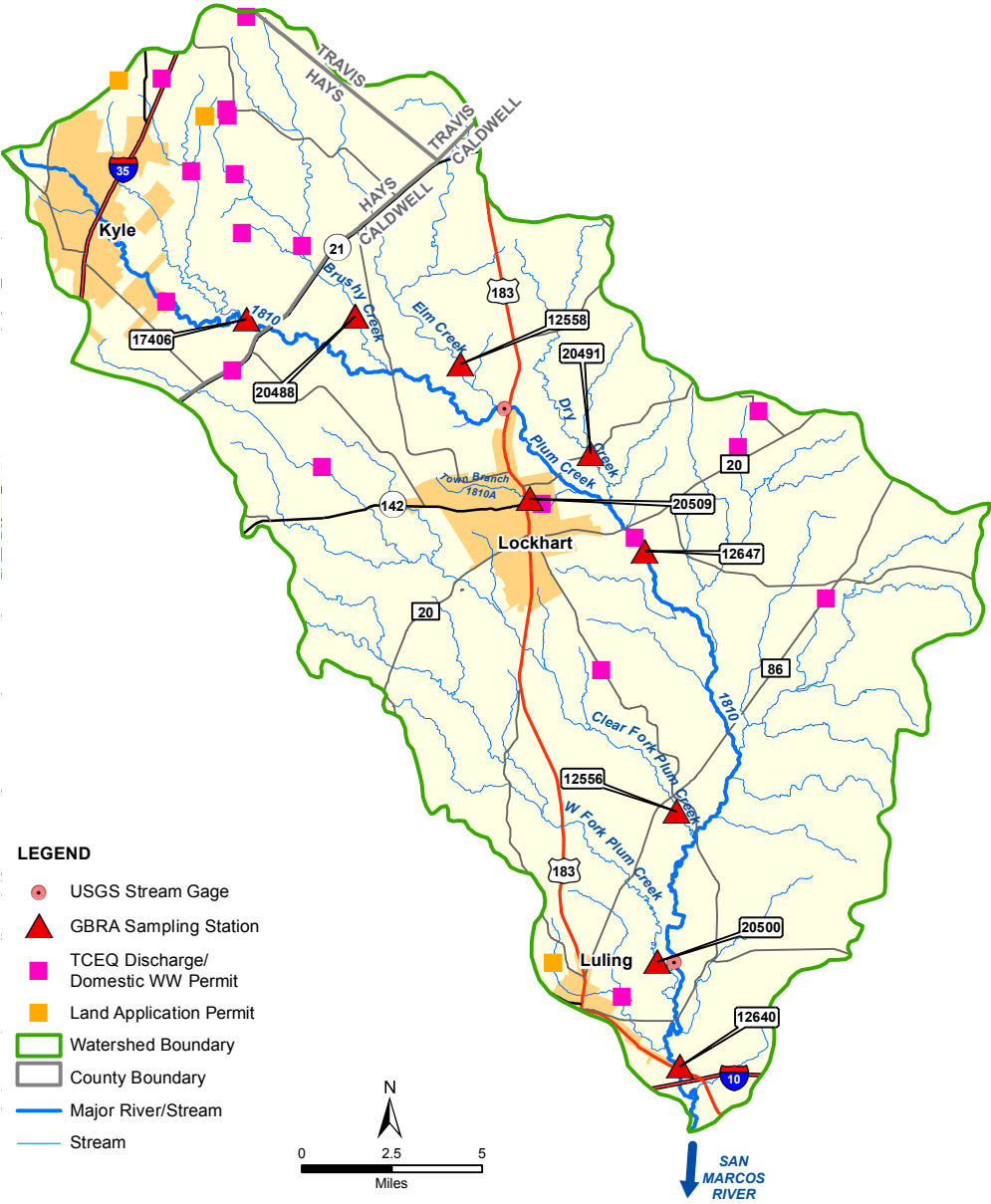


PLUM CREEK



PLUM CREEK

Segment 1810 represents the 52 mile long Plum Creek tributary of the San Marcos River. Plum Creek has a large 389 square mile drainage area that encompasses the cities of Buda, Kyle, Uhland, Lockhart and Luling. This watershed has been historically dominated by agricultural land use, but is rapidly urbanizing as the population of the area increases. The headwaters of Plum Creek are fed by natural springs from the Leona aquifer, with additional contributing springs arising throughout the watershed. The stream is largely wastewater dominant, as it receives the treated effluent discharge of twelve permitted wastewater treatment facilities.

Plum Creek is a historically intermittent creek with contributing flows from several springs along its length. The creek become perennial as the surrounding communities of Buda, Kyle, Lockhart and Luling have developed in the watershed. These four cities contribute the bulk of the base flow to the stream by discharging wastewater effluent from five major discharges along its length. The Plum Creek Segment 1810 was listed on the Texas 303(d) list of impaired water bodies, as required by Clean Water Act Sections 303(d) and 305(b) in 2004. The middle and upper end of the water body from below Lockhart at CR 202 to

the upper end of the segment were found to be impaired for contact recreation with an E. coli geometric mean of 183 MPN/100 mL. The stream was also noted to have concerns for Nitrate+Nitrite Nitrogen at this time because over 25% of all measurements exceed the screening criteria of 1.95 mg/L. In 2006, the Texas State Soil and Water Conservation Board (TSSWCB), GBRA and Texas AgriLife Extension began working with local stakeholders to develop a Watershed Protection Plan (WPP) for the Plum Creek watershed. The TSSWCB also funded additional water quality monitoring in the watershed to facilitate

the development of the WPP by filling data gaps to supplement the existing CRP monitoring program. This plan was designed to address the known water quality impairments and concerns in the watershed. The WPP became the first plan in the state of Texas to be accepted by the EPA as meeting all guidance requirements and implementation of the plan began in 2008. In addition to identifying the sources of bacteria and nutrient loading in the watershed, the plan also identified a number of implementation activities that could be voluntarily undertaken by stakeholders in order to reduce targeted bacteria and

nutrient loading. These activities include feral hog removal, addressing leaking septic tanks, nutrient management training, pet waste management, and storm system conveyance assessments. In 2010, the TCEQ moved the watershed from assessment category 5a, which would require a regulatory TMDL to address the impairments in the watershed to category 4b, which would allow for the WPP to attempt to address the impairment with best management practices that are expected to result in attainment of the water quality

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Plum Creek

Drainage Area: 389 square miles

Length: 52 miles

Tributaries: Bunton Branch, Porter Creek, Andrew’s Branch, Richmond Branch, Cowpen Creek, Brushy Creek, Elm Creek, Dry Creek, Town Creek (1810A), Clear Fork, West Fork,

Aquifer: Edwards Balcones Fault Zone, Leona Aquifer, Carrizo-Wilcox Aquifer

River Segments: 1810, 1810A

Cities and Communities: Buda, Kyle, Uhland, Lockhart, Luling
Counties: Hays, Caldwell

EcoRegion: Edwards Plateau, Texas Blackland Prairie, Post Oak Savannah

Climate: Average annual rainfall 34.43 inches, Average annual temperature 70.64° F

Vegetation Cover: Evergreen Forest 1.21%, Deciduous Forest 11.64%, Shrubland 34.12%; Grassland 12.10%; Woody Wetlands: 3.07% Cultivated Crops 7.20% ; Pasture Hay 20.92%

Land Uses: urban, suburban sprawl, light industry, and recreational.

Development: Low Intensity 0.59% ; Medium Intensity 0.36%; High Intensity 0.09%; Open Space 6.52%

Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and agriculture and ranching.

Soils: Dark, waxy soil to sandy loam, limestone to black waxy chocolate and grey loam

Permitted Wastewater Treatment Facilities: Domestic 12, Land Application 2, Industrial 2

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standard. Following the acceptance of the plan the TSSWCB has funded several additional monitoring projects that have been used to quantitatively track the effectiveness of water quality restoration implementation activities over time. In the latest 2014 Texas Integrated Report of Surface Water Quality the geometric mean for E. coli in all three assessment units of the watershed has increased since the initial listing in 2004. Total Phosphorus and dissolved oxygen have also been added to nitrate nitrogen as ongoing concerns in the watershed. The TSSWCB funded a nitrate isotope study, in which the GBRA and USGS conducted monitoring of the surface water, shallow groundwater and springs from the

contributing Leona aquifer in order to determine the sources of nitrate nitrogen in the watershed. The results of this study showed that the majority of nitrate nitrogen in this watershed came from a wastewater source during normal and low flows, but during high flows additional contributions occurred from a mixture of nitrogen fertilizers and septic waste. This study eliminated past supposition that nitrate could be entering the watershed from atmospheric deposition or naturally occurring nitrate deposits. The TSSWCB also funded a bacterial source tracking study conducted by the GBRA and the Texas A&M Soil and Microbiology Laboratory (TAMU SAML). The results of this study showed that the majority

of bacteria samples collected during the twelve month long study came from wildlife sources and less than 10% of the bacteria came from a source that could be identified as human. The TCEQ has divided the creek into three assessment units that represent the upper, middle and lower portions of the watershed. Each section of the watershed was examined for water quality trends over time.

Assessment Unit 1810_01 represents the lower portion of the watershed from the confluence with the San Marcos River to 2.5 miles upstream of the Clear Fork tributary. This AU has been historically monitored at station 12640 at the County Road 135 crossing southeast of the city of Luling, TX. This station was monitored

by the TCEQ and its predecessor agencies from 1983 until 1998, when monitoring duties were transferred to the GBRA under the Clean Rivers Program. This AU receives the discharges from the Clear Fork and West Fork tributaries of Plum Creek, as well as the discharge of the Salt Branch tributary, which receives the effluent from one of the two wastewater treatment facilities in the City of Luling. The Luling North WWTF is permitted to discharge up to 0.9 million gallons per day (MGD). This facility treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen



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does not exceed 3 mg/L and *E. coli* does not exceed 126 MPN/100 mL. Recently, several large wastewater permits to serve subdivisions near the City of Umland have been issued to the Walton Group. These WWTFs are permitted to discharge into the Clear Fork tributary of this AU, but to date no construction has begun on these projects. In the most recent 2014 Texas Integrated Report of Surface Water Quality this AU had an assessed geometric mean of *E. coli* concentrations of 156.78 MPN/100 mL. This AU also had assessed concerns for dissolved oxygen grab and 24 hour average concentrations, below the screening criteria of 5.0 mg/L. The 2014 report also identified nutrient concerns for nitrate nitrogen and total phosphorus above the respective screening criteria of 1.95 mg/L and 0.69 mg/L. The assessed average of total phosphorus was 1.17 mg/L and the assessed average for nitrate nitrogen was 3.75 mg/L. The GBRA analyzed the most recent data from this AU and discovered several notable trends. The dissolved oxygen concentrations at this station are significantly decreasing over time, and this parameter correlates directly with stream flow (Figures 1 & 2). Total phosphorus concentration are also significantly increasing over time, and this parameter has an inverse relationship with stream flow (Figures 3 & 4).

Assessment Unit 1810_02 encompasses the middle portion of the watershed from 2.5 miles upstream of the Clear Fork tributary to 0.5 miles upstream of state highway 21. Historically, this AU

has been monitored at station 12647 at the County Road 202 crossing southeast of the city of Lockhart. This station was monitored by the TCEQ from 1981 and its predecessor agencies until 2005, when monitoring duties were transferred to the GBRA under the Clean Rivers Program. This AU receives the discharges from the Brushy Creek, Elm Creek, Dry Creek and Town Creek (1810A) tributaries. This AU also receives the discharges from both wastewater treatment facilities in the City of Lockhart, as well as permitted treatment plants for the Shadow Creek and Sunfield neighborhoods. The Lockhart #2 FM20 WWTF is permitted to discharge up to 1.5 million gallons per day (MGD). The Lockhart #1 Larremore WWTF is permitted to discharge up to 1.1 million gallons per day (MGD). Both facilities treat the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen does not exceed 3 mg/L and *E. coli* does not exceed 126 MPN/100 mL. The 2014 Texas Integrated Report of Surface Water Quality reported that this AU had an assessed geometric mean of *E. coli* concentrations of 200.13 MPN/100 mL. This AU also assessed nutrient concentrations for nitrate nitrogen of 7.69 mg/L and total phosphorus of 1.52 mg/L, which were above the respective screening criteria of 1.95 mg/L and 0.69 mg/L. The 2014 report also identified a concern for impaired biological habitat because the average index of biological

integrity (IBI) for 5 screening events at this station was 24.40, which fell below the 29.00 IBI score needed to meet a high aquatic life use. Several of these screening events occurred during drought conditions and a full aquatic life monitoring event during normal stream flow conditions may be warranted in order to confirm this concern. The unclassified Town Creek (1810A) tributary to Plum Creek was also assessed in the 2014 report and the TCEQ identified concerns for the geometric mean of *E. coli* bacteria and average concentration of nitrate nitrogen and dissolved oxygen grabs over the 6 data points analyzed. GBRA reviewed all of the data available at station 20509 in Lockhart City Park through December of 2016. The GBRA found that the assessed concerns were justified for *E. coli* and nitrate nitrogen with a calculated geometric mean of *E. coli* of 273 MPN/100 mL, and an average nitrate nitrogen concentration of 10.0 mg/L over the 26 data points examined. This creek is heavily influenced by spring flows from the Leona aquifer, which has historically high nitrate nitrogen concentrations and the *E. coli* concentrations in this segment are most likely due to wildlife influences in this park setting. An aquatic life monitoring (ALM) event was performed at this station in 2017 to determine whether the dissolved oxygen concern was impacting the life in this stream. During the first day of the ALM, a trail of horses traveled through the middle of the stream bed, which visibly disturbed the substrate and fish nesting areas. This

disturbance may have contributed to the intermediate fish and macroinvertebrate community scores observed on that day, but a successive monitoring event two months later confirmed that the fish community had recovered to high levels and the macroinvertebrate community were exceptional. The GBRA also identified several water quality trends in AU 1810_02. The nitrate nitrogen concentrations in this AU are significantly decreasing over time and are also inversely correlated with stream flow (Figures 5 & 6). This trend indicates that nitrate levels are diluted in the water column as flows increase following several years of drought conditions in the watershed. The *E. coli* concentrations for which there is an impairment in this AU, are not significantly changing over time (Figure 7).

Assessment Unit 1810_03 encompasses the middle portion of the watershed from 0.5 miles upstream of of State Highway 21 to the upper end of the segment above FM 150 in the City of Kyle. This AU has been monitored at station 17406 on Plum Creek Road upstream of the city of Umland by the GBRA under the Clean Rivers Program. This AU receives the discharge from the Porter Creek tributary, which receives the wastewater discharge from the city of Buda. This AU also receives the effluent discharge from the city of Kyle. The Buda WWTF is permitted to discharge up to 1.5 million gallons per day (MGD). The Kyle WWTF is

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permitted to discharge up to 4.5 million gallons per day (MGD). The Buda WWTF treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 5 mg/L, total suspended solids (TSS) does not exceed 12 mg/L, ammonia nitrogen does not exceed 2 mg/L and total phosphorus does not exceed 0.8 mg/L, and E. coli does not exceed 126 MPN/100 mL. The Kyle WWTF treats the effluent to ensure that the daily average for carbonaceous biochemical oxygen demand (CBOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, ammonia nitrogen

does not exceed 3 mg/L, and E. coli does not exceed 126 MPN/100 mL. The 2014 Integrated Report identified impairment for E. coli bacteria in this segment, as well as screening concerns for nitrate nitrogen and total phosphorus. The position of this AU upstream of the majority of the spring influences in the watershed cause it to experience a greater influence from wastewater effluent than the downstream AUS. The assessed E.coli bacteria geometric mean concentration of 306.54 MPN/100 mL, average nitrate nitrogen concentration of 14.17 mg/L and average total phosphorus concentration of 2.83 mg/L are also greater than in

any of the downstream AUS. The nutrient loading in this AU is most likely directly linked to the effects of wastewater effluent according to the nitrate nitrogen isotope study performed by the GBRA and USGS. The E. coli loading does not appear to be from human sources according to the bacterial source tracking study performed by the GBRA and TAMU SAML, but the rapid urbanization of this AU be contributing to additional use of the riparian corridors along the stream segment by contributing native wildlife. The wildlife are potentially being crowded closer to the stream in order to avoid human contact in the more urbanized

portions of the watershed. Several water quality trends were identified by the GBRA in this AU. The nitrate nitrogen concentrations are significantly increasing and this parameter is inversely correlated with stream flow (Figures 8 & 9). The chloride concentrations were also significantly increasing over time and inversely correlated with stream flow (Figures 10 & 11). The nutrient and salt concentrations will likely continue to increase as additional wastewater is discharged into this portion of the creek from an expanding population.

Table 1

Station 12640 - Plum Creek at CR 135 12/2002 - 11/2016					
AU 1810_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.1	29.3	6.2	181	32.2
pH	7.8	8.3	7.0	180	6.5 - 9.0
Chloride (mg/L)	152	444	9.4	161	350.00
Sulfate (mg/L)	77	163	14.9	163	150.00
Total Dissolved Solids (mg/L)	731	1729	155	180	1120.00
NH3-N (mg/L)	0.15	0.66	<0.02	132	0.33
Total Phosphorus (mg/L)	0.60	2.69	<0.05	176	0.69
Chlorophyll-a (µg/L)	2.5	19.2	<1.0	161	14.1
Nitrate Nitrogen (mg/L)	1.83	7.96	<0.05	174	1.95
TKN (mg/L)	0.85	1.92	0.42	87	N/A
AU 1810_01 Recreational Use					
E. coli (MPN/100 mL)	198 Geomean	13,000	9	173	126 Geomean
AU 1810_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.4	14.6	3.4	180	≥3.0 Minimum & ≥5.0 Average

Table 2

Station 12647 - Plum Creek at CR 202 12/2002 - 11/2016					
AU 1810_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.0	28.8	8.1	135	32.2
pH	7.9	8.5	7.4	135	6.5 - 9.0
Chloride (mg/L)	86	139	5.0	116	350.00
Sulfate (mg/L)	76	319	5.0	116	150.00
Total Dissolved Solids (mg/L)	556	741	145	134	1120.00
NH3-N (mg/L)	0.17	1.43	<0.05	116	0.33
Total Phosphorus (mg/L)	1.03	2.69	0.14	133	0.69
Chlorophyll-a (µg/L)	3.2	15.5	<1.0	108	14.1
Nitrate Nitrogen (mg/L)	5.99	51.6	0.32	129	1.95
TKN (mg/L)	0.77	2.69	<0.2	106	N/A
AU 1810_02 Recreational Use					
E. coli (MPN/100 mL)	264 Geomean	>24,000	16	119	126 Geomean
AU 1810_02 Aquatic Life Use					
Dissolved Oxygen (mg/L)	8.2	13.6	3.9	135	≥3.0 Minimum & ≥5.0 Average

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Table 3

Station 17406 – Plum Creek at Plum Creek Road 02/2003 - 10/2016					
AU 1804_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	20.2	28.4	6.03	181	32.20
pH	7.8	8.7	7.0	181	6.5 – 9.0
Chloride (mg/L)	108	267	16.3	166	350.00
Sulfate (mg/L)	92	173	36.0	166	150.00
Total Dissolved Solids (mg/L)	640	1040	214	181	1120.00
NH3-N (mg/L)	0.74	15.5	<0.02	131	0.33
Total Phosphorus (mg/L)	1.90	5.26	<0.04	177	0.69
Chlorophyll-a (µg/L)	2.64	11.6	<1.0	162	14.1
Nitrate Nitrogen (mg/L)	9.41	34.8	0.22	171	1.95
TKN (mg/L)	1.07	8.13	<0.2	89	N/A
AU 1810_03 Recreational Use					
<i>E. coli</i> (MPN/100 mL)	348 Geomean	17,000	36	171	126 Geomean
AU 1810_03 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.6	14.1	2.2	181	≥3.0 Minimum & ≥5.0 Average

Table 4

Station 20509 – Town Branch at Lockhart City Park 03/2008 - 10/2016					
AU 1810A_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	21.5	26.6	11.2	26	32.20
pH	7.9	8.1	7.3	26	6.5 – 9.0
Chloride (mg/L)	30.0	40.9	21.8	26	350.00
Sulfate (mg/L)	64.0	78.6	48.2	26	150.00
Total Dissolved Solids (mg/L)	509	582	366	26	1120.00
NH3-N (mg/L)	0.16	0.60	<0.10	26	0.33
Total Phosphorus (mg/L)	<0.05	0.17	<0.02	26	0.69
Chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	14.1
Nitrate Nitrogen (mg/L)	10.0	15.2	3.07	26	1.95
TKN (mg/L)	0.26	0.48	<0.20	22	N/A
AU 1804_05 Recreational Use					
<i>E. coli</i> (MPN/100 mL)	273 Geomean	1400	59	26	126 Geomean
AU 1804_05 Aquatic Life Use					
Dissolved Oxygen (mg/L)	9.2	14.0	3.6	26	≥3.0 Minimum & ≥5.0 Average

Table 5

Station 12556 – Clear Fork at Salt Flat Road 12/2008 - 12/2016					
AU 1810_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurements	Screening Criteria
Temperature (°C)	19.4	28.7	6.5	109	32.20
pH	7.7	8.2	6.6	110	6.5 – 9.0
Chloride (mg/L)	263	2690	<1.0	92	350.00
Sulfate (mg/L)	61	124	15.6	92	150.00
Total Dissolved Solids (mg/L)	867	5213	167	110	1120.00
NH3-N (mg/L)	0.18	0.65	<0.10	110	0.33
Total Phosphorus (mg/L)	0.11	0.90	<0.02	110	0.69
Chlorophyll-a (µg/L)	6.8	157	<1.0	92	14.1
Nitrate Nitrogen (mg/L)	0.94	5.69	<0.05	41	1.95
TKN (mg/L)	0.78	2.96	<0.2	74	N/A
AU 1810_01 Recreational Use					
<i>E. coli</i> (MPN/100 mL)	225 Geomean	12,000	3	110	126 Geomean
AU 1810_01 Aquatic Life Use					
Dissolved Oxygen (mg/L)	7.8	13.1	1.2	110	≥3.0 Minimum & ≥5.0 Average

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Figure 1

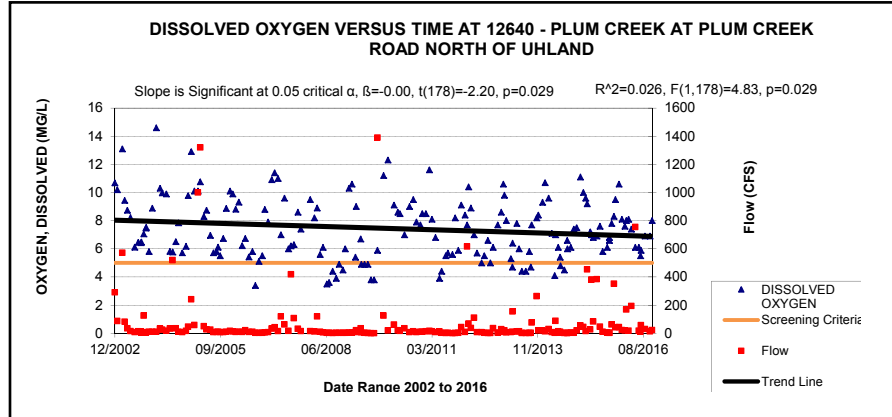


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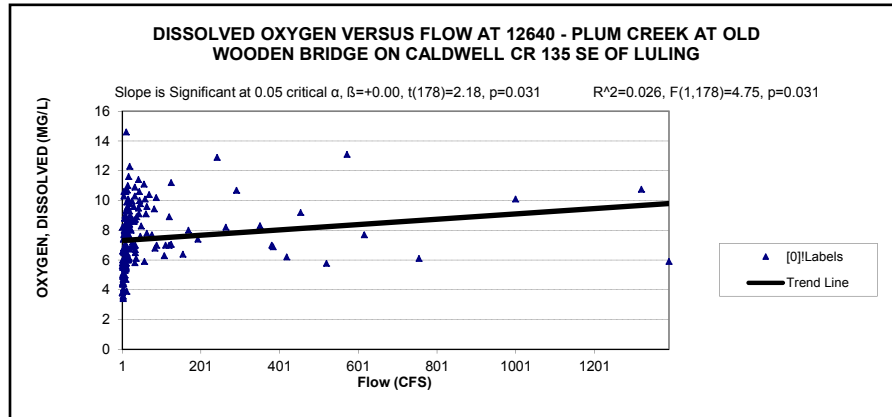


Figure 3

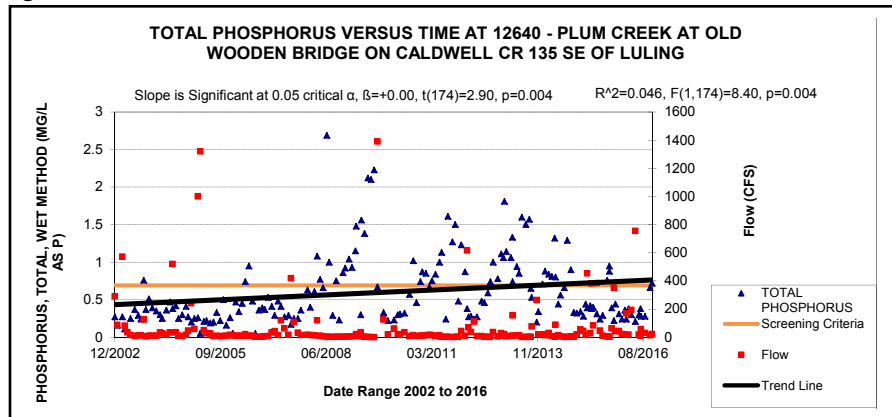


Figure 4

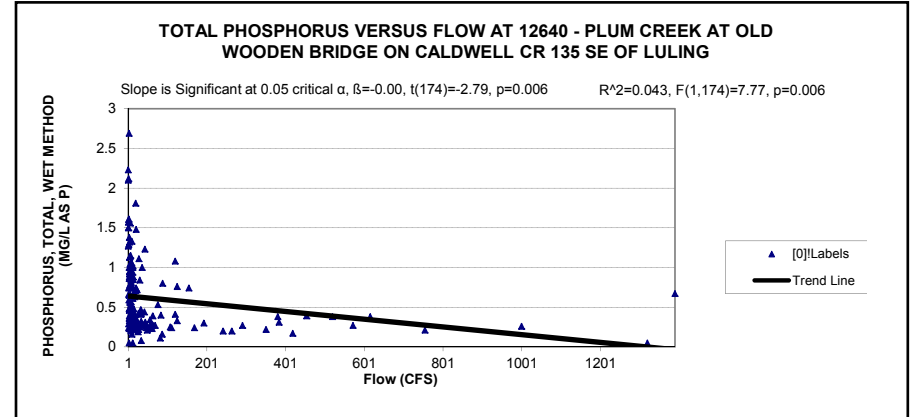


Figure 5

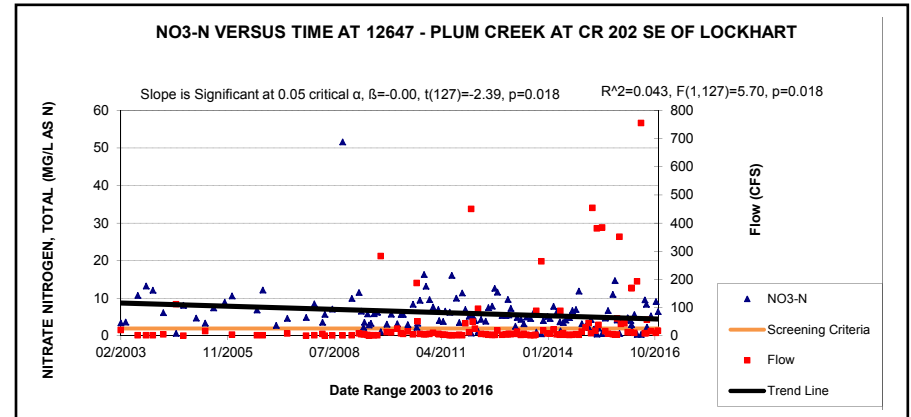
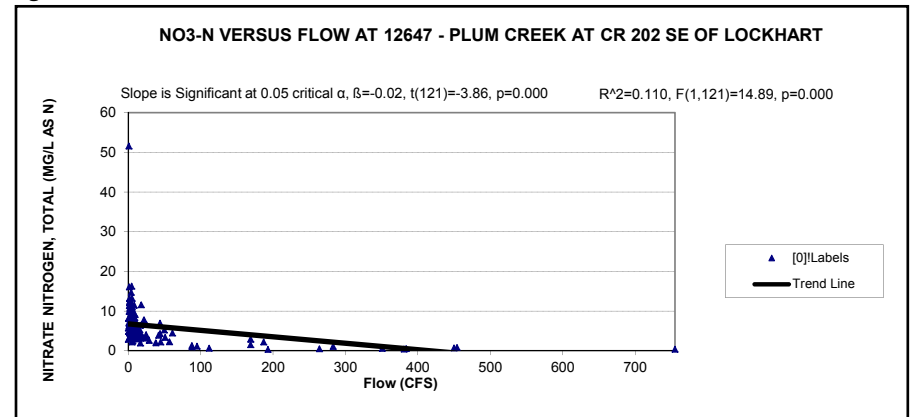


Figure 6



PLUM CREEK

Figure 7

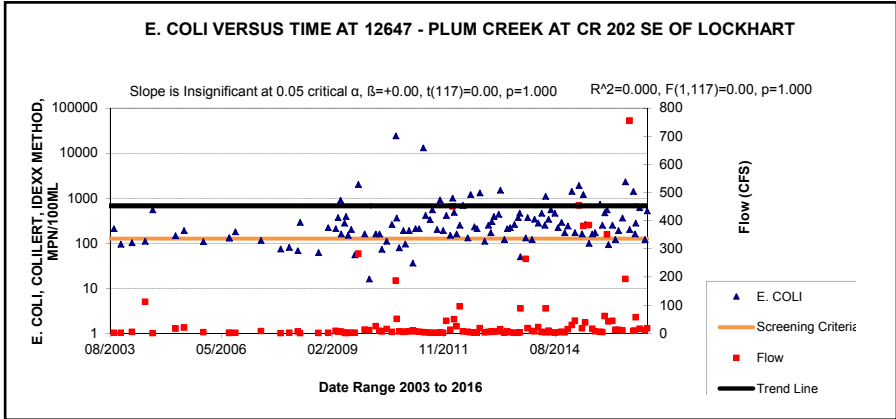


Figure 10

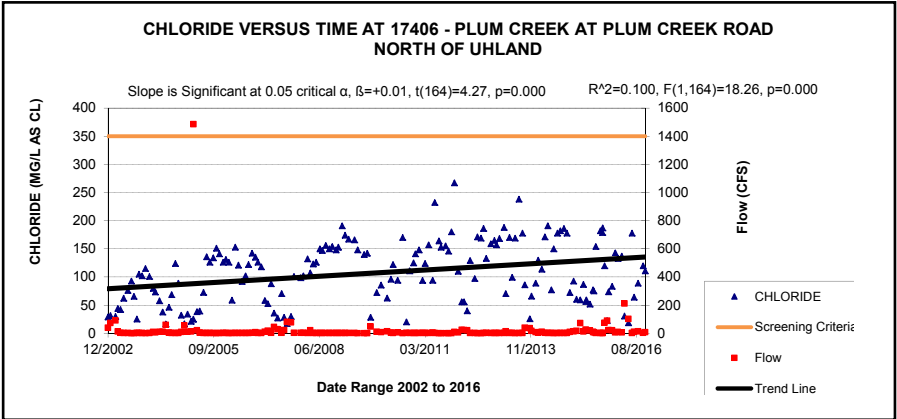


Figure 8

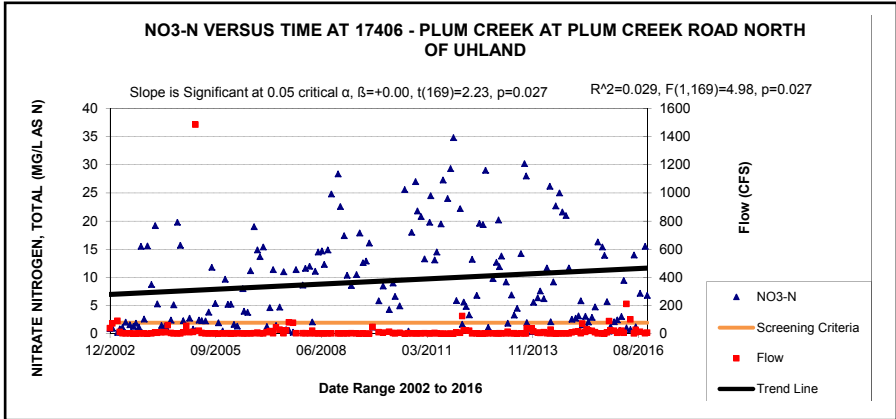


Figure 11

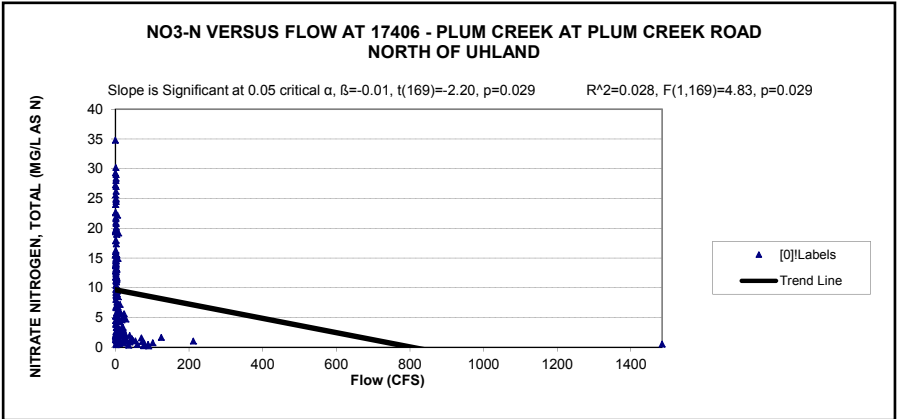


Figure 9

