YEAR 2
JANUARY 2019 – DECEMBER 2019

REGIONAL WET WEATHER CHARACTERIZATION PROGRAM

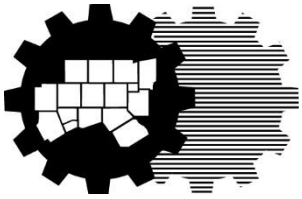
ANNUAL MONITORING REPORT FOR NORTH CENTRAL TEXAS

North Central Texas Council of Governments

This page intentionally left blank

Regional Wet Weather Characterization Program Annual Monitoring Report for North Central Texas

- Year 2 -
(January 2019 – December 2019)



Prepared by the
North Central Texas Council of Governments
Submitted to Texas Commission on Environmental Quality
March 1, 2020

This page intentionally left blank

The Regional Wet Weather Characterization Program Annual Monitoring Report was prepared by the North Central Texas Council of Governments (NCTCOG) on behalf of eight regional participants. The Annual Monitoring Report is submitted to the Texas Commission on Environmental Quality (TCEQ), either directly or by reference, along with each participant's annual report of their stormwater management programs to comply with the Regional Wet Weather Characterization Plan Proposal for the Fourth Term (2018 – 2022), approved by TCEQ on June 30, 2017. The Monitoring Report was submitted to TCEQ on March 1, 2020.

This page intentionally left blank

Table of Contents

List of Tables

List of Figures

REGIONAL WET WEATHER CHARACTERIZATION PROGRAM

Since 1996, a regional stormwater monitoring program has been ongoing in the North Central Texas region among the Phase 1 entities for compliance with Federal and State stormwater permit requirements. The Dallas-Fort Worth Regional Wet Weather Characterization Program (RWWCP) was first negotiated with the United States Environmental Protection Agency (USEPA) and incorporated into each entity's permit for the first term in 1996. The negotiated program reduced the number of sampling stations from the application phase of sampling but increased the number of samples per station to obtain better statistical representation. While several of the participants have changed through the years, the RWWCP has been a successful regional partnership, with eight participating entities currently undergoing chemical and bioassessment sampling during a Fourth Monitoring Term, 2018 – 2022.

First Monitoring Term

During the initial monitoring term (1996 - 2001), seven municipalities (Dallas, Fort Worth, Arlington, Irving, Garland, Plano, and Mesquite), and the Dallas and Fort Worth Districts of the Texas Department of Transportation (TxDOT), received joint approval from the U.S. Environmental Protection Agency (EPA) for a regional monitoring program. The program utilized the assistance of a shared consultant team and the U.S. Geological Survey (USGS), to sample and analyze stormwater runoff from 22 outfalls in primarily small watersheds of a single land use type. The participants worked through the North Central Texas Council of Governments (NCTCOG) to form a regional partnership and strategy to conduct wet-weather monitoring activities for the regional monitoring program. The sample collections served to characterize typical urban runoff from these limited land use types and were useful for estimating general pollutant loadings. However, they did little to evaluate impacts on actual receiving streams.

Second Monitoring Term

In the second monitoring term (2006 - 2010), the Regional Wet Weather Characterization Program (RWWCP) was administered by the Texas Commission on Environmental Quality (TCEQ) and implemented through NCTCOG and a consultant team led by Atkins. Approval was obtained to utilize in-stream stations for the regional monitoring program to better assess the impact on receiving streams. The revised program was termed the Regional Wet Weather Characterization Program (RWWCP) and was added as an option in Part IV.A.3 of the Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System (MS4) permits issued to the Phase I North Central Texas governmental entities. Since the RWWCP language existed outside of each permit, it allowed greater flexibility for making changes to the program.

During the second term, the North Texas Tollway Authority (NTTA) joined the regional program. All other participants remained the same, except TxDOT-Fort Worth District, who became a co-permittee with the cities of Fort Worth and Arlington and was no longer required to conduct wet weather monitoring. According to the original RWWCP protocol, municipal participants collected data from three sample sites in the watershed (typically upstream, midstream, and downstream) and the transportation agencies collected data from two sites (upstream and downstream only). Samples were collected quarterly from each site during a qualifying rainfall event and were analyzed for 18 parameters. The primary goal of the new in-stream monitoring program was to obtain baseline data on receiving streams in North Central Texas for use in determining long-term water quality trends.

Dallas and Fort Worth used their own staff to collect samples, while the consultant team assisted the remaining partners with field data collection, stormwater sample analysis, and technical assistance. As an added component, the City of Fort Worth selected the Representative Rapid Bioassessment Monitoring option (Part IV.A.2) in their permit, which allowed the sampling frequency to be reduced from four times a year per site, to once per year per site. In place of chemical sampling at all sampling sites, Fort Worth conducted two bioassessments each year at a minimum of nine sites. These bioassessments were based on protocols developed by the EPA. A summarization of this

bioassessment data was included along with the chemical data in the regional monitoring report for each year of the monitoring term.

Third Monitoring Term

In the third monitoring term (2011-2015), the Cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite and Plano, together with the North Texas Tollway Authority (NTTA) and TxDOT-Dallas District agreed to continue their regional partnership and work cooperatively through NCTCOG to develop a revised RWWCP. This revised plan effectively monitored at least 50% of each entity's jurisdictional area by the end of the monitoring term. This extension of jurisdictional coverage allowed a reasonable assessment of each entity's jurisdictional watersheds while also achieving a balance among the various goals of obtaining valid scientific information, meeting permit compliance, and addressing what is practicable for each entity. The primary goal of the RWWCP during this permit term was to continue the assessment of urban impact on receiving stream water quality and to document any improvement presumably resulting from local best management practices (BMP) implementation. The data collected during the monitoring term built upon the set of regional data needed from each site for meaningful trend analysis. Since assessing the impact of urban runoff on receiving stream quality is a primary focus of this program, assessing the biological integrity of the streams was deemed fundamental in the third term. During the third term, 24 watersheds were chemically monitored, and 12 watersheds were bio-assessed across the region, with substantial overlap between the two sampling approaches.

At the end of the sampling effort, a final summary report was prepared by Atkins to assess the sampling effort. The report found that more than half of the watersheds sampled had high bacteria exceedances, with an average number of nine exceedances in the studied watersheds. Stream degradation was noted by the consultant team in about half of the sampled watersheds based on the analyzed data. Additional monitoring was recommended at these sites. The final report also analyzed the specific characteristics of the monitored watersheds. This approach provided participants individual watershed information which could be used to implement BMPs and other monitoring practices in the future. Due to the data collected in the third permit term, many of the watersheds studied were classified as high priority for continued monitoring. Watersheds that were classified as a high priority were generally those with stream degradation, those with a high number of monitored parameter criteria exceedances, and those with existing Total Maximum Daily Loads (TMDLs).

As a result of the third monitoring term findings, several recommendations were made for modifying the RWWCP for the fourth term, including the following:

- Impaired Waterbodies Focus – Focused monitoring of impaired water bodies to assist with TMDL efforts underway in North Central Texas by the participants.
- Rapid Bio-Assessment Improvements – Continue to implement rapid bio-assessments and encourage additional participants to undertake rapid bio-assessments as part of the RWWCP. To allow for comparisons, parameters to record during the bio-assessment chemical monitoring activities should be expanded to include/match those of the wet weather monitoring.
- Revise Monitored Pollutants – During the third term, Carbaryl was chosen to replace Diazinon that was undetected in the second term. Carbaryl was not detected in any watershed during the third term, and therefore was recommended that it no longer needed to be monitored for the fourth term, but possible replacements could be dieldrin or atrazine.
- Revise Monitored Pollutants – Due to no recognized correlation between total coliforms and freshwater pathogens by TCEQ or EPA, it was recommended that total coliforms be removed from the list of monitoring parameters. It was also recommended to add ammonia nitrogen, nitrate nitrogen, and orthophosphate to the monitoring parameters for wet weather chemical monitoring. The additions of these nutrients would allow for better comparisons between bioassessment and wet weather chemical monitoring results. Additionally, for the Duck Creek, Johnson Creek, and White Rock Creek (headwaters) subwatersheds, it was recommended that sampling of dissolved fractions of metals be included to determine the concentration of bioavailable metals.

REGIONAL WET WEATHER CHARACTERIZATION PROGRAM – CURRENT MONITORING TERM

This report documents the second year of the fourth monitoring term (2018 – 2022) involving continuing revised approaches to both the chemical and bioassessment monitoring protocols. The North Central Texas Regional Wet Weather Characterization Plan Proposal for the Fourth Term, dated October 11, 2016, was approved by TCEQ on June 30, 2017. The approved Plan can be found in Appendix A. Upon agreement of the RWWCP participants, the resulting third monitoring term recommendations were incorporated in the approved fourth monitoring term proposal.

For the fourth term (2018-2022), the cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, and Plano, and the NTTA (herein referred to as participants), agreed to continue their regional partnership and continue working through the NCTCOG to develop a revised regional monitoring program. As a result of TxDOT obtaining a statewide permit incorporating both the Dallas and Fort Worth Districts, their requirement to conduct wet weather monitoring was removed, and therefore they are not included in the current RWWCP fourth monitoring term.

The fourth term of the RWWCP began on January 1, 2019. Phase I stormwater permit information for each participant is included in Table 1. The permits defer to the approved RWWCP for sampling protocols and the final list of parameters to be tested.

Table 1: Permit Term Four RWWCP Participants

Permittee	TPDES Permit Number	Date Issued	Expiration Date
Arlington	WQ0004635000	08/15/2019	05/15/2024
Dallas	WQ0004396000	08/06/2019	08/06/2024
Fort Worth	WQ0004350000	03/08/2018	03/08/2023
Garland	WQ0004682000	10/15/2019	10/15/2024
Irving	WQ0004691000	12/10/2019	12/10/2024
Mesquite	WQ0004641000	05/24/2018	05/24/2023
Plano	WQ0004775000	12/02/2015	12/02/2020
North Texas Tollway Authority	WQ0004400000	08/15/2018	08/15/2023

The RWWCP participants selected Atkins (herein referred to as the consultants) as the lead contractor, and subconsultants Freese and Nichols, Inc. and Dougherty Sprague Environmental, Inc., to provide regional storm water monitoring services for the fourth term. The consultants will complete a variety of storm water monitoring compliance activities for the cities of Arlington, Garland, Irving, Mesquite, Plano, and NTTA, including storm water monitoring, bioassessments, and a Best Management Practices (BMP) Analysis and Evaluation Plan for all participating entities, including Dallas and Fort Worth. A Monitoring Program and Quality Assurance Project Plan for Wet Weather Equipment Deployment and Sampling Protocol (Appendix B), and Monitoring Program and Quality Assurance Project Plan for Bioassessments (Appendix C) have been documented and provided for the fourth term. For the duration of the fourth term, the cities of Dallas and Fort Worth will conduct their own collection of storm water samples and bioassessments. This report does include the results of their data collection efforts, Appendices F, H, and I.

The regional participants are using a sampling plan that will effectively monitor at least 50% of their jurisdictional area by the end of the monitoring term. As in the third monitoring term, in-stream watershed monitoring will be conducted at each location for a minimum of two years to provide greater statistical robustness of the data. The participants will maintain fixed sampling stations to the extent practicable. This will enable the data to be examined for trends and show improvements or decline in water quality within the fixed sampling period.

Monitored subwatersheds were prioritized based on TMDLs and Clean Water Act Section 303(d) streams located within the watersheds that cover the jurisdictional area of the municipalities.

Participants are monitoring these impaired waterbodies in order to assess the impacts of storm water on these impaired streams. Monitored subwatersheds were also prioritized to match those that have been historically monitored in previous terms, however some additional subwatersheds were added based on the TMDLs and impairments discussed above. Over the fourth monitoring term, 13 subwatersheds will be monitored chemically and 13 subwatersheds will be monitored biologically, according to the sampling schedule in Table 2.

Table 2: Regional Wet Weather Characterization Program Sampling Schedule

Jurisdiction Subwatershed	Number of Samples to be Collected[1]				
	2018	2019	2020	2021[2]	2022[2]
Arlington					
Johnson Creek	4C	4C			
Fish Creek – Mountain Creek Lake	4C	4C			
Rush Creek – Village Creek			8C	8C	
Dallas					
Floyd Branch – White Rock Creek	2B	2B	2B	2B	
Five Mile Creek – Trinity River		12C		12C	
Headwaters Five Mile Creek	2B	2B	2B	2B	
Headwaters Turtle Creek	12C		12C		
White Rock Creek – White Rock Lake	2B	2B	2B	2B	
City of Dallas – White Rock Creek		12C		12C	
Bachman Branch – Elm Fork Creek	2B	2B	2B	2B	
Turtle Creek – Trinity River	12C		12C		
Fort Worth					
Headwaters Sycamore Creek	2C/4B	4B	4B	4B	4B
Lake Como-Clear Fork Trinity River	4B	2C/4B	4B	4B	4B
Marine Creek-West Fork Trinity River	4B	2C/4B	4B	4B	4B
Mary's Creek	2C/4B	4B	4B	4B	4B
Sycamore Creek-West Fork Trinity River	4B	4B	2C/4B	4B	4B
Whites Branch-Big Fossil Creek	4B	4B	2C/4B	4B	4B
Garland					
Duck Creek	12C	12C			
Rowlett Creek – Lake Ray Hubbard	2B	2B	12C/2B	12C/2B	
Irving					
Delaware Creek – West Fork Trinity River	8C/2B	8C/2B			
Grapevine Creek – Elm Fork Trinity River			4C	4C	
Estelle Creek – Bear Creek			4C/2B	4C/2B	
Mesquite					
South Mesquite Creek	4C	4C	4C	4C	
North Mesquite Creek	4C	4C	4C	4C	
Plano					
Spring Creek	4C	4C			
Headwaters Rowlett Creek	2B	2B	4C	4C	
Brown Branch Rowlett Creek			4C/2B	4C/2B	
North Texas Tollway Authority					
Cotton Branch – Hackberry Creek	4C	4C	4C	4C	
Cotton Creek – Mountain Creek Lake	4C	4C	4C	4C	

Note: [1] B-Signifies Bioassessment Samples; C-Signifies Chemical Samples
[2]The City of Fort Worth will conduct additional chemical sampling during 2021 and 2022 at watersheds selected after sampling 2020, and based on the chemical, physical, and biological assessment results done in 2018-2020.

Chemical Sampling

Most participants are performing chemical sampling on one subwatershed within their jurisdiction for two consecutive years and then moving to a second subwatershed for another two years. Exceptions include the NTTA and cities of Dallas, Fort Worth, and Mesquite. Due to the size of their jurisdictional area, Dallas selected eight subwatersheds and Fort Worth selected six subwatersheds for chemical and/or biological monitoring that rotate. Mesquite has a unique situation where only two subwatersheds and the two creeks of those subwatersheds are almost wholly contained within the city limits. Mesquite has chosen to establish permanent in-stream monitoring stations in each of the two creeks and to sample them concurrently all four years. NTTA has also chosen to establish in-stream monitoring stations in two creeks within NTTA right-of-ways and to sample them concurrently all four years. Figure 1 displays the monitored subwatersheds for the fourth term. Appendix A provides additional documentation of the chemical sampling occurring for NTTA, Dallas, Fort Worth, and Mesquite.

For chemical monitoring, grab samples will be collected during the first flush (defined as the 30-minute period following a quantifiable rise in stream level) and analyzed for *E. coli*, oil and grease, and pH. An additional first flush sample and four subsequent samples collected at equal time intervals will be taken over the first two hours of the event and combined for a composite sample. Samples will be collected for no more than two hours, regardless of storm duration. Grab samples will be obtained either manually or through an automated collection device.

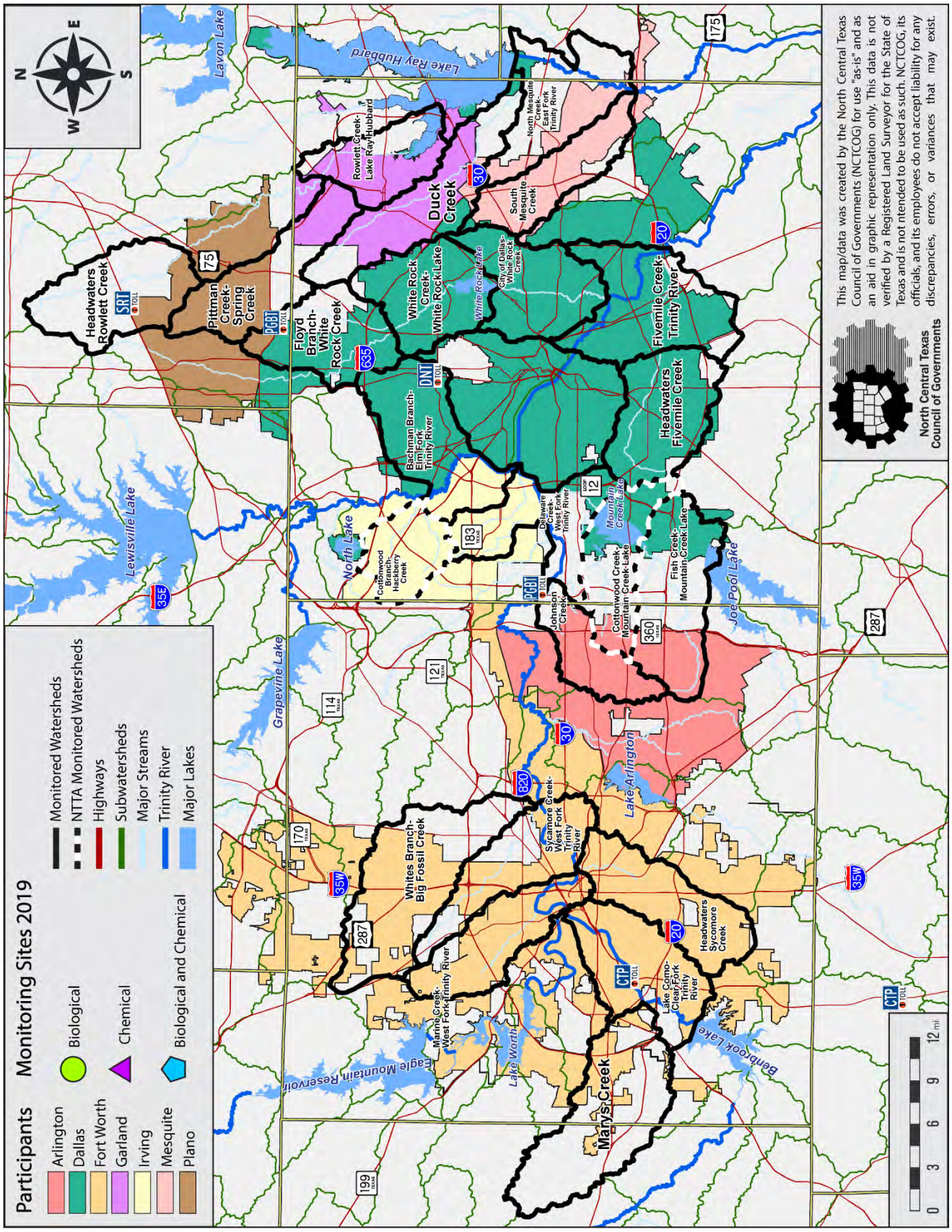
Sampling will be conducted only on qualifying events which are defined as satisfying the following requirements: 1) antecedent dry period of 72 hours minimum; 2) rainfall volume of 0.10 inch minimum; and, 3) a quantifiable increase in water surface elevation attributable to stormwater runoff. Rain gauges were deployed in each watershed to support the assessment of local wet weather conditions.

Chemical samples will be collected with automatic sampling equipment that will allow the collection of water through stainless steel strainer and flexible sampling tubing using a peristaltic pump. Samples will then be pumped into four, 1-gallon glass containers, located in a stormwater sampler shelter. The automatic samplers will also be equipped with bubbler flow modules that activate the samplers based on an increase in water surface elevation in the stream conveyance channel. Upon successful collection, the samples are preserved in ice and shipped immediately to the laboratory for analysis. Each sample is analyzed for 19 parameters which are listed in Table 3.

Table 3: RWWCP Fourth Monitoring Term Regional Parameter Set

Parameter	Method of Collection
Oil & Grease	Grab
pH	Grab
E. coli	Grab
Total Dissolved Solids (TDS)	Composite
Total Suspended Solids (TSS)	Composite
Biochemical Oxygen Demand (BOD5)	Composite
Chemical Oxygen Demand (COD)	Composite
Total Nitrogen	Composite
Dissolved Phosphorus	Composite
Total Phosphorus	Composite
Atrazine	Composite
Total Arsenic	Composite
Total Chromium	Composite
Total Copper	Composite
Total Lead	Composite
Total Zinc	Composite
Ammonia Nitrogen	Composite
Nitrate Nitrogen	Composite
Orthophosphate	Composite

Figure 1: RWWCP Fourth Monitoring Term - Monitored Subwatersheds



Bioassessments

In the fourth monitoring term, the cities of Dallas, Fort Worth, Garland, Irving, and Plano are conducting bioassessments; representing a substantial increase in the use of bioassessments as a component of the RWWCP. EPA and TCEQ have developed an array of methods and approaches that can be used in conducting bioassessments. As EPA states in their manual, *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*, 2nd Ed. (1999), the protocols described are not "intended to be used as a rigid protocol without regional modifications. Instead, they provide options for agencies or groups that wish to implement rapid biological assessment and monitoring techniques."

The regional program participants that are implementing bioassessments will be performing bioassessments based upon EPA and TCEQ protocols. Specific protocols are detailed in manuals provided by each agency, but generally, program participants will be conducting bioassessments involving habitat assessment, a measurement of standard field physical conditions, and the collection and identification of macroinvertebrates and other biota. Habitat parameters will be compared to baseline standards for a reference site or reference conditions to determine the habitat's overall health.

OVERVIEW OF CHEMICAL AND BIOASSESSMENT PROTOCOLS

The consultant team prepared the *Monitoring Program and Quality Assurance Project Plan for Wet Weather Equipment Deployment and Sampling Protocol: 2018–2021* and, *Monitoring Program And Quality Assurance Project Plan For Bioassessments: 2018–2021,* as the protocols for the RWWCP participants. These protocols were included as Appendix B and Appendix C, respectively. The protocol documents include detailed location information for the stormwater sampling and bioassessment sites for the cities of Arlington, Garland, Irving, Mesquite, Plano, and the NTTA.

All chemical sampling sites are equipped with automatic samplers (ISCO 6712, ISCO 730 Bubbler Module) that contain four 1-gallon glass sample containers. The sampler collects 0.5-gallon aliquots every 30 minutes after the initial sample for 120 minutes. Sample container one, or the grab sample container, contains one 1-gallon aliquot, sample containers two and three contain two 0.5-gallon aliquots, and sample container four contains one 0.5-gallon aliquot. All the upstream sampling sites include a tipping bucket rain gauge (ISCO 674) to verify rainfall amounts and antecedent dry periods. Graduated cylinder rain gauges are used at some of the other sites. If the on-site rain gauge information is not applicable (e.g. malfunction or qualifying storm is only at the mid- or downstream stations), an online rain gauge is used to verify the rainfall amount and antecedent dry period. The consultants used Pace Analytical Services Laboratories and their subcontracted laboratories, Armstrong Forensic Laboratory, Inc. and ALS Laboratory, to analyze the samples. Appendix E includes the applicable laboratory certifications.

The cities of Dallas and Fort Worth conducted their sampling operations and have developed protocol documents to address the minor variances in their programs. Their respective protocols are described below.

City of Dallas Protocol

The City of Dallas uses the Regional Stormwater Monitoring and Bioassessment Protocols as their base protocols for stormwater sampling and bioassessment activities in accordance with Appendix B and Appendix C. The City of Dallas utilizes city personnel to operate their own equipment and to collect stormwater samples. City of Dallas staff also conducts bioassessment activities. The protocol documents include maps of Dallas' 2012 through 2015 stormwater sampling and bioassessment sites. No changes have been made to this protocol for Year 2 activities.

The City of Dallas uses the ISCO 6712 model with ISCO 674 Rain Gauge and ISCO 750 Flow Meter for stormwater sample collection. The City of Dallas uses a program script designed to collect and analyze samples for parameters with short hold time from the three sampling stations in one rain event. Sampler equipment is programmed to activate at a 1/10-inch level rise recorded by the rain gauge within a two-hour period. At activation, the sampler collects two one-gallon samples (1st flush). Then after fifteen minutes, the sampler fills the remaining two one-gallon jars (composite) over an hour period in five equal aliquots. The City of Dallas used Pace Analytical Laboratories to carry out analyze the collected samples. Appendix E includes the laboratory certifications.

City of Fort Worth Protocol

The City of Fort Worth has developed a separate protocol, *City of Fort Worth RWWCP Monitoring Plan*, Appendix I, for conducting their stormwater sampling and bioassessment activities. The City of Fort Worth utilizes city personnel to operate their own equipment and to collect stormwater samples. City of Fort Worth staff also conduct bioassessment activities. The protocol document includes location information for Fort Worth's stormwater sampling and bioassessment sites. The City of Fort Worth has updated their protocol for the fourth monitoring term, 2018-2022. The updated City of Fort Worth protocol is included as Appendix I.

The City of Fort Worth has identified chemical sampling sites for years 2018-2020. Automatic water samplers (ISCO 3700 or other) are deployed at the site(s) to be monitored prior to the rain event. The samplers are programmed to initiate sampling at a 1.0-inch rise in receiving stream water level. Upon activation, the sampler collects a "first flush" grab sample and the first of four sub-samples for a time-weighted composite sample. Subsequent sub-samples are collected at 30-minute intervals. The City of Fort Worth Water Department Centralized Water and Wastewater Laboratory conducted analysis of most parameters and subcontracted analysis of the remaining parameters to Xenco Laboratories. Appendix E includes the laboratory certifications.

YEAR 2 CHEMICAL SAMPLING AND BIOASSESSMENT ACTIVITIES

Figure 2, RWWCP Fourth Monitoring Term, Year 2 (2019) Subwatersheds and Monitoring Sites, depicts the subwatersheds sampled in Year 2 (2019) as well as the location of the chemical sampling stations and bioassessment sites. Table 4 contains the corresponding list of Year 2 chemical monitoring and bioassessment sites that are part of the RWWCP, along with location information.

Figure 2: RWWCP Fourth Monitoring Term, Year 2 (2019) Subwatersheds and Monitoring Sites

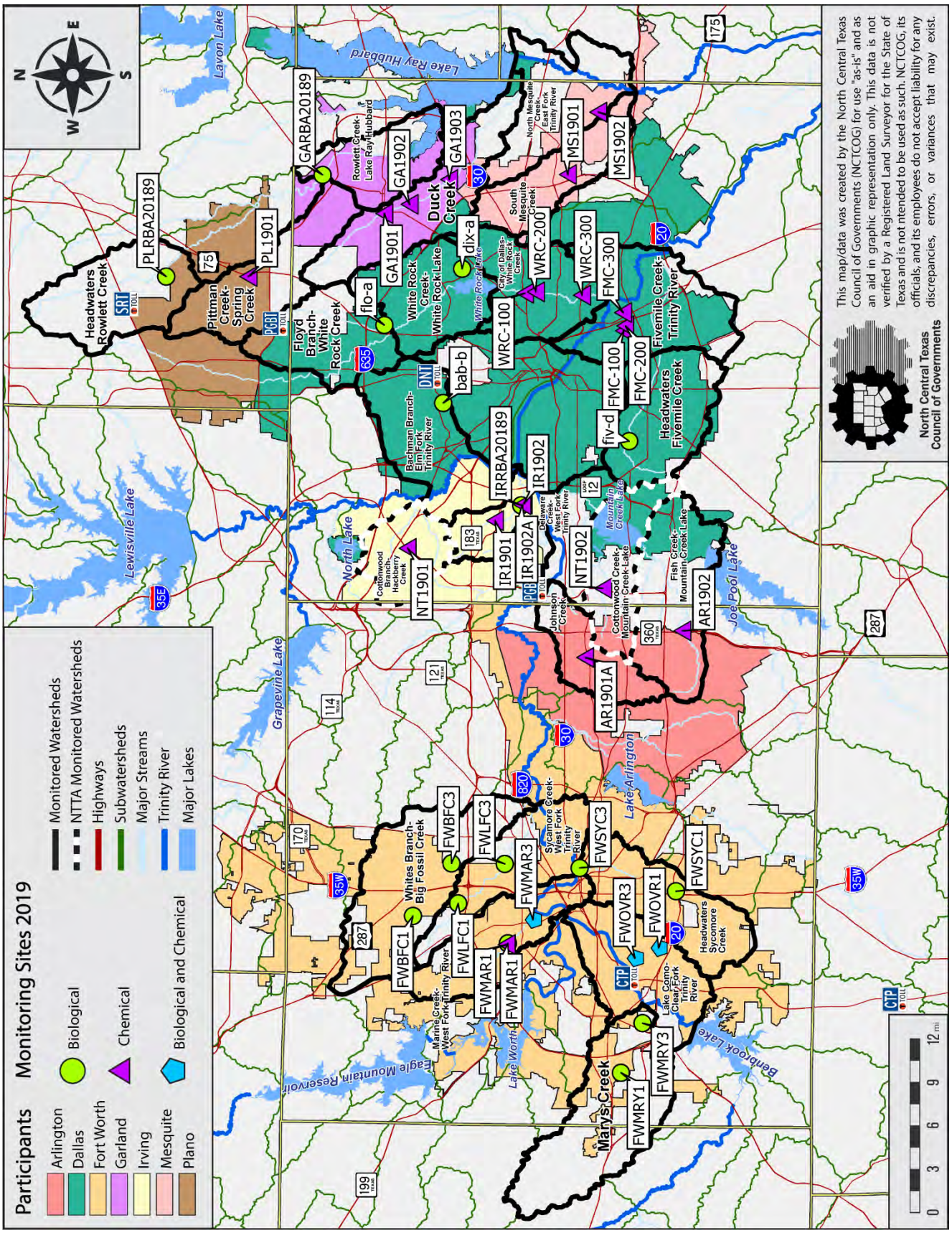


Table 4: RWWCP Year 2 (2019) Chemical Sampling and Bioassessment Site Locations

Jurisdiction Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2019
Arlington				
Johnson Creek				
	AR1901A	Johnson Creek at East Sanford Street	32.7428360/-97.087583	4C
Fish Creek – Mountain Creek Lake	AR1902	Fish Creek at SH 360	32.6623528/-97.0613889	4C
Dallas				
Five Mile Creek-Trinity River	FMC-100	3200 Linfield Road at Honey Springs Branch	32.710769/-96.765777	4C
	FMC-200	4400 Vandervoort Drive at Honey Springs Branch	32.709680/-96.760929	4C
	FMC-300	8000 Carbondale St. at Honey Springs Branch	32.711500/-96.747856	4C
City of Dallas-White Rock Creek	WRC-100	3800 Samuell Blvd. at White Rock Creek	32.792756/-96.728893	4C
	WRC-200	5219 Military Parkway at White Rock Creek	32.783709/-97.727515	4C
	WRC-300	5100 C. F. Hawn Frwy at White Rock Creek	32.745551/ -96.730780	4C
Bachman Branch – Elm Fork Trinity	bab-b	0.25 mile south of Midway Road and W. Northwest Hwy intersection at Banchman Branch	32.8604418/-96.8369522	2B
Floyd Branch – White Rock Creek	flo-a	Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail	32.9090690/-96.7601368	2B
White Rock Creek – White Rock Lake	dix-a	Northeast of Peavy Road and E. Lake Highlands intersection at Dixon Branch	32.8446960/-96.7047586	2B
Headwaters Five Mile Creek	fiv-d	Westmoreland Road and Pentagon Pkwy intersection at Five Mile Creek	32.7064408/-96.8745138	2B
Fort Worth[2]				
Marine Creek – West Fork Trinity River	FWMAR1	3500 Macie, bridge crossing in Buck Sansom Park	32.8079/-97.3703	1C
	FWMAR1	West of Angle Avenue in Buck Sansom Park	32.8069/-97.3691	2B
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	32.7862/-97.3460	1C/2B
Lake Como - Clear Fork Trinity River	FWOVR1	NW of Granbury Rd and Trail Lake Dr	32.6820/-97.3738	1C/2B
	FWOVR3	Overton Park West south of intersection with Bellaire	32.7017/-97.3839	1C/2B
Sycamore Creek – West Fork Trinity River	FWLFC1	2200 block Cantrell Sansom	32.8478/-97.3297	2B
	FWLFC3	Dead end of Mesquite Rd. south of 3800 Long Ave.	32.8095/-97.2909	2B
White's Branch – Big Fossil Creek	FWBFC1	West of parallel to Pepperidge Lane	32.8854/-97.3421	2B
	FWBFC3	N. Beach St. north of Paula Ridge	32.8536/-96.2904	2B

Jurisdiction Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2019
Headwaters Sycamore Creek	FWSYC1	I-35W northbound frontage road beneath SE Loop IH-820 eastbound	32.6677/-97.3178	2B
	FWSYC3	Dead end of Scott St. west of Beach St.	32.7475/-97.2949	2B
Mary's Creek	FWMRY1	3900 Block Longvue (FM 2871)	32.7133/-97.4966	2B
	FWMRY3	Winscott Road (Vickery Blvd.) in South Z Boaz Park	32.6954/-97.4477	2B
Garland				
Duck Creek	GA1901	Duck Creek between Forest North and South	32.9090727/-96.6503388	4C
	GA1902	Duck Creek at Rick Oden Park/Briarwood Drive	32.888176/-96.641277	4C
	GA1903	Duck Creek under La Prada Bridge	32.8554635/-96.6168702	4C
Rowlett Creek – Lake Ray Hubbard	GARBA20189	Rowlett Creek bellow Atchison Topeka and Santa Fe Railroad bridge	32.960095/-96.612327	2B
Irving				
Delaware Creek – West Fork Trinity River	IR1901	Delaware Creek at Sowers Road	32.8175600/-96.9528400	4C
	IR1902	Delaware Creek at Oakdale	32.7938200/-96.9363500	1C
	IR1902A[3]	Delaware Creek at Maple Street	32.794972/ -96.937083	3C
	IRRBA20189	Delaware Creek in Fritz Park	32.79590/-96.93770	2B
Mesquite				
South Mesquite Creek	MS1901	North of New Market Road	32.7572500/-96.6119444	4C
North Mesquite Creek	MS1902	North Mesquite Creek at Edward's Church	32.7321111/-96.55055000	4C
Jurisdiction Watershed	**Station ID**	**Location**	**Latitude/Longitude**	**# of samples in 2019**
Plano				
Pittman Creek - Spring Creek	PL1901	Spring Creek at 16th Street	33.021317/-96712406	4C
Headwaters Rowlett Creek	PLRBA20189	Rowlett Creek at Sun Creek Park	33.08920/-96.70870	2B
North Texas Tollway Authority				
Cottonwood Branch – Hackberry Creek	NT1901	Unnamed Tributary at SH 161 N. of Gateway Drive	32.889808/-96.980065	4C
Cotton Creek – Mountain Creek Lake	NT1902	Cottonwood Creek at SH 161 S. of Dickey Road	32.728181/-97.019460	4C

Notes:
[1]B-Signifies bioassessment samples; C signifies chemical samples.
[2]Table 4 includes the primary bioassessment sites for the City of Fort Worth for each watershed. The City of Fort Worth Sampling Protocol identifies an additional bioassessment site for each watershed that may be used as an alternative depending on local conditions at the time of sampling.
[3]Due to construction activities, IR1902 was moved to a new location and was renamed IR1902A

Chemical Sampling

All samples were successfully collected and analyzed in Year 2, January 2019 – December 2019 of the fourth term. Due to the construction activities and failed sampling attempts, first quarter sampling of PL 1901 was not completed until May 18, 2019. Also due to construction activities in the second quarter, the sampling equipment located at IR1902 was relocated to the nearest upstream access and renamed IR1902A.

The sampling data and summary statistics for Year 2 of the monitoring term are included in Year 2 Regional Chemical Sampling Data. The complete raw sampling data and sample collection reports are provided in Appendix F and Appendix G, respectively.

Bioassessments

The Cities of Dallas, Fort Worth, Garland, Irving, and Plano conducted bioassessment activities in Year 2. All scheduled bioassessments were successfully conducted. An overview of each entity's bioassessment activities is provided below. For complete details, refer to bioassessment reports for Dallas (Appendix H), Fort Worth (Appendix I), and Garland, Irving, and Plano (Appendix D).

City of Dallas

The City of Dallas performs rapid bioassessment protocol (RBP) monitoring as a part of the RWWCP and conducts additional RBP monitoring beyond the regional program as part of their individual MS4 Permit Stormwater Management Program. The City uses the RBP as set forth in the TCEQ *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data (TCEQ, 2007, RG-416)*. The RBP monitoring evaluates the chemical, physical, and biological in-stream features that promote a healthy and diverse habitat; as such they provide a good assessment of overall watershed health. The RBP monitoring program involves performing an Aquatic Life Use (ALU) assessment through benthic macro-invertebrate collection, habitat assessment, and evaluating water quality samples.

Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15th to June 30th): Targets spring's optimal conditions for biological community growth.
- Summer Period (July 1st to September 30th): Reflects impacts from typical summer low flows and higher water temperatures.

Under the RBP, each water body is given a composite score that is determined through evaluation of numbers and diversity of macro invertebrates, water quality parameters, stream habitat features and other metrics. A sample of each monitoring site's macro invertebrate community determines the sites' Aquatic Life Use (ALU) metric. Since 2005, the City of Dallas has used the Benthic Macro-invertebrate Index of Biotic Integrity (IBI) to test ALU. A sample from each monitoring site is tested according to the IBI. The City of Dallas' 2019 bioassessment report is included as Appendix H of this report. Note that the report contains data for all the sites monitored by Dallas in 2019.

City of Fort Worth

The City of Fort Worth performs rapid bioassessments on representative creeks within six subwatersheds twice per year as a part of the RWWCP monitoring program and to satisfy their storm water monitoring program requirements. Methods for bioassessments are based on protocols set forth in TCEQ, EPA, and Texas Parks and Wildlife guidance documents. A description of methodology may be found in the full bioassessment report in Appendix I. Regional rapid bioassessments included habitat assessment, chemical and physical water quality parameter evaluation, sample collection and analysis of benthic macroinvertebrate. Sampling was conducted during spring (May) and fall (October)

2019 on three sites on most of the creeks. Sycamore Creek site 3 (SYC3) wasn't sampled during spring 2019 as it was unwadeable, and Marine Creek site 1 (MAR1) wasn't sampled during fall 2019 as it was dry.

Habitat assessments are based on USEPA guidelines for high gradient streams as outlined in *Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers*, second edition (EPA 841-B-99-002). Macroinvertebrate data were analyzed using methods for the TCEQ-based Texas Index of Biotic Integrity (IBI) for kick net samples. The metric calculation scores at a site for the IBI are compared to values in TCEQ guidelines and each site is assigned an aquatic life use rating. The values for the aquatic life use ratings found in the TCEQ guidelines were developed based on data collected from ecoregional reference sites. This method gives an individual value for each site without a direct comparison to a specific reference site, but to values from ecoregional reference sites. Individual sites may be compared to themselves year to year on a seasonal basis (spring to spring and fall to fall) to demonstrate community changes within each reach.

Garland, Irving, and Plano

Stream rapid bioassessments were conducted on Rowlett Creek in Garland, Delaware Creek in Irving, and Rowlett Creek Headwaters in Plano, in 2019. All three creeks were sampled once between June 12 and 14, 2019, during the "Index" period and another time between September 16 and 18, 2019, during the "Critical" period. The TCEQ (2012) recommends one sample be collected during the Index period and one during the Critical period when two samples are collected at the same site during the same year. The TCEQ (2012) also recommends samples be collected at least 1 month apart, when flows are relatively low, and not recently impacted by rainfall runoff. Benthic macroinvertebrate and fish communities were sampled, and data compared with metrics from the TCEQ. Habitat, water chemistry, and flow were also measured in each trip.

The streams are in the Texas Blackland Prairie ecoregion (Ecoregion 32). Within an ecoregion, soils, climate, landforms, and vegetation are expected to be similar. Reference conditions for benthic macroinvertebrates and fish inhabiting wadeable streams in the Texas Blackland Prairie ecoregion are described by TCEQ. Evaluating benthic macroinvertebrates and fish communities with the TCEQ-established metrics to calculate aquatic life use may indicate whether the streams have been impacted by human activities. Appendix D contains the detailed bioassessment report for Garland, Irving, and Plano.

YEAR 2 REGIONAL MONITORING PROGRAM CHEMICAL SAMPLING DATA SUMMARY

Analytical results and field measurements from all storm events sampled during Year 2 (January-December 2019) are summarized for each parameter in Table 5. The table includes descriptive statistics of minimum, maximum, mean (average), median, and standard deviation. Note that for each of the chemical sampling sites, i.e. AR1901, there were four samples collected during the year (i.e. n=4). The arithmetic mean has been provided for all the parameters except for *E.coli*; the geometric mean was calculated for all bacteria samples. The raw (unmodified) data is provided in Appendix F.

The data includes cases where concentrations of some parameters for samples are below the detection limit (BDL) of the analytical equipment. When data for all samples collected during the year for a given parameter at a sample site (dataset) contained values below the detection limit ("<"), values are reported as "BDL" in Table 5. In cases where datasets contained values both below and above the detection threshold, the value of one-half the detection limit was used in the statistical calculations. The City of Fort Worth places emphasis on its bioassessment activities and collects one

sample per year at each of its designated sampling sites. Therefore, summary statistics are not included in Table 5 for the City of Fort Worth (raw data is provided in Appendix F).

Table 5: Year 2 (2019) Stormwater Data Summary

PARAMETER / STATISTICS	ARLINGTON		GARLAND			IRVING		MESQUITE		PLANO	NTTA		DALLAS					
	AR1901A	AR1902	GA1901	GA1902	GA1903	IR1901	IR1902A*	MS1901	MS1902	PL1901	NT1901	NT1902	WRC-100	WRC-200	WRC-300	FMC-100	FMC-200	FMC-300
TDS (mg/L)																		
Minimum	124	156	186	194	188	116	144	248	204	171	88	118	200.0	188.0	262.0	322.0	188.0	239.0
Maximum	772	770	676	522	592	452	454	506	484	277	187	170	314.0	308.0	315.0	216.3	324.0	320.0
Mean	310	484	430	311	413	249	328	377	323	213	137	142	259.8	241.5	282.3	203.0	240.3	261.5
Median	171	505	429	263	435	214	357	377	302	201	136	141	262.5	235.0	276.0	203.0	224.5	243.5
Std. Dev	310	310	266	149	188	144	140	132	133	48	50	26	49.3	51.9	22.8	80.2	58.5	39.1
TSS (mg/L)																		
Minimum	19.8	23.6	23.0	19.6	19.6	104.0	12.3	65.2	14.8	130.2	13.2	38.0	26.0	110.0	25.0	64.0	21.0	74.0
Maximum	438.0	325.0	65.0	46.6	126.0	1440.0	267.0	248.0	723.0	410.0	696.0	118.0	74.0	56.8	49.0	933.0	246.0	134.0
Mean	193.2	171.7	48.2	31.5	63.4	640.2	157.1	155.6	228.9	318.1	201.2	63.8	43.3	45.0	35.8	305.5	101.8	108.8
Median	157.5	169.0	52.4	29.8	54.0	508.4	174.5	154.5	88.9	366.0	47.7	49.6	36.5	36.6	34.5	112.5	70.0	113.5
Std. Dev	178.6	149.5	18.2	11.2	52.7	573.5	115.2	77.5	336.3	131.5	330.9	37.7	22.0	27.0	10.9	420.4	100.1	29.7
BOD (mg/L)																		
Minimum	1.00	2.53	3.29	3.47	3.26	6.04	1.00	3.43	1.00	7.00	3.69	4.68	1.00	1.00	2.10	2.70	1.00	1.00
Maximum	16.40	28.00	12.90	14.80	32.50	35.20	9.00	7.16	8.70	21.70	19.90	16.80	31.00	36.00	29.00	26.90	14.10	12.60
Mean	7.83	12.98	8.78	8.69	15.92	19.99	5.04	5.10	4.72	14.55	12.57	8.85	11.35	11.53	9.73	9.60	6.45	5.95
Median	6.95	10.70	9.46	8.25	13.97	19.35	5.09	4.90	4.59	14.75	13.35	6.95	6.70	4.55	3.90	4.40	5.35	5.10
Std. Dev	6.65	10.85	4.43	4.72	13.97	12.09	3.95	1.92	3.63	6.30	8.12	5.43	13.37	16.45	12.93	11.57	5.91	4.84
COD (mg/L)																		
Minimum	9.0	12.0	26.0	23.0	20.0	45.0	15.0	14.0	14.0	13.0	22.0	17.5	17.5	17.5	17.5	17.5	17.5	10.0
Maximum	34.1	60.0	72.0	54.0	53.0	211.0	47.0	47.0	51.3	90.0	85.0	31.9	47.8	46.2	44.5	77.2	47.0	45.9
Mean	19.2	27.6	46.9	34.3	37.0	97.7	31.8	34.6	25.8	48.5	49.6	25.9	31.5	27.5	25.1	33.4	25.5	22.7
Median	16.8	19.3	44.8	30.1	37.5	67.4	32.6	38.7	19.0	45.6	45.7	27.0	30.3	23.1	19.3	19.4	18.8	17.5
Std. Dev	10.6	21.9	19.2	14.4	15.6	76.7	16.1	14.3	17.2	34.4	30.2	6.1	13.3	13.6	13.0	29.3	14.4	15.8
TOTAL NITROGEN (mg/L)																		
Minimum	1.50	2.30	0.97	1.20	1.69	1.58	1.20	0.64	0.75	0.67	1.30	1.30	0.52	0.01	0.52	0.13	0.35	0.46
Maximum	11.00	3.60	2.30	1.60	19.40	6.00	1.90	1.40	1.80	4.30	5.50	2.00	1.30	1.00	0.89	4.10	3.50	3.10
Mean	4.65	2.98	1.69	1.38	10.50	2.98	1.53	1.11	1.29	2.19	3.35	1.61	0.86	0.64	0.68	2.83	1.84	1.55

PARAMETER / STATISTICS	ARLINGTON		GARLAND			IRVING		MESQUITE		PLANO	NTTA		DALLAS					
	AR1901A	AR1902	GA1901	GA1902	GA1903	IR1901	IR1902A*	MS1901	MS1902	PL1901	NT1901	NT1902	WRC-100	WRC-200	WRC-300	FMC-100	FMC-200	FMC-300
Median	3.05	3.02	1.74	1.36	10.45	2.16	1.50	1.20	1.30	1.90	3.30	1.56	0.81	0.79	0.65	3.55	1.75	1.33
Std. Dev	4.31	0.72	0.59	0.18	8.09	2.04	0.33	0.34	0.43	1.55	1.94	0.31	0.33	0.44	0.18	1.86	1.32	1.24
NITRATE N (mg/L)																		
Minimum	0.34	0.38	0.38	0.18	0.29	0.12	0.22	0.18	0.27	0.51	0.40	0.28	NA	NA	NA	NA	NA	NA
Maximum	9.61	0.63	1.22	0.88	19.40	0.83	0.38	0.53	0.73	0.87	1.19	0.81	NA	NA	NA	NA	NA	NA
Mean	2.71	0.49	0.76	0.55	8.48	0.45	0.32	0.38	0.49	0.69	0.77	0.49	NA	NA	NA	NA	NA	NA
Median	0.45	0.48	0.72	0.58	7.12	0.42	0.35	0.41	0.48	0.69	0.74	0.43	NA	NA	NA	NA	NA	NA
Std. Dev	4.60	0.11	0.37	0.30	8.12	0.29	0.08	0.16	0.23	0.15	0.39	0.25	NA	NA	NA	NA	NA	NA
AMMONIA N (mg/L)																		
Minimum	0.1700	0.1300	0.1300	0.0890	0.0575	0.1665	0.0980	0.0690	0.0250	0.0250	0.1800	0.1200	NA	NA	NA	NA	NA	NA
Maximum	0.5000	0.2810	1.3640	0.2620	1.0300	0.9900	0.2100	0.5000	0.1500	0.2600	1.1600	1.6370	NA	NA	NA	NA	NA	NA
Mean	0.2800	0.1953	0.4550	0.1905	0.3619	0.4644	0.1345	0.2498	0.0838	0.1263	0.5185	0.5243	NA	NA	NA	NA	NA	NA
Median	0.2250	0.1850	0.1629	0.2056	0.1800	0.3505	0.1150	0.2150	0.0801	0.1101	0.3670	0.1700	NA	NA	NA	NA	NA	NA
Std. Dev	0.1534	0.0629	0.6064	0.0729	0.4539	0.3702	0.0511	0.1827	0.0537	0.1059	0.4372	0.7426	NA	NA	NA	NA	NA	NA
ORTHOPHOSPHATE (mg/L)																		
Minimum	0.025	0.025	0.015	BDL	0.140	0.015	0.020	0.015	0.015	0.015	0.015	BDL	NA	NA	NA	NA	NA	NA
Maximum	0.130	0.200	0.200	BDL	2.540	0.200	0.260	0.160	0.125	0.125	0.200	BDL	NA	NA	NA	NA	NA	NA
Mean	0.072	0.085	0.068	BDL	1.170	0.081	0.116	0.081	0.056	0.084	0.093	BDL	NA	NA	NA	NA	NA	NA
Median	0.066	0.058	0.028	BDL	1.000	0.054	0.093	0.075	0.041	0.098	0.078	BDL	NA	NA	NA	NA	NA	NA
Std. Dev	0.045	0.079	0.089	BDL	1.194	0.085	0.104	0.072	0.050	0.049	0.089	BDL	NA	NA	NA	NA	NA	NA
DISSOLVED PHOSPHORUS (mg/L)																		
Minimum	0.0460	0.0386	0.0500	0.0090	0.0980	0.0500	0.0460	0.0210	0.0500	0.0450	0.0500	0.0500	0.03	0.03	0.03	0.06	0.11	0.06
Maximum	0.1700	0.1300	0.1400	0.0880	3.0000	0.5900	0.1770	0.0750	0.2410	0.0883	0.3100	0.1600	0.13	0.12	0.17	0.91	0.37	0.18
Mean	0.0790	0.0672	0.0850	0.0493	1.0563	0.2375	0.0958	0.0490	0.1353	0.0611	0.1788	0.0775	0.08	0.06	0.08	0.29	0.19	0.11
Median	0.0500	0.0500	0.0750	0.0500	0.5635	0.1550	0.0800	0.0500	0.1250	0.0555	0.1775	0.0500	0.08	0.04	0.06	0.10	0.14	0.10
Std. Dev	0.0607	0.0422	0.0436	0.0323	1.3284	0.2500	0.0616	0.0221	0.0951	0.0193	0.1063	0.0550	0.06	0.04	0.07	0.41	0.12	0.05
TOTAL PHOSPHORUS (mg/L)																		
Minimum	0.058	0.025	0.056	0.041	0.582	0.037	0.160	0.025	0.025	0.244	0.056	0.035	0.06	0.07	0.07	0.21	0.20	0.18
Maximum	0.650	0.430	0.180	0.108	2.860	0.880	0.306	0.151	0.330	0.470	0.900	0.310	0.19	0.20	0.13	0.92	0.38	0.23
Mean	0.385	0.147	0.104	0.077	1.357	0.471	0.228	0.102	0.167	0.369	0.312	0.163	0.13	0.14	0.10	0.57	0.29	0.20

PARAMETER / STATISTICS	ARLINGTON		GARLAND			IRVING		MESQUITE		PLANO	NTTA		DALLAS					
	AR1901A	AR1902	GA1901	GA1902	GA1903	IR1901	IR1902A*	MS1901	MS1902	PL1901	NT1901	NT1902	WRC-100	WRC-200	WRC-300	FMC-100	FMC-200	FMC-300
Median	0.417	0.066	0.090	0.080	0.993	0.483	0.223	0.115	0.156	0.380	0.146	0.154	0.13	0.14	0.10	0.58	0.28	0.20
Std. Dev	0.271	0.190	0.053	0.028	1.024	0.359	0.071	0.061	0.148	0.099	0.397	0.138	0.07	0.05	0.03	0.39	0.09	0.02
ATRAZINE (µg/L)																		
Minimum	0.040	0.050	0.005	0.005	0.005	0.005	0.042	0.005	0.005	0.005	BDL	0.050	NA	NA	NA	NA	NA	NA
Maximum	0.056	0.058	0.050	0.055	0.060	0.095	0.111	0.091	0.115	0.2655	BDL	0.052	NA	NA	NA	NA	NA	NA
Mean	0.049	0.053	0.038	0.040	0.041	0.050	0.063	0.049	0.055	0.098	BDL	0.051	NA	NA	NA	NA	NA	NA
Median	0.050	0.051	0.048	0.050	0.050	0.050	0.050	0.050	0.050	0.060	BDL	0.050	NA	NA	NA	NA	NA	NA
Std. Dev	0.007	0.004	0.022	0.023	0.025	0.037	0.032	0.035	0.045	0.115	BDL	0.001	NA	NA	NA	NA	NA	NA
TOTAL ARSENIC (mg/L)																		
Minimum	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00200	0.00100	0.00100	BDL	BDL	BDL	BDL	BDL	BDL
Maximum	0.00500	0.00884	0.00500	0.00500	0.00500	0.00820	0.00500	0.00500	0.00500	0.00500	0.00650	0.00582	BDL	BDL	BDL	BDL	BDL	BDL
Mean	0.00374	0.00495	0.00238	0.00243	0.00270	0.00530	0.00321	0.00240	0.00320	0.00393	0.00363	0.00406	BDL	BDL	BDL	BDL	BDL	BDL
Median	0.00448	0.00500	0.00175	0.00185	0.00240	0.00600	0.00341	0.00180	0.00340	0.00435	0.00350	0.00470	BDL	BDL	BDL	BDL	BDL	BDL
Std. Dev	0.00184	0.00392	0.00180	0.00177	0.00170	0.00316	0.00178	0.00178	0.00201	0.00132	0.00256	0.00212	BDL	BDL	BDL	BDL	BDL	BDL
TOTAL CHROMIUM (mg/L)																		
Minimum	0.00200	0.00200	0.00200	0.00200	0.00200	0.00655	0.00200	0.00200	0.00200	0.00750	0.00200	0.00200	BDL	BDL	BDL	0.004	BDL	BDL
Maximum	0.01640	0.02570	0.01400	0.00500	0.03000	0.05200	0.02200	0.00600	0.01100	0.01400	0.02200	0.01460	BDL	BDL	BDL	0.014	BDL	BDL
Mean	0.00935	0.01035	0.00598	0.00275	0.01080	0.03114	0.01258	0.00385	0.00500	0.00993	0.00967	0.00768	BDL	BDL	BDL	0.007	BDL	BDL
Median	0.00950	0.00685	0.00395	0.00200	0.00560	0.03300	0.01315	0.00370	0.00350	0.00830	0.00500	0.00705	BDL	BDL	BDL	0.006	BDL	BDL
Std. Dev	0.00693	0.01059	0.00543	0.00150	0.01324	0.01870	0.00940	0.00196	0.00424	0.00354	0.01079	0.00546	BDL	BDL	BDL	0.005	BDL	BDL
TOTAL COPPER (mg/L)																		
Minimum	0.00370	0.00272	0.00548	0.00422	0.01040	0.01080	0.00209	0.00500	0.00327	0.01200	0.00351	0.00500	BDL	BDL	BDL	0.010	0.010	0.010
Maximum	0.03200	0.02850	0.01800	0.01800	0.03500	0.05100	0.01500	0.01400	0.01300	0.03700	0.02800	0.01200	BDL	BDL	BDL	0.024	0.024	0.027
Mean	0.01438	0.01331	0.01312	0.00873	0.02335	0.03495	0.00709	0.00740	0.00657	0.02150	0.01213	0.00756	BDL	BDL	BDL	0.014	0.014	0.014
Median	0.01090	0.01100	0.01450	0.00636	0.02400	0.03900	0.00563	0.00530	0.00500	0.01850	0.00850	0.00662	BDL	BDL	BDL	0.010	0.010	0.010
Std. Dev	0.01314	0.01191	0.00537	0.00635	0.01200	0.01775	0.00555	0.00440	0.00437	0.01168	0.01121	0.00313	BDL	BDL	BDL	0.007	0.007	0.009
TOTAL LEAD (mg/L)																		
Minimum	0.00100	0.00100	0.00200	0.00100	0.00100	0.00481	0.00100	0.00280	0.00100	0.00650	0.00100	0.00100	BDL	BDL	BDL	0.005	BDL	BDL
Maximum	0.02200	0.01750	0.00700	0.00500	0.02100	0.04000	0.01400	0.00557	0.01100	0.01500	0.01200	0.00910	BDL	BDL	BDL	0.029	BDL	BDL
Mean	0.01098	0.00798	0.00413	0.00263	0.00925	0.02170	0.00668	0.00459	0.00475	0.01030	0.00500	0.00525	BDL	BDL	BDL	0.013	BDL	BDL

PARAMETER / STATISTICS	ARLINGTON		GARLAND			IRVING		MESQUITE		PLANO	NTTA		DALLAS					
	AR1901A	AR1902	GA1901	GA1902	GA1903	IR1901	IR1902A*	MS1901	MS1902	PL1901	NT1901	NT1902	WRC-100	WRC-200	WRC-300	FMC-100	FMC-200	FMC-300
Median	0.01045	0.00670	0.00377	0.00225	0.00750	0.02100	0.00586	0.00500	0.00350	0.00940	0.00350	0.00545	BDL	BDL	BDL	0.009	BDL	BDL
Std. Dev	0.00968	0.00703	0.00232	0.00170	0.00954	0.01476	0.00547	0.00122	0.00450	0.00353	0.00497	0.00333	BDL	BDL	BDL	0.011	BDL	BDL
TOTAL ZINC (mg/L)																		
Minimum	0.0211	0.0140	0.0360	0.0244	0.0269	0.0640	0.0120	0.0140	0.0020	0.0620	0.0287	0.0360	BDL	BDL	BDL	0.013	0.045	0.029
Maximum	0.1400	0.1610	0.0900	0.0550	0.1670	0.2500	0.0700	0.0319	0.0670	0.2000	0.1700	0.2100	BDL	BDL	BDL	0.013	0.021	0.038
Mean	0.0676	0.0783	0.0670	0.0341	0.0857	0.1820	0.0378	0.0257	0.0260	0.1175	0.0729	0.0832	BDL	BDL	BDL	0.013	0.013	0.033
Median	0.0546	0.0692	0.0710	0.0285	0.0745	0.2070	0.0346	0.0285	0.0175	0.1040	0.0465	0.0434	BDL	BDL	BDL	0.013	0.016	0.032
Std. Dev	0.0566	0.0737	0.0240	0.0142	0.0694	0.0826	0.0240	0.0082	0.0283	0.0670	0.0653	0.0846	BDL	BDL	BDL	0.013	0.013	0.004
OIL AND GREASE (mg/L)																		
Minimum	1.00	1.90	0.56	0.56	0.56	0.18	2.08	0.19	0.18	0.19	0.18	1.00	BDL	BDL	1.30	BDL	BDL	1.30
Maximum	2.92	2.92	2.50	4.20	2.50	2.50	2.80	2.50	2.50	5.03	2.50	2.65	BDL	BDL	31.20	BDL	BDL	2.60
Mean	2.23	2.54	1.24	2.44	1.44	1.45	2.46	1.44	1.31	2.69	1.33	2.11	BDL	BDL	9.40	BDL	BDL	2.23
Median	2.50	2.68	0.96	2.50	1.35	1.57	2.48	1.53	1.28	2.77	1.32	2.40	BDL	BDL	2.55	BDL	BDL	2.50
Std. Dev	0.84	0.47	0.86	1.49	0.85	1.06	0.30	1.24	0.97	1.99	1.13	0.76	BDL	BDL	14.55	BDL	BDL	0.62
pH (su)																		
Minimum	8.20	8.20	7.60	8.10	6.90	8.10	5.50	8.02	7.88	6.70	8.20	7.30	6.93	6.94	6.96	7.36	7.58	7.44
Maximum	9.10	8.80	8.00	8.80	7.40	9.00	8.70	8.40	8.30	8.30	8.91	9.20	8.31	8.19	8.05	8.24	8.01	7.9
Mean	8.58	8.50	7.73	8.40	7.18	8.55	7.80	8.23	8.16	7.73	8.48	8.23	7.64	7.53	7.58	7.65	7.85	7.61
Median	8.50	8.50	7.65	8.35	7.20	8.55	8.50	8.25	8.23	7.95	8.40	8.20	7.66	7.50	7.66	7.51	7.90	7.56
Std. Dev	0.39	0.26	0.19	0.36	0.21	0.37	1.54	0.16	0.19	0.70	0.30	0.78	0.56	0.51	0.45	0.40	0.19	0.21
E. COLI (col/100 mL)																		
Minimum	50	50	1	1	1	1	300	163	50	2420	50	1	71	101	64	181	291	105
Maximum	11200	4352	4000	5600	5600	19863	25600	4600	2200	8800	5200	4352	248	921	866	24196	1414	770
Mean	3613	2205	1618	3205	2018	8266	7245	2331	1150	5073	2417	1597	160	512	336	7186	852	313
Median	1601	2210	1235	3610	1235	6600	1540	2280	1200	4000	2000	1018	160	512	78	2184	852	189
Std. Dev	5113	1765	1949	2528	2642	9141	12291	2197	1076	3323	2600	2056	125	469	459	11381	794	311

*IR1902 and IR1902A results were combined for this summary

SUBWATERSHED LAND USE ANALYSIS

The land use composition of watersheds can often have a significant impact on the pollutant loads generated in stormwater runoff. Various studies have associated certain types of pollutants with particular land use types and a similar correlation was found in the North Central Texas area during the first permit term's sampling effort (Alan Plummer & Associates, Inc. & Camp Dresser & McKee, 1994; Pitt, 2005; USEPA, 1983; UWRRC, ASCE, & WEF, 1992). Higher levels of metals, oil and grease, and total suspended solids were found in areas that were predominantly industrial whereas higher levels of nutrients, biochemical oxygen demand (BOD), pesticides and herbicides were associated with predominantly residential watersheds. Studies have also correlated pollutant runoff levels to the degree of impervious surface coverage, and these have in turn been associated with various land use types (CWP, 2003). For example, heavy industrial areas are recognized for their expansive buildings surrounded by large parking lots and are on average 80% impervious. Residential areas customarily have lots that are only partially covered with dwellings, driveways and sidewalks, and the rest is usually grassy or wooded. Impervious estimates for these areas are usually in the range of 50-75%.

Land Use Classification and Composition for Subwatershed and Drainage Areas

This report provides land use classifications for each subwatershed containing the 2019 sampling sites. Land use classifications were determined for each subwatershed using the 2015 NCTCOG Regional Land Use data. NCTCOG's standard 42 land use categories were combined into the following six categories for the purpose of this analysis: commercial, industrial, open space, residential, roads, and water. Table 6 shows the land use classifications used for this analysis as well as the percentage of impervious cover typically related to each land use type.

Table 7 includes land use composition estimates of drainage areas for each of the chemical sampling sites. Land use category percentages were calculated based on the proportion of each land use type over the total area for that site's drainage area and expressed as a percent. Note that in most cases, the sampling sites are arranged as upper, middle, and lower sites within a subwatershed. However, the drainage area and associated land use percentages provided in Table 7 for the midstream and downstream sampling sites excludes the drainage area of the upstream site(s). The total drainage area and land use for the midstream and downstream sites may be calculated by adding in the area for the upstream site(s). While it may be expected that some portion of pollutant loading is cumulative as pollutants travel towards the midstream and downstream sites, it is also recognized that pollutant attenuation through degradation, settling, and dilution could also occur.

Table 8 provides detailed watershed descriptions of land use composition estimates for the subwatershed and site drainage area for each chemical sampling site. Figure 3 – Figure 15, depict the 2016 Watershed Boundary Dataset HUC12 subwatersheds, 2015 NCTCOG land use categories, chemical sampling site drainage areas, 2019 sampling sites, airports, lakes, streams, Trinity River, and city and county boundaries. Figure 3 – Figure 15, depict the land use composition of subwatersheds where chemical sampling took place. The land use composition of the watersheds in figure 3 – figure 15 can often have a significant impact on the pollutant loads generated in stormwater runoff.

Table 6: 2015 NCTCOG Regional Land Use Classifications

LAND USE CATEGORIES	MONITORING LAND USE CATEGORIES	% IMPERVIOUS COVER
Office	Commercial	70 - 90%
Commercial		
Educational		
Large Stadium		
Railroad		
Communication		
Transit		
Mixed Use		
Retail		
Hotel/Motel		
Institutional/Semi-Public		
Utilities		
Parking		
Airport	Road	90%
Primary Highways		
Secondary Highway		
Major Arteries		
Minos Arteries		
Connecting		
Private Roads		
Service Roads		
Access Ramps		
Driveways		
Trails		
Industrial	Industrial	80%
Parks/Recreation	Open	10 - 45%
Landfill		
Cemeteries		
Residential Acreage		
Ranchland		
Timberland		
Farmland		
Improved Acreage		
Flood Control		
Under Construction		
Vacant		
Group Quarters	Residential	50 - 75%
Single Family		
Multi-Family		
Mobile Homes		
Water	Water	N/A
Small Water Bodies		

Table 7: Land Use Composition Estimates for Chemical Sampling Drainage Areas

Subwatershed	Site ID	Location	Drainage Area Total (Acres)	Commercial (Acres/%)	Industrial (Acres/%)	Open Space (Acres/%)	Residential (Acres/%)	Water (Acres/%)	Roads (Acres/%)
Arlington									
Johnson Creek	AR1901A	Johnson Creek at East Sanford Street	6024.2	1722.7/28.6	65.1/1.1	653.1/10.8	2476.9/41.1	3.8/0.1	1102.7/18.3
Fish Creek	AR1902	Fish Creek at SH 360	4915.5	894.1/18.2	71.0/1.4	1008.7/20.5	1657.7/33.7	5.6/0.1	1278.4/26.0
Dallas									
Five Mile Creek-Trinity River	FMC-100	3200 Linfield Road at Honey Springs Branch	1096.5	130.7/11.9	0.9/0.1	148.7/13.6	699.2/63.8	0.0/0.0	117.0/10.7
	FMC-200	4400 Vandervoort Drive at Honey Springs Branch	1167.2	150.5/12.9	0.9/0.1	175.4/15.0	783.1/67.1	0.0/0.0	57.3/4.9
	FMC-300	8000 Carbondale St. at Honey Springs Branch	1509.4	305.2/20.2	22.5/1.5	296.9/19.7	881.8/58.4	0.0/0.0	3.0/0.2
City of Dallas – White Rock Creek	WRC-100	3800 Samuell Blvd. at White Rock Creek	7708.0	1181.7/15.3	11.6/0.2	1187.6/15.4	4012.7/52.1	43.9/0.6	1270.4/16.5
	WRC-200	5219 Military Parkway at White Rock Creek	8307.0	1233.3/14.8	6.1/0.1	1294.3/15.6	3972.3/47.8	57.6/0.7	1743.4/21.0
	WRC-300	5100 C. F. Hawn Frwy at White Rock Creek	16901.1	2799.0/16.6	151.6/0.9	6116.3/36.2	7329.3/43.4	298.5/1.8	206.4/1.2
Fort Worth									
Lake Como-Clear Fork Trinity River	FWOVR1	NW of Granbury Rd and Trail Lake Dr	473.3	26.3/5.6	0.0/0.0	19.6/4.1	305.7/64.6	0.0/0.0	121.8/25.7
	FWOVR3	Overton Park West south of intersection with Bellaire	2887.5	365.3/12.6	9.9/0.3	123.1/4.3	1739.3/60.1	6.6/0.2	643.4/22.5
Marine Creek-West Fork Trinity River	FWMAR1	3500 Macie, bridge crossing in Buck Sansom Park	7595.3	764.1/10.1	146.9/1.9	3468.5/45.7	2059.8/27.1	255.8/3.4	900.2/11.9
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	13130.7	1466.4/11.2	476.9/3.6	4582.0/34.9	3627.4/27.6	282.2/2.1	2695.8/20.5

Subwatershed	Site ID	Location	Drainage Area Total (Acres)	Commercial (Acres/%)	Industrial (Acres/%)	Open Space (Acres/%)	Residential (Acres/%)	Water (Acres/%)	Roads (Acres/%)
Garland									
Duck Creek	GA1901	Duck Creek between Forest North and South	7644.7	1847.8/24.2	315.5/4.1	772.3/10.1	3101.6/40.6	6.8/0.1	1600.7/20.9
	GA1902	Duck Creek at Rick Oden Park/Briarwood Drive	8754.2	1982.6/22.6	419.1/4.8	935.7/10.7	3604.0/41.2	6.8/0.1	1805.0/20.6
	GA1903	Duck Creek under La Prada Bridge	14587.5	3213.7/22.0	1122.1/7.7	1536.6/10.5	5825.1/39.9	12.8/0.1	2877.1/19.7
Irving									
Delaware Creek	IR1901	Delaware Creek at Sowers Road	3107.0	598.6/19.3	3.4/0.1	116.7/3.8	1717.5/55.3	0.7/0.0	670.1/21.6
	IR1902	Delaware Creek at Oakdale	4755.2	972.7/20.5	17.4/0.4	373.6/7.9	2397.6/50.4	0.7/0.0	993.3/20.9
	IR1902A	Delaware Creek at Maple Street	4741.2	972.7/20.5	17.4/0.4	369.2/7.8	2390.7/50.4	0.7/0.0	990.5/20.9
Mesquite									
South Mesquite Creek	MS1901	North of New Market Road	9962.1	2302.4/23.1	456.4/4.6	1641.1/16.5	3291.6/33.0	12.2/0.1	2258.3/22.7
North Mesquite Creek	MS1902	North Mesquite Creek at Edward's Church	6239.4	824.6/13.2	229.3/3.7	1920.2/30.8	2165.4/34.7	15.4/0.2	1084.5/17.4
Plano									
Pittman Creek - Spring Creek	PL1901	Spring Creek at 16th Street	5596.5	679.2/12.1	26.7/0.5	456.5/8.2	3023.9/54.0	4.4/0.1	1405.8/25.1
North Texas Tollway Authority									
Cottonwood Branch-Hackberry Creek	NT 1901	Unnamed Tributary at SH 161 N. of Gateway Dr.	1509.0	278/18.4	0.0/0.0	557.5/36.9	18.1/1.2	0.0/0.0	655.4/43.4
Cottonwood Creek-Mountain Creek Lake	NT1902	Cottonwood Creek at SH 161 S. of Dickey Road	3318.1	465.1/14.0	398.8/12.0	670.9/20.2	1184.9/35.7	0.0/0.0	598.3/18.0

Table 8: Detailed Subwatershed and Drainage Area Land Use Descriptions

Participant	Subwatershed Name	Subwatershed Land Use Description	Site Number	Drainage Area Land Use Description
Arlington	Johnson Creek	Located in Tarrant County and has a total area of 13580.9-acre. The land is predominantly residential (29.4%) and commercial (26.8%) and is composed by 19.8% of roads, which includes primary and secondary highways, major and minor arteries, connecting, private and service roads, access ramps, driveways, trails, and airports. 14.0% of this subwatershed is denominated as open space areas and 0.3% denominated as water bodies. Industrial areas are concentrated in the northeast region and consists of 9.7% of land use.	AR1901A – East Sanford Street	The delineated drainage area coves 6024.2-acres and consists predominantly of 41.1% residential property and 18.3% of roads. There are also several commercial (28.6%) properties and open space (10.8%) near the sampling site. Industrial land use accounts for 1.1% and is concentrated in the southeast direction of this delineated drainage site. An estimation of 0.1% water features is present in this drainage site.
	Fish Creek – Mountain Creek Lake	Located in southeast of Tarrant County and southwest of Dallas County and has a total area of 27537.3-acre. The land use is predominantly made up of open space (35.2%) and residential areas (28.7%). Roads cover up 20.1% of land use and includes the Tarrant Arlington Municipal, and part of Grand Prairie Municipal airports. Commercial (11.3%) and Industrial (2.2%) areas are spread out along the subwatershed, and water features counts for 2.5% of land use composition.	AR1902 – Fish Creek at SH 360	The delineated drainage site has a total area of 4915.5-acres and consists predominantly of residential (33.7%) and open space (20.5%) properties and commercial (18.2%). Arlington Municipal Airport is located inside of this drainage site and composes roads land use of 26.0%. Industrial (1.4%) land use can be observed west of Arlington Municipal Airport. Water bodies counts for 0.1% of this delineated drainage site.
Dallas	Five Mile Creek – Trinity River	Located in south-central Dallas County and has a total area of 30309.3-acre. The land use is predominantly made of open space (48.1%) and residential (18.9%). The open space is along the eastern and southern part of the watershed, along Five Mile Creek and its tributaries. Several highways (13.2%) go through this watershed and include: IH-20, IH-45, SH-12, SH-310, SH-175, and SH-342. The industrial area (4.0%) is located in the southern part of the watershed, south of I-20. The commercial area (13.6%) is located in the center of the watershed, along I-45. The watershed contains 2.3% water features.	FMC-100 – 3200 Linfield Road at Honey Springs Branch	The delineated drainage site has a total area of 1096.5-acres and consists predominantly of residential property (57.1%). Roads account for 19.4% of the subwatershed, while commercial property (10.9%) is found in the center of the subwatershed. Open space (12.5%) is along the stream bank. There is one industrial (0.1%) site in the lower watershed. There are no water features in the subwatershed.
			FMC-200 – 4400 Vandervoort Drive at Honey Springs Branch	The delineated drainage site has a total area of 1167.2-acres and consists predominantly of residential property (57.3%). Roads make up 19.0% of the area, and commercial (10.5%) property is located close by. Open space (13.1%) is fairly even throughout the drainage area. Industrial land use accounts for 0.1%. There are no water features in this subwatershed.
			FMC-300 – 8000 Carbondale St. at Honey Springs Branch	The delineated drainage site has a total area of 1509.4-acres and consists predominantly of residential (48.8%). IH-45 and SH-310 cross through this subwatershed, and the majority of the commercial (13.5%) property is located along either side of the highways. There is a large industrial site (0.1%) just east of SH-310. Residential property is located in the upper subwatershed, while the open (16.3%) is just below it. There are no water features in this subwatershed.

Participant	Subwatershed Name	Subwatershed Land Use Description	Site Number	Drainage Area Land Use Description
	City of Dallas – White Rock Creek	City of Dallas – White Rock Creek watershed is located in central Dallas County. This 22,322.7- acre watershed is predominately made up of residential (36.5%) property and open space (28.0%). The open space is primarily in the central and southern part of the watershed, around the bank of White Rock Creek. There are several highways (19.5%) that go through this area: IH-30, SH-12, SH-175, and SH-352. The majority of the industrial (0.4%) and commercial (13.8%) sites are located south of I-30 with a few others along the other major roadways in the watershed. This watershed contains 1.7% water features.	WRC-100 – 3800 Samuell Blvd. at White Rock Creek	This subwatershed covers a 7708.0-acre area and consists primarily of residential (50.5%) property in the upper reaches of the watershed. There are a few roads (21.5%) that cross through this drainage area and include IH-30, SH-12, and SH-78. Open space (12.4%) is located around the banks of White Rock Creek. Commercial (14.9%) is located near the residential area. There is one small industrial (0.1%) site that is close to SH-12. This subwatershed contains 0.6% water features.
			WRC-200 – 5219 Military Parkway. at White Rock Creek	This subwatershed covers an 8307.0-acre area. Residential (47.8%) property and open space (15.6%) make up the majority of this subwatershed. Residential property is located in the upper part of the subwatershed. Highways that are in this drainage area include: IH-30, SH-12, SH-78, and SH-352. Commercial (14.8%) property is evenly dispersed and open space (15.6%) is primarily along the banks of White Rock Creek and includes parks and recreation. There are a couple of industrial (0.1%) sites south of IH-30. This subwatershed contains 0.7% water features.
			WRC-300 – 5100 C. F. Hawn Frwy at White Rock Creek	This 16901.1-acre subwatershed consists primarily of open space (20.2%) and residential (41.5%) property. The majority of open space is parks and recreation along White Rock Creek and its tributaries. The residential property is located in the upper watershed. There are a few roads (21.4%) that intersect this subwatershed and include SH-310, SH-352, and SH-175. Commercial (15.2%) property is intermixed with the residential property. There are a few industrial (0.7%) sites that is located in the upper watershed just south of SH-352. This subwatershed contains 1.1% water features.

Participant	Subwatershed Name	Subwatershed Land Use Description	Site Number	Drainage Area Land Use Description
Fort Worth	Lake Como – Clear Fork Trinity River	Located in the northwest of City of Fort Worth and has a total area of 25064.8 acres. The land use is predominantly made up of residential (38.2%) and road (21.4%). Open space makes up 20.0% of the total area, and commercial 18.6%. Industrial and water features occupy 0.7% and 1.1% respectively.	FWOVR1 – NW of Granbury Rd and Trail Lake Dr	Has a total area of 473.3 acres and primarily consist of residential property (64.6%). Roads are the second largest feature in this watershed and make up 25.7% of the total area. Interstate 20 goes through the southern portion of the watershed. Commercial and open space occupy 5.6% and 4.1% respectively. There are no water or industrial features in this drainage area.
			FWOVR3 – Overton Park West south of intersection with Bellaire	Has a total area of 2887.5 acres. Residential (60.2%) and road (22.3%) make up the majority of this subwatershed. Commercial land use accounts for 12.7%, and open space for 4.3%. Industrial and water features occupy 0.3% and 0.2% respectively.
	Marine Creek – West Fork Trinity River	Marine Creek-West Fork Trinity River is located on the western side of Fort Worth's city limits in Tarrant County. Marine Creek-West Fork Trinity River covers a 21,021.9-acre area and consists predominately of open space (30.2.0%) with dense residential (24.4%), commercial (14.7%), and industrial (6.6%) areas in the southern portion and along the western and eastern corners. The road land use estimate for this watershed is 22.4% which includes IH-Loop 820 and SH-183 (NW 28th Street). This watershed has 1.7% water features.	FWMAR1 – 3500 Macie, bridge crossing in Buck Sansom Park	The subwatershed delineated for this sampling location covers a 7595.3 -acre area and almost half of the area consists of open space (45.7%), followed by residential (27.1%) properties. Roads (11.9%) including IH-Loop 820 and major arterials such as Angle Avenue, Marine Creek Parkway and commercial (10.1%) properties comprise most of the remaining areas. Water (3.4%) features such as Marine Creek Reservoir on the north side of IH-Loop 820 and industrial (1.9%) areas round out the balance of this area.
			FWMAR3 – Saunders Park south of Mule Alley and downstream of JV1A	The drainage area delineated for this site covers 13130.7 acres and consists primarily of open space (34.9%) land use, residential (27.6%) properties and roads (20.5%) spaces. The remaining areas are commercial (11.2%) and industrial (3.6%) sites with scattered areas of water (2.1%) features. Highways and major roadways going through this area are SH-183 (NW 28th Street), a short section of IH-Loop 820, Long Avenue, Longhorn Road, McLeroy Boulevard and all of Meacham International Airport.
Garland	Duck Creek	Located northeast of Dallas County and its total area is 27179.5-acre. This subwatershed is predominantly residential (34.8%) and open space (25.4%). Residential areas are dispersed throughout the land while open spaces are concentrated in the southeast tip of the subwatershed. Commercial areas (17.4%) and roads (17.2%) also make up a large part of this subwatershed. Industrial areas (4.6%) are	GA1901 – Duck Creek between Forest North and South	This delineated drainage site has a total area of 4644.7-acres. The predominant land use is residential properties (40.6%) and roads (20.9%). Commercial properties (24.2%) are centralized in this drainage site, and industrial areas (4.1%) can be found south among commercial properties. Open space composes 10.1% of the drainage area. 0.1% of water features are found in this watershed.

Participant	Subwatershed Name	Subwatershed Land Use Description	Site Number	Drainage Area Land Use Description
		located along commercial areas, and 0.6% of land use is classified as water bodies.	GA1902 – Duck Creek at Rick Oden Park/Briarwood Drive	This delineated drainage site has a total area of 8754.2-acres. The predominant land use is residential properties (41.2%) and roads (20.6%). Commercial properties (22.6%) are centralized in this drainage site, and industrial areas (4.8%) can be found south among commercial properties. Open space composes 10.7% of the drainage area. 0.1% of water features are found in this watershed.
			GA1903 – Duck Creek under La Prada Bridge	This delineated drainage site has a total area of 14587.0-acres and is predominantly composed of residential properties (39.9%). Most of the commercial properties (22.0%) and industrial sites (7.7%) are concentrated northwest of this drainage area. Open areas (10.5%) are randomly dispersed. Roads compose 29.7% of land use, and only 0.1% of water bodies are present in this drainage area.
Irving	Delaware Creek – West Fork Trinity River	Located in west-central of Dallas County near Mountain Creek Lake, and it covers a total area of 21599.4-acre. Open space (32.4%) acreage is predominantly, followed by residential (26.8%) and commercial areas (17.9%). Roads acreage consists of 16.5% of this subwatershed, which includes part of Dallas NAS (Hensley/Millennium Dallas) airport. Part of Trinity River crosses Delaware Creek subwatershed, and it complements the water body percentage of 2.1%. Industrial areas consist of 4.3% of this subwatershed.	IR1901 – Delaware Creek at Sowers Road	The drainage area delineated for this site covers 3107.0-acres and is mainly composed of residential properties (55.3%). Commercial properties (19.3%) and a few open space (3.8%) are dispersed throughout. Roads composes 21.6% of the drainage site and no industrial land use features are present. Water features compose 0.1% of this watershed.
			IR1902 – Delaware Creek at Oakdale	The drainage area delineated for this site covers 4755.2 acres and is mainly composed of residential (50.4%) and commercial (20.5%) properties. Roads composes 20.9% of the drainage site and open space (7.9%) can be observed towards the center. Industrial land use features compose 0.4% and there are no water features recorded for this area.
			IR1902A – Delaware Creek at Maple Street	The drainage area delineated for this site covers 4741.2 acres and similarly to IR1902 composed of residential (50.4%) and commercial (20.5%) properties. Roads composes 20.9% of the drainage site and open space (7.8%) can be observed towards the center. Industrial land use features compose 0.4% and there are no water features recorded for this area.
Mesquite	South Mesquite Creek	Located in eastern Dallas County, southwest of Lake Ray Hubbard. South Mesquite Creek covers a 17,840-acre area and the land use is predominantly made up of residential (30.5%) and open space (31.1%) areas which are dispersed across the entire watershed. The majority of commercial (17.1%) areas are located along roads (18.2%). The	MS1901 – North of New Market Road	The drainage area delineated for this site covers 9962.1 acres and is mainly composed of residential (33.0%) and commercial (23.1%) properties. Roads also participate in a reasonable portion of the drainage area with 22.7% of the land use. Open space (16.5%) are centralized and becomes denser towards south of the drainage area. Clusters of industrial (4.6%) land use are located west of

Participant	Subwatershed Name	Subwatershed Land Use Description	Site Number	Drainage Area Land Use Description
		industrial sites (2.6%) are concentrated in the western part of the watershed. This watershed has 0.6% water features.		the drainage area. 0.1% of water compose the land use in this drainage area.
	North Mesquite Creek	Located between the far eastern edge of Dallas County and northwestern tip of Kaufman County. North Mesquite Creek Watershed covers a 21.862.5-acre area and consists mostly of open space (64.3%) and residential (20.9%) property. Residential property is primarily located on the western side of the subwatershed with a small section along the southern edge. Roads land use estimate for this subwatershed is 10.9%, including Mesquite Metro Airport. Industrial (1.5%) sites are mostly located in the central portion of this watershed. Most of the commercial (10.5%) areas are located throughout the watershed along roads and residential areas. This subwatershed contains 1.3% of water features.	MS1902 – North Mesquite Creek at Edward's Church	The drainage area delineated for this site covers 6239.4 acres and is mainly composed of residential properties (34.7%) and open space (30.8%). Commercial properties (13.2%) are spread over the drainage area. Clusters of industrial land use (3.7%) are concentrated towards the middle east of the drainage area. Roads compose 17.4% of land use and water bodies only 0.2%.
Plano	Pittman Creek – Spring Creek	Located in the lower southwest side of Collin County and upper north east side of Dallas County and its total area is 23387.2-acre. This subwatershed is composed predominantly of residential (45.4%) and open space area (20.9%). There are clusters of commercial properties (18.1%) and industrial area is mainly concentrated towards the middle of this subwatershed. Water bodies consists of 0.2% of the subwatershed area.	PL1901 – Spring Creek at 16th Street	The drainage area delineated for this site covers a 5596.5-acre area and primarily consists of residential properties (54.0%) and roads (25.1%). Open space (8.2%) is scattered throughout the drainage area but is mostly located along Spring Creek and mixed in with the residential and commercial property. Clusters of commercial (12.1%) properties is dispersed in this drainage area. There is a very small section of industrial (0.5%) sites and water bodies (0.1%) present.
NTTA	Cottonwood Branch – Hackberry Creek	A 13,325-acre subwatershed located in northeast Dallas County. This subwatershed is composed predominately of roads acreage (39.0%) which is due to a large portion of the DFW International Airport residing in the western side of the subwatershed. Throughout the subwatershed, there are patches of open areas (22.7%) and clusters of commercial (23.1%) areas. Some of the residential (13.2%) areas are scattered along the southern edge of the watershed. The water bodies composition for this subwatershed is 1.2% and industrial land use is 0.7%.	NT1901 – Unnamed Tributary at SH 161 N. of Gateway Dr.	The delineated drainage area covers 1509.0 acres. It is in the center of the Cottonwood Branch – Hackberry Creek subwatershed, and east of the Dallas/Fort Worth International airport. This drainage area is composed of 36.9% open space and 18.4% commercial. 43.4% of road land use incudes the west side property of DFW International airport. 1.2% of area is designated as residential. There are no industrial or water features in this watershed.
	Cottonwood Creek – Mountain Creek Lake	Located southwestern of Dallas County and southeastern of Tarrant County. This subwatershed has a total area of 18857.1-acres and is predominantly residential (24.2%) and open space (23.8%). Roads acreage contributes with 17.3% of land use composition, which includes Dallas NAS (Hensley/Millennium Dallas), and part of Grand Prairie Municipal airport. Commercial (13.1%) and industrial (8.5%) areas are dispersed throughout the subwatershed. Mountain Creek Lake is located inside of this subwatershed, and the water body percentage of 13.1%.	NT1902 – Cottonwood Creek at SH 161 S. of Dickey Road	The delineated drainage area covers 3318.1 acres and the predominant land use is residential properties (35.7%) and open space (20.2%). Industrial sites (16.2%) and open space areas are mainly concentrated on the east side of the drainage area near the chemical sampling site. Commercial properties (14.0%) are dispersed throughout the drainage area and roads compose 18.0 % of the land use. There is no area designated as water body.

Figure 3: Arlington, Johnson Creek Subwatershed, AR1901A

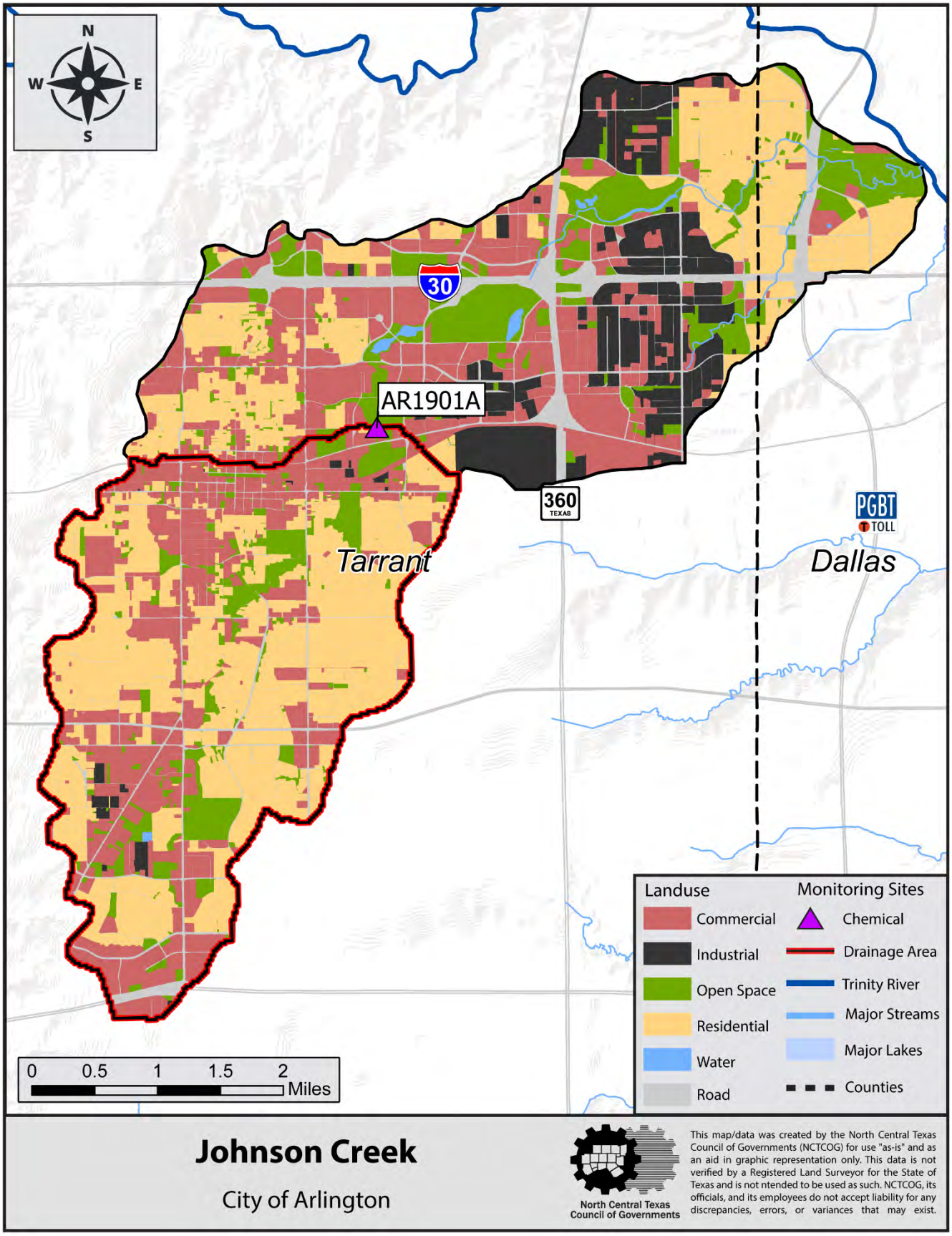


Figure 4: Arlington, Fish Creek - Mountain Creek Lake Subwatershed, AR1902

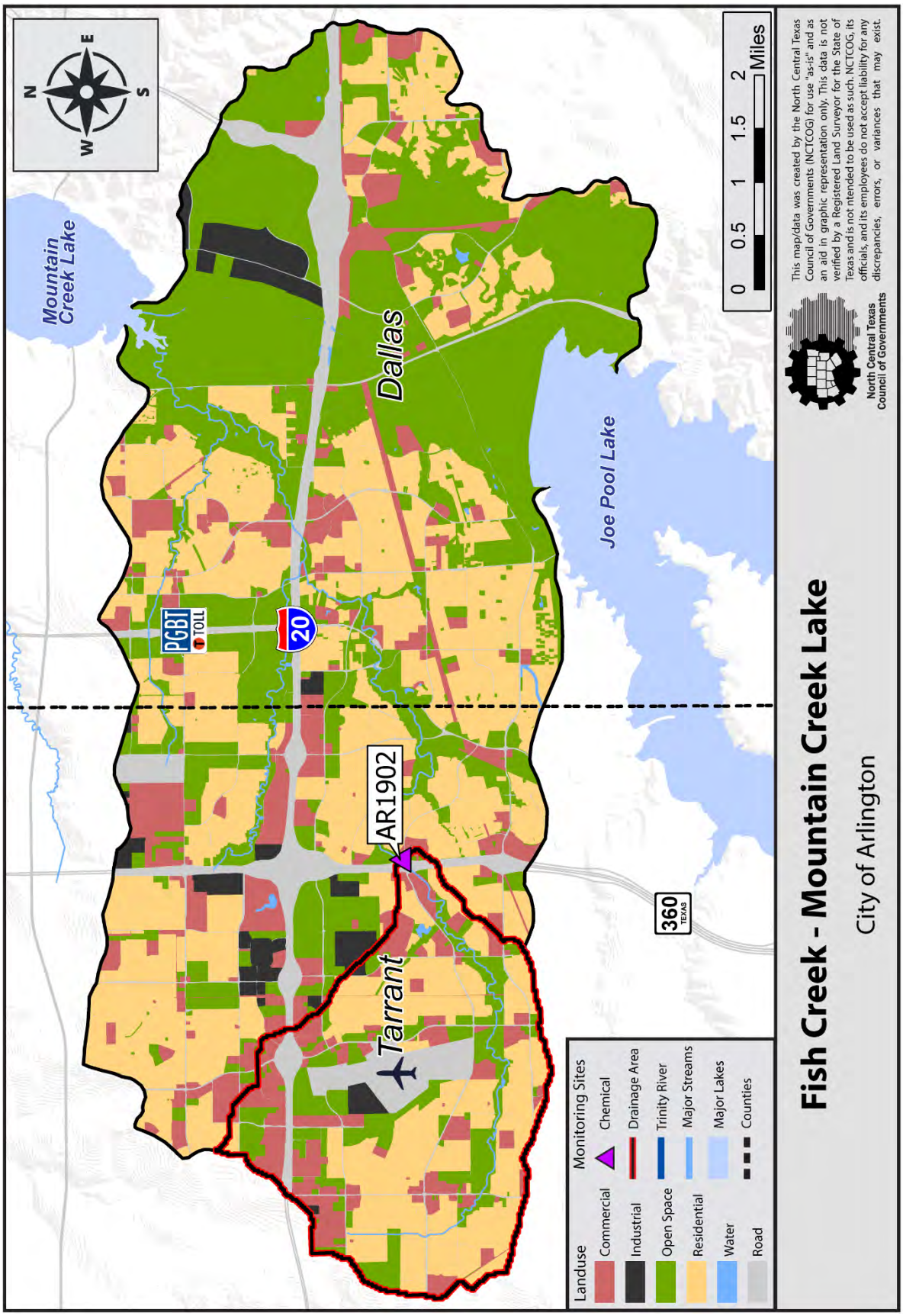


Figure 5: Dallas, Five Mile Creek - Trinity River Subwatershed, FMC-100, FMC-200, FMC-300

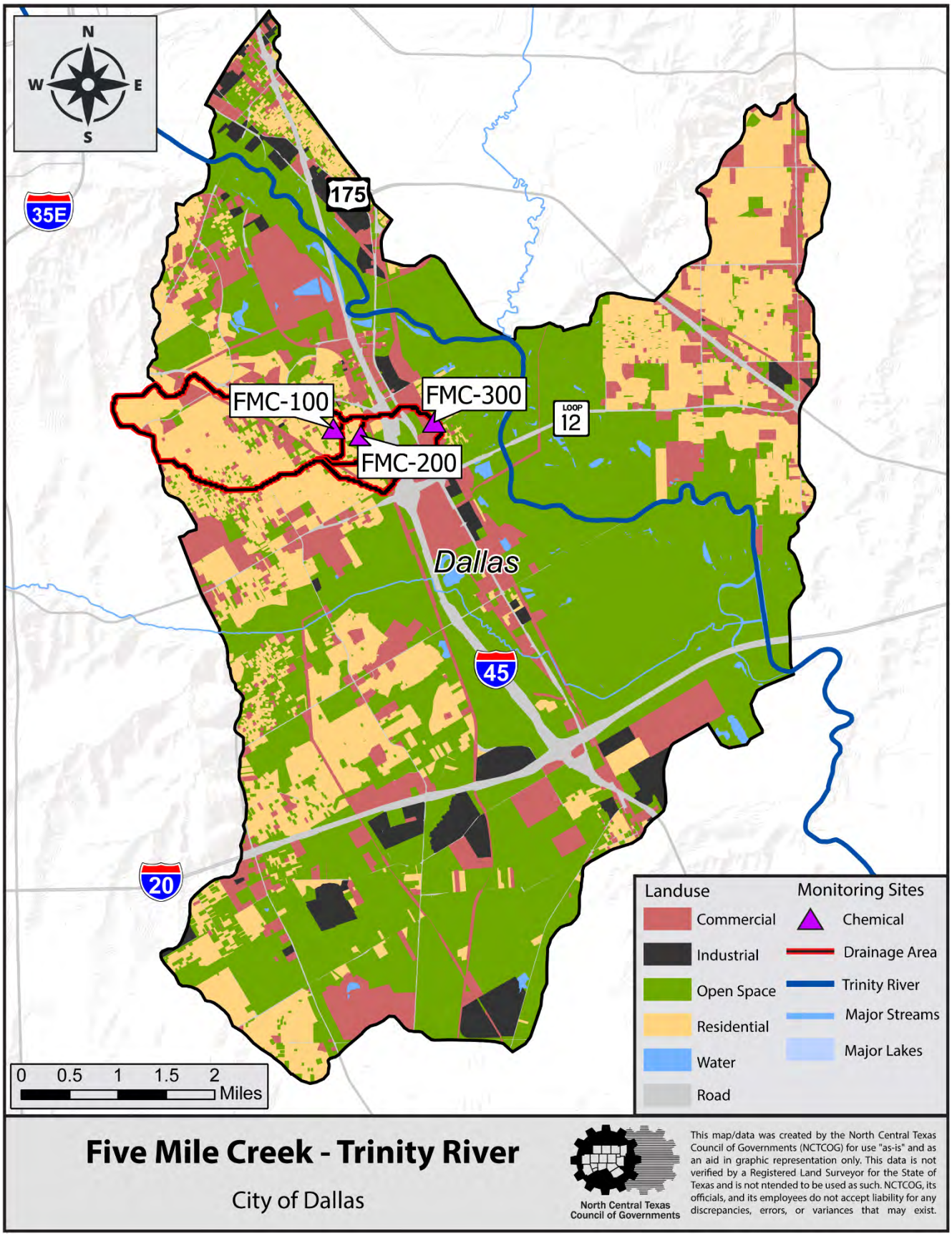


Figure 6: Dallas, City of Dallas - White Rock Creek, WRC-100, WRC-200, WRC-300

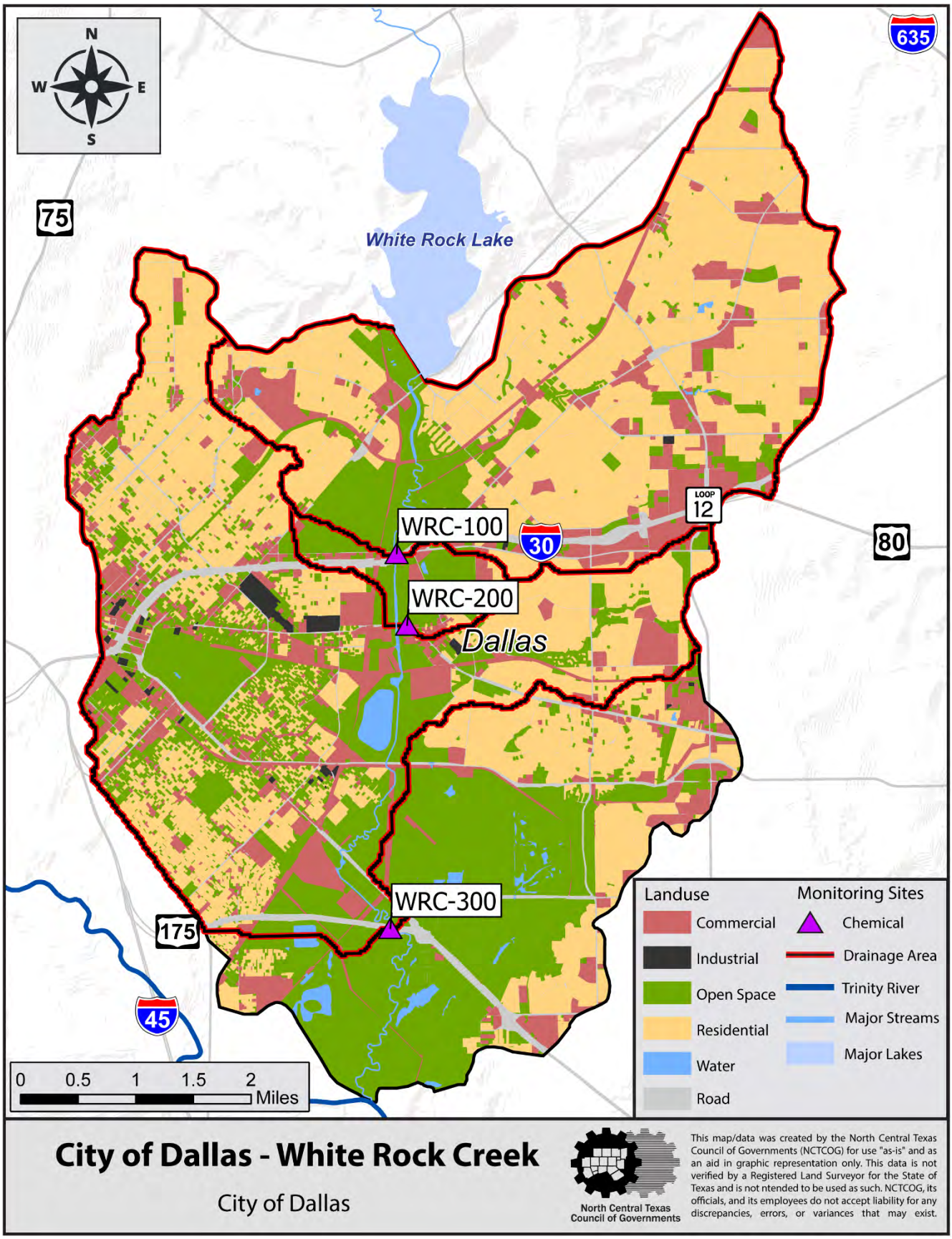


Figure 7: Fort Worth, Marine Creek - West Fork Trinity River Subwatershed, FWMAR1, FWMAR3

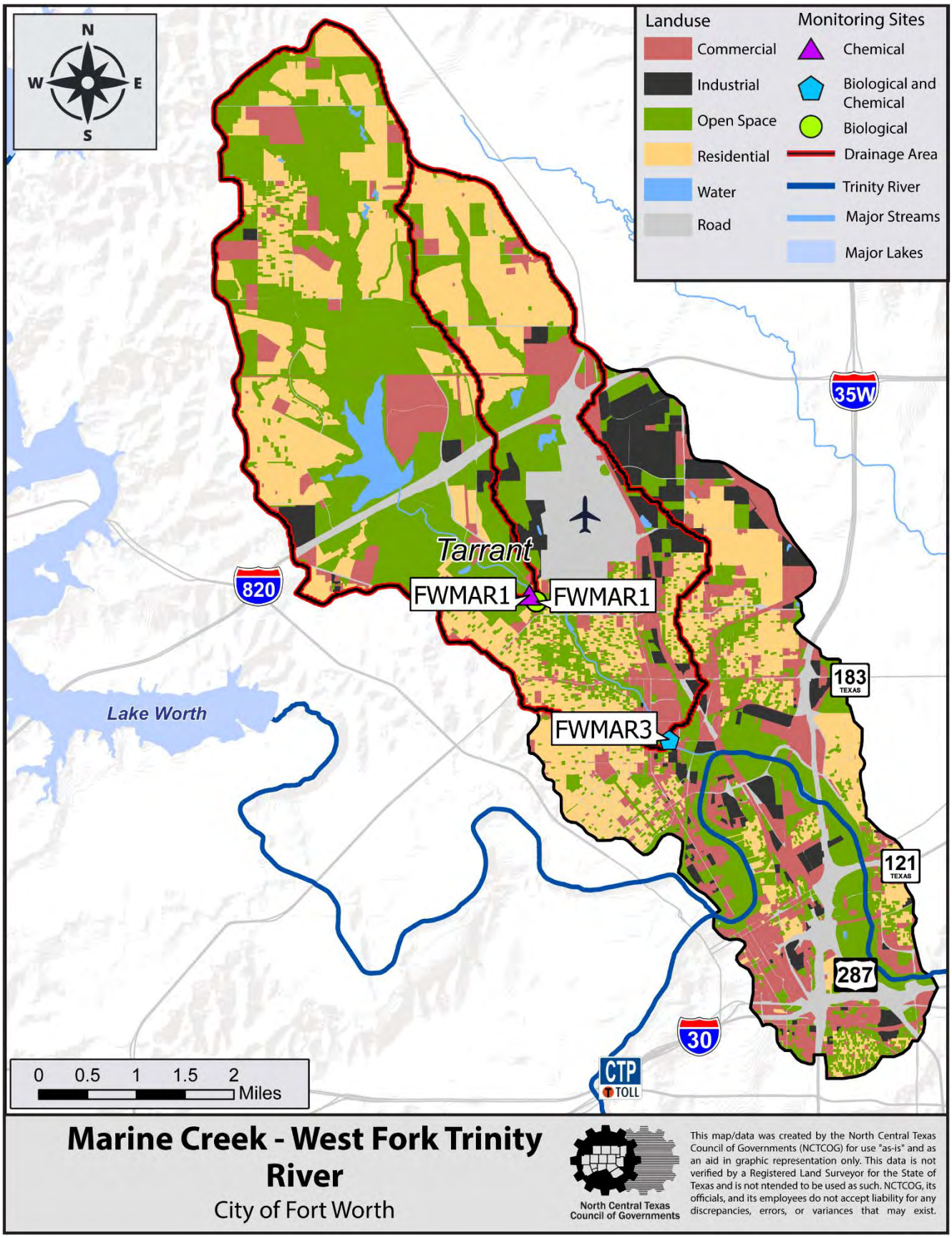


Figure 8: Fort Worth, Lake Como - Clear Fork Trinity River Subwatershed, FWOVR1, FWOVR3

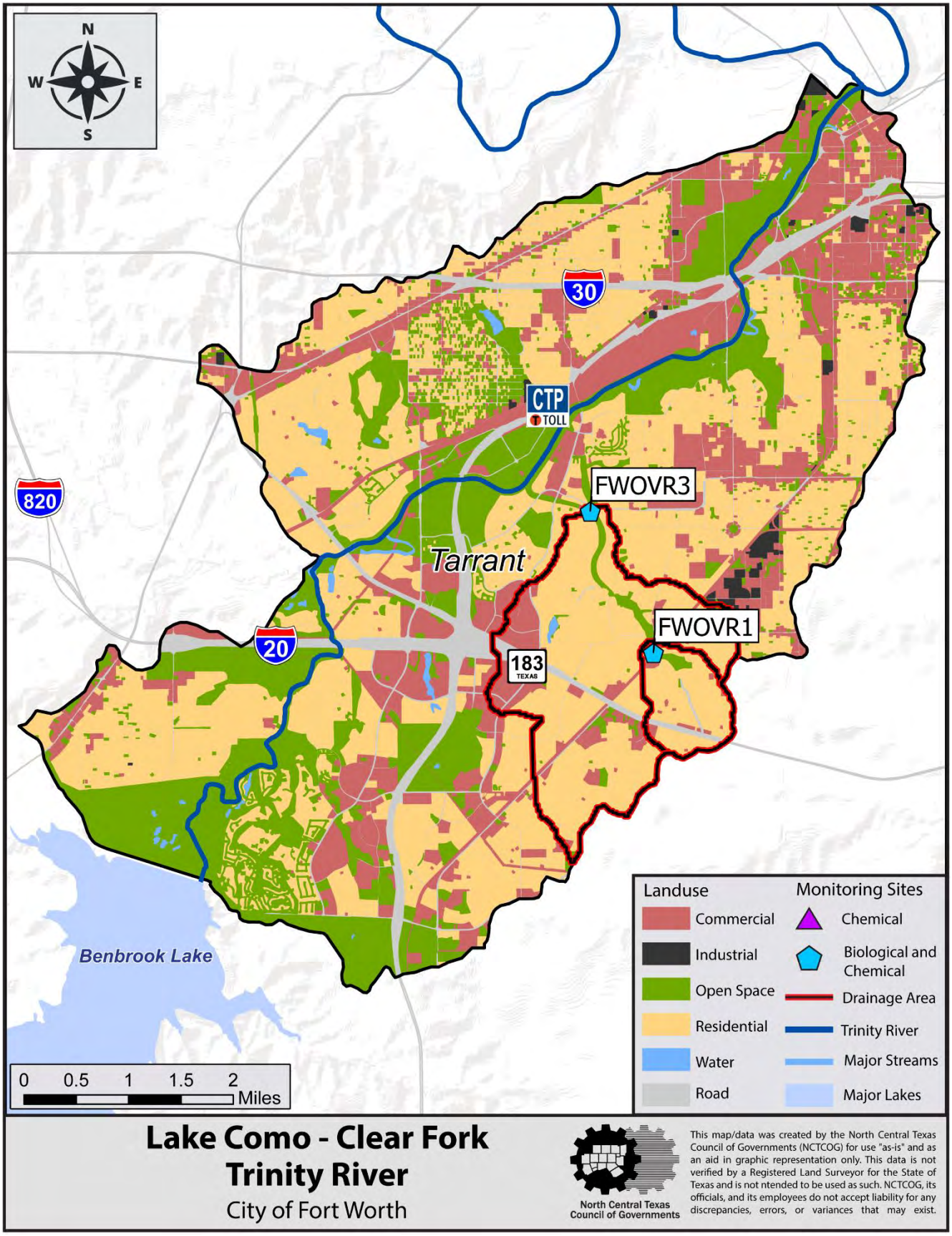


Figure 9: Garland, Duck Creek - GA1901, GA1902, GA1903 - Duck Creek under La Prada Bridge

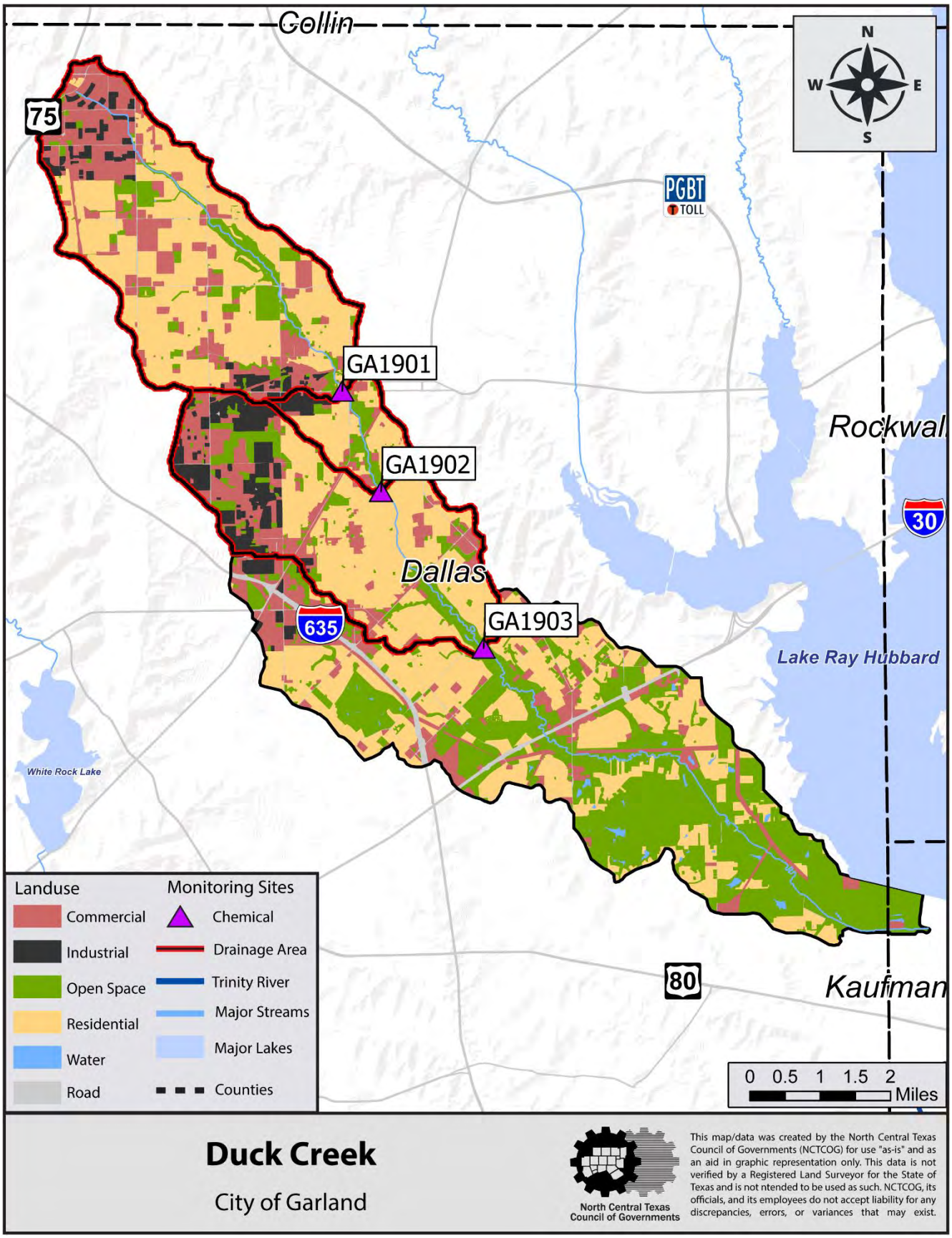


Figure 10: Irving, Delaware Creek - West Fork Trinity River Subwatershed, IR1901, IR1902A*

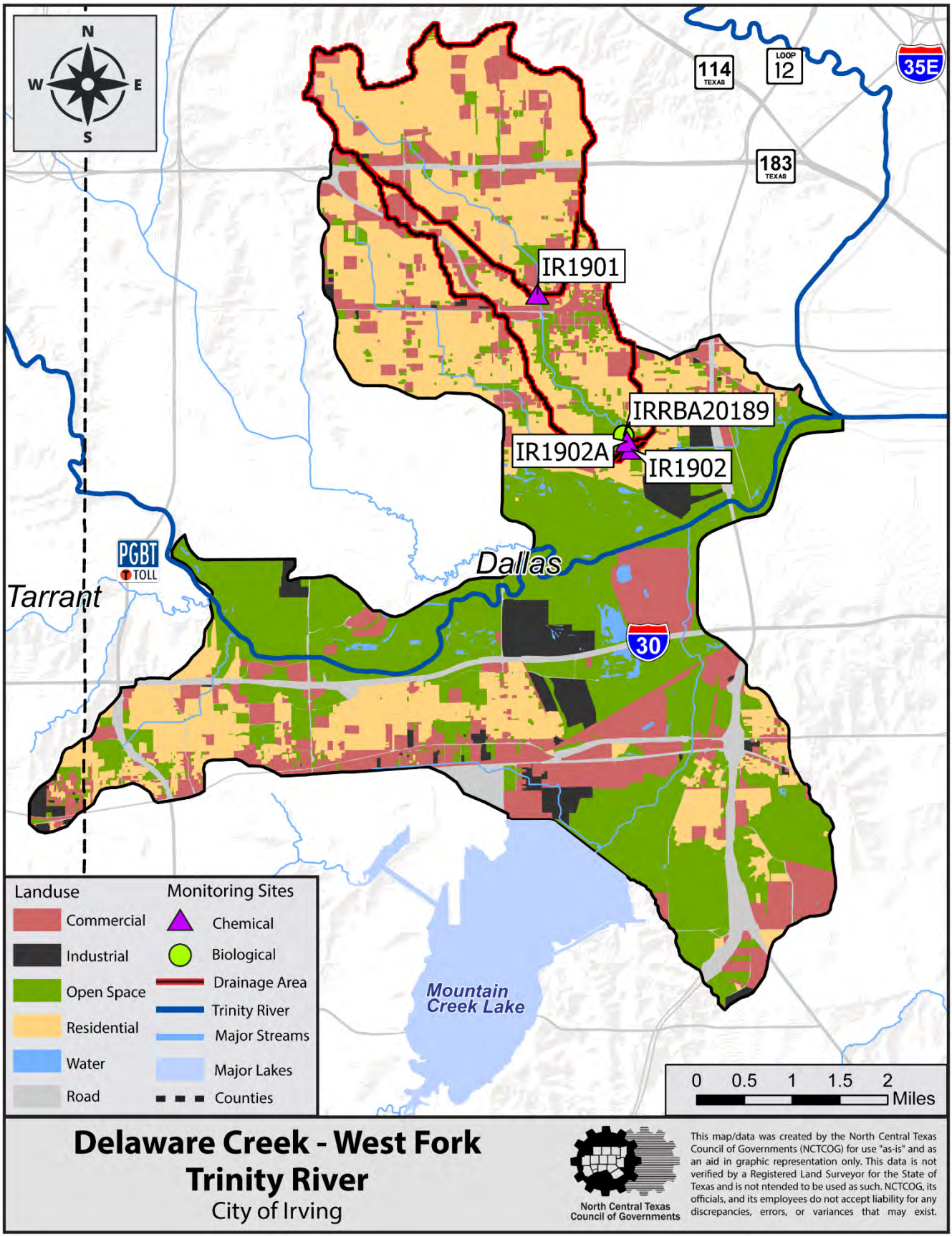


Figure 11: Mesquite, South Mesquite Creek Subwatershed, MS1901

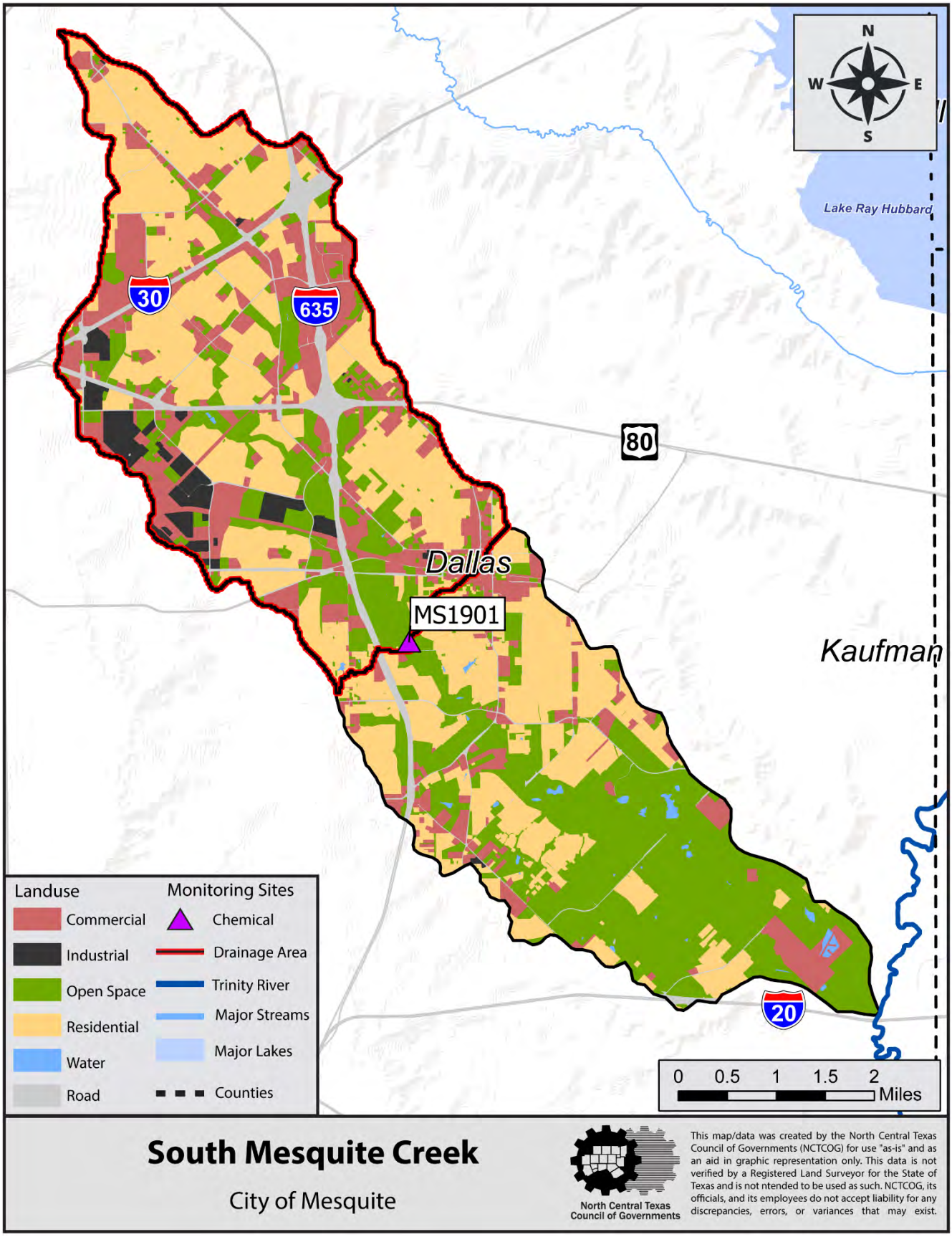


Figure 12: Mesquite, North Mesquite Creek Subwatershed, MS1902

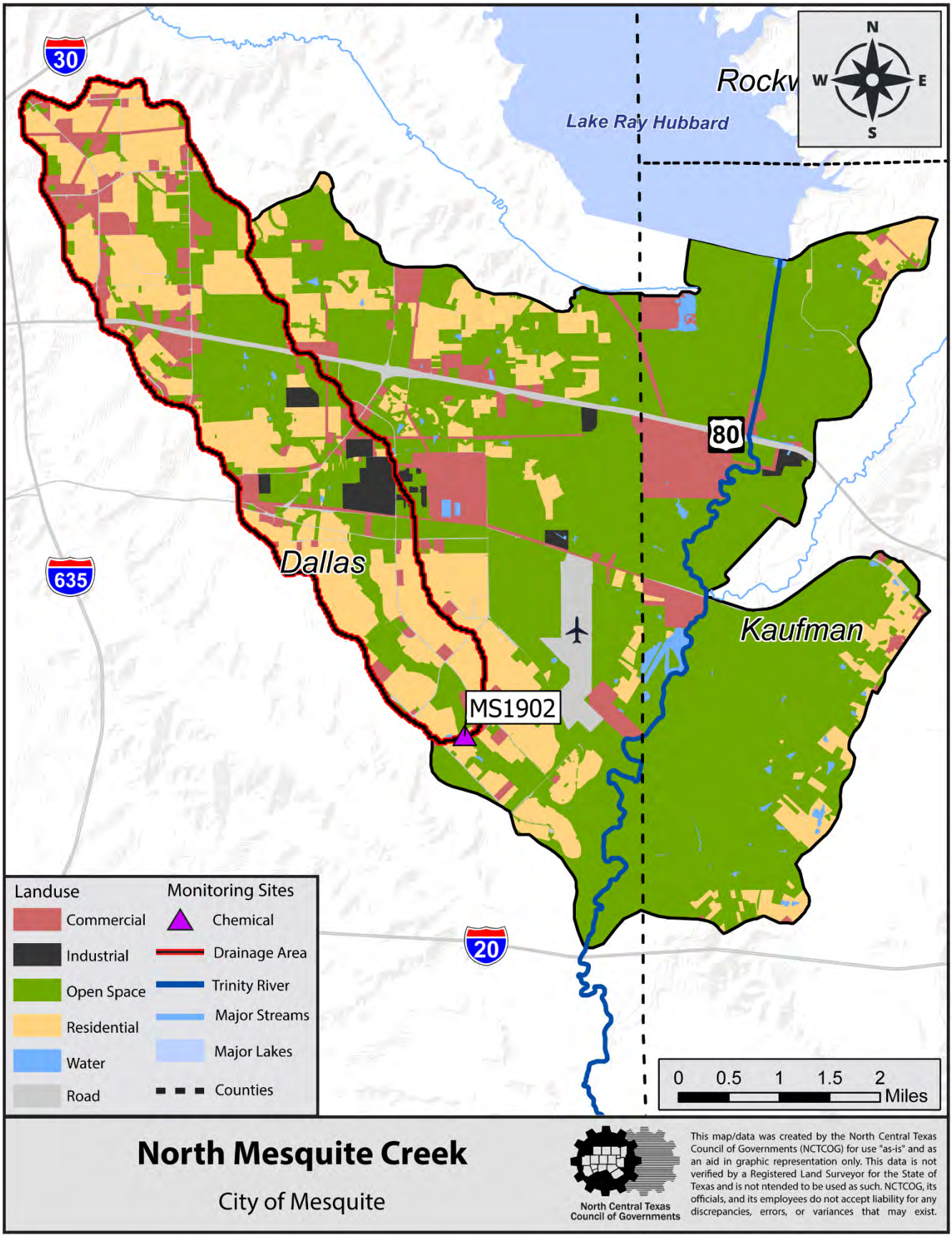


Figure 13: Plano, Pittman Creek - Spring Creek Subwatershed, PL1901

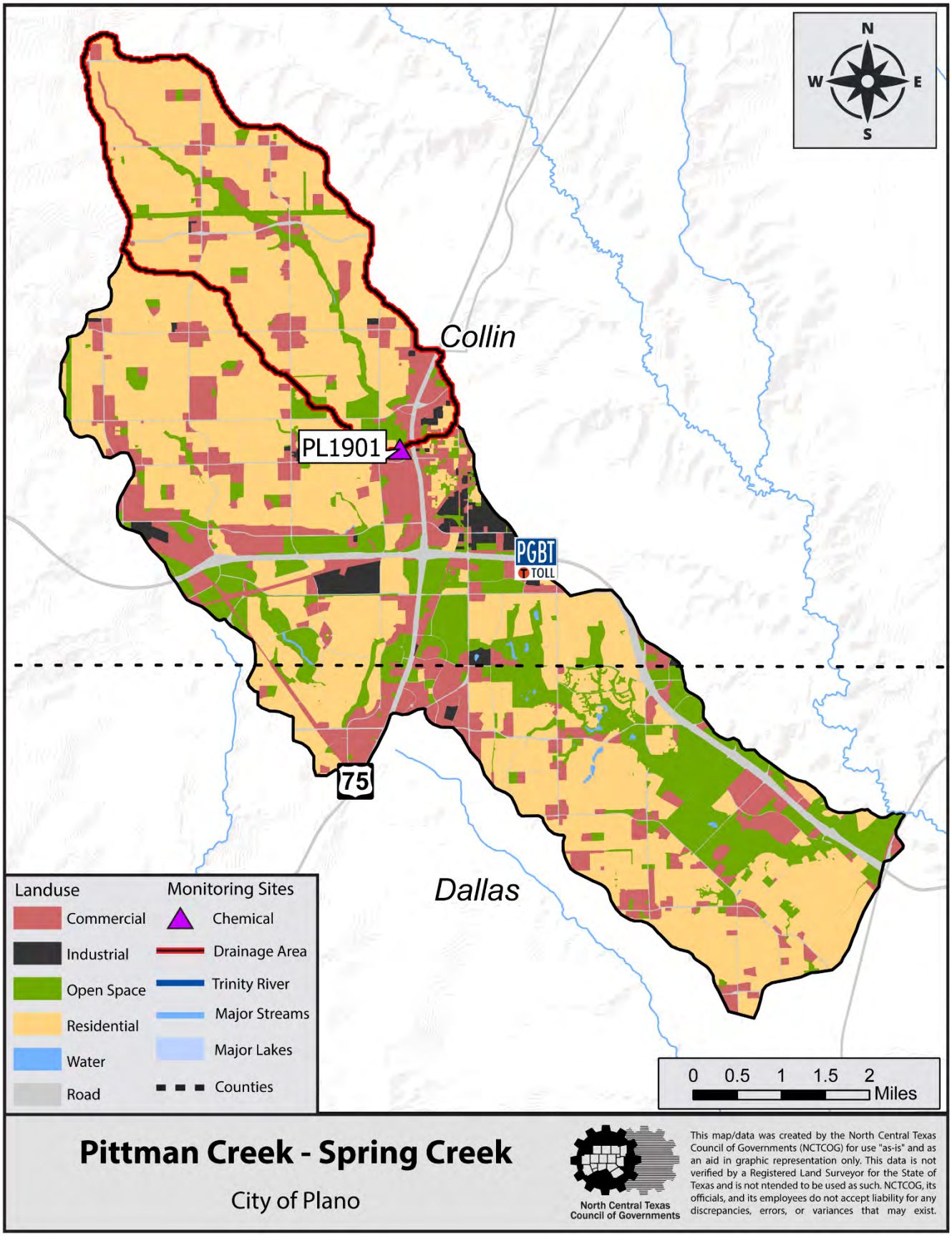


Figure 14: North Texas Tollway Authority, Cottonwood Branch - Hackberry Creek Subwatershed, NT1901

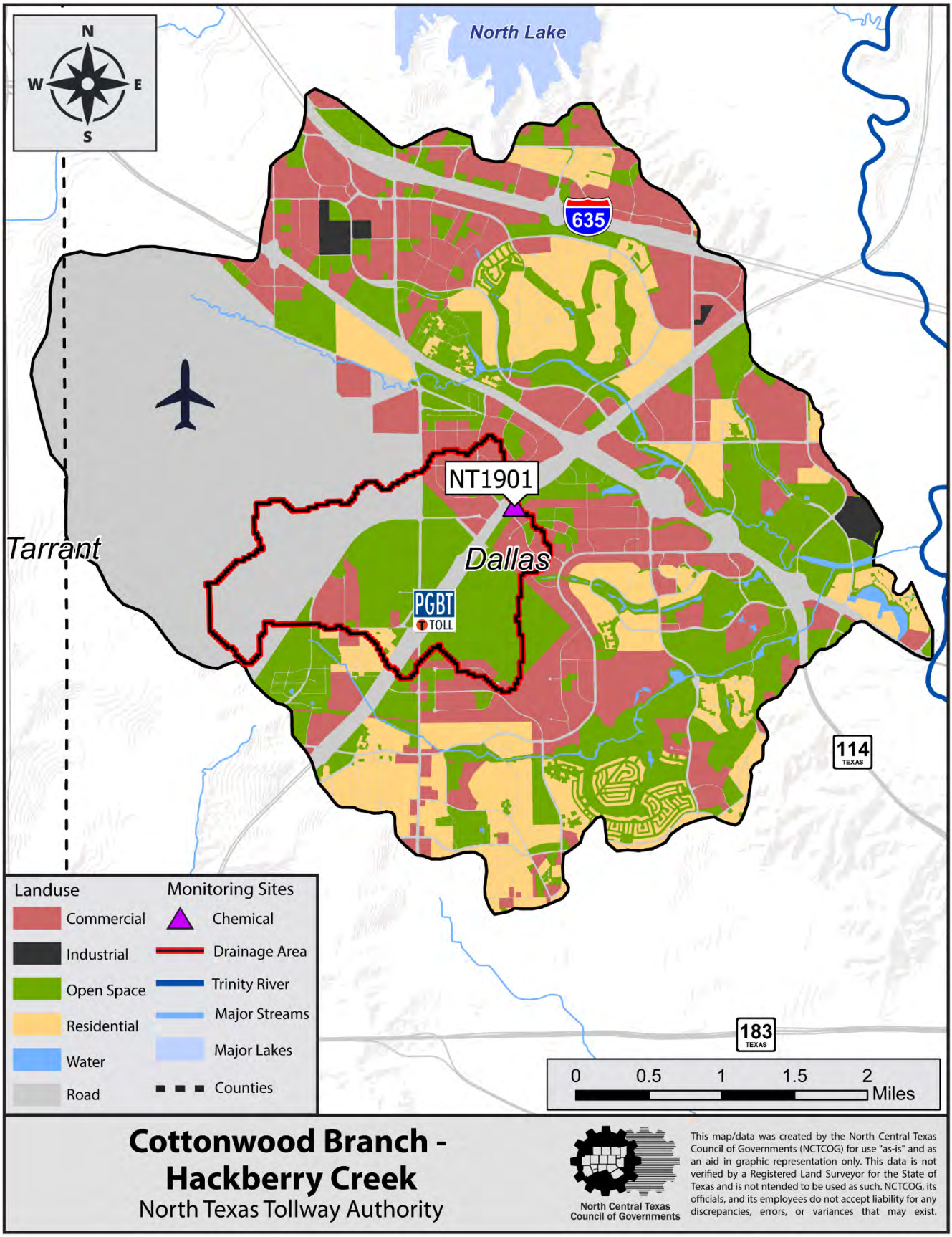
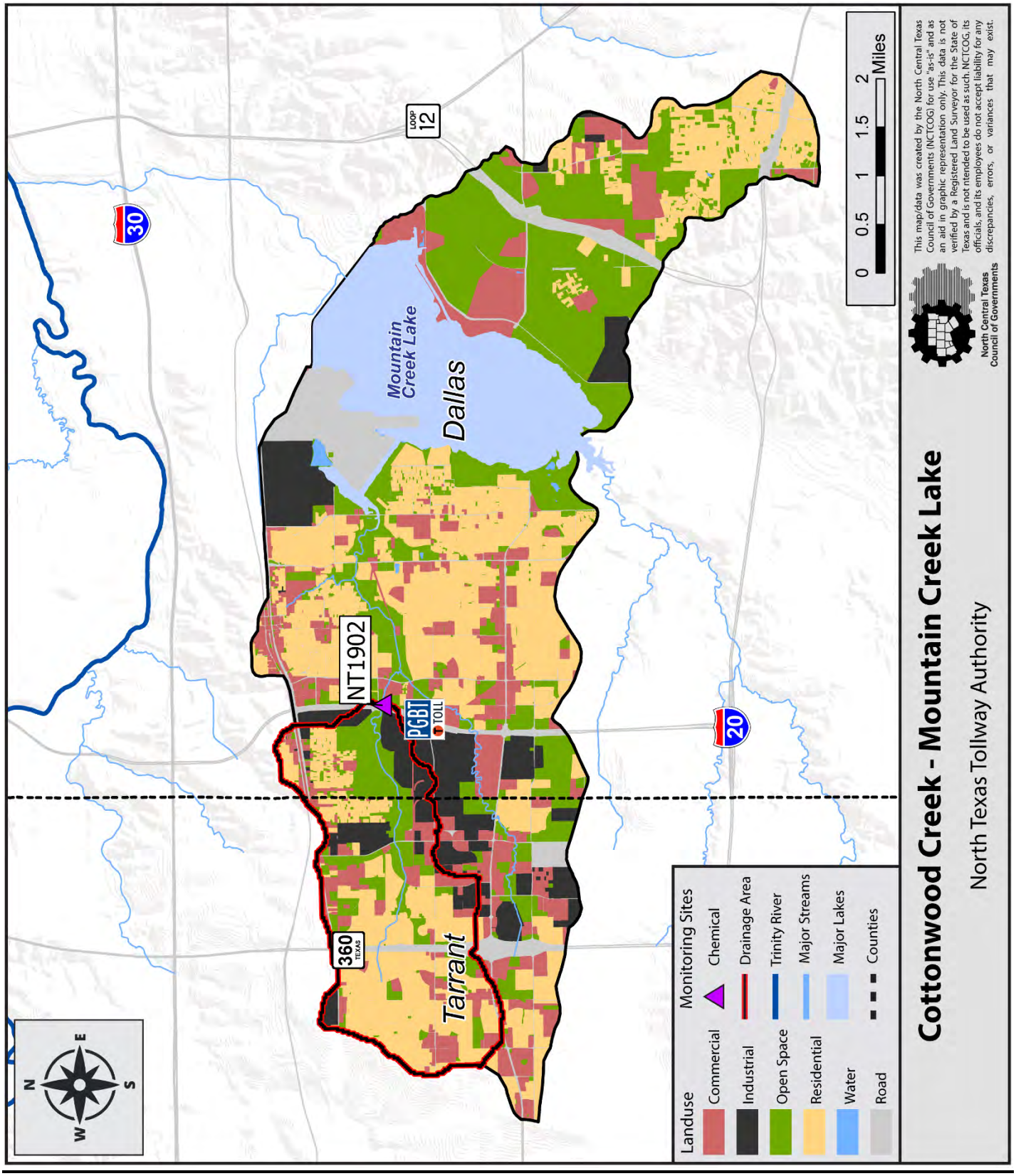


Figure 15: North Texas Tollway Authority, Cottonwood Creek - Mountain Creek Lake, NT1902



2019 STORM EVENTS AND MONTHLY RAINFALL

Table 9 includes each storm event by site, Rainfall Total, Peak 1-Hr Rate, Peak Depth and Antecedent Dry Period. The Rainfall Total is the total amount of rainfall measured for a qualifying storm event that is sampled. The Peak 1-Hr Rate is the highest amount of measurable rainfall during a 1-hour time frame. The Peak Depth is the highest measurable level the stream rose during the sampling event. The Antecedent Dry Period is the dry period prior to a storm event in which more than 0.10 inch of rain occurred. This information is normally collected from the ISCO equipment (rain gauge and bubbler module) and graphed using ISCO's proprietary Flowlink software. On-line internet rain gauges were used if the site rain gauge was not working. Sample collection reports are provided in Appendix G.

Table 9: Year 2 (2019) Storm Event Data

STORM EVENT DATE	SITE ID	RAINFALL TOTAL (in)	Peak 1-HR RATE (in/hr)	PEAK DEPTH (ft)	ANTECEDENT DRY PERIOD (hrs)
1st QUARTER					
1/11/2019	AR1901A	0.28	0.08	1.5	197
	AR1902	0.39	0.05	1.8	197.5
	GA1901	0.30	0.13	0.8	198
	GA1902	0.30	0.13	1.1	198
	GA1903	0.30	0.13	0.2 (est.)	198
	IR1901	0.35	0.15	0.6	190.5
	IR1902	0.35	0.15	0.2	190.5
	MS1902	0.18	0.07	2.2	197
	NT1901	0.23	0.08	1.3	198
	NT1902	0.23	0.08	2.5	198
2/7/2019	MS1901	0.21	0.21	5.0	628
5/18/2019	*PL1901	2.62	2.20	9.8	170
2ND QUARTER					
4/13/2019	AR1902	1.51	0.50	4.4	114
	GA1901	0.48	0.35	1.6	128
	GA1902	0.48	0.35	3.8	128
	GA1903	0.48	0.35	4.9	128
	IR1901	1.80	0.44	Unknown	127.5
	NT1901	0.45	0.36	2.0	127
	NT1902	0.44	0.20	1.1	159
5/8/2019	AR1901A	1.16	1.16	7.2	93
	IR1902A	0.97	0.96	5.7	94.5
	MS1901	0.68	0.68	6.6	95
	MS1902	0.68	0.68	3.3	95
	PL1901	0.72	0.71	2.8	145
3RD QUARTER					
7/10/2019	AR1901A	1.96	1.20	5.0	96
	AR1902	0.91	0.91	3.5	95.5
	IR1902A	0.7	0.69	3.2	408
	NT1902	0.95	0.80	5.1	94
8/3/2019	GA1901	0.70	0.30	0.8	828
	GA1902	0.70	0.30	0.6	828
	GA1903	0.70	0.30	0.8	828
	IR1901	0.2	0.18	0.4	564

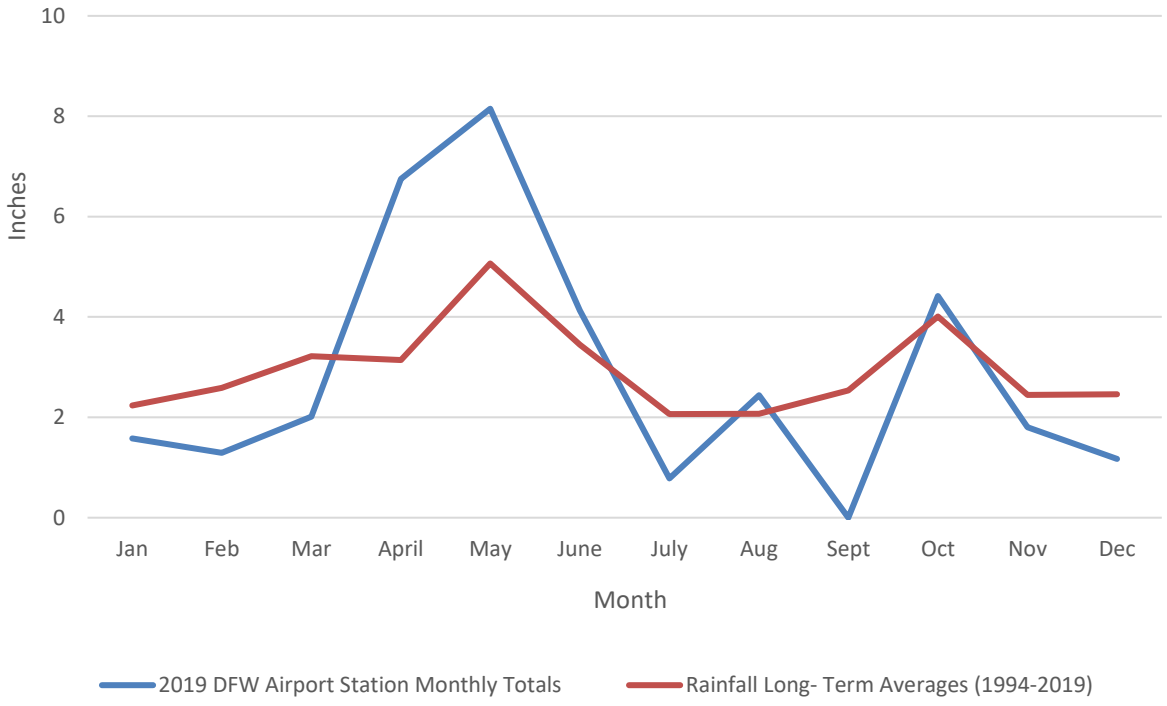
STORM EVENT DATE	SITE ID	RAINFALL TOTAL (in)	Peak 1-HR RATE (in/hr)	PEAK DEPTH (ft)	ANTECEDENT DRY PERIOD (hrs)
	MS1901	0.16	0.12	3.3	830
	MS1902	0.16	0.12	1.5	830
	PL1901	0.32	0.13	1.8	828
	NT1901	0.13	0.11	1.4	564
4TH QUARTER					
	AR1901A	2.60	1.88	5.7	989
	AR1902	0.41	0.39	1.3	989
	GA1901	0.42	0.25	1.1	493
	GA1902	0.42	0.25	1.2	493
	GA1903	0.42	0.25	4.5	493
10/10/2019	IR1901	0.52	0.44	Unknown	987
	IR1902A	0.52	0.44	4.0	987
	MS1902	0.79	0.74	3.1	494
	PL1901	0.16	0.16	1.7	494
	NT1901	0.54	0.45	3.1	987
	NT1902	1.60	1.36	2.9 (est.)	988
10/24/2019	MS1901	0.27	0.22	6.8	86

*PL1901 first quarter sample was collected during the second quarter.

Monthly Rainfall Data for January 2019 – December 2019

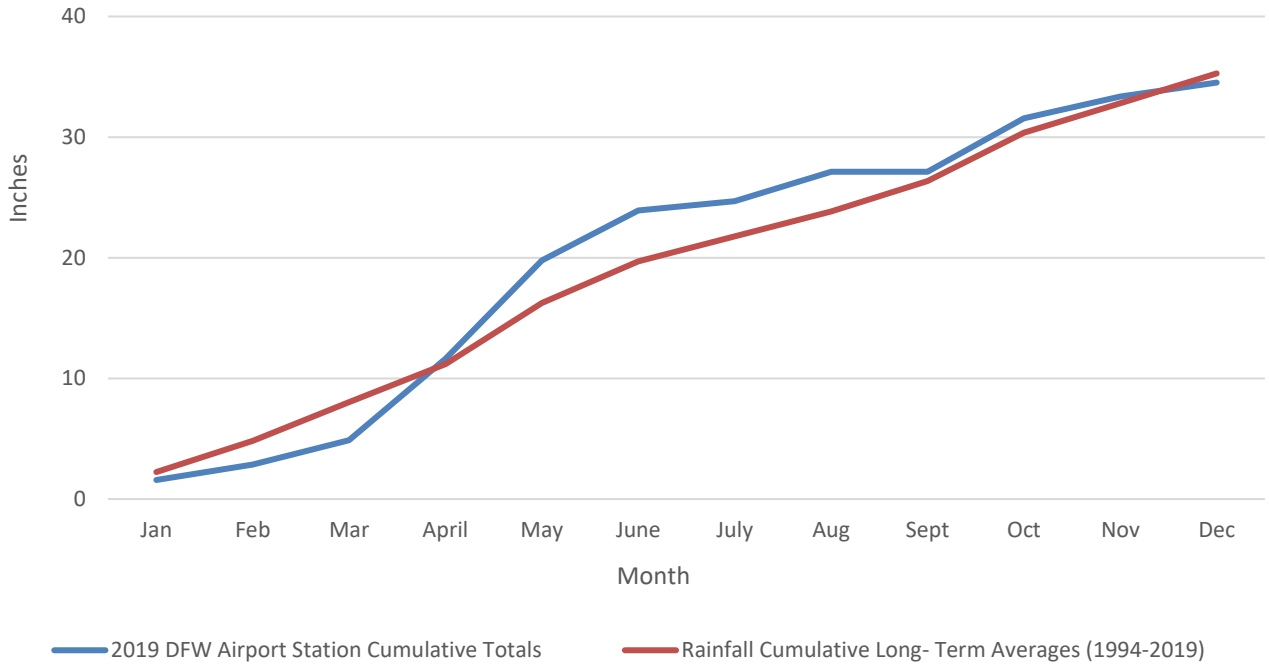
The monthly rainfall totals for the 2019 sampling year were tracked using the Dallas/Fort Worth International Airport (DFW Airport Station) rain gauge and compared to long-term averages (National Oceanic and Atmospheric Administration, 2020). Figure 16 depicts monthly rainfall totals compared to the long-term monthly average rainfall at the DFW Airport Station. Figure 17 displays 2019 cumulative rainfall amounts versus the cumulative long-term monthly averages at the DFW Airport Station. The rainfall amounts during 2019 did not have as many significant rain events in comparison to 2018. The 2019 trend followed closely to the long-term averages (1974-2019). Two months in 2019, April and May, experienced more rain then the long-term averages (1974-2019). smaller spikes can be seen in August and October 2019. The remaining months had rainfall totals that were lower than the average rainfall for that month. In 2019, the DFW Airport Station cumulative monthly rainfall totals were not that different from the long-term cumulative rainfall averages from January through December 2019, as shown in Figure 17. Small variances can be seen from January 2019 – April 2019 with a lower monthly total rainfall then that average long-term averages and from April 2019 – September 2019 with a greater monthly total rainfall then the long-term average.

Figure 16: 2019 Monthly Rainfall Totals, Dallas/Fort Worth International Airport Rain Gauge



(Source: NOAA Climatic Data Center, 2020)

Figure 17: 2019 Cumulative Monthly Average Rainfall Totals, Dallas/Fort Worth International Airport Rain Gauge



(Source: NOAA Climatic Data Center, 2020)

BIBLIOGRAPHY

Alan Plummer and Associates, Inc., Camp Dresser & McKee, Inc. 1994. *Storm Water Discharge Characterization FY92 and FY93, Final Summary Report,* Deliverable 4.11. North Central Texas Council of Governments.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Center for Watershed Protection (CWP). 2003. *Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph No. 1*. Available at https://owl.cwp.org/mdocs-posts/impacts-of-impervious-cover-on-aquatic-systems-2003/

Linam, Gordan, Kleinsasser, L., and Mayes, K. 2002. *Regionalization of the Index of Biotic Integrity for Texas Streams*. Resource Protection Division, Texas Parks and Wildlife.

National Oceanic and Atmospheric Administration (NOAA). 2019. DFW Airport Hourly Rainfall data from 1974 to 2019. Available at https://www.ncdc.noaa.gov/cdo-web/datasets/LCD/stations/WBAN:03927/detail

National Research Council (NRC). 2008. *Urban Stormwater Management in the United States*. National Academies Press, Washington, D.C.

Pitt, Robert, et al. 2005. The National Stormwater Quality Database, *A Compilation and Analysis of NPDES, Stormwater Monitoring Information*, Version 1.1. USEPA Office of Water. Washington, D.C.

Texas Commission on Environmental Quality (TCEQ). 2007. Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data. TCEQ Surface Water Quality Monitoring Program. TCEQ RG-416. June 2007.

Texas Commission on Environmental Quality (TCEQ). 2012. Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue. RG-415.

The Urban Water Resources Research Council of the American Society of Civil Engineers. 1992. *Design and Construction of Urban Stormwater Management Systems*. Chapter 5: Hydrology and Introduction to Water Quality. Water Environment Federation.

U.S. Environmental Protection Agency (EPA). 1983. *Results of the Nationwide Urban Runoff Program Vol. 1 Final Report* (Report Number PB84-185552). Washington, D.C.: Water Planning Division.

U.S. Environmental Protection Agency (EPA). 1982. *Results of the Nationwide Urban Runoff Program Vol. 2 Appendices* (Report Number PB84-185560). Washington, D.C.: Water Planning Division.

Appendices

APPENDIX A: Regional Wet Weather Characterization Plan Proposal for the Fourth Term Submission and Letter of Approval from TCEQ

APPENDIX B: Monitoring Program and Quality Assurance Project Plan for Wet Weather Characterization Equipment Deployment and Sampling Protocol: 2018-2022

APPENDIX C: Monitoring Program and Quality Assurance Project Plan for Bioassessments: 2018-2022

APPENDIX D: 2019 Stream Bioassessment: Rowlett Creek, City of Garland, Rowlett Creek Headwaters, City of Plano, and Delaware Creek, City of Irving

APPENDIX E: Lab Certifications and Accreditations

APPENDIX F: Raw Sampling Data

APPENDIX G: Sample Collection Reports

APPENDIX H: Dallas Bioassessment Report

APPENDIX I: Fort Worth Bioassessment Report