

Segment 1806 comprises the 103 mile portion of the Guadalupe River that flows from the confluence between the North Fork and South Forks in Kerr County to Canyon Reservoir in Comal County. This summary report will discuss this segment as two sub-watersheds in order to better describe the effects of a Total Maximum Daily Load (TMDL) implementation plan that has been put into place upstream of Flat Rock Dam in the City of Kerrville. The TCEQ has divided this segment into eight assessment units (AUs). The three AUs that describe the lower sub-watershed below Flat Rock Dam are 1806\_02 from the confluence with Big Joshua Creek to Flat Rock dam in Kerrville, 1806\_08 from the confluence with Honey Creek upstream to the confluence with Big Joshua Creek and 1806\_01 which covers the lower 25 miles of segment from 1.7 miles downstream of Rebecca Creek Road up to the confluence with Honey Creek. These three AUs represent over 93% of the total river reach for this segment. For information regarding the remaining five AUs in this segment please refer to the section of this report covering the Guadalupe River above Flat Rock Dam.

In 2002, segment 1806 was listed on the Texas 303(d) list of impaired waterbodies, as required by Clean Water Act Sections 303(d) and 305(b). The TCEQ found that two assessment units 1806\_06 and 1806\_04 in the City of Kerrville had bacteria levels that exceeded the primary contact recreation standard geometric mean of 126 colony forming units of E. coli

per 100 mL (CFUs/100mL) of water. Please see the section of this summary report regarding the upper subwatershed above Flat Rock Dam for a more in depth discussion of the resulting TMDL study that was accepted by the EPA in 2007 and implementation plan that was put into place in 2011. In 2008, AU 1806\_08 in the lower sub-watershed was also found to be in non-support of

the primary contact recreation standard. An assessed E. coli geometric mean of 140 most probable number per 100 mL (MPN/100 mL) of water was identified downstream of Big Joshua Creek in Kendall County. This new impairment was included into impairment category 4a at this time, because the TMDL reach covered the entire segment.

In the most recently approved 2014



Texas Integrated Report of Surface Water Quality, Segment 1806 of the Guadalupe River is no longer listed as impaired for contact recreation. The data from that report revealed that the geometric means of E. coli data from all eight AUs of this segment are now fully supporting primary contact recreation standards.

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### **Guadalupe River below Flat Rock Dam**

Drainage Area: 827 square miles

Streams and Rivers from Flat Rock Dam to Canyon Lake: Silver Creek, Turtle Creek, Steel Creek, Verde Creek (1806G), Bluff Creek, Cherry Creek, Bruins Creek, Wilson Creek, Cypress Creek (1806B), Holliday Creek, Flat Rock Creek, Block Creek, Joshua Creek (1806H), Violet Creek, Sister Creek, Jacobs Creek, Wasp Creek, Bear Creek, Sabinas Creek, Goss Creek, Spring Creek, Swede Creek, Panther Creek, Walter Creek, Honey Creek, Curry Creek, Spring Branch, Swine Creek, Elm Creek, Cypress Creek, Miller Creek Aquifer: Trinity, Edwards Plateau

River Segments: 1806

**Cities:** Center Point, Comfort, Kendalia, Bergheim, Bulverde, Spring Branch **Counties:** Kerr, Comal, Kendall, Blanco **EcoRegion:** Edwards Plateau Climate: Average annual rainfall 31.68 inches, Average annual temperature January 38°, July 95°
Vegetation Cover: Evergreen Forest 30.7%; Deciduous Forest 7.0%; Shrubland 48.8%; Grassland: 9.6%; Cultivate Crops 0.4%; Pasture Hay 0.4%
Land Uses: urban, unincorporated suburban sprawl, cattle, goat and sheep production, light and heavy industry, and recreational
Development: Low Intensity 0.5%; Medium Intensity 0.2%; High Intensity 0.1%; Open Space 2.3%
Water Body Uses: aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Land Application 6, Domestic 1

In the 2014 Integrated Report, the AU 1806 08 geometric means dropped to a concentration of 109 MPN/100 L and were removed from the 303(d) list. The TMDL process and associated watershed protection and stewardship activities were focused on the AUs upstream of Flat Rock Dam, near the City of Kerrville. The TMDL may have contributed to the recovery of this stream segment, none of the TMDL activities were directly targeted at the impairment on AU1806\_08. The majority of the BMPs that were implemented in this segment were focused on the urban areas immediately surrounding the city of Kerrville and therefore unlikely to directly affect this rural AU. The diminished E. coli concentrations in this AU may have been more profoundly affected by the

The reduced non-point source runoff associated with these drought years corresponded with several years of lower E. coli concentrations, which proved to be beneficial to the assessment of this segment. Unfortunately, as rainfalls and stream flow have begun to rise out of drought levels, the bacteria geometric mean in this AU has also begun to increase.

Assessment Unit 1806\_02 represents a ~32 mile reach between Big Joshua Creek in Kendall County upstream to the Flat Rock Dam in Kerr County. This AU falls in the transition area between the portion of the watershed that is managed by the UGRA and the watershed downstream of Kerr County, which is managed by the

extended drought that began in 2008. GBRA. There are two USGS gages located in this AU, two miles downstream of Flat Rock Dam and downstream of the City of Comfort. The UGRA performs routine sampling at four stations within the AU. The most upstream monitoring station located on this AU is 15113, which is located off Split Rock Road near SH 27, ~1.5 miles downstream of Flat Rock Dam and Kerrville Lake. A regression analysis of the data from June of 2003 to December of 2016 revealed several water quality trends at this station. This station has experienced an increase in specific conductance (TDS is calculated from this measurement), an increase in pH, and a decrease in Total Suspended Solids (Figures 1 & 2 & 3). Although no significant correlations with stream flow



were noted for these parameters, stream flow was significantly decreasing over time and the changes in these parameters were most likely due to prolonged drought conditions. This station also has the lowest E. coli geometric mean in the AU, with a concentration of 22 MPN/100 mL. The excellent water quality (Table 1) at this station, including the diminishing suspended sediments and exceptional bacteria values may be due to the proximity of this station to active best management practices associated with the TMDL implementation plan that have been put into place immediately upstream. The only concern in this segment is for biological habitat. Two aquatic life monitoring events were performed in 2012 and 2014, which scored the biological habitat below the "excellent" designation for this water body. These scores were partially depressed due to low flow conditions during aquatic life monitoring, likely as a result of several years of drought. The next downstream station in this AU is 12608, which is located at Center Point Lake, ~5.1 miles downstream of Split Rock Road. The only statistically significant observation that could be made at this station was that stream flow was diminishing over time, just as in the other stations in this AU (Figure 4). The 62 MPN/100 mL geometric mean of E. coli at this station was slightly higher than any other station in this AU. This value was most likely slightly elevated due to depositions from water fowl on Center Point Lake. The next downstream

monitoring location is station 12605, which is located just upstream of the Kerr County line at the Hermann Sons Road crossing of the Guadalupe River. This station is located ~8.4 miles downstream of Center Point Lake. An analysis of the data from this station over the same time period as the other stations in this AU has revealed several trends. A significant reduction in flow over time (Figure 5) and an increase in sulfate over time (Figure 6) have been documented at this station. The sulfate trend at this station was not statistically correlated with changes in stream flow, but the similar chloride anion did inversely correlate with stream flow. The geometric mean concentration of 44 MPN/100mL of E.coli at this station was even lower than in the Center point station upstream. The average annual streamflow recorded at USGS gage near this this monitoring station for the period of data examined was 194 cfs. The next station is the only routine monitoring station in this AU located outside of Kerr County. This station 12602 is located near the FM 1621 bridge in the town of Waring ~16.4 miles downstream of the Kerr County line. This monitoring station in downstream of the only permitted wastewater discharge in this The Kendall County Water Control AU. and Improvement district is permitted to discharge up to 0.35 million gallons day of treated wastewater into per the Guadalupe River below the city of Comfort. This wastewater is treated to a high level with permit limits of 5 mg/L of Biochemical Oxygen Demand (BOD), 5

mg/L of TSS, 2 mg/L of Ammonia Nitrogen and 1 mg/L of Total Phosphorus. Much of this wastewater is reused for irrigation of a local golf course, since a Texas Administrative Code Title 30 Chapter 210 authorization for beneficial use was granted by the TCEQ in 2002. A regression analysis revealed one trend over time. The chloride anion concentration was found to be significantly increasing over time (Figure 7). A significant correlation with flow was not observed for chloride. Water quality parameters at this station were within normal assessment criteria and met all designated uses (Table 4). Although this station is positioned immediately upstream of a previously assessed E.coli impairment on AU 1806\_08, the geometric mean for E. coli always remained well below the primary contact recreation standard. The E. coli geometric mean at the Waring monitoring station is currently 49 MPN/100 mL for all data available.

Assessment Unit 1806\_08 is located immediately upstream of the confluence with Honey Creek in Comal County and comprises a reach of approximately 39 miles upstream to the confluence with Big Joshua Creek in Kendall County. This AU flows northeast of the City of Boerne and is frequently used for contact recreation and fishing activities. The only monitoring station in this AU is station 17404, which is located on the Guadalupe River upstream of the FM 474 Bridge in Kendall County. Station 17404 has been monitored quarterly by the GBRA since 2001. The E. coli data



collected from this station was used to assess the 140 MPN/100 mL geometric mean and resulting 303(d) listing for non-support of the 126 MPN/100 mL primary contact recreation standards in 2008. This AU was included into category 4a with the other impaired AUs on this stream segment, due to the existence of the TMDL that was approved in 2007. The land use for this AU differed significantly from the other impaired AUs included in the segment 1806 TMDL and no BMPs were specifically targeted at this area as a part of the TMDL implementation plan. This AU is much more rural and has a greater potential to be influenced by agricultural runoff than the urbanized AUs upstream in the city of Kerrville. Only one permitted discharge occurs in this AU, but it is located on a small tributary, whose confluence is ~13 miles downstream of the monitoring station at FM 474. The effects of this discharge would be measured at station 13700 in the downstream AU. The data for station 17404 was reviewed from January of

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2003 to December of 2016 to look for trends in water quality. Water quality trending was noted for several parameters at this station. The chloride and sulfate anions both appeared to be significantly increasing with time (Figures 8 & 9). Total Hardness appears to be significantly decreasing with time (Figure 10). All three of these trends are significantly correlated with stream flow. The chloride and sulfate levels both decrease as stream flow increases (Figures 11 & 12). Total Hardness increases as stream flow increases (Figure 13). These correlations seem to make sense as the anions are diluted by additional water in the system and more calcium carbonate is flushed out of the limestone of the surrounding Edwards Plateau during higher flow events. Although a significant correlation between stream flow and time was not noted for the data collected at this station, the effects of the multi-year drought, beginning in 2008, on stream flow have been identified at several other monitoring locations within segment 1806. At several stations outside of this AU, significant decreases in stream flow over time have been noted (See Figures 4 & 5). The quarterly monitoring frequency for this particular monitoring station may have made identification of long term flow patterns more difficult due to the lower resolution of data collected, but flows at this station most likely followed similar patterns to other stations in the segment. The mean chloride level for this assessment unit was 23.3 mg/L with a maximum value of 38.4 mg/L.

The mean sulfate level was 24.8 mg/L with a maximum value of 36.9 mg/L. At no point did the concentrations of either chloride or sulfate anions exceed the 50 mg/L general use screening criteria (Table 5). Although this station was removed from the 303(d) list for primary contact recreation in the 2014 Texas Water Quality Inventory, an analysis of all of the E. coli data collected to date reveals a long term geometric mean of 140 MPN/100 mL. By reducing the data to the 7 year periods that bracket each 2 year assessment several predications can be made. The 2016 assessment will cover a seven year period beginning in December of 2007 and ending in November of 2014. No significant trending pattern was found for E. coli at this station (Figure 14). An analysis of this data during the 2016 assessment period of record revealed that this AU will have a slightly higher geometric mean of 117 MPN/100 mL. If the 2018 assessment advances the data forward two more years then several years of low concentration data will be removed from the assessment. A preliminary analysis of the E. coli data from this period of record indicates a geometric mean of 146 MPN/100 mL which is greater than the contact recreation standard of 126 MPN/100 mL for this AU. . This is primarily due to an abundance of higher E. coli concentrations in the years 2014 through 2016. These concentrations were most likely higher due to a greater amount of non-point source runoff resulting from higher rainfall totals

following the extended drought period.

The most downstream AU 1806\_01 covers a 25 mile reach in Comal County from a point 1.7 miles downstream of Rebecca Creek Road upstream to the confluence of Honey Creek near the Kendall County line. This AU is represented by a single monitoring station 13700. Station 13700 is located on the Guadalupe River upstream of the FM 311 Bridge near the USGS gaging station in Spring Branch and has been monitored monthly by the GBRA since 1996. This segment of the Guadalupe River immediately upstream of Canyon Lake is a part of the Guadalupe River Paddling Trail and is known for clear water with abundant contact recreation. There are no known permitted discharges into this assessment unit. The 2014 Texas Integrated Report of Water Quality indicates full support of all designated uses and the geometric mean of E. coli was well below the primary contact reaction standard of 126 MPN/100 mL with a concentration of 62 MPN/100 mL. A review of the data from December of 2002 to November of 2016 was conducted at this station. The average stream flow at the nearby USGS gage during this time period was 362 cfs. Several important data trends were identified at this station. Much like the other stations upstream, stream flow at this station appears to be significantly declining (Figure 15). This trend is most likely due to several years of drought, beginning in 2008, including an extended period during from August till October

of 2011, when the stream flow at this station was measured at 0.00 cfs and the river was reduced to unconnected pools of water. A significant increase in chlorides and sulfates over time was also identified at this station (Figure 16 & 17). These rising chloride and sulfate levels can be at least partially explained by the overall reduction in streamflow, because chlorides are significantly increasing as stream flow decreases (Figure 18). Although the concentrations of these anions appear to increasing, at no point did any value exceed the stream general use screening criteria of 50 mg/L. All of the available data shows that this station appears to support the AU's designated uses (Table 6). The geometric mean of E. coli at this station remains at 64 MPN/100 mL with a maximum recorded value of 2400 MPN/100 mL. The average concentrations measured for all water quality parameters fall within the designated use criteria for this segment.



	Station 15113 -	Guadalupe at Spli	t Rock Road 02/3	2003 - 12/2016	
		AU 1806_02	General Use	,	
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature ('C)	21.8	30.0	9.8	65	32.20
pH (S.U.)	8.1	8.5	7.6	64	6.5 - 9.0
Chloride	26.4	45.1	17.6	55	50.00
Sulfate	17.1	23.8	10.8	55	50.00
Total Dissolved Solids (mg/L)	316	378	268	64	400.00
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33
Total Phosphorus (mg/L)	<0.04	0.08	<0.04	55	0.69
Chlorophyll-a (µg/L)	<1.0	13.3	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.63	1.4	<0.04	52	1.95
TKN (mg/L)	0.41	0.71	<0.2	21	N/A
	•	AU 1806_02 Re	creational Use		
<i>Ec.oli</i> (MPN/100 mL)	23 Geomean	120	<1	54	126 Geomean
	•	AU 1806_02 Au	uatic Life Use	•	•
Dissolved Oxygen	9.5	14.2	5.5	64	≥4.0 Minimum & ≥6.0 Average

Table 2							
	Station 12615	- Guadalupe at C	enter Point 02/20	03 - 12/2016			
		AU 1806_02	General Use				
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria		
Temperature ('C)	21.7	31.5	9.1	73	32.20		
pH (S.U.)	8.0	8.4	6.6	73	6.5 - 9.0		
Chloride	26.2	45.6	16.0	55	50.00		
Sulfate	22.5	32.0	14.9	55	50.00		
Total Dissolved Solids (mg/L)	322	385	267	73	400.00		
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33		
Total Phosphorus (mg/L)	<0.04	0.15	<0.04	55	0.69		
Chlorophyll-a (µg/L)	<1.0	6.6	<1.0	54	14.10		
Nitrate Nitrogen (mg/L)	0.57	1.48	<0.05	52	1.95		
TKN (mg/L)	0.35	0.59	<0.2	20	N/A		
AU 1806_02 Recreational Use							
<i>E c.oli</i> (MPN/100 mL)	62 Geomean	3500	5	144	126 Geomean		
AU 1806_02 Aquatic Life Use							
Dissolved Oxygen	8.5	8.4	6.6	73	≥4.0 Minimum & ≥6.0 Average		

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Table 3

S	itation 12605 - G	uadalupe at Hern	1ann Sons Road O	2/2003 - 12/2016			
AU 1806_02 General Use							
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria		
				Measurements			
Temperature ('C)	20.9	29.4	9.4	56	32.20		
pH (S.U.)	8.0	8.4	7.4	56	6.5 - 9.0		
Chloride	25.0	52.4	13.0	56	50.00		
Sulfate	24.8	37.6	9.2	56	50.00		
Total Dissolved Solids	330	379	275	56	400.00		
(mg/L)							
NH3-N (mg/L)	N/A	N/A	N/A	N/A	0.33		
Total Phosphorus (mg/L)	<0.04	0.07	<0.04	56	0.69		
Chlorophyll-a (µg/L)	<1.0	6.6	<1.0	55	14.10		
Nitrate Nitrogen (mg/L)	0.59	1.49	<0.05	53	1.95		
TKN (mg/L)	0.31	0.59	<0.2	22	N/A		
AU 1806_02 Recreational Use							
<i>Ec.oli</i> (MPN/100 mL)	44 Geomean	520	5	55	126 Geomean		
AU 1806_02 Aquatic Life Use							
Dissolved Oxygen	8.8	13.9	6.0	56	≥4.0 Minimum & ≥6.0		
					Average		

Table 5

Station	n 17404 - Guadalu	pe at FM 474 NE	of Boerne Data fr	om 12/2002 - 11/2	016
		AU 1806_08	General Use		
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria
				Measurments	
Temperature ('C)	19.6	29.0	8.4	56	32.20
pH (S.U.)	7.9	8.2	7.4	56	6.5 - 9.0
Chloride	23.2	38.4	7.5	55	50.00
Sulfate	24.9	36.9	10.8	55	50.00
Total Dissolved Solids	348	408	180	56	400.00
(mg/L)					
NH3-N (mg/L)	<0.10	0.35	<0.10	55	0.33
Total Phosphorus (mg/L)	<0.02	0.21	<0.02	55	0.69
Chlorophyll-a (µg/L)	<1.0	2.52	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.36	1.21	<0.02	55	1.95
TKN (mg/L)	<0.2	0.52	<0.2	35	N/A
		AU 1806_08 Re	creational Use	•	
<i>Ec.oli</i> (MPN/100 mL)	140 Geomean	>4800	16	55	126 Geomean
· · ·	•	AU 1806_08 A	quatic Life Use	•	•
Dissolved Oxygen	9.1	14.8	5.7	56	≥4.0 Minimum & ≥6.0
					Average

Table 4

Statio	on 12602 - Guadal	upe at FM 1621 i	n Waring Data fro	m 06/2003 - 12/20	16
		AU 1806_02	General Use		
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature ('C)	21.0	31.3	9.0	58	32.20
pH (S.U.)	8.1	8.6	6.7	58	6.5 - 9.0
Chloride	25.4	40.4	13.0	57	50.00
Sulfate	26.5	37.0	14.0	58	50.00
Total Dissolved Solids (mg/L)	344	401	242	58	400.00
NH3-N (mg/L)	<0.10	<0.10	<0.10	41	0.33
Total Phosphorus (mg/L)	<0.02	0.09	<0.02	56	0.69
Chlorophyll-a (µg/L)	<1.0	3.37	<1.0	54	14.10
Nitrate Nitrogen (mg/L)	0.61	1.61	<0.04	53	1.95
TKN (mg/L)	0.23	0.8	<0.2	54	N/A
		AU 1806_02 Re	creational Use		
<i>Ec.oli</i> (MPN/100 mL)	49 Geomean	2000	<2	57	126 Geomean
		AU 1806_02 Ad	uatic Life Use		
Dissolved Oxygen	9.3	12.6	6.7	58	≥4.0 Minimum & ≥6.0 Average

Table 6

Station 13700 – Guadalupe at FM 311 in Spring Branch Data from 12/2002 - 11/2016							
AU 1806_01 General Use							
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria		
				Measurments			
Temperature ('C)	20.8	33.0	5.3	161	32.20		
pH (S.U.)	8.0	8.5	7.5	161	6.5 - 9.0		
Chloride	21.9	35.6	9.1	161	50.00		
Sulfate	24.1	33.9	12.5	161	50.00		
Total Dissolved Solids	339	644	275	161	400.00		
(mg/L)							
NH3-N (mg/L)	<0.10	0.95	<0.10	80	0.33		
Total Phosphorus (mg/L)	<0.02	0.28	<0.02	161	0.69		
Chlorophyll-a (µg/L)	<1.0	6.2	<1.0	159	14.10		
Nitrate Nitrogen (mg/L)	0.36	1.78	<0.02	159	1.95		
TKN (mg/L)	<0.2	0.95	<0.2	63	N/A		
AU 1806_01 Recreational Use							
<i>E c.oli</i> (MPN/100 mL)	64 Geomean	>2400	<2	161	126 Geomean		
AU 1806_01 Aquatic Life Use							
Dissolved Oxygen	9.5	14.9	5.2	160	≥4.0 Minimum & ≥6.0		
					Average		



Figure 2







Figure 4



Figure 5



![](_page_7_Figure_10.jpeg)

![](_page_7_Figure_11.jpeg)

![](_page_8_Figure_1.jpeg)

Figure 8

![](_page_8_Figure_3.jpeg)

![](_page_8_Figure_4.jpeg)

![](_page_8_Figure_5.jpeg)

### Figure 10

![](_page_8_Figure_7.jpeg)

Figure 11

![](_page_8_Figure_9.jpeg)

Figure 12

![](_page_8_Figure_11.jpeg)

![](_page_9_Figure_1.jpeg)

Figure 14

![](_page_9_Figure_3.jpeg)

![](_page_9_Figure_4.jpeg)

![](_page_9_Figure_5.jpeg)

#### Figure 16

![](_page_9_Figure_7.jpeg)

Figure 17

![](_page_9_Figure_9.jpeg)

![](_page_9_Figure_10.jpeg)

![](_page_9_Figure_11.jpeg)