Little Brazos River Tributaries Assessment and Planning Monitoring Support Final Report and Data

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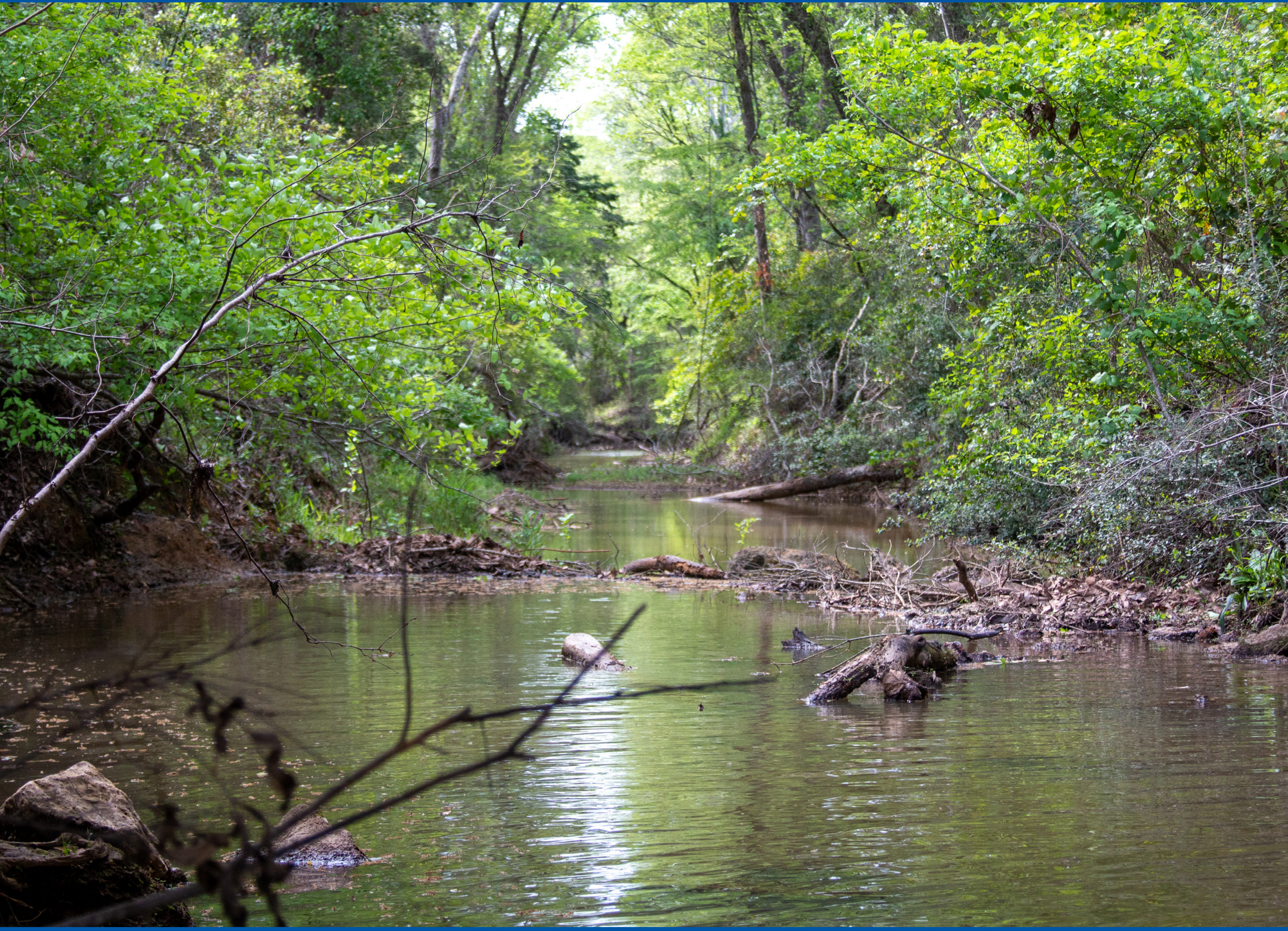

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Texas Water Resources Institute

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List of Acronyms

AU	Assessment Unit
BRA	Brazos River Authority
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
DO	Dissolved Oxygen
LDC	Load Duration Curve
NELAC	National Environmental Laboratory Accreditation Conference
OSSFs	On-site Sewage Facilities
QA	Quality Assurance
QAPP	Quality Assurance Protection Plan
QC	Quality Control
QPR	Quarterly Progress Report
RUAA	Recreational Use Attainability Analyses
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TMDL	Total Maximum Daily Load
TCEQ	Texas Commission on Environmental Quality
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
USGS	United States Geological Survey
WPP	Watershed Protection Plan
WWTFs	Wastewater Treatment Facilities

Executive Summary

TCEQ conducts a water body assessment on a biennial basis to satisfy requirements of the federal Clean Water Act (CWA) Sections 305(b) and 303(d). The resulting *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d) (Texas Integrated Report)* describes the status of water bodies throughout the state of Texas. The most recent report, the *2022 Texas Integrated Report*, includes an assessment of water quality data collected from December 1, 2013, to November 30, 2020.

The *Texas Integrated Report* assesses water bodies at the assessment unit (AU) level. An AU is a sub-area of a segment, defined as the smallest geographic area of use support reported in the assessment (TCEQ 2020). Each AU is intended to have relatively homogeneous chemical, physical, and hydrological characteristics, which allows assignment of site-specific standards (TCEQ 2020). A segment identification number and AUs are combined and assigned to each water body in a segment.

The Little Brazos River is located within the larger Brazos River Basin. Its headwaters are in Limestone County, and it flows southwest down to Robertson County where it roughly parallels the flow of the larger Brazos River until emptying into the Brazos River in Brazos County. The Little Brazos River is not currently listed as impaired in the *Texas Integrated Report*, but several of its tributaries are. This report will focus on the impaired tributaries; Walnut Creek (AU 1242O_01), Mud Creek (AU 1242K_01), Pin Oak Creek (AU 1242L_01), Spring Creek (AU 1242M_01), and Campbells Creek (AU 1242I_01).

Water quality in these small creeks within the Brazos River basin currently exceed recreational use standards for bacteria concentrations. These creeks were first listed as impaired in the *2002 Texas Integrated Report* except for Walnut Creek, which was designated impaired in 2006. Prior to this monitoring project, routine water quality monitoring had not been conducted on these creeks since 2010. Data collected in 2010 was used in the *2014 Texas Integrated Report*. In the 2014 report, the *E. coli* geometric means for these creeks ranged from 609 to 1,877 MPN/100 mL; well above the applicable water quality primary contact recreation standards of 126 MPN/100 mL in place for all tributaries at the time. The lack of updated data mandates that these waterbodies remain categorized as impaired in the most recent assessment, the *2022 Texas Integrated Report,* due to their prior impaired status.

In the 2018, Texas Surface Water Quality Standards, the TCEQ recommended water quality standard changes for these five creeks to a secondary contact recreation 1 standard of 630 MPN/100 mL. This recommendation was made based upon the results of recreational use attainability analyses (RUAA) conducted by the Brazos River Authority (BRA) under TSSWCB Project (08-54). U.S. EPA has approved the change in standard for Campbells Creek and the State of Texas continues to await decisions on the other four creeks. Regardless, these creeks continue to remain impaired due to lack of recent data that also precludes their ability to be delisted, even if water quality standard change recommendations are approved for all creeks.

Future action to address these water quality impairments will likely be necessary. The RUAA conducted by BRA was an initial step to appropriately address these water quality impairments; however, historical data suggests that these creeks may remain impaired even if secondary contact 1 standards (630 MPN/100 mL) are applied to all tributaries. Furthermore, the lack of sufficient data collection since 2010 could have prevented assessments from occurring in the future, guaranteeing that these waterbodies will remain impaired.

Water quality and quantity collection was needed to fill this data gap and provide data necessary to demonstrate whether *E. coli* concentrations meet applicable water quality standards or not. Should data meet these standards, the creek(s) will be removed from the impaired waters list as appropriate. Should the waterbodies remain impaired with further monitoring, remedial action such as development of TMDLs or a WPP will be necessary. Each of these actions requires a reasonable amount of water quality and quantity data to assess current conditions and estimate pollutant loading reductions necessary to meet applicable water quality standards.

This project increased the spatial and temporal distribution of water quality monitoring activity in this watershed to better define current instream water quality conditions, thus providing an increase in the quantity of water quality data available for future water body assessments. This will help to build a more robust data set for future planning purposes should remedial action be needed. Additionally, expanded data will aid in identifying potential cases and sources of pollution. It is through monitoring and adequate data that watershed managers will be able to get a true assessment of water quality inhibitors.

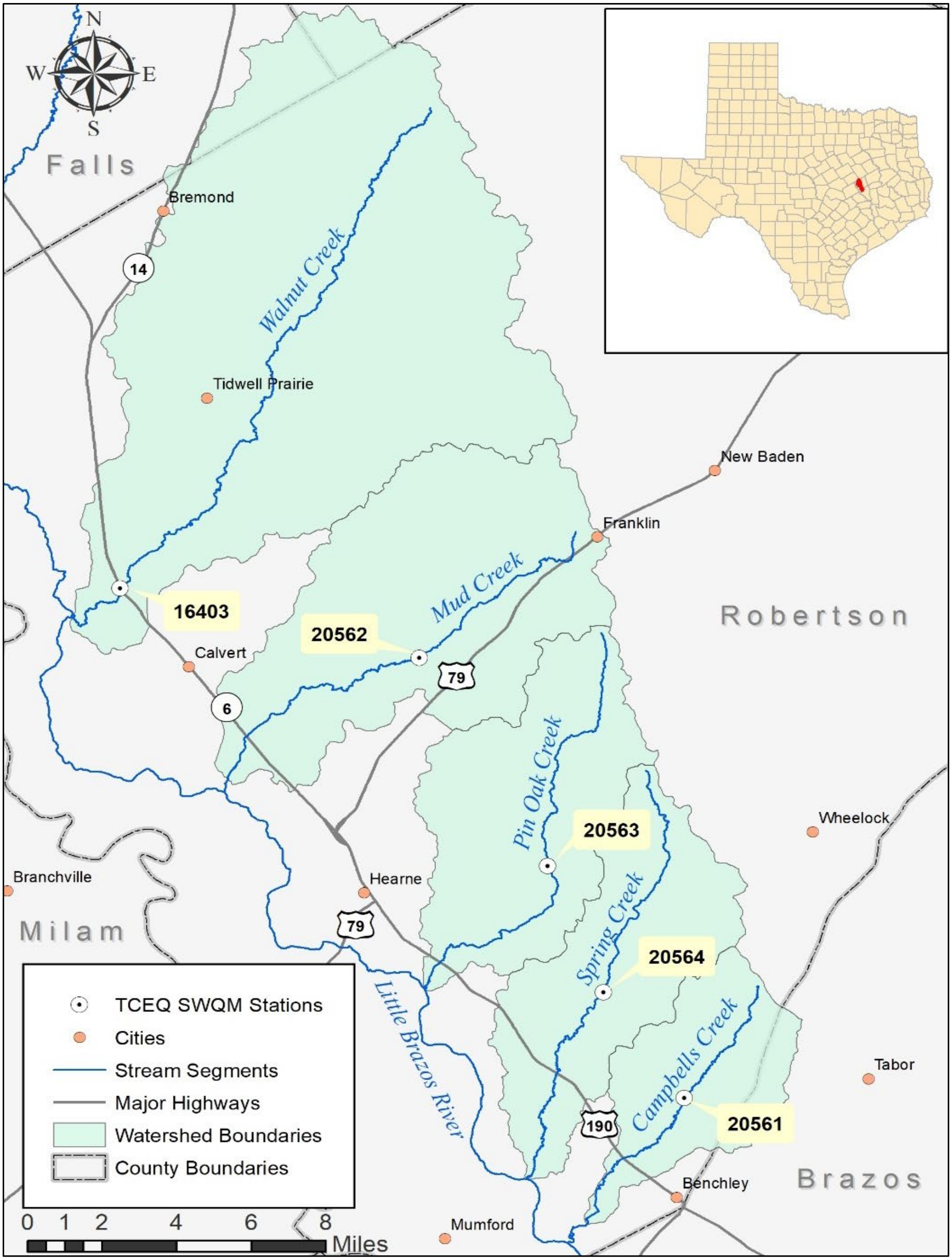

Figure 1. Overview of impaired tributaries emptying into the Little Brazos River within the larger Brazos River Basin. Shows active SWQM stations that were used in this project.

Project Description

Throughout this project, routine water quality monitoring was conducted with a focus on collecting paired flow rate and *E. coli* concentration data in each selected tributary of the Little Brazos River. Data was collected at five sites (one per tributary) monthly for 21 months, resulting in 105 total samples (Figure 1). All sampling procedures, methods, sampling sites, and planned project activities are fully described in the project quality assurance project plan (QAPP). Monthly sampling included field parameters, streamflow measurement, and *E. coli* grab samples to sufficiently fill data gaps, thus enabling future water quality assessments and watershed analysis.

Water quality and quantity data were uploaded to the TCEQ Surface Water Quality Monitoring Information System (SWQMIS) for future waterbody assessments. Collected data and water quality findings and trends are summarized in this final project report to provide an informational basis for any future work conducted in these watersheds.

Station 16403

This surface water quality monitoring (SWQM) station is along Walnut Creek at State Highway 6, northwest of Calvert. Walnut creek is currently categorized as impaired due to elevated bacteria. RUAA conducted by the BRA indicates that sources of pollution in this waterbody could be permitted wastewater discharge, non-permitted grazing livestock, and OSSFs.

Station 20562

This SWQM station is in Mud Creek along Jack Brewer Road. Specifically, 2.03 kilometers north on Robertson County Road 160 and 464 meters west from the intersection of Jack Brewer Road. This creek is currently categorized as impaired due to elevated bacteria. The RUAA conducted by the BRA indicates that sources of pollution at this creek could be permitted wastewater discharge, non-permitted grazing livestock, and OSSFs.

Station 20563

This SWQM station is along Pin Oak Creek at FM 391, 103 meters north and 1.61 kilometers east of the intersection of FM 391 and FM 2549 in Robertson County. This creek is currently categorized as impaired due to elevated bacteria. The RUAA conducted by the BRA indicates that sources of pollution could be OSSFs.

Station 20564

This SWQM station is along Spring Creek at Jack Rabbit Lane, stream segment 1242M. Specifically, 1.02 kilometers south and 1.86 kilometers east from the intersection of Jack Rabbit Lane and FM 2549 in Robertson County. This creek is categorized as impaired due to elevated bacteria and has screening concerns for depressed DO. The RUAA conducted by the BRA indicates that sources of pollution could be OSSFs.

Station 20561

This SWQM station is along Campbells Creek at Jackrabbit Lane. Specifically, 2.25 kilometers north and 1.3 kilometers west from the intersection of Jack Rabbit Lane, and east of Old San Antonio Road. This creek is currently categorized as impaired due to elevated bacteria and has screening concerns for depressed DO. The RUAA conducted by the BRA indicates that sources of pollution could be permitted wastewater discharge, non-permitted grazing livestock, and Campbells Creek has the highest density of OSSFs out of all five tributaries.

Task 1: Project Administration

TWRI has effectively administered, coordinated, and monitored all work performed under this project including technical and financial supervision and preparation of status reports.

Subtask 1.1: QPRs

To track project progress, TWRI submitted quarterly progress reports (QPRs) to the Texas State Soil and Water Conservation Board (TSSWCB). QPRs contained an overview of project activities completed during each quarter, an overview of activities to be completed in the next quarter, and highlighted related issues or problems associated with the project. The QPRs were submitted by the 1st of December, March, June, and September and distributed to all Project Partners.

Subtask 1.2: Reimbursement Forms

TWRI provided financial supervision to ensure tasks and deliverables were acceptable and completed within budget. Financial supervision consisted of submitting appropriate reimbursement forms at least quarterly to TSSWCB and submitting necessary budget revisions.

Subtask 1.3: Project Coordination

TWRI hosted quarterly coordination meetings or conference calls with Project Partners to discuss project activities, the project schedule, communication needs, deliverables, and other requirements. TWRI developed lists of action items needed following each project coordination meeting and distributed them to project personnel.

Subtask 1.4: Final Report

TWRI developed this Final Report that summarizes activities completed during the duration of the project as well as the conclusions reached. The Final Report also discusses the extent to which the project goals and measures of success were achieved.

Task 2: Quality Assurance

TWRI developed data quality objectives and quality assurance/control (QA/QC) activities to ensure data generated through this project were of known and acceptable quality.

Subtask 2.1: QAPP Development

TWRI developed a QAPP for activities in Tasks 3 and 4 consistent with the most recent versions of *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* and the *TSSWCB Environmental Data Quality Management Plan*. All monitoring procedures and methods prescribed in the QAPP were to be consistent with the guidelines detailed in the *TCEQ Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue (RG-415)* and *Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data (RG-416)*. [Consistency with Title 30, Chapter 25 of the Texas Administrative Code, *Environmental Testing Laboratory Accreditation and Certification*, which describes Texas' approach to implementing the National Environmental Laboratory Accreditation Conference (NELAC) standards, were required where applicable.] After developing the QAPP, TWRI sent draft and final versions to TSSWCB, and a final document was approved.

Subtask 2.2: QAPP Implementation

TWRI implemented the approved QAPP. TWRI submitted revisions and amendments of the QAPP to TSSWCB when necessary.

Task 3: Surface Water Quality Monitoring

TWRI collected water quality and quantity data of known and acceptable quality for future waterbody assessments.

Subtask 3.1: Sampling Site Reconnaissance and Selection

TWRI conducted sampling site reconnaissance to determine the safest, most accessible sites for water quality monitoring in the project watersheds. One site was selected per creek.

Subtask 3.2: Water Quality Monitoring

TWRI conducted monthly ambient water quality monitoring at five sites for 21 months (105 total samples). Sampling included basic field parameters (temperature, pH, DO, conductivity, and flow where conditions allow) and grab sample collection (analyzed for *E. coli*). Water samples were delivered to a NELAP accredited laboratory with the appropriate holding time for bacterial analysis. Sampling events were documented in QPRs.

Subtask 3.3: Water Quality Data Submission

The TWRI maintained a master database of all collected water quality data from this project. Collected data was submitted to the TSSWCB by TWRI for submission to SWQMIS quarterly.

Conclusion

TWRI worked diligently to complete all project tasks and turn in deliverables on time to the TSSWCB through the project time period. As a result, more water quality data was collected for the watershed and made accessible for future planning within the Little Brazos River watershed. The additional 21 monthly ambient water quality data samples for each tributary fills data gaps enabling future water quality assessments and watershed analysis. This data will be a great tool for stakeholders to determine a path forward for improving the water quality in the watershed.

Projects such as this are why accomplishments are being made toward restoring water quality in Texas. The need for such projects statewide in the future is crucial for continued success.

Appendix A: Data Summary Report

TCEQ conducts a water body assessment on a biennial basis to satisfy requirements of the federal Clean Water Act (CWA) Sections 305(b) and 303(d). The resulting *Texas Integrated Report of Surface Water Quality (Texas Integrated Report)* describes the status of water bodies throughout the state of Texas. The most recent report, the *2022 Texas Integrated Report*, includes an assessment of water quality data collected from December 1, 2013, to November 30, 2020.

The *Texas Integrated Report* assesses water bodies at the assessment unit (AU) level. An AU is a sub-area of a segment, defined as the smallest geographic area of use support reported in the assessment (TCEQ, 2022). Each AU is intended to have relatively homogeneous chemical, physical, and hydrological characteristics, which allows a way to assign site-specific standards (TCEQ, 2022). A segment identification number and AUs are combined and assigned to each water body to divide into a segment.

For the scope of this project, there are five tributaries that drain into the Little Brazos River. These tributaries are identified with unique AUs and TCEQ monitoring stations that allow independent water quality analysis for each tributary. At least 10 data points within the most recent 7 years of available data are required for all water quality parameters except bacteria, which requires a minimum of 20 samples. All but one tributary was first listed as impaired due to elevated levels of bacteria in the *2002 Texas Integrated Report* (TCEQ, 2002). Walnut Creek (AU 1242O_01) was designated as impaired for elevated levels of bacteria in the *2006 Texas Integrated Report* (TCEQ, 2006). Additionally, Campbells Creek (AU 1242I_01) and Spring Creek (AU 1242M_01) have low dissolved oxygen (DO) concerns based on screening levels of 2 mg/L and 3 mg/L respectively.

There were five active monitoring stations (one per watershed) where monitoring was conducted for this project. Prior to this project, routine water quality monitoring had not been conducted on these creeks since 2010. The surface water quality monitoring (SWQM) station IDs were 16403, 20562, 20563, 20564, and 20561(Figure 1). These stations are located at Walnut Creek (AU 1242O_01), Mud Creek (AU 1242K_01), Pin Oak Creek (AU 1242L_01), Spring Creek (AU 1242M_01), and Campbells Creek (AU 1242I_01), respectively (Figure 1). These five stations were monitored monthly for field parameters such as temperature, DO, specific conductance, and pH. This type of monitoring is considered routine monitoring because all data and parameters are collected for each site routinely every month. Additionally, instantaneous flow rate was measured, and water grab samples from each tributary were analyzed for *Escherichia coli* (*E. coli)* concentrations.

Texas Surface Water Quality Standards

Water quality standards are established by the state and approved by the U.S. Environmental Protection Agency (EPA) to define a water body's ability to support its designated uses, which may include aquatic life use (fish, shellfish, and wildlife protection and propagation), primary contact recreation (swimming), public water supply, and fish consumption. Water quality indicators for these uses include DO (aquatic life use), *E. coli* (primary contact recreation), pH, temperature, and total dissolved solids (TCEQ, 2022).

Bacteria

Concentrations of fecal indicator bacteria are evaluated to assess the risk of illness during contact recreation. In freshwater environments, concentrations of *E. coli* are measured to evaluate the presence of fecal contamination in water bodies from warm-blooded animals and other sources. The presence of fecal indicator bacteria, such as *E. coli*, suggests that associated pathogens from the intestinal tracts of warm-blooded animals could be reaching water bodies and may cause illness in people that recreate in them. Common sources that indicator bacteria can originate from include wildlife, domestic livestock, pets, malfunctioning on-site sewage facilities (OSSFs), urban and agricultural runoff, sewage system overflows, and direct discharges from wastewater treatment facilities (WWTFs). There is a specific standard for *E. coli* in freshwater for water bodies that are used for primary contact recreation. The standard for primary contact recreation is a geometric mean of 126 most probable number (MPN) of *E. coli* per 100 mL of water from at least 20 samples (30 TAC § 307.7 2014). The standard for secondary contact recreation is 630 MPN of *E. coli* per 100 mL of water from at least 20 samples.

As previously mentioned, all five tributaries are impaired due to elevated bacteria levels *2022 Texas Integrated Report* (TCEQ 2022). Four of the tributaries, Mud Creek, Pin Oak Creek, Spring Creek, and Walnut Creek are designated for primary contact recreation, and Campbells Creek is designated for secondary contact recreation. Historical data showed a large trend upwards of *E. coli* in 2009 (Figure 2). Bacteria standards were surpassed during 2009, when correlating instantaneous flow was also high (Figure 12). This led project partners to think that even if secondary contact recreation standard were approved for all tributaries, they would still be impaired. Data collected from this TWRI-led monitoring project indicates all AUs have relatively stable bacteria levels with a geomean consistently above the maximum *E. coli* criterion for recreational use at 126 MPN/100 mL, but below 630 MPN/100 mL (Figure 4; Figure 5). Current bacteria levels are consistently lower than historical monitoring, so approval of secondary recreation would likely qualify the tributaries for removal from the CWA 303(d) list. This supports the RUAA conclusions that if water quality standards for all tributaries are changed to match the secondary contact recreation 630 MPN/100mL of Campbells Creek, then they may no longer be impaired (Figure 4; Figure 5).

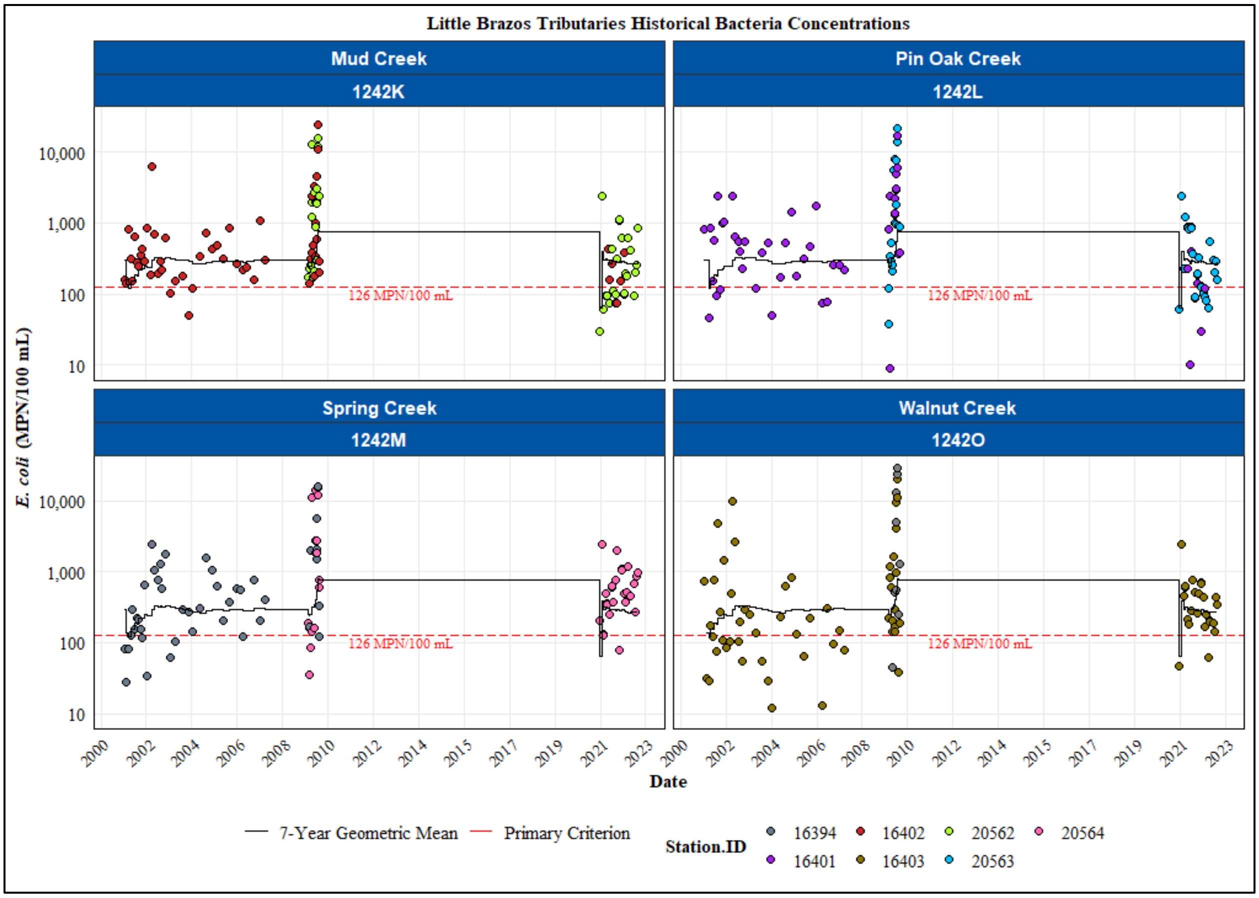

Figure 2. Historic *E. coli* concentration at SWQM stations within Mud Creek, Pin Oak Creek, Spring Creek, and Walnut Creek. These Little Brazos River tributaries are classified as primary contact recreation. This sets the standard criterion for *E. coli* at 126 MPN/100mL.

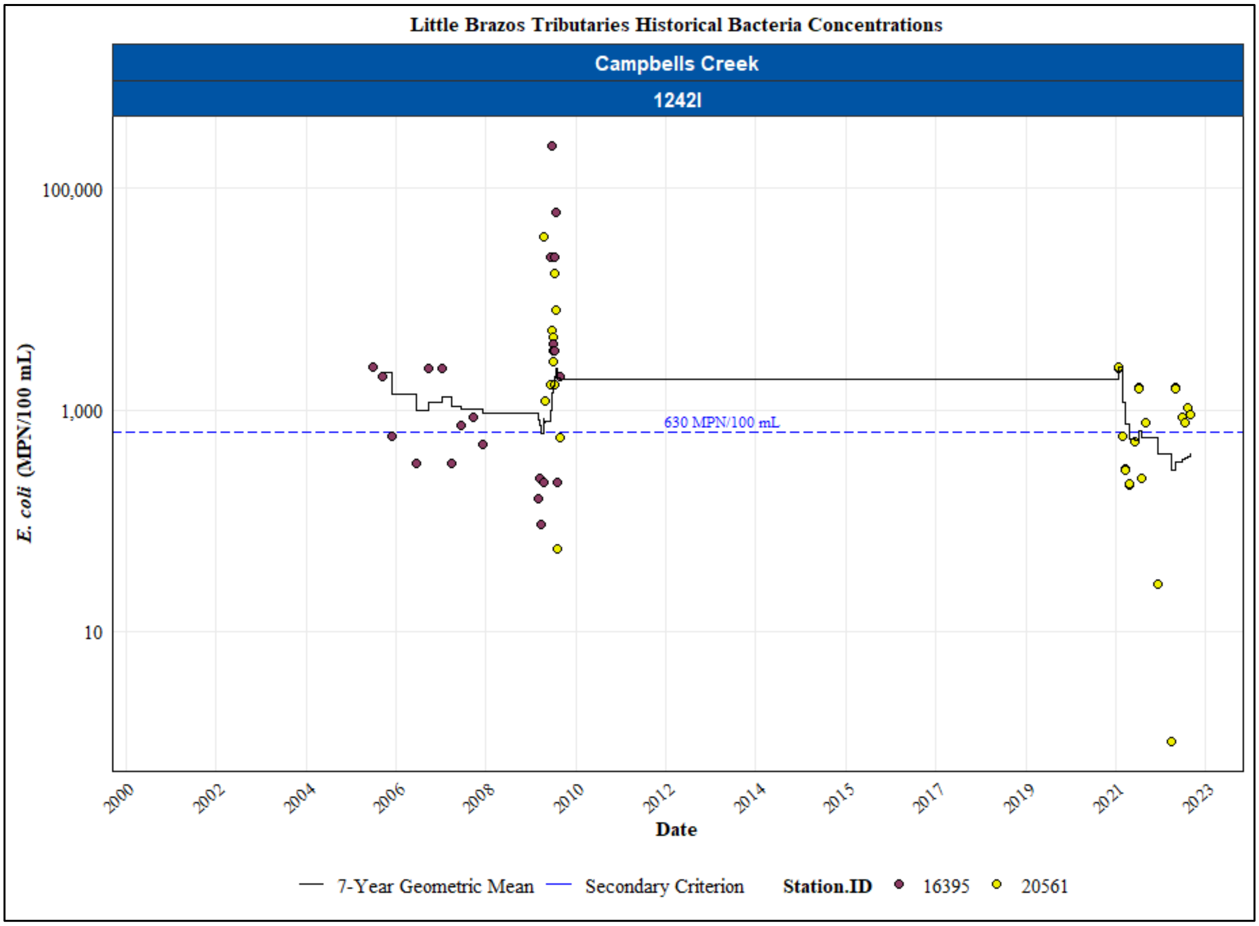

Figure 3. Historic *E. coli* concentrations for Campbells Creek throughout at SWQM station 20561. Campbells Creek is classified as secondary contact recreation with a standard bacteria criterion at 630 MPN/100 mL.

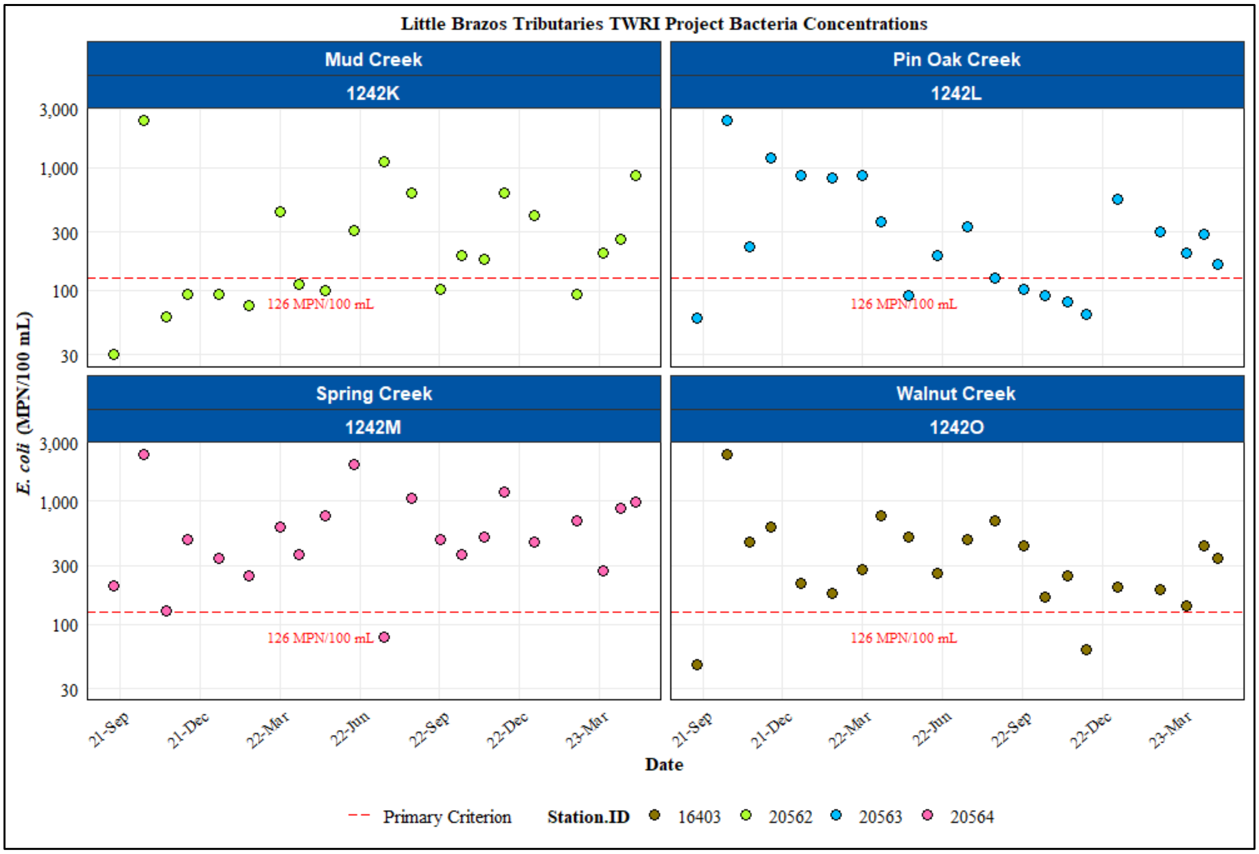

Figure 4. Bacteria concentrations at SWQM stations in the Mud Creek, Pin Oak Creek, Spring Creek, and Walnut Creek. These Little Brazos River tributaries are classified as primary contact recreation. This sets the standard criterion for *E. coli* at 126 MPN/100mL.

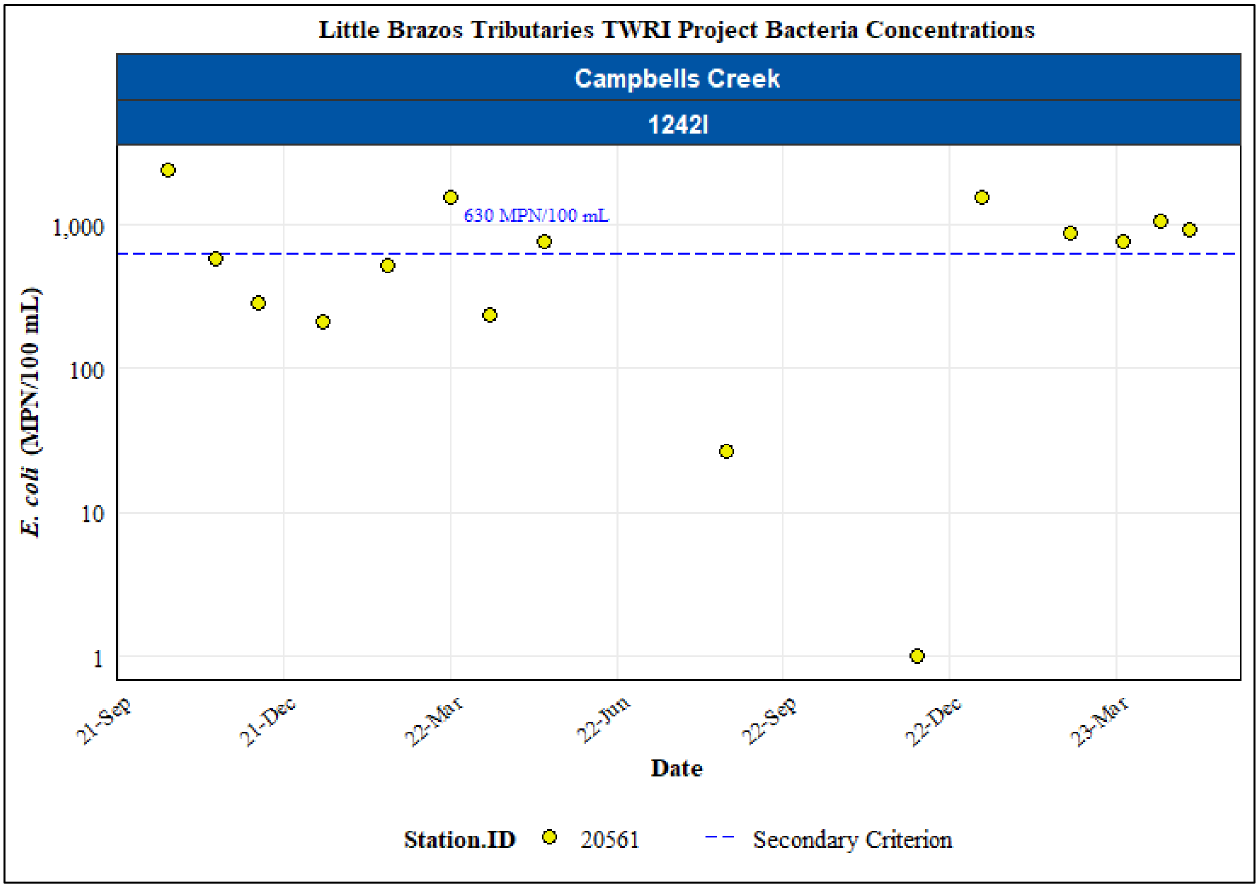

Figure 5. *E. coli* concentrations for Campbells Creek throughout the project period at SWQM station 20561. Campbells Creek is classified as secondary contact recreation with a standard bacteria criterion at 630 MPN/100 mL.

Dissolved Oxygen

Dissolved oxygen is used to determine a water body's aquatic life uses. Aquatic life uses measure whether a water body can support and maintain a healthy aquatic ecosystem. If DO levels drop too low, fish and other aquatic species will not survive. Typically, DO will fluctuate throughout the day, with the highest levels occurring in the mid to late afternoon due to photosynthesis. DO levels are usually at their lowest just before dawn as both plants and animals in the water consume oxygen through respiration. Furthermore, seasonal fluctuations in DO are common because of decreased oxygen solubility in water as temperature increases; therefore, DO levels are typically lower during the summer and higher in the winter months. While DO can fluctuate naturally, human activities can also cause abnormally low DO levels. Excessive organic matter (vegetative material, untreated wastewater, etc.) can result in depressed DO levels as bacteria break down the materials and consume oxygen. Excessive nutrients from fertilizers and manures can also depress DO as aquatic plant and algae growth increase in response. More respiration from plants and the decay of organic matter as plants die off can also decrease DO concentrations.

On the *2022 Texas Integrated Report*, Campbells Creek (AU 1242I_01) has concerns for depressed DO based on a screening level criterion of 2 mg/L. Additionally, Spring Creek (AU 1242M_01) also has concerns for depressed DO based on screening levels of 3 mg/L. All other tributaries are fully supporting the screening level DO criterion of 5 mg/L. Historical DO data for these tributaries indicates otherwise healthy conditions with a geomean significantly above all screening criterion despite some exceedances, although with extensive monitoring in 2009 the geomean fell significantly (Figure 6; Figure 7; Figure 8). Notably, these exceedances are largely during 2009, when bacteria and instantaneous flow levels were very high. Data collected by the TWRI during this project is shown in Figure 9, Figure 10, Figure 11; and are presented with the current rolling geomean. Project data collected agrees with historic data, tributaries have normal levels of DO with a rolling geomean above the screening criterion for each tributary. However, DO levels for Campbells Creek (AU 1242I_01) dropped below the criterion during periods of very low flow in November and December (Table 9). Also, for Spring Creek (AU 1242M_01) DO levels below the criterion were reported in the summer months and are therefore likely due to some combination of warmer temperatures and low flow (Table 7). For both creeks the geomean remains much higher than the screening criterion. Overall, the DO concentration indicates a potentially healthy aquatic ecosystem throughout the TWRI-led monitoring project and beyond.

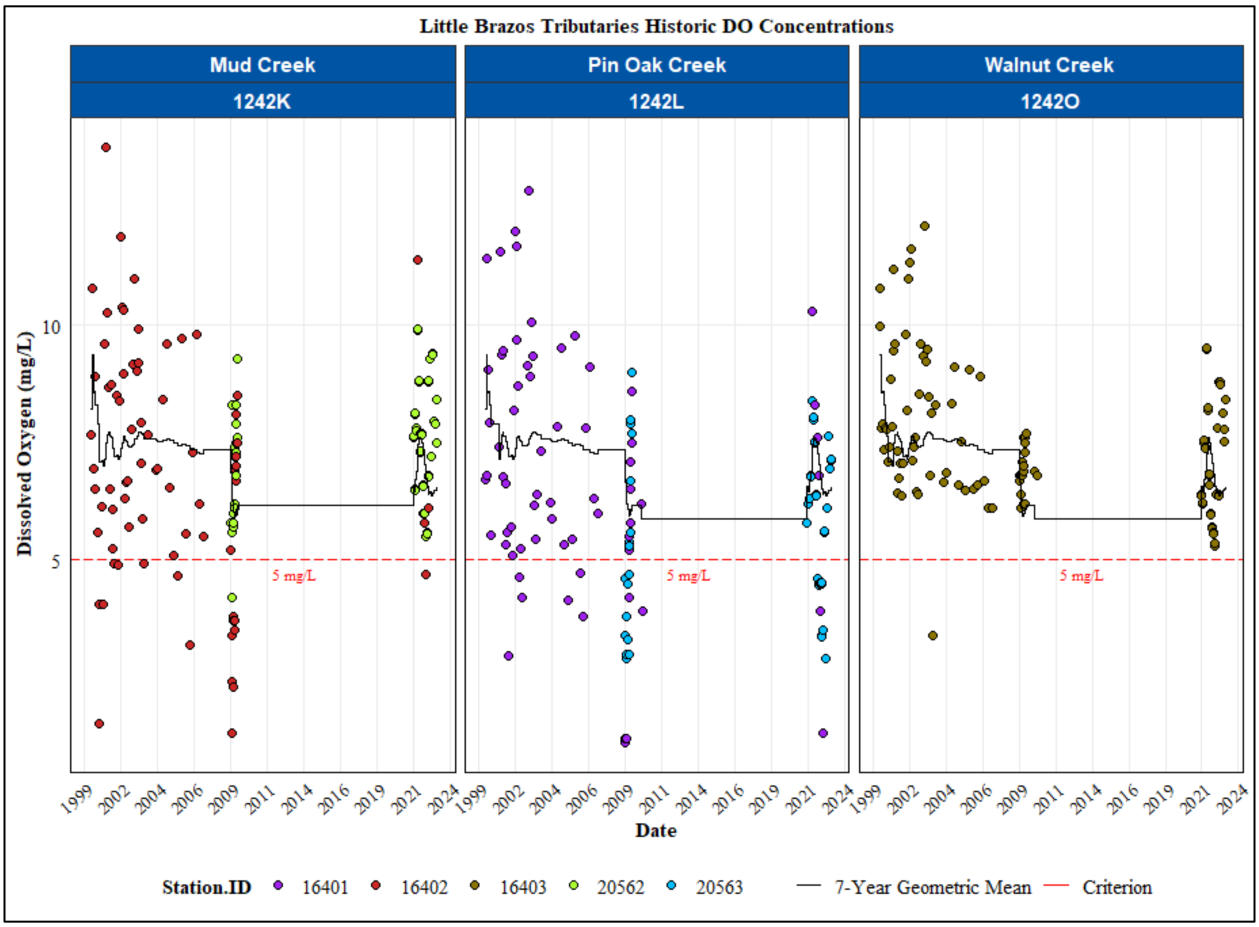

Figure 6. Historic DO concentrations for Mud Creek, Pin Oak Creek and Walnut Creek at all respective SWQM stations. These tributaries are listed as fully supporting the DO screening criterion of 5 mg/L.

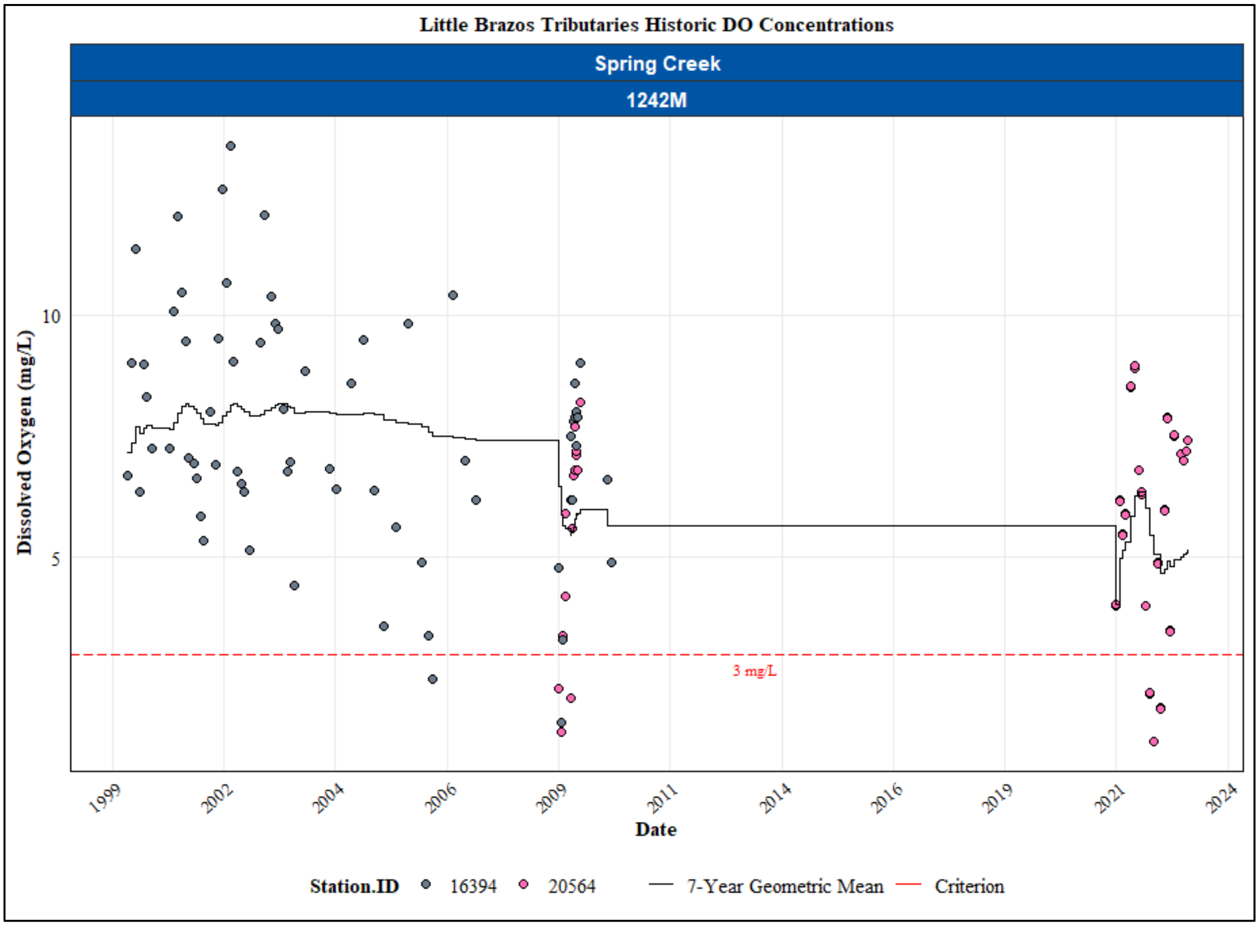

Figure 7. Historic DO concentrations at Spring Creek in all segment SWQM stations. Spring Creek is listed for DO concerns at a screening level of 3 mg/L.

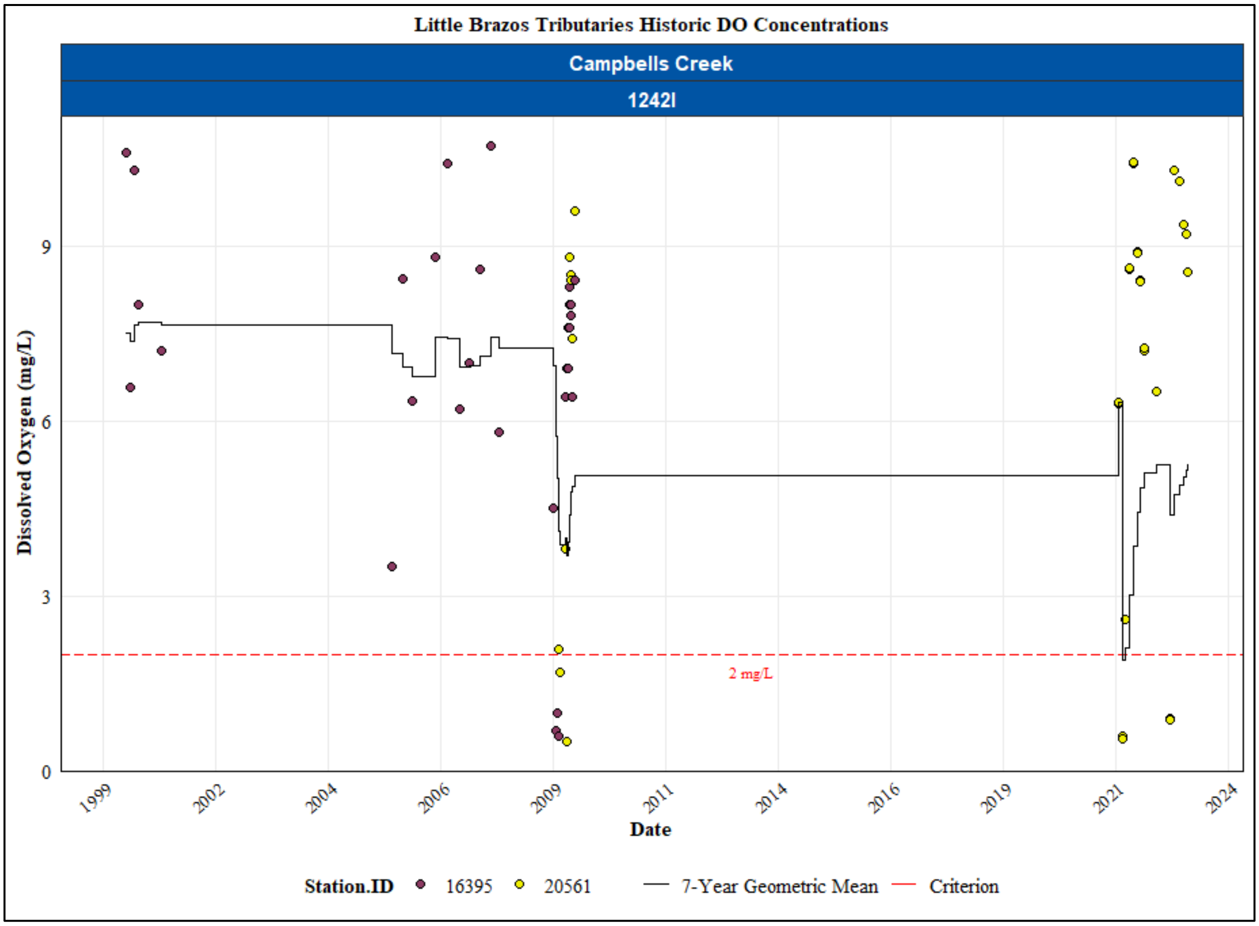

Figure 8. Historic DO concentration at Campbells Creek in all segment SWQM stations. Campbells Creek is listed for DO concerns at a screening level of 2 mg/L.

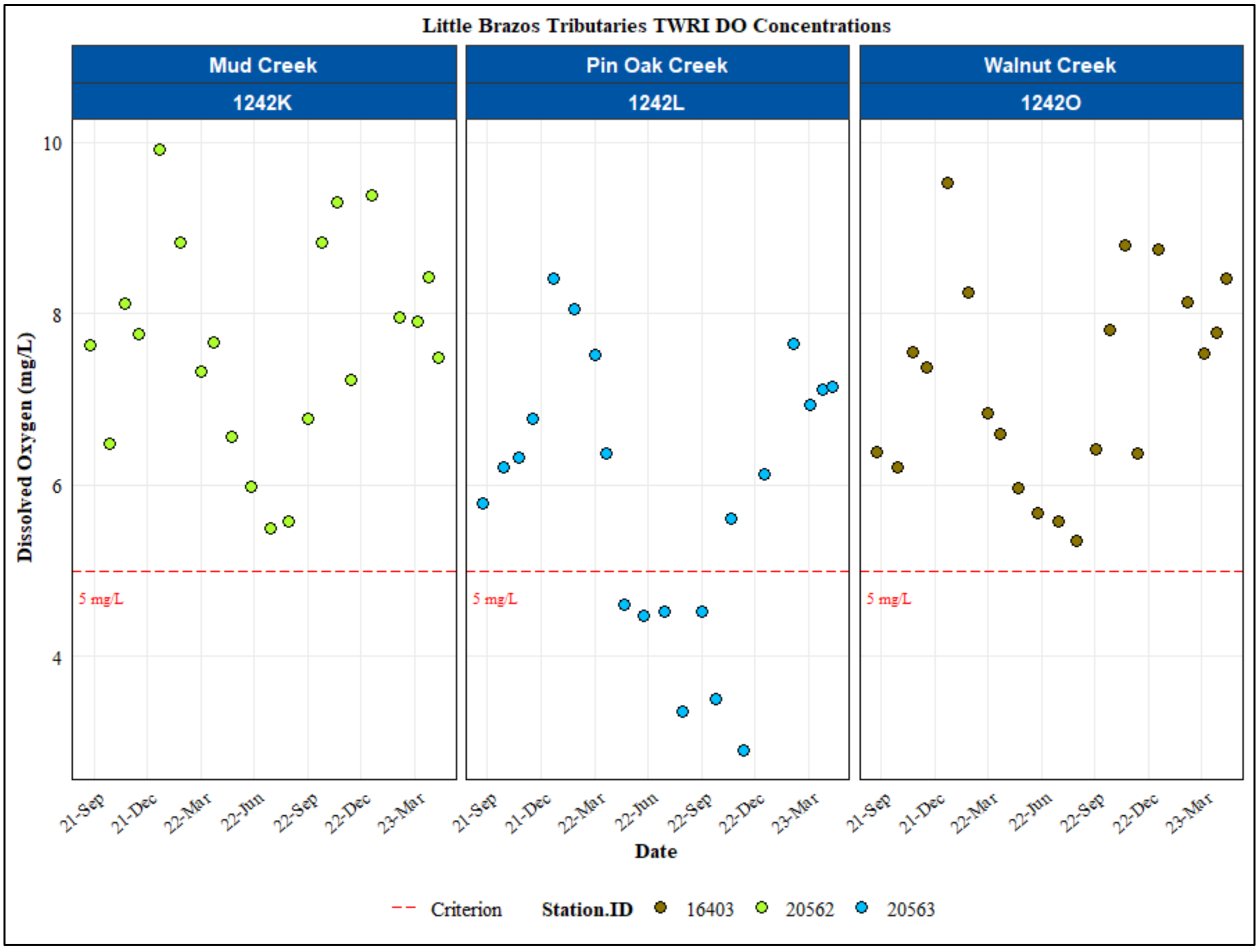

Figure 9. DO concentrations at SWQM stations in Mud Creek, Pin Oak Creek and Walnut Creek. DO screening criterion for these tributaries is 5mg/L, and there are no listed concerns for DO.

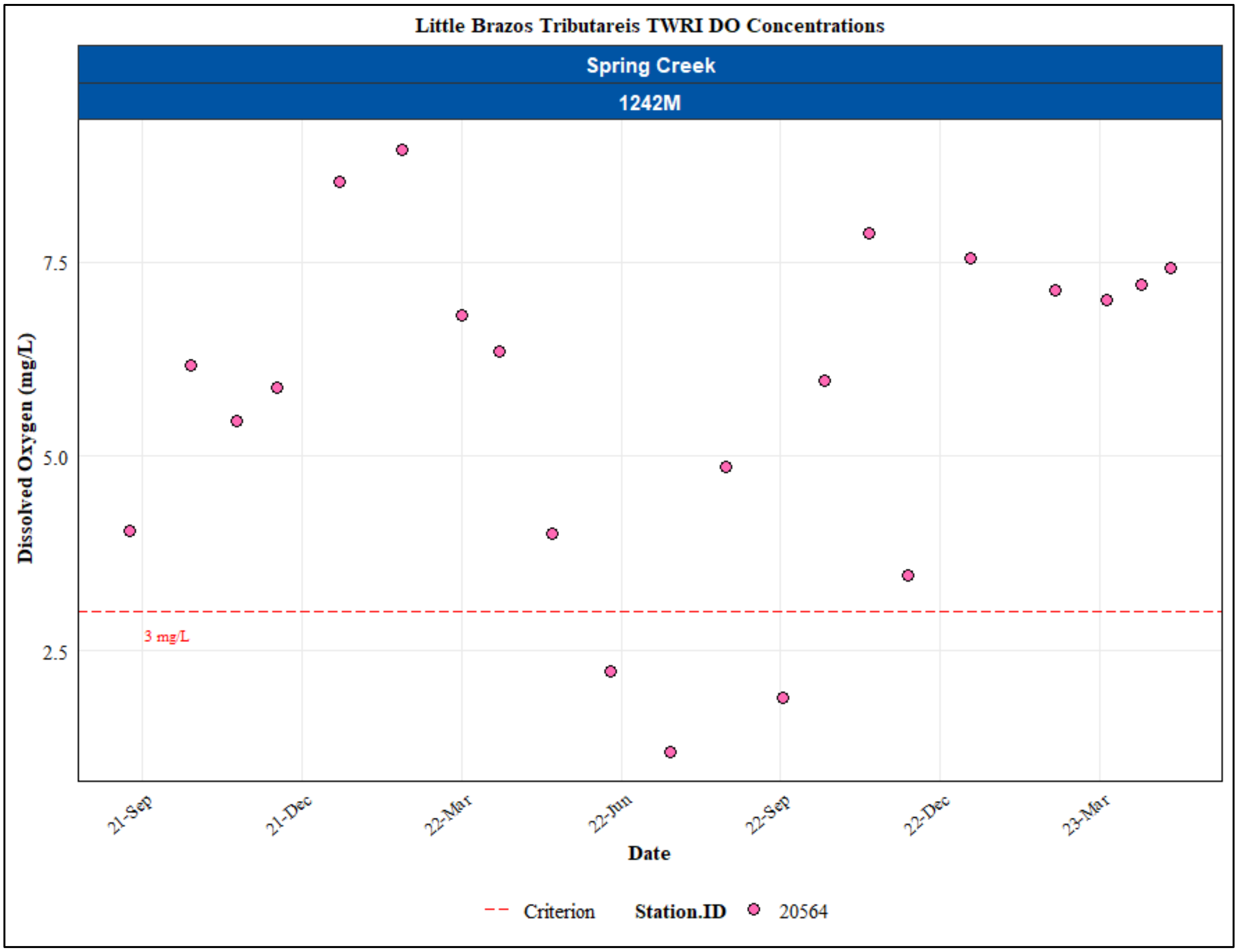

Figure 10. Concentration of DO in Spring Creek throughout the duration of the project at SWQM station 20564. Spring Creek is listed for DO concerns below the 3 mg/L screening level.

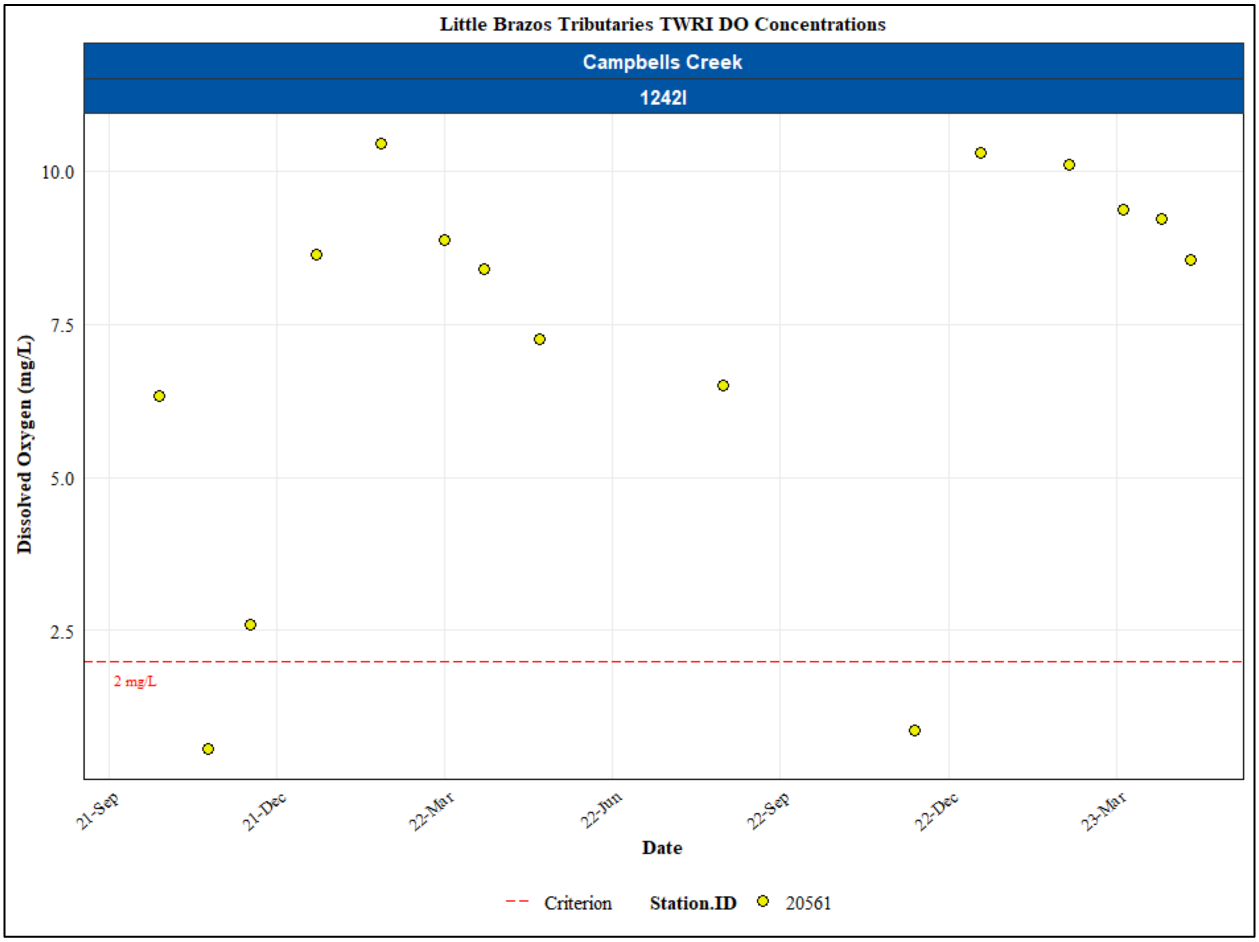

Figure 11. Concentration of DO in Campbells Creek throughout the duration of the project at SWQM station 20561. Campbells Creek is listed for DO concerns below the 2 mg/L screening level.

Flow

Generally, streamflow (the amount of water flowing in a river/creek at a given time) is dynamic and always changing in response to both natural (e.g. precipitation events) and anthropogenic (e.g. changes in land cover) factors. From a water quality perspective, streamflow is important because it influences the ability of a water body to assimilate pollutants.

Flow data is useful in creating flow duration curves (FDC) and load data curves (LDC). The LDC method is widely used to characterize water quality data across different flow conditions in a watershed. An LDC provides visual display of streamflow, load capacity, and water quality exceedance by first developing a FDC using flow measurements.

Historical flow measurements for the Little Brazos tributaries show very high flow in 2009 for Campbells Creek, Mud Creek, and Spring Creek (Figure 12). This coincides with the high bacteria and low DO measurements. Elevated flow in these tributaries seems to be an uncommon occurrence that highly influenced bacteria levels. For water quality data collected over the course of the TWRI-led project, instantaneous flow was collected at SWQM sites 16403, 20561, 20562, 20563, 20564 (Figure 13). This recent flow data is much lower than historical data on at least an order of magnitude for Campbells Creek and Mud Creek.

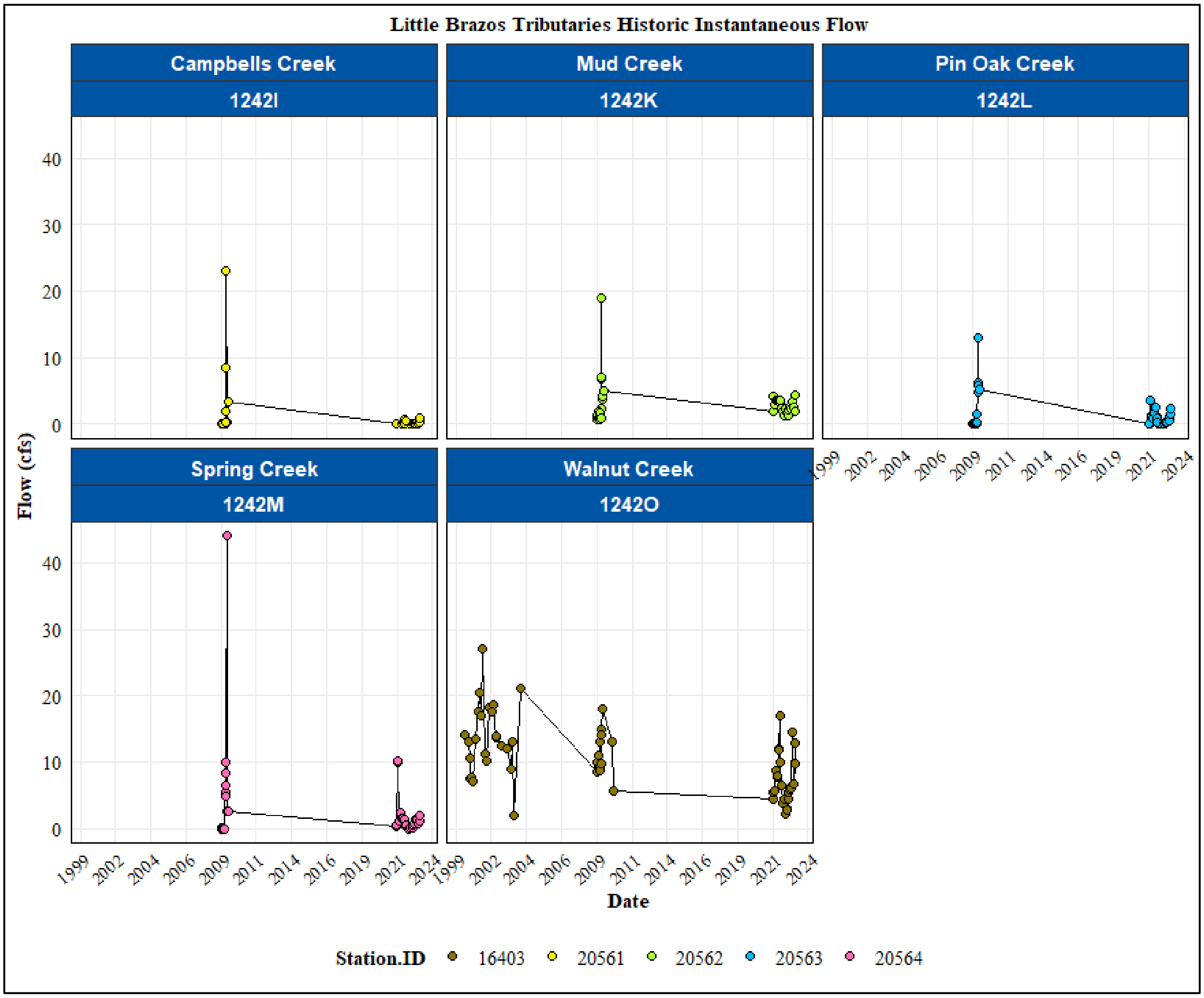

Figure 12. Historic flow for each tributary at all SWQM stations in each stream segment. The solid line represents SWQM stations used for this project and the dotted line represents stations not used for this project.

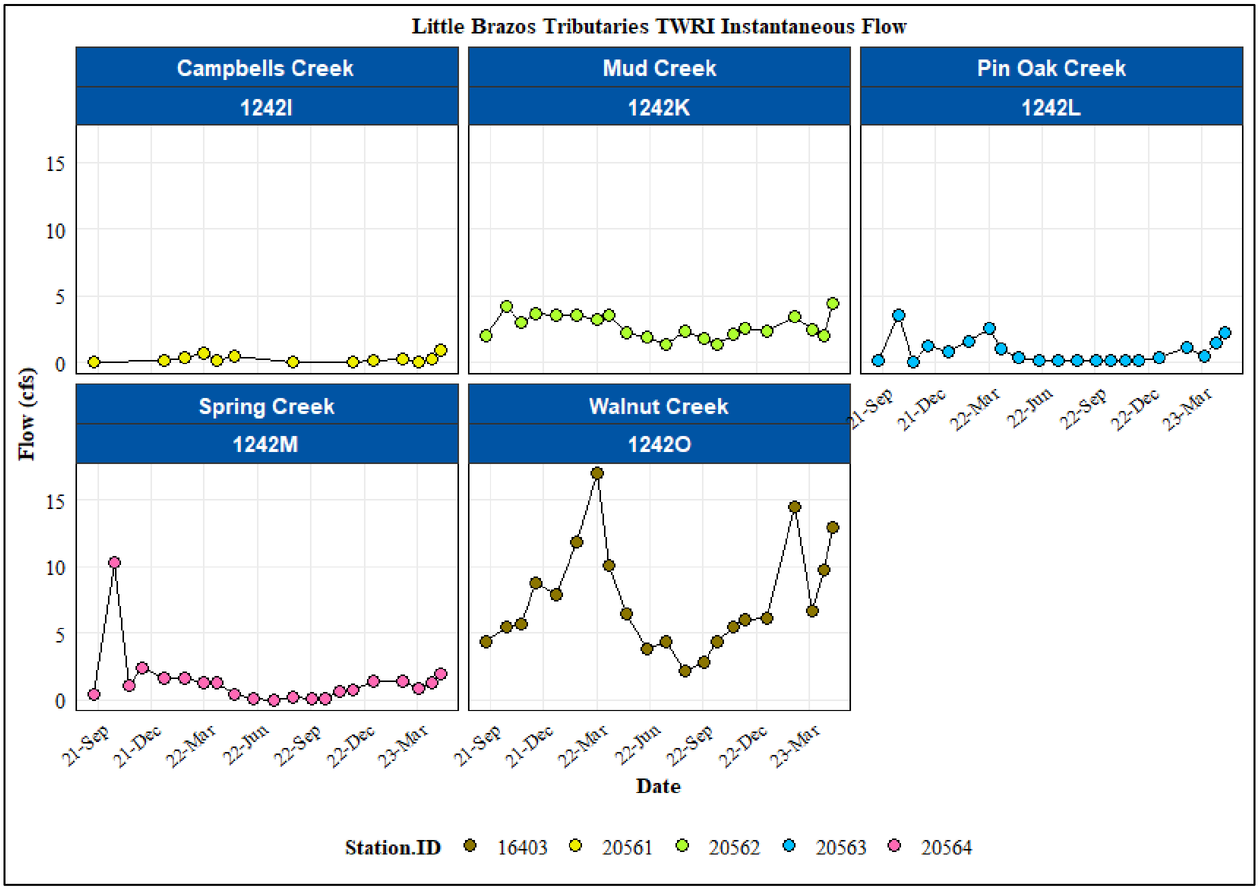

Figure 13. Instantaneous flow values measured in cubic feet per second (cfs) at each project SWQM station in the Little Brazos Tributaries. Campbells Creek was completely dry during some sampling event and therefore has less data points (Table 10).

Monitoring Data

Station 16403

Table 1. Routine water quality parameters for Station 16403 at Walnut Creek.

Date	Water Temperature (Celsius)	Specific Conductance (microS/cm)	Dissolved Oxygen (mg/L)	pH
2021-09-23	19.9	783	6.38	7.63
2021-10-27	22.5	756	6.21	7.47
2021-11-22	14.4	864	7.55	7.15
2021-12-15	16.1	902	7.37	7.43
2022-01-19	11.7	974	9.52	7.56
2022-02-23	13.8	949	8.25	7.52
2022-03-29	19.5	768	6.84	7.26
2022-04-19	18.9	806	6.6	7.14
2022-05-19	24.8	963	5.97	7.72
2022-06-21	27.2	880	5.67	7.81
2022-07-25	27.6	1080	5.57	7.69
2022-08-25	25.3	964	5.35	7.37
2022-09-26	23.5	864	6.41	7.78
2022-10-20	13.5	1170	7.81	7.5
2022-11-14	11.5	791	8.8	7.48
2022-12-06	16.6	943	6.36	7.23
2023-01-10	13.5	1000	8.75	7.5
2023-02-27	17.4	653	8.13	7.37
2023-03-28	17.5	717	7.53	7.4
2023-04-17	16.6	831	7.77	7.51
2023-05-03	20.2	665	8.41	7.49

Table 2. Bacteria and flow data measured for Station 16403 at Walnut Creek. Red cells indicate measurements over criterion.

Date	*E. coli* (MPN/100mL)	Days Since Last Precipitation Event	Instantaneous Flow (cfs)
2021-09-23	46.5	29	4.35
2021-10-27	2420	0	5.49
2021-11-22	461	11	5.67
2021-12-15	613	1	8.69
2022-01-19	214	8	7.83
2022-02-23	178	0	11.9
2022-03-29	276	6	16.9
2022-04-19	770	6	10.1
2022-05-19	517	13	6.43
2022-06-21	261	0	3.83
2022-07-25	488	11	4.37
2022-08-25	687	2	2.17
2022-09-26	435	19	2.86
2022-10-20	167	3	4.38
2022-11-14	248	0	5.42
2022-12-06	61.6	4	5.94
2023-01-10	199	7	6.16
2023-02-27	192	0	14.4
2023-03-28	140	7	6.65
2023-04-17	435	11	9.74
2023-05-03	345	5	13.0

Station 20562

Table 3. Routine water quality parameters for Station 20562 at Mud Creek.

Date	Water Temperature (Celsius)	Specific Conductance (microS/cm)	Dissolved Oxygen (mg/L)	pH
2021-09-23	18.5	284	7.63	6.81
2021-10-27	21.6	287	6.48	6.5
2021-11-22	14.5	333	8.12	6.66
2021-12-15	17.9	299	7.76	6.79
2022-01-19	13.2	323	9.91	6.91
2022-02-23	12.6	391	8.83	7.55
2022-03-29	19.6	396	7.33	6.79
2022-04-19	17.5	364	7.67	7.66
2022-05-19	24.9	323	6.57	6.75
2022-06-21	26.8	273	5.98	6.87
2022-07-25	27.8	255	5.49	6.88
2022-08-25	25.2	358	5.57	7.11
2022-09-26	23.6	284	6.77	7.53
2022-10-20	12.8	304	8.82	7.9
2022-11-14	10.6	362	9.3	7.47
2022-12-06	17.7	309	7.22	7.45
2023-01-10	13.1	322	9.37	7.41
2023-02-27	17.9	339	7.95	7.24
2023-03-28	17.2	349	7.9	7.17
2023-04-17	15.2	371	8.42	7.72
2023-05-03	20.8	11.5	7.49	7.78

Table 4. Bacteria and flow data measured for Station 20562 at Mud Creek. Red cells indicate measurements over the criterion.

Date	*E. coli* (MPN/100mL)	Days Since Last Precipitation Event	Instantaneous Flow (cfs)
2021-09-23	30.1	29	1.98
2021-10-27	>2420	0	4.26
2021-11-22	60.5	11	3.04
2021-12-15	93.3	1	3.66
2022-01-19	93.4	7	3.60
2022-02-23	75.4	0	3.53
2022-03-29	435	7	3.20
2022-04-19	112	6	3.52
2022-05-19	98.8	13	2.28
2022-06-21	308	3	1.89
2022-07-25	1120	11	1.32
2022-08-25	613	2	2.33
2022-09-26	102	19	1.76
2022-10-20	194	3	1.40
2022-11-14	178	0	2.07
2022-12-06	613	4	2.59
2023-01-10	411	7	2.30
2023-02-27	93.3	0	3.42
2023-03-28	201	7	2.49
2023-04-17	261	11	1.99
2023-05-03	866	5	4.45

Station 20563

Table 5. Routine water quality parameters for Station 20563 at Pin Oak Creek. Red cells indicate measurements below the criterion.

Date	Water Temperature (Celsius)	Specific Conductance (microS/cm)	Dissolved Oxygen (mg/L)	pH
2021-09-23	18.4	548	5.79	6.14
2021-10-27	21.1	458	6.2	6.29
2021-11-22	14.5	588	6.32	6.58
2021-12-15	17.2	654	6.78	6.63
2022-01-19	12.7	698	8.4	6.75
2022-02-23	12.5	707	8.05	7.25
2022-03-29	20.3	619	7.51	6.65
2022-04-19	18.0	717	6.36	7.2
2022-05-19	23.9	673	4.61	6.52
2022-06-21	25.7	591	4.47	6.4
2022-07-25	27.2	544	4.53	6.43
2022-08-25*	25.2	426	3.35	6.51
2022-09-26*	22.5	484	4.53	7.6
2022-10-20*	13.0	479	3.5	6.95
2022-11-14	10.8	443	5.61	7.33
2022-12-06	16.7	531	2.91	7.01
2023-01-10	13.6	571	6.12	6.84
2023-02-27	18.3	772	7.65	7.02
2023-03-28	17.0	817	6.94	6.94
2023-04-17	16.9	727	7.11	7.41
2023-05-03	20.9	571	7.14	6.65

*oil sheen was observed

Table 6. Bacteria and flow data measured for Station 20563 at Pin Oak Creek. Red cells indicate measurements above the criterion.

Date	*E. coli* (MPN/100mL)	Days Since Last Precipitation Event	Instantaneous Flow (cfs)
2021-09-23	60.2	11	0.11
2021-10-27	>2420	0	3.51
2021-11-22	225	11	0.05
2021-12-15	1200	1	1.20
2022-01-19	866	8	0.85
2022-02-23	816	6	1.61
2022-03-29	866	7	2.60
2022-04-19	365	6	0.98
2022-05-19	90.6	13	0.32
2022-06-21	194	0	0.09
2022-07-25	328	11	<0.1
2022-08-25*	125	2	<0.1
2022-09-26*	102	19	<0.1
2022-10-20*	90.4	3	0.11
2022-11-14	80.1	0	0.19
2022-12-06	63.8	3	<0.1
2023-01-10	548	7	0.35
2023-02-27	299	0	1.10
2023-03-28	201	7	0.47
2023-04-17	285	11	1.48
2023-05-03	162	5	2.27

*oil sheen was observed

Station 20564

Table 7. Routine water quality parameters for Station 20564 at Spring Creek. Spring Creek DO criterion is 3 mg/L. Red cells indicate measurements below the criterion.

Date	Water Temperature (Celsius)	Specific Conductance (microS/cm)	Dissolved Oxygen (mg/L)	pH
2021-09-23	18.9	159	4.04	6.54
2021-10-27	20.4	239	6.16	6.63
2021-11-22	14.8	182	5.46	6.83
2021-12-15	17.6	173	5.89	6.66
2022-01-19	12.5	194	8.53	6.76
2022-02-23	9.85	204	8.94	7.62
2022-03-29	19.5	213	6.81	6.84
2022-04-19	17.8	174	6.34	7.67
2022-05-19	24.2	168	4.01	6.99
2022-06-21	26.1	180	2.23	6.79
2022-07-25	26.7	305	1.2	6.98
2022-08-25*	24.9	214	4.86	6.64
2022-09-26	22.8	218	1.89	7.16
2022-10-20	12.1	205	5.97	7.11
2022-11-14	10.0	189	7.87	7.42
2022-12-06	18.3	220	3.47	7.19
2023-01-10	13.9	231	7.54	7.20
2023-02-27	18.7	229	7.13	7.13
2023-03-28	17.3	198	7.01	7.33
2023-04-17	15.7	194	7.20	7.62
2023-05-03	20.6	196	7.43	7.51

*Deceased animal carcass near water body

Table 8. Bacteria and flow data measured for Station 20564 at Spring Creek. Red cells indicate measurements above the criterion.

Date	*E. coli* (MPN/100mL)	Days Since Last Precipitation Event	Instantaneous Flow (cfs)
2021-09-23	204	11	0.431
2021-10-27	>2420	0	10.3
2021-11-22	128	11	1.08
2021-12-15	488	1	2.36
2022-01-19	345	8	1.58
2022-02-23	250	6	1.55
2022-03-29	613	7	1.31
2022-04-19	365	6	1.31
2022-05-19	770	13	0.44
2022-06-21	1990	0	0.10
2022-07-25	78.4	11	-0.007
2022-08-25*	1050	2	0.147
2022-09-26	488	19	0.018
2022-10-20	365	3	0.113
2022-11-14	517	0	0.60
2022-12-06	1200	4	0.732
2023-01-10	461	7	1.365
2023-02-27	687	0	1.40
2023-03-28	272	7	0.78
2023-04-17	866	11	1.25
2023-05-03	980	5	1.88

*Deceased animal carcass near water body

Station 20561

Table 9. Routine water quality parameters for Station 20561 at Campbells Creek. Campbells creek DO criterion is 2 mg/L. Red cells indicate measurement below the criterion.

Date	Water Temperature (Celsius)	Specific Conductance (microS/cm)	Dissolved Oxygen (mg/L)	pH
2021-09-23	*Dry*	*Dry*	*Dry*	*Dry*
2021-10-27*	21.6	809	6.32	7.25
2021-11-22*	15.3	2560	0.56	6.69
2021-12-15*	17.7	1050	2.59	6.62
2022-01-19*	13.0	1220	8.63	7.11
2022-02-23	10.1	1430	10.4	7.56
2022-03-29	20.3	1250	8.88	7.08
2022-04-19	18.7	1710	8.39	7.59
2022-05-19	25.5	1450	7.25	7.68
2022-06-21	*Dry*	*Dry*	*Dry*	*Dry*
2022-07-25	*Dry*	*Dry*	*Dry*	*Dry*
2022-08-25*	25.7	1250	6.51	7.02
2022-09-26	*Dry*	*Dry*	*Dry*	*Dry*
2022-10-20	*Dry*	*Dry*	*Dry*	*Dry*
2022-11-14	*Dry*	*Dry*	*Dry*	*Dry*
2022-12-06*	18.8	1310	0.88	7.00
2023-01-10	13.9	756	10.3	7.54
2023-02-27	19.5	1160	10.1	7.29
2023-03-28	17.5	1360	9.37	7.18
2023-04-17	16.6	1110	9.21	7.37
2023-05-03	22.1	4.7	8.54	7.33

*no-flow/pooled flow severity

Table 10. Bacteria and flow data for Station 20561 at Campbells Creek. Campbells Creek is categorized as secondary contact recreation with a criterion at 630 MPN/100mL. Red cells indicate measurements above the criterion.

Date	*E. coli* (MPN/100mL)	Days Since Last Precipitation Event	Instantaneous Flow (cfs)
2021-09-23	*Dry*	23	*Dry*
2021-10-27*	>2420	0	0
2021-11-22*	579	11	*Dry*
2021-12-15*	288	1	*Dry*
2022-01-19*	214	8	0.135
2022-02-23	517	2	0.346
2022-03-29	1550	7	0.700
2022-04-19	238	6	0.134
2022-05-19	770	13	0.501
2022-06-21	*Dry*	0	*Dry*
2022-07-25	*Dry*	11	*Dry*
2022-08-25*	26.5	2	0
2022-09-26	*Dry*	19	*Dry*
2022-10-20	*Dry*	3	*Dry*
2022-11-14	*Dry*	0	*Dry*
2022-12-06*	<1	4	*Dry*
2023-01-10	1550	7	<0.1
2023-02-27	866	0	0.228
2023-03-28	770	7	0.072
2023-04-17	1050	11	0.27
2023-05-03	921	5	0.96

*no-flow/pooled flow severity

Data Conclusions

Continued monitoring of the Little Brazos tributaries is essential to building a robust dataset for stakeholders to make informed choices. Analysis of the accumulated data shows that *E. coli* levels exceed primary contact criterion for the tributaries. However, the rolling geometric mean demonstrates that *E. coli* concentrations have been consistently lower than secondary contact recreation in the last few years. Additional data may help pinpoint what is causing the elevated bacteria levels. In contrast, DO concentration has remained above the criterion besides a few outliers and continues to follow the historical trend of satisfactory concentrations. Recent flow data is shown to be much lower than historical data, this could be due to recent drought conditions during this time period. With continued monitoring and data collection FDCs and LDCs can be built to better characterize this watershed.

References

TCEQ. 2002. 2002 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/waterquality/assessment/02twqi/twqi02.html

TCEQ. 2006. 2006 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/waterquality/assessment/06twqi/twqi06.html

TCEQ. 2010. 2010 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/20txir/2020_303d.pdf

TCEQ. 2019. Surface Water Quality Monitoring Data Management Reference Guide. July 2019. www.tceq.texas.gov/waterquality/data-management/dmrg_index.html.

TCEQ. 2020. 2020 Guidance for Assessing and Reporting Surface Water Quality in Texas (May 2020): In Compliance with Sections 305(b) and 303(d) of the Federal Clean Water Act.

TCEQ. 2022. 2022 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2022/2022-303d.pdf

The NELAC Institute (TNI) Standard. 2016. Volume 1, Management and Technical Requirements for Laboratories Performing Environmental Analysis, Module 2, Quality Systems General Requirements. EL-V1M2- Rev. 2.1.

USGS 2005. Oberg, K.A., Morlock, S.E., and Caldwell, W.S. Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers. Special Investigations Report 2005-5183.