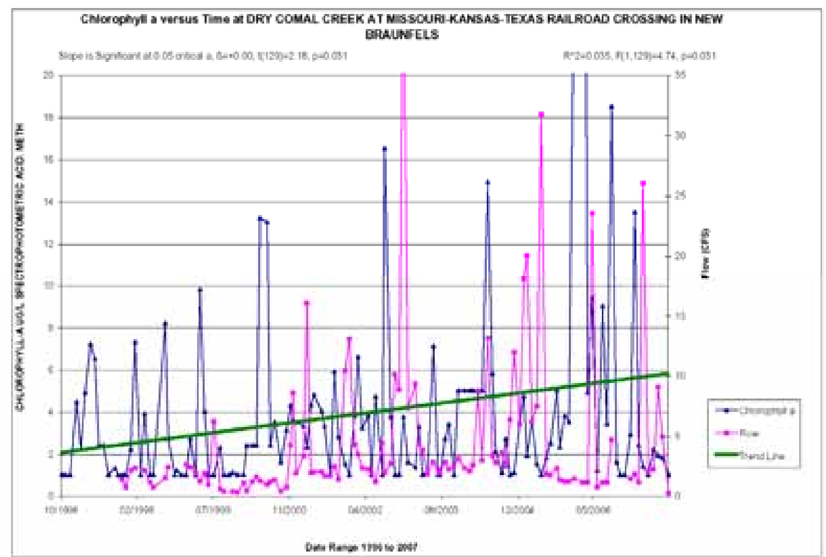


Figure 4. The Dry Comal Creek (12570) is exhibiting an upward trend in Chlorophyll a concentration.

concentration on the Comal River is less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter. Whereas, the median concentration for chlorophyll a on the Dry Comal Creek is 2.4 micrograms per liter and exceeded the screening concentration five times over the period of record.

An explanation for the upward trend in the concentration of chlorophyll a in the Dry Comal Creek may be the predominant low flow conditions that have defined the creek since 2005. Low flow conditions give the stream more time to assimilate the nutrients, resulting in an increase in algal and macrophyte growth. 2005 and 2006 had prolonged dry periods. Regardless of meteorological conditions, reduction in recharge due to impervious cover in the Dry Comal Creek watershed will continue to result in a corresponding reduction in base flow with more frequent and prolonged low flow conditions, making low base flow the norm rather than the exception.

The Comal River is a slow, meandering stream with a silt substrate that supports large stands of rooted aquatic macrophytes. The stream standard for contact recreation for ***E. coli*** is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* at the Comal River at Hinman Island site is 52 organisms per 100 milliliters, well below the stream standard. In the period of record seven of the 132 measurements exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. There is a slight upward trend in the *E. coli* concentration seen in the data, but it is only statistically significant when both the IDEXX and MTEC laboratory data sets are combined. Often, *E. coli* concentrations increase with rises in flow due to storm water runoff as shown in Figure 5.

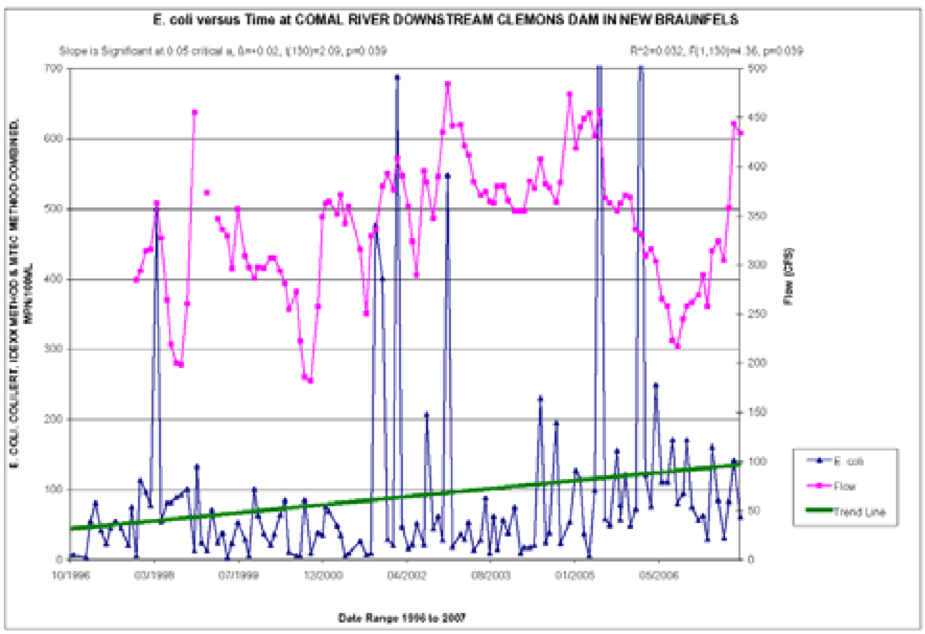


Figure 5. The Hinman Island site (12653) is exhibiting an upward trend in *E. coli* concentration.

The Dry Comal Creek exhibits typical concentrations of *E. coli* bacteria for a stream that receives the majority of its flow from a rural watershed with agricultural bacterial loading. The geometric mean for *E. coli* is 153 organisms per 100 milliliters in the data set that begins in 2002, exceeding the stream standard of 126 organisms per 100 milliliters. 21 out of 134 sampling events (15.7%) exceeded the single sample grab standard of 394 organisms per 100 milliliters for *E. coli* (Figure 6).

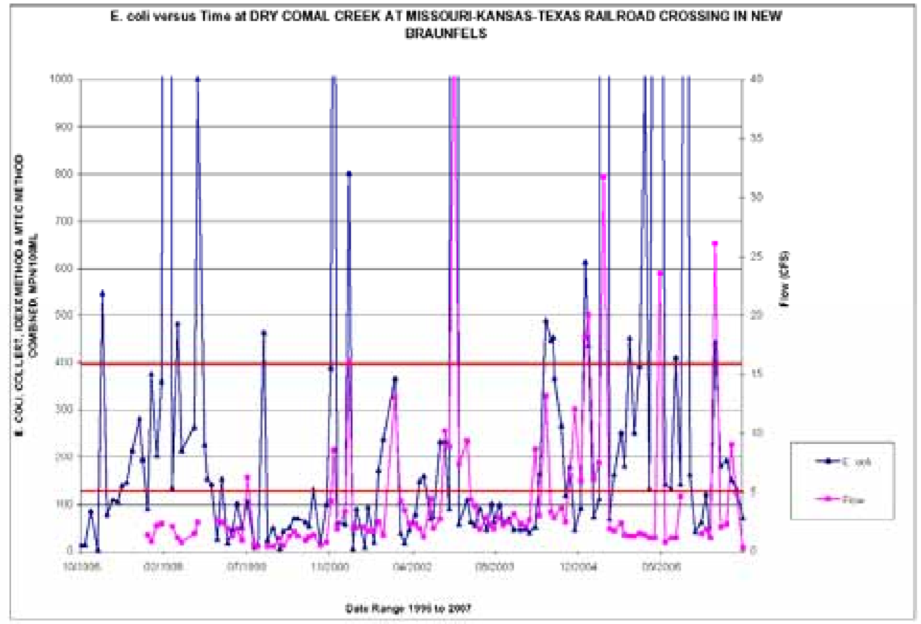
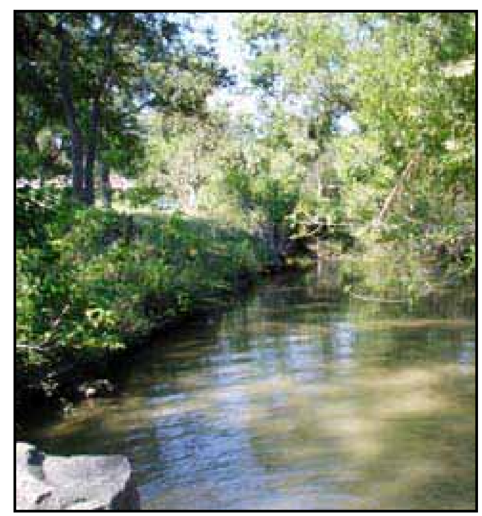


Figure 6. The Dry Comal Creek (12570) exceeded the stream standard for *E. coli* on several occasions (The red lines indicate the stream standards for geometric mean of 126 MPN and grab sample concentration of 394 MPN.

The suspended solids in the Comal River ranged from 1 to 18.3 milligrams per liter, with a median of 1.9 milligrams per liter, and ranged from 1.7 to 78.8 mg/L, with a median of 6 mg/L for the Dry Comal Creek. Non-point pollution in the form of rainfall runoff carries in suspended solids and associated bacteria and oxygen-depleting organic material. Pairing figure 6 with figures 7and 8 it is evident that the storm events in the Dry Comal Creek watershed carry in high levels of bacteria and suspended material. Possibly due the smaller size of the watershed, the correlation between flow and suspended material is not significant in the Comal River watershed.



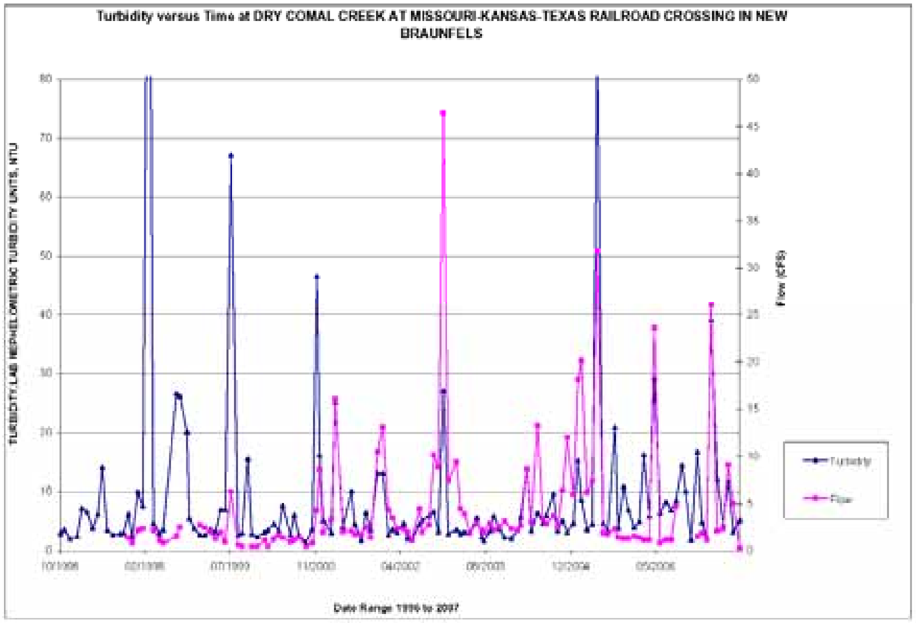


Figure 7. Turbidity versus time at Dry Comal Creek (12570).

Dry Comal Creek at Seguin Street in New Braunfels (site no. 12570).

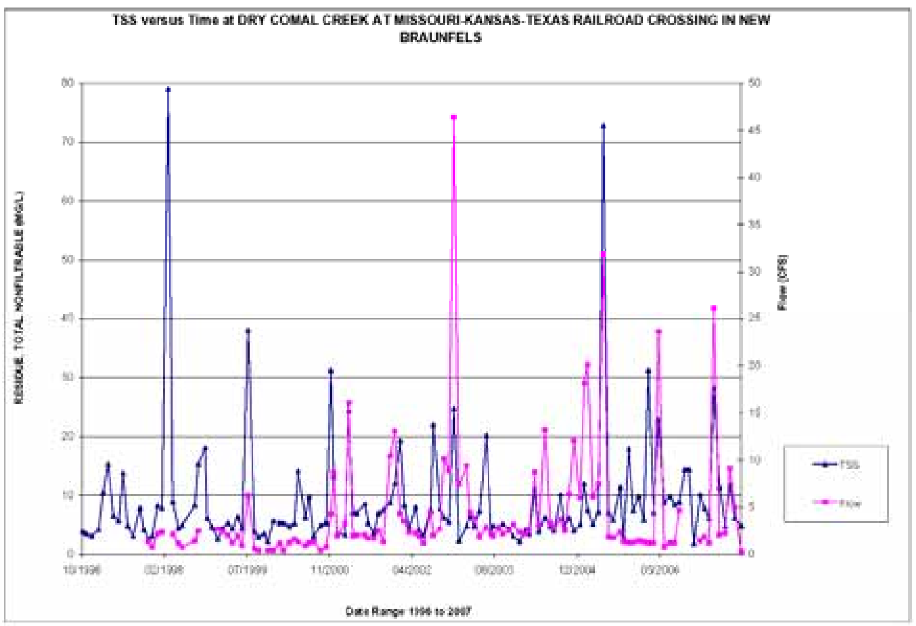
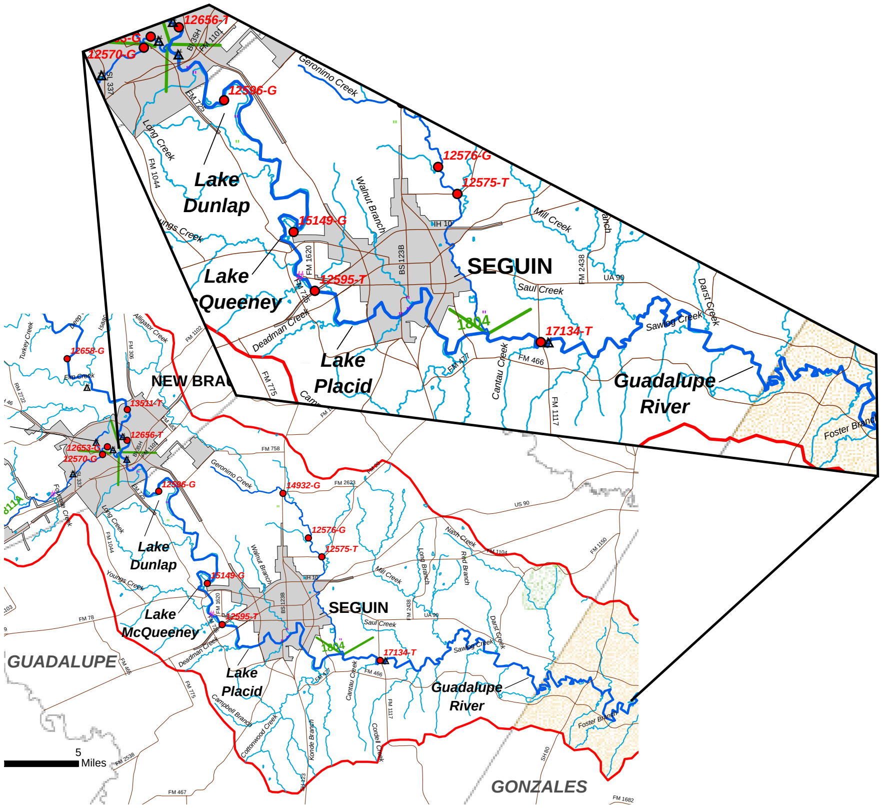


Figure 8. Total suspended solids versus time at Dry Comal Creek (12570).

Dry Comal Creek at Seguin Street in New Braunfels 100 meters upstream (site no. 12570).



Segment 1804, the **Guadalupe River below the Comal River**, extends from the confluence of the Guadalupe and Comal Rivers, in New Braunfels, 103 miles downstream to the confluence with the San Marcos River. The segment is separated into four assessment units. Assessment unit 1804_01 consists of the lower 25 miles of the segment from the confluence with the San Marcos River to approximately 8 miles downstream of the FM1117 crossing in Gonzales County. Assessment unit 1804_02 consists of the area approximately 8 miles upstream of the FM1117 crossing to 58 miles upstream at Lake McQueeney Dam. Assessment unit 1804_03 consists of the 7 mile portion of the river upstream of Lake McQueeney Dam. Assessment unit 1804_04 consists of the upper 13 miles of the segment from 7 miles upstream of Lake McQueeney Dam to the confluence with the Comal River in Comal County. The segment is found in three Texas counties: Comal County, Guadalupe County and Gonzales County. GBRA has routinely monitored the Guadalupe River at AC's Place, on the north bank of Lake Dunlap (site no.12596), monthly since 1990. GBRA has routinely monitored the Guadalupe River at Hot Shot's on the Southeast bank of Lake McQueeney (site no. 15149), monthly since 1997. GBRA has routinely monitored the Guadalupe River, below H-5 Dam, before the San Marcos River confluence (site no.15110), monthly since 1996. TCEQ has monitored the Guadalupe River at IH10 (site no. 12595) on a quarterly basis since 1998. TCEQ has also monitored the Guadalupe River at FM 1117 (site no. 17134) on a quarterly basis since 1999. There is additional data on this segment of the Guadalupe River from a special study by GBRA during 2004 and 2005 to address nutrient concerns on the power plant lakes. Espy Consultants has also submitted data to TCEQ from a study funded by New Braunfels Utilities in this segment, but the study and its findings has not yet been released. The 2008 Texas Water Quality Inventory Report has no impairments or concerns listed for Segment 1804.

The upper portion of segment 1804 is heavily influenced by the Comal River tributary. The Comal River maintains a fairly consistent annual stream flow from its springs, which often makes up a majority of the water entering the segment, especially during times of dry weather or drought. The upper portion of the segment often exhibits many of the water quality properties of the Comal River. As the water moves downstream it is impounded by a series of six dams, which are operated by the GBRA to generate hydroelectric power. The river must initially pass through the Dunlap Dam, which impounds Lake Dunlap; followed by the McQueeney Dam, which impounds Lake McQueeney; TP4 Dam, which impounds Lake Placid; Nolte Dam, which impounds Meadow Lake; H-4 Dam, which impounds Lake Gonzales; and the H-5 Dam, which impounds Lake Wood. The water impounded in these series of hydroelectric lakes does not take on many of the properties of a reservoir and maintains the attributes of a flowing stream segment, due to the shallow depths and lower retention time of the water in these structures. The river must support approximately 528 cubic feet per second (cfs) discharge at the Lake Dunlap power plant in order for the power plants to generate power. When a discharge of this level cannot be supported, the water is allowed to pass directly through the turbines of the plant without the generation of power. The flow from the Guadalupe is diverted through a water canal above the Dunlap Dam to the hydroelectric turbines. It is from this canal that a pipeline takes raw water to the city of San Marcos Water Treatment Plant. Two additional tributaries contribute to the base flow near the city of Seguin, the Walnut Branch and the Geronimo Creek. The Geronimo Creek tributary of segment 1804 is heavily spring flow dominated and is discussed in a seperate section of this report.

Each hydroelectric impoundment has its own unique structure and associated water quality characteristics. Historical data has shown that four out of five years these run-of-river impoundments function as rivers with short residence times. In those years with low flows in the Guadalupe River, longer water residence times in the impoundment will create more “reservoir-like” conditions. The impoundments will weakly stratify in the deep portions. Additionally, the longer residence times allow for nutrient uptake by algae and aquatic plants, promoting blooms and nuisance aquatic infestations.

These impoundments are subject to localized flooding and extended periods of high releases from Canyon Reservoir needed to evacuate the flood pool. Runoff carries in sediment and the prolonged high flows keep sediment suspended. An example of the effect of flow on suspended sediments can be seen in figure 1. The total suspended solids measured at the GBRA sampling location in Lake Dunlap increase with high flows and there are times when the flows are sufficient enough to keep the solids in suspension. In addition to adding organic oxygen-demanding material, suspended solids create turbid conditions that shade out the sunlight and can have the potential bringing in and maintaining elevated bacteria concentrations.

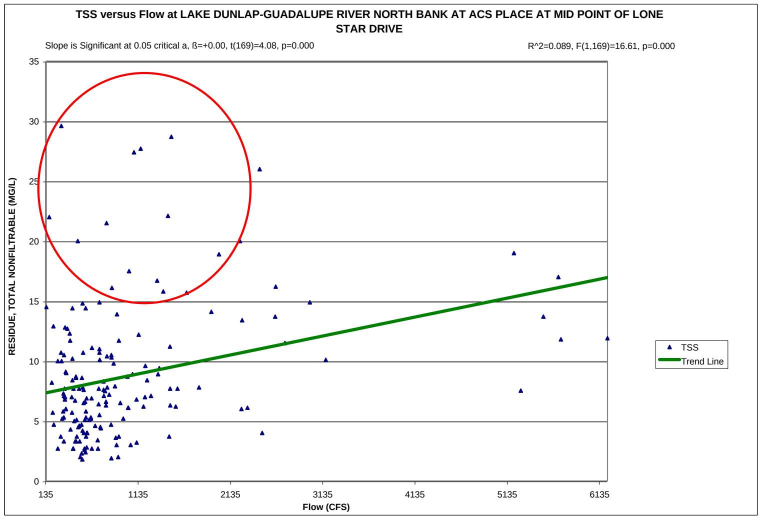


Figure 1. Relationship of flow and suspended solids at the GBRA Lake Dunlap site (12596). Runoff during storm events bring in sediments with the high flows. Prolonged high flows from reservoir releases upstream keep those sediments suspended in the water column (red circle).

Lake Dunlap

The most upstream run-of river impoundment, Lake Dunlap begins at the city of New Braunfels and it banks are almost completely lined with residences. The impoundment is narrow and shallow. It has a plunge point midway down the reservoir. Here, in years of low flow, inflow that is cooler because of the temperature of the springs and bottom release of the upstream reservoir, will dip down and flow along the bottom of the impoundment, creating a warm strata of water along the surface. It is at this plunge point that the impoundment will begin to weakly stratify. In years of normal to high river flows, inflows are sufficient enough to keep the water mixed and prevent this stratification from occurring. Figure 2 shows how the temperature of the surface water is impacted by the inflows.

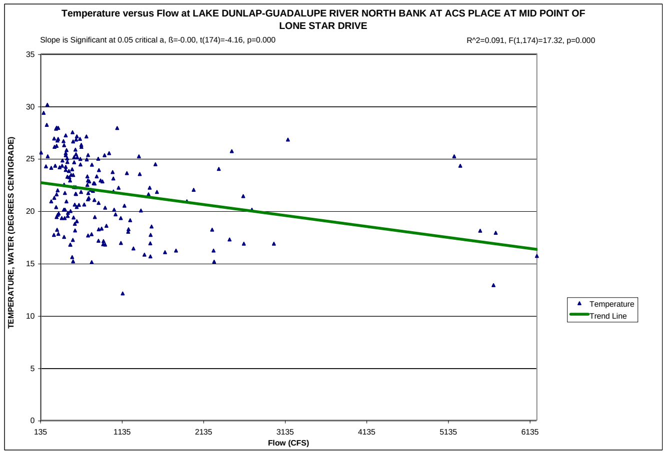


Figure 2. Relationship of temperature and flow at the GBRA monitoring location on Lake Dunlap (12596).

Reviewing the data over the last 10 years at the GBRA station on Lake Dunlap, the dissolved oxygen concentrations ranged from 6.43 to 18.3 milligrams per liter (mg/L), with a median concentration of 9.1 mg/L and not falling below the dissolved oxygen requirement of 5.0 mg/L. The temperature at the surface ranged from 11ºC to 30.9ºC, with a median temperature of 22ºC. The pH never fell outside of the standard range of 6.5 to 9.0 units. The **specific conductance** is showing a very slight rise over time, with a median concentration of 521 micromhos per centimeter (umhos/cm), ranging from 233 umhos/cm to 705 umhos/cm. Lower conductivities occur with elevated flows due to localized rainfall.

The total suspended solids ranged from 1.8 to 201 mg/L, with a median concentration of 7.5 mg/L. Hardness is impacted by the hard water coming from the Comal River and its springs from the Edwards Aquifer. It ranged from 152 mg/L to 353 mg/L, with a median concentration of 248 mg/L. Chloride and sulfate concentrations did not exceed the stream standard of 50 mg/L through historical period of data, ranging from 6 to 41 mg/L chloride (median = 18 mg/L) and 2 to 33 mg/L sulfate (median = 24.4 mg/L).

Nitrate nitrogen, ammonia nitrogen and total phosphorus was measured at the GBRA location on Lake Dunlap. The nitrate concentration was reported alone and in combination with nitrite nitrogen. The Edwards Aquifer contributed to the nitrate concentrations in the Comal River. The median concentration for nitrate nitrogen was 1.0 mg/L, ranging from 0.08 to 3.0 mg/L, exceeding the screening concentration of 1.95 mg/L five out of 260 monitoring events. The ammonia nitrogen concentrations ranged from less than method detection to 0.35 mg/L, exceeding the screening concentration only one time. The median concentration for total phosphorus was 0.08 mg/L, ranging from less than method detection to 0.4 mg/L and never exceeded the screening concentration of 0.69 mg/L. There was limited data available for orthophosphate but the concen-trations in the data set never exceeded the screening concentration of 0.37 mg/L.

Chlorophyll a concentrations exceeded the screening criteria of 14.1 micrograms per liter (ug/L) three times. These exceedences occurred when the flow in the impoundment was extremely low. The bacteria concentrations, as fecal coliform or as ***E. coli***, exceeded the associated stream standard for contact recreation 33 times (11.8%) over the historical period of record of sixteen years.

Lake McQueeney

Lake McQueeney has the largest open water area of all of the hydroelectric impoundments. Its banks, like Lake Dunlap, are lined with residences with large yards. Along this open area is the area referred to as Treasure Island, a residential subdivision with greater than 80 high-end homes. Because of the high water table on the island, the effectiveness of the septic tanks that serve the residences here is highly suspect. Failing septic tanks or septic tanks that drain to the lake rather than a drain field can be sources of bacteria and nutrients. GBRA's sampling location is directly across the open area of the impoundment from Treasure Island. The location has seen spikes in chlorophyll a associated with low flow conditions. Figure 3 shows the negative correlation of chlorophyll a and flow. Low flow conditions create longer residence times, allowing for uptake of nutrients and blooms to occur. Sources of the nutrients for the algae are both point and non-point sources, such as the upstream wastewater discharges, septic tanks that have direct connection with the surface water and excess fertilizers used by residences along the banks and carried in by runoff. Historically, Lake McQueeney's chlorophyll a concentrations show a slight downward trend. The median concentration for chlorophyll a over the period of record was 3.4 ug/L.

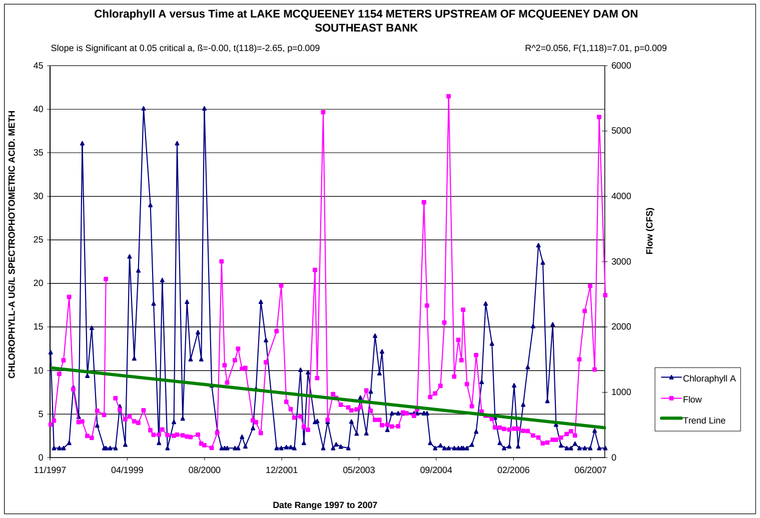


Figure 3. Inverse relationship of chlorophyll a concentration and flow at the GBRA monitoring site on Lake McQueeney (15149).

Reviewing the other historical data on Lake McQueeney at the GBRA monitoring location, the temperature ranged from 12.1ºC to 32.4ºC, with a median temperature of 23ºC. The pH ranged from 7.1 to 8.38 pH units, not falling outside the standard range of 6.5 to 9.0. The conductivity ranged from 293 to 600 umhos/cm, with a median conductivity of 516 umhos/cm. The median dissolved oxygen concentration was 9.23 mg/L, ranging from 5.8 to 13.78 mg/L, not falling below the stream standard of 5.0 mg/L.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were measured at the GBRA location. Nitrate nitrogen ranged from 0.13 to 1.6 mg/L, with a median concentration of 0.78 mg/L. The ammonia nitrogen concentrations ranged from less than method detection to 0.21 mg/L, with a median concentration of 0.04 mg/L. The total phosphorus concentrations ranged from less than method detection to 0.98 mg/L, exceeding the screening concentration of 0.69 mg/L two times. Referring to figure 4, there appears to be a slight correlation between spikes in total phosphorus and spikes in flow, but there are times when the total phosphorus spikes are associated with low flows. Because the phosphorus is measured as total phosphorus, the concentration of the nutrient could be in the organic form, such as in algal cells. A review of the chlorophyll a concentrations during those periods shows a period of higher than normal concentrations. The historical data shows a slight downward trend in total phosphorus concentrations over time.

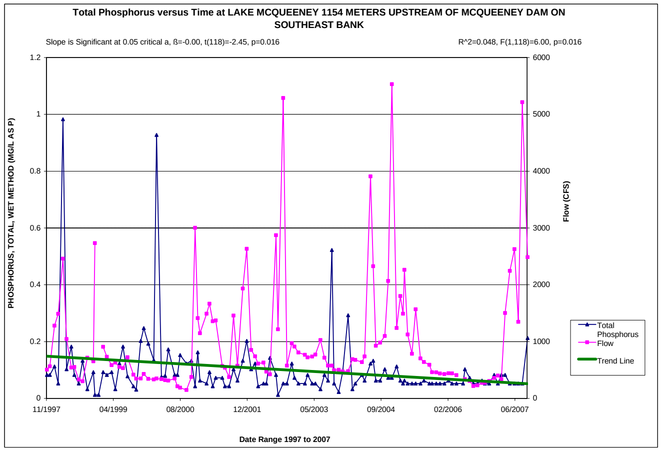


Figure 4. Total phosphorus is correlated with flow at Lake McQueeney (15149) monitoring and showing a slight downward trend over time.

Median chloride and sulfate concentrations were 17.6 and 24.5 mg/L, never exceeding the stream standard concentration of 50 mg/L. The total suspended solids ranged from 1.7 to 43.7 mg/L, with a median concentration of 9.2 mg/L. The median hardness concentration was 245 mg/L.

The bacteria concentrations, either as fecal coliform or ***E. coli***, exceeded the associated stream standard for contact recreation only four times over the period of record. The number of exceedences was considerably less than the GBRA Lake Dunlap location. This is most likely due, more to the location of the GBRA site in Lake McQueeney being in an open water area with available sunlight and ultraviolet disinfection than to a source of contamination of fecal bacteria in Lake Dunlap.

Lake Placid and **Meadow Lake**

Lake Placid and **Meadow Lake** are shallow and narrow. Both these impoundments and the riverine portion that connects the two, referred to as Lake Seguin, are susceptible to impacts by urbanization. They received non-point source pollution from runoff from homes and streets. As seen in other urbanized areas, impervious cover created by streets, parking lots and roof tops, allow the pollutants that might be captured and bio-degraded by soils, to instead readily wash over cement and pavement, directly into the surface water bodies.

The TCEQ maintains a monitoring location on Lake Placid at IH 10, downstream of the Commercial Metals steel mill. The list of parameters includes field, nutrient, and inorganics. The temperature, pH, dissolved oxygen and conductivity median concentrations and ranges were comparable to the monitoring locations that GBRA maintains in Lakes Dunlap and McQueeney. The similarity applies to the ammonia nitrogen, nitrate nitrogen, total phosphorus, chloride and sulfate between these impoundments. At this location there were no sampling events that exceeded the screening concentrations or stream standards for these parameters. The median concentration for total suspended solids was higher at the TCEQ site as compared to the upper impoundments but the range was similar to Lake McQueeney. The median chlorophyll a concentration was less than the method detection.

Where the Lake Placid site differed the most from the upstream impoundment sites was in the ***E. coli*** concentrations. The monitoring site in Lake McQueeney had a geometric mean of 14 organisms per 100 milliliters over the historical period, and Lake Dunlap had a geometric mean of 44 organisms over the same period. The TCEQ Lake Placid site had a geometric mean of 139 organisms per 100 milliliters, exceeding the contact recreation standard of 126 organisms per 100 milliliters. Looking for explanations for the differences, one must consider that there were only 19 sampling events on Lake Placid as compared to 135 monitoring events for *E. coli* on Lakes Dunlap and McQueeney. Also, the site on Lake Placid is located under a bridge that not only shades the site, but has a population of birds that roost above the monitoring location.

TCEQ also monitors the Lake Placid location for heavy metals, both in the water and in the sediment. Table 1 gives the metals concentrations in the TCEQ data set, that begins in late 2004. There were 10 sampling events for total and dissolved metals in water and six sampling events for metals in sediment.

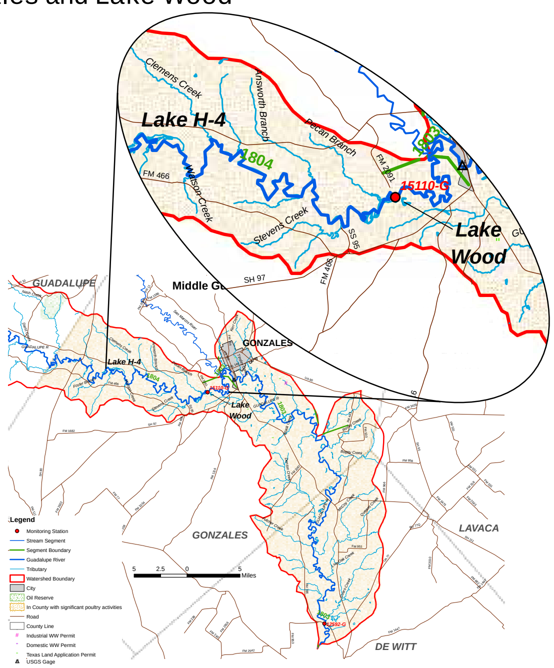
Table 1. Metals in water and sediment as measured at the TCEQ monitoring location on Lake Placid at IH 10 near Seguin.

	Metal (median concentrations)										
	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Nickel	Silver	Zinc
Water, total (ug/L)	<MD*	---	<MD*	<MD*	0.81	148	<MD*	7.9	<MD*	<MD*	<MD*
Water, dissolved (ug/L)	<MD*	---	<MD*	<MD*	<MD*	<MD*	1.0	2.0	<MD*	<MD*	<MD*
Sediment, total (ug/kg)	5.99	108	0.36	33.8	10.9	---	18.1	410	13.5	<MD*	71.5

*MD = method detection

Additional information can be found in the section on "metals in water."

Lake Gonzales and Lake Wood



Lake Gonzales and Lake Wood are very long and narrow. Lake Gonzales has very limited residential development along its banks. Lake Wood has some development but it, like Lake Gonzales, flows through agricultural lands, dominated by row crops and pastureland. Lake Wood has been severely impacted by sediment loading. The sediment that is picked up by flood waters from upstream has been deposited in the area directly in front of the dam that impounds the lake, reducing the depth at this location to less than four feet.

TCEQ maintains a quarterly monitoring site in the riverine portion above Lake Gonzales and downstream of the city of Seguin. The site located at FM 1117 has a parameter list that includes the same parameters that GBRA monitors at their locations. Comparing the TCEQ site that is downstream of the city and its wastewater treatment plants, we see no significant changes in water quality. The median concentrations for pH, dissolved oxygen, conductivity and temperature are comparable to the other upstream sites and none fall outside of the stream standards. The total suspended solids, chloride and sulfate are comparable as well.

Nitrate nitrogen had a median concentration of 1.44 mg/L, ranging between 0.64 to 2.75 mg/L, slightly higher than the upstream locations. Three of the data points were higher than the screening concentration for nitrates of 1.95 mg/L (10.5%). Ammonia nitrogen had a median concentration of less than method detection and never exceeded the screening concentration of 0.33 mg/L. The median concentration for total phosphorus was slightly higher at the FM1117 location (0.11 mg/L) as compared to the median concentrations upstream (0.08, 0.06, <0.06 mg/L moving from upstream to downstream). Figure 5 shows that there is downward trend in the concentration of total phosphorus over time.

The geometric mean for the ***E. coli*** concentrations was 27 organisms per 100

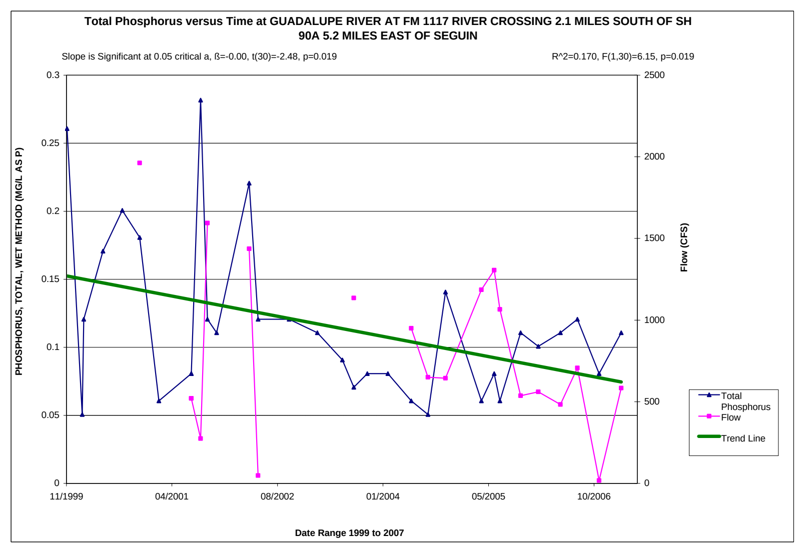


Figure 5. Downward trend in total phosphorus concentration over time at the TCEQ monitoring site located on the Guadalupe River at FM 1117 (17134).

milliliters and only exceeded the stream standard for contact recreation one time.

Guadalupe River downstream of the H-5 dam

GBRA's last monitoring site in this segment, the **Guadalupe River downstream of the H-5 dam**, is downstream of Lake Wood. Flow at this location is impacted by hydroelectric generation. Although the site is not located in an impoundment it can be compared to the upstream locations because those sites are similar in flow and exhibit riverine characteristics the majority of the time. The median concentrations for pH, dissolved oxygen, conductivity and temperature are comparable to the upstream sites, and none fall outside of the stream standards. The total suspended solids, chloride and sulfate are comparable as well. As shown in figure 6, there is a significant negative correlation of chloride with flow, and the same is seen with conductivity and sulfates, indicating that as flows increase the background concentration of chloride and other dissolved constituents, are diluted. In figures 7 and 8, total suspended solids and turbidity are directly correlated with flow, increasing as flow increases.

Nitrate nitrogen had a median concentration of 0.79 mg/L, ranging between

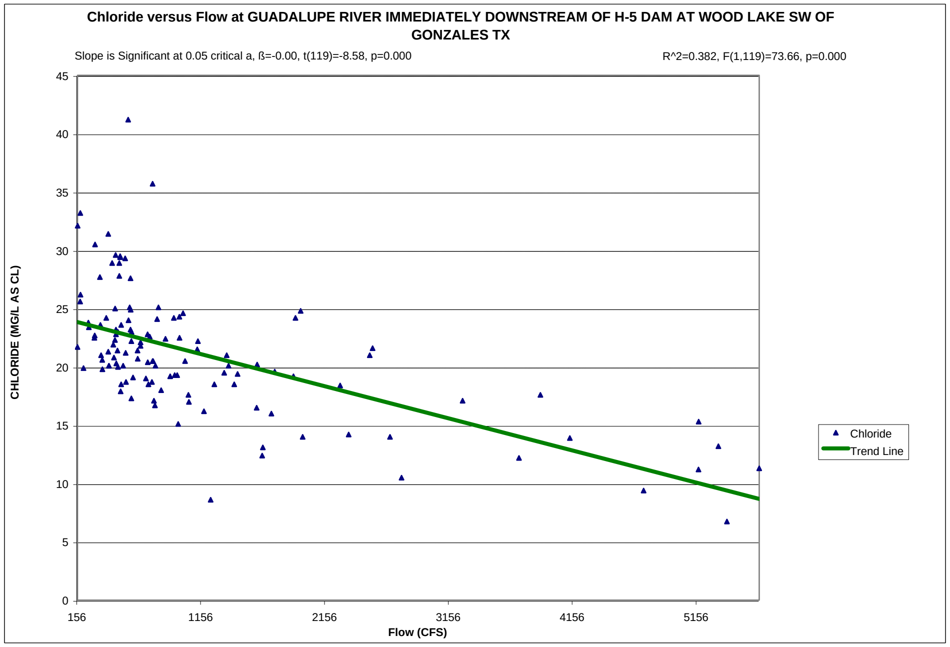


Figure 6. Background chloride concentrations at the GBRA monitoring site located at the Guadalupe River at H-5 (15110) are diluted with high river flows.

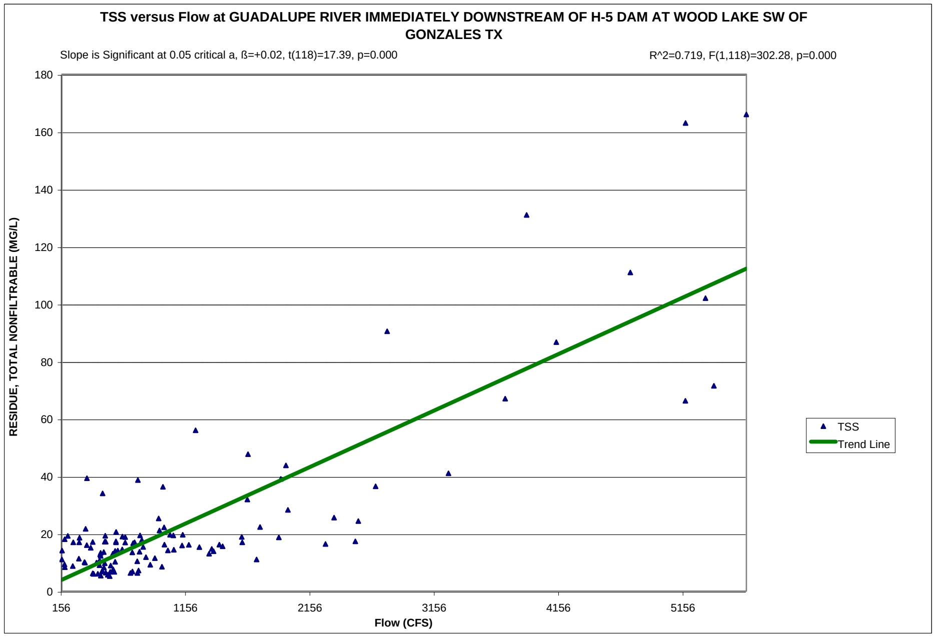


Figure 7. Positive relationship between flow and total suspended solids contributed by stormwater runoff at the Guadalupe River at H-5 monitoring location (15110).

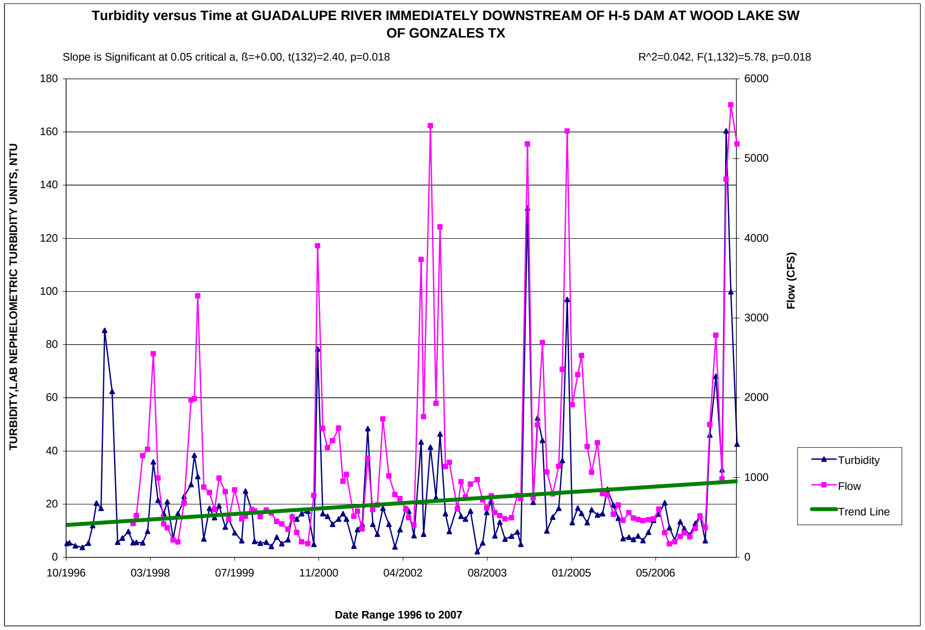


Figure 8. Positive relationship between flow and turbidity contributed by stormwater runoff at the Guadalupe River at H-5 monitoring location (15110).

0.02 to 1.9 mg/L, slightly lower than the locations in Lake Dunlap and Lake Placid, and more comparable to the Lake McQueeney site. None of the data points were higher than the screening concentration for nitrates of 1.95 mg/L. Ammonia nitrogen had a median concentration of 0.04 mg/L and never exceeded the screening concentration of 0.33 mg/L. The median concentration for total phosphorus was comparable to the FM1117 location (0.10 mg/L).

The geometric mean for fecal coliform and ***E. coli*** were 38 and 31 organisms per 100 milliliters, respectively. Out of the 200 measurements combined, 13 sampling events exceeded the respective stream standard for contact recreation, or 6.5% of the time. The median concentration for chlorophyll a was 3.0 ug/L, exceeding the screening concentration of 14.1 ug/L two times.

Stakeholder Concerns

Stakeholder issues in this portion of the Guadalupe River basin include concerns of the impacts of trash that comes from upstream and the impacts of nutrient loading from the New Braunfels wastewater discharges. The river downstream of Canyon Reservoir and the Comal River are highly recreated. The residents that live along the hydro lakes downstream see the impacts of the recreational pressure in the form of trash and vegetation as this material floats down and collects along bulkheads and piers. Aquatic vegetation is broken off and floats downstream as people are tubing or canoeing in areas of submerged plants such as hygrophilla and vallisneria (eelgrass). The plant mass collects in low flow areas and when a large mass builds up it breaks free and floats further downstream, eventually arriving in Lake Dunlap in amounts that impede boat traffic and swimming, collecting floating trash, and creating aesthetically unappealing conditions.

There are seven domestic wastewater discharge permits and one industrial wastewater discharge permit issued in segment 1804. The city of New Braunfels has two wastewater facilities that combine to discharge to Lake Dunlap. The Kuehler plants combined have a permitted discharge volume of 7.3 million gallons per day (MGD), with quality limits of 10 mg/L biochemical oxygen demand and 15 mg/L total suspended solids. The residents along Lakes Dunlap and McQueeney have raised concerns that these facilities impact the water quality of the impoundments by discharging nutrients that promote the growth of algae and aquatic macrophytes. Considering the history of infestations of aquatic vegetation in these hydroelectric impoundments it is a valid concern. The TCEQ renewed the discharge permits without nutrient limitations but required that the city perform a study to determine the appropriate amount of nutrient limitations that should be required by the wastewater plants. The results of the study have not been released to date.

Other large permitted discharges are from the city of Seguin. One plant is permitted to discharge up to an annual daily average of 4.9 MGD of treated domestic wastewater to the Guadalupe River. The second wastewater treatment plant is permitted to discharge up to an annual daily discharge rate of 2.13 MGD of treated domestic wastewater into the Geronimo Creek, 190 feet upstream of the confluence with the Guadalupe River. Both Seguin wastewater treatment plants must meet a 7 day average biochemical oxygen demand of 20 mg/L and a 7 day average total suspended solids level of 20 mg/L. The Walnut Branch plant has an ammonia limitation of 3 milligrams per liter.

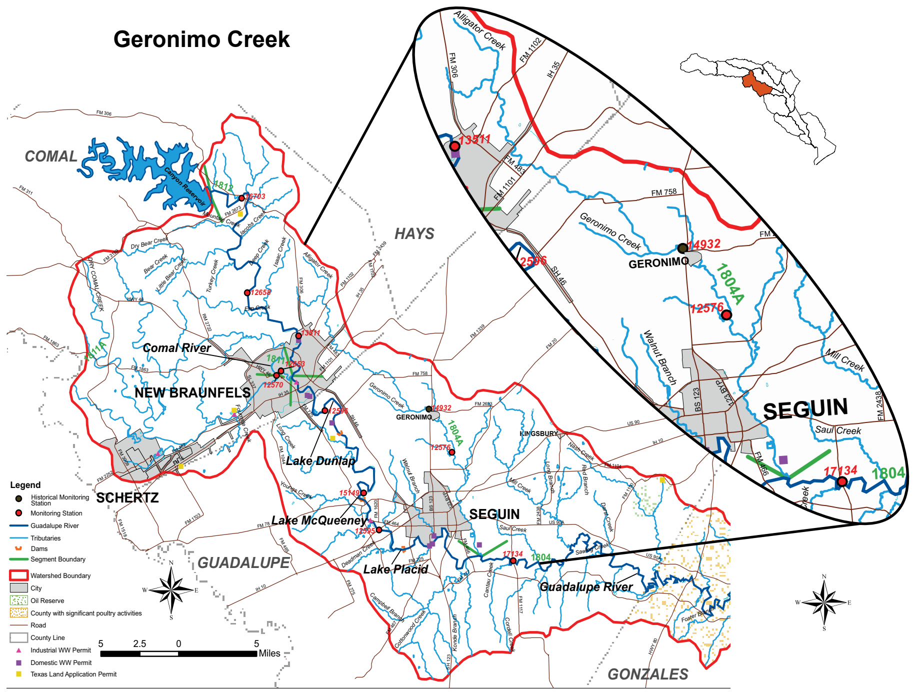
A concern of residents along Lake Placid just upstream of the city of Seguin is the discharges and nonpoint source pollution associated with the steel mill that is located on the east banks of the impoundments. In the 1980s the steel mill was linked to contamination of nearby wells with chromium. Since that time, the facility has implemented a progressive environmental program on site that includes reuse of process water and extensive treatment of stormwater before it leaves the facility grounds. Also, TCEQ has a monitoring location downstream of the facility previously discussed in this section.

Segment 1804 of the Guadalupe River has had a number of problems with invasive plant species. The aquatic species include blooms of filamentous algae referred to as “witch’s hair”, waterhyacinth, hydrilla and water lettuce. It is because of the infestation of the upper lakes by hydrilla in the mid-90s that the residents along Lakes Dunlap, McQueeney and Placid organized into homeowner associations. These groups are very active, expanding their areas of concern outside of aquatic vegetation to include water safety, quality and quantity issues. It is members of these groups that make up a large part of the active membership of the Guadalupe River Basin Clean Rivers Program Stakeholders Committee.

The upper lakes are not alone in their battle with aquatic weed infestations. The waterhyacinth, *Eichhornia crassipes*, has dominated the impoundments at Lake Gonzales and Lake Wood. This invasive plant covers the surface of the lakes, which prevents mixing and oxygen exchange, and shades out sunlight, reducing native plant habitat. This plant also impedes recreational activities such as swimming and canoeing, while generally reducing the aesthetic quality of the lakes. In order to combat this nuisance, in 2008, the GBRA and the Texas Park and Wildlife Department have funded a treatment program that includes mechanical shredding and chemical treatment. The shredding process was followed by a chemical treatment with 2, 4-D in Lake Gonzales and glyphosphate in the Lake Wood area. Treatment of aquatic vegetation is not new to this portion of the river basin. In the 1990’s, infestations of hydrilla, *Hydrilla verticillata,* in Lake McQueeney and Lake Dunlap were treated by introducing sterile, triploid grass carp, into these lakes as a biological control, as well as chemical treatments with aquatic herbicides.

Surface of cove in Lake Wood completely covered with Water-Hyacinth.

Geronimo Creek



Geronimo Creek, Segment 1804A, has been monitored by GBRA as part of the Clean Rivers Program since late 1996. The creek was monitored at the SH 123 crossing until August 2003, at which time the routine monitoring site was moved to the Haberle Road crossing. The new site was a past TCEQ monitoring site and an ecoregion reference site. Reviewing the historical data at the Haberle Road site, the median **dissolved oxygen** (DO) is 9.21 milligrams per liter (mg/L), ranging from 6.9 to 13 mg/L. The stream meets its designated uses, never dropping below the screening level of 5.0 mg/L for dissolved oxygen. The 2008 draft Texas Water Quality Inventory has Geronimo Creek listed with a concern due to elevated **nitrate-nitrogen** concentrations because 11 of the 60 measurements exceeded the screening level of 1.95 mg/L. In addition, the stream is listed as impaired because the geometric mean for ***E. coli* bacteria** (162 organisms per 100 milliliters) exceeded the contact recreation stream standard of 126 organisms per 100 milliliters.

Water Quality

The median **specific conductance** at the Haberle Road site is 875 micromhos per centimeter (umhos/cm), ranging from 485 to 982 umhos/cm. **Temperature** fluctuations correspond with season, with a median temperature of 22.9°C and ranging from a minimum of 11.9°C to a maximum of 27°C. **Total suspended solids** and **turbidity** have median values of 1 and 6.2mg/L respectively and exhibit fluctuations that correspond to storm water runoff.

The historical site on Geronimo Creek, located at SH 123 (site #14932, referred to as "SH123 site"), is approximately 3.6 miles upstream from the current monitoring site located at Haberle Road (site #12576, referred to as "Haberle Road site"). In order to provide the most continuous temporal analysis of this creek, the data from the two sites was combined into a single dataset. Additionally, the data was modified to remove four data points in 1990 collected at the Haberle Road site, due to the large time gap between these points and any subsequent collections. Several statistical differences between these two stations immediately became apparent.

The average **flow** (based on instantaneous flow data taken at time of sampling) of the SH123 site was 5.73 cubic feet per second (cfs) with a standard deviation of 3.21 cfs for the 72 data data points collected between November 1997 and August 2003. The average flow of the Haberle Road site was 14.2 cfs with a standard deviation of 8.43 cfs for the 47 data points collected between September 2003 and September 2007. The combined average flow for these two stations was 9.09 cfs with a standard deviation of 7.17 cfs over the entire 119 data points. The GBRA attributes the large differences in average flow and variability between these two stations to the 3.6 mile distance between the stations and the influence of springs and intermittent creeks in the drainage basin.

The **pH** data of the 85 events collected at the SH123 site from October 1996 through August 2003 showed a median value of 7.65 standard units (S.U.) and a standard deviation of 0.27 S.U. The pH data of the 53 events collected at the Haberle Road site from September 2003 to September 2007 showed a median value of 7.75 S.U. and a standard deviation of 0.09 S.U. As seen in Figure 1, the pH levels appeared to stabilize when the sampling location was changed to Haberle Road. The SH123 site is approximately 1.5 miles removed from the headwater springs that feed the creek and much more likely to experience data variability due to groundwater influences. The new station at Haberle Road is located approximately 5 miles downstream of the headwater springs and appears to exhibit much less variability in pH readings, which may be the result of the stabilizing effects of increased flows and water volume at the downstream station. The average pH over the entire 138 point dataset was 7.69 S.U. with a standard

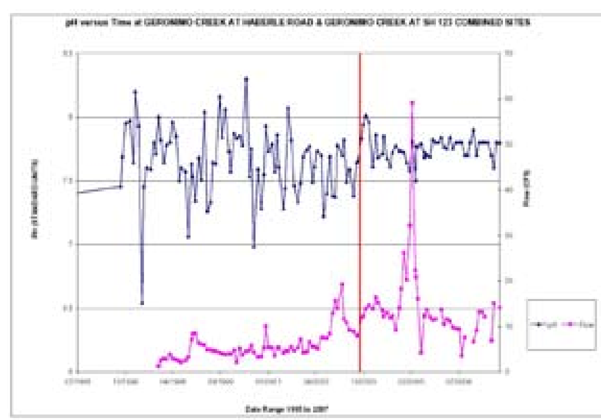


Figure 1. pH versus Time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) Stations. The vertical line in the middle of the chart represents the transition from the station at SH 123 to the station at Haberle Road.

deviation of 0.23 S.U.

Five selenium analyses were performed on Geronimo Creek from May 2001 to April 2007. The first four analyses were performed at the SH 123 site, ending with a collection in June of 2003. The final data point was collected at the Haberle Road site, downstream from the previous station (Figure 2). The mean selenium concentration across all data five Geronimo data points was 2.11 parts per billion (ppb) with a standard deviation of 0.22 ppb. The final data point at the Haberle Road site exhibited the highest observed value of 2.42 ppb, which could indicate a temporally or spatially increasing trend in this watershed. Although this level is well below the drinking water maximum contaminant level (MCL) of 50 ppb, and below the acute and chronic concentrations set by US EPA (20 ppb and 5 ppb respectively), the GBRA believes that these levels should be monitored closely due to the close ties between groundwater and surface water in this water body and the general absence of selenium in other parts of the Guadalupe watershed.

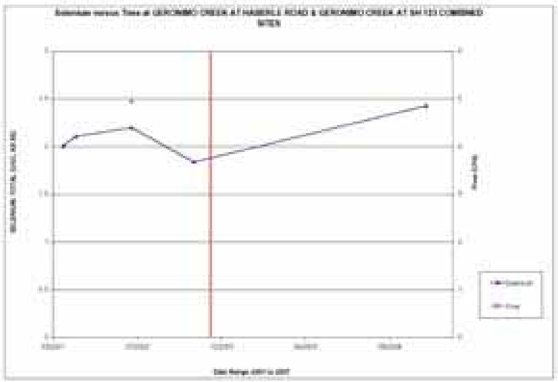


Figure 2. Selenium versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transiton from the SH 123 station to the Haberle Road station.

Initially, phosphorus concentrations in Figure 3 appear to show a shift to a lower and more stable concentration after the transition to the Haberle Road site on 06/2003. However, the statistics show very little change between these two sites and the variability has actually increased at the Haberle Road site. The data collected from the SH123 site has a mean value of 0.076 milligrams per liter (mg/L) with a standard deviation of 0.054 mg/L for the 84 data points collected, while the data from the Haberle Road site has a value of 0.073 mg/L with a standard deviation of 0.088 mg/L for the 49 data points collected. Removing the outlying data point of 0.66 mg/L collected on 09/16/2003, the mean for the Haberle Road site is reduced to 0.060 mg/L with a standard deviation of 0.020 for 50 data points. The change in concentration and variability between these two sites is most likely due to the diluting effects of a higher average flow at Haberle Road site. The least squares trend line for this monitoring parameter, seen in Figure 4, appears to show a downward trend in overall phosphorus levels.

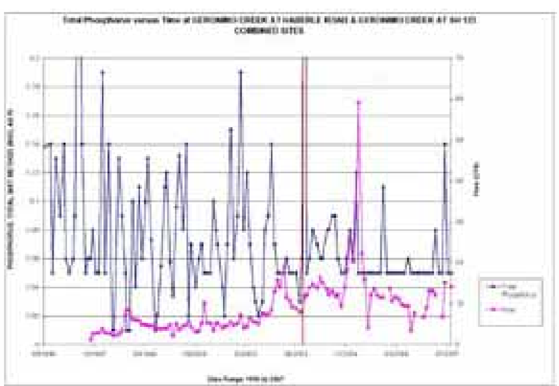


Figure 3. Total Phosphorus versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transiton from the SH 123 station to the Haberle Road station.

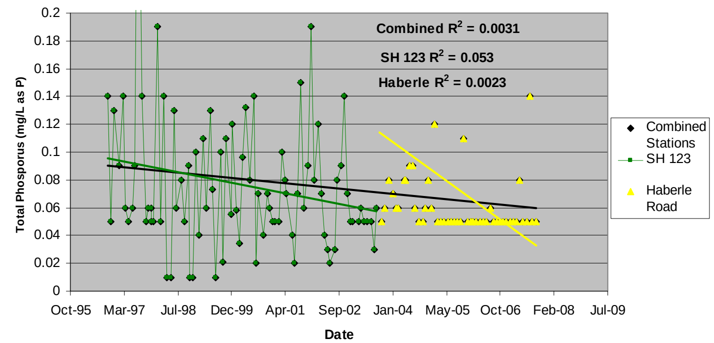


Figure 4. Total phosphorus versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) station.

Chloride also shows a significant decrease in average concentration and variability with the change of site locations. The SH 123 site has an average chloride concentration of 60.6 mg/L with a standard deviation of 12.1 mg/L for the 85 data points collected, while the Haberle Road site has an mean chloride concentration of 40.0 mg/L with a standard deviation of 5.45 mg/L over the 51 data points measured. The mean chloride concentration of the combined sites over the entire 133 point dataset was 53.2 mg/L with a 14.2 mg/L standard deviation. The least squares trend line for this monitoring parameter seen in Figure 5, appears to show a downward trend in chlorides overall and at each station individually.

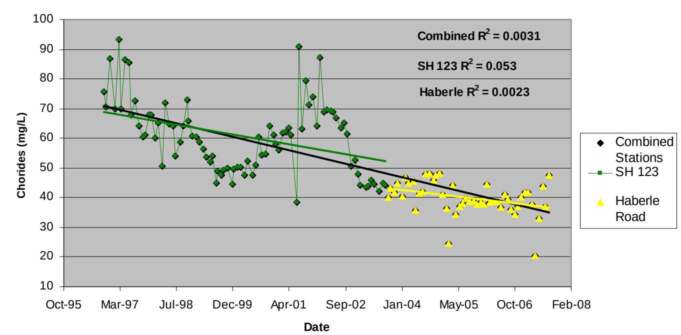


Figure 5. Chloride versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) station.

The nitrate concentrations for Geronimo Creek appear to be fairly consistent despite two changes in test method and a change in station location (Figure 6). Over the entire 137 data points collected on Geronimo Creek the average nitrate observed was 11.07 mg/L with a standard deviation of 2.91 mg/L. The minimum value observed was 5.2 mg/L and the maximum value observed was 18.2 mg/L. The mean concentration for nitrates is over 1 mg/L higher than the MCL of 10.0 mg/L suggested by the EPA for drinking water. The maximum concentration measured is nearly twice the MCL. There is a significant amount of groundwater influence on Geronimo Creek and many drinking water wells in this watershed are known to share nitrate values similar to or even higher than the creek itself. The GBRA is very concerned about the potential effects of these nitrate levels on the water supply for this region, especially as this particular watershed appears ready for explosive growth over the next decade. The radical deviation of the nitrate concentrations in Geronimo Creek from similar streams in the Guadalupe basin present an interesting question about the source of this contamination.

The Geronimo Creek has exceeded the water quality standard for contact recreation (measurement of the indicator bacteria, ***E. coli***, in a grab sample) of 394 colony forming units (CFU) in sixteen, or 1.29%, of the 129 data points collected. The mean *E. coli* concentration observed on Geronimo Creek is 262 CFU with a standard deviation of 493 CFU. The large amounts of variability in the ***E. coli*** measurements for the stream do not always appear to have an obvious explanation (Figure7). At least two of the points that display values greater than the water quality standard correlate closely with high flow events. However, the majority of the other abnormalities had average or below average flows. The unexplained values in question could conceivably be attributed to upstream groundwater influences or the dominance of agricultural land use that occurs in this watershed.

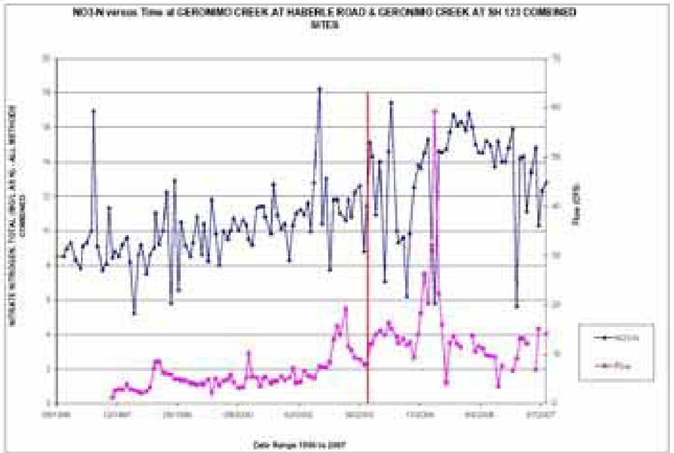


Figure 6. Nitrate nitrogen versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transiton from the SH 123 (14932) and Haberle Road (12576) station.

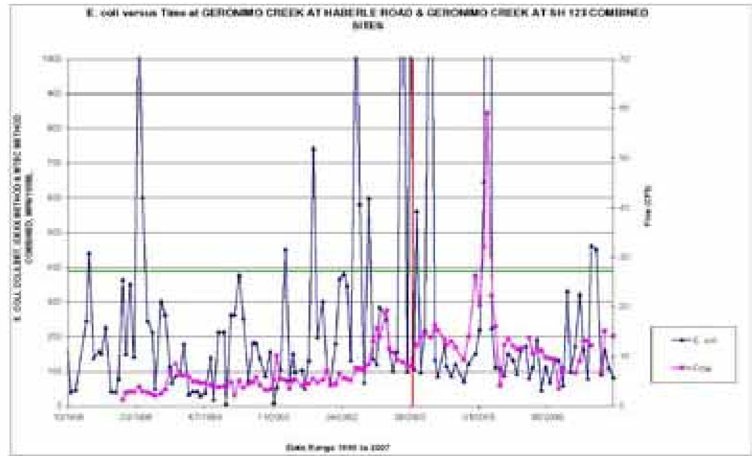


Figure 7. E. *coli* versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transiton from the SH 123 (14932) and Haberle Road (12576) station.

Geronimo Creek at SH 123 (site no. 14932).

Geronimo Creek at Haberle Road (site no. 12576).