Trinity River Authority
of Texas

Trinity River Basin Total Dissolved Solids Assessment – Phase I

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CHAPTER I

PROJECT OBJECTIVES AND APPROACH

On behalf of the Trinity River Authority of Texas (Authority), a review of Total Dissolved Solids (TDS) in the Trinity River Basin was performed by Alan Plummer Associates, Inc. (APAI). This project was financed through the Texas Clean Rivers Program in cooperation with the Texas Commission on Environmental Quality (TCEQ). The intent of this review was to characterize current TDS conditions in the basin and to identify data sources, tools, and issues to consider when evaluating monitoring programs, surface water quality criteria, and future activities. The types of activities that may be relevant include: electric power generation; advanced water and wastewater treatment; reservoir operations; and water management strategies.

The project included a review of available data from the TCEQ Surface Water Quality Monitoring (SWQM) database for stations within the Trinity River Basin, as well as data for waterbodies from which water is currently imported, or is planned to be imported, into the basin. Observations were made regarding historical data variations, and comparisons were made to the Texas Surface Water Quality Standards (TSWQS) criteria, and the Texas and federal drinking water criteria for TDS.

In addition to the data review, a preliminary review was made of analytical methodologies and modeling approaches that could be used in the Trinity River Basin as tools for determining possible TDS conditions associated with potential water management strategies. Such tools could provide a foundation for future decision-making regarding establishing surface water quality criteria, reservoir operations, and waterbody protection.

CHAPTER II

BACKGROUND INFORMATION

The concentration of Total Dissolved Solids (TDS) in drinking water has historically been regarded as an indicator of palatability and general aesthetic characteristics of the water. Discharges that may contribute to increases in TDS concentrations include: agricultural runoff; urban runoff; municipal and industrial wastewater; mining operations; oilfield operations; power plant cooling water and desalination reject wastes. Natural sources such as interconnections with groundwaters containing high concentrations of TDS and contact with soluble, mineral-bearing rocks can also contribute TDS to waters. The sources of TDS are site-specific and vary in surface waters, as well as groundwaters.

2.1 MEASUREMENT OF TOTAL DISSOLVED SOLIDS

The measurement of TDS is used to define the overall concentration of minerals and salts in solution. While the TDS test provides a quantitative measure of the total amount of dissolved minerals present, it does not identify the specific ions comprising the total ionic make-up or provide information on the relative quantities of the individual ions. The TDS data reviewed in this study were determined using one of the two analytical methods approved for the Texas Clean Rivers Program. The following are approved methods: 1) a gravimetric method and 2) calculation of TDS using conductivity measurements.

2.1.1 Measuring Total Dissolved Solids Gravimetrically

The TDS concentration of a particular sample is determined by a laboratory analysis in which the water is filtered using a standard glass fiber filter to remove suspended solids. The water in the filtrate is removed by evaporation. The filtrate is then dried to a constant weight at 180 degrees Centigrade. The TDS concentration is determined by weighing the residual solids and dividing the resulting milligram (mg) quantity by the volume of the original water sample measured in liters (L). The result is the TDS concentration in mg/L.

2.1.2 Estimating Total Dissolved Solids Using Conductivity

Conductivity measurements can be used to estimate TDS concentrations in waters. The TDS concentration of a sample is calculated by multiplying the conductivity (in micromhos per centimeter) by an empirical factor.

Electrically charged dissolved particles (ions) make natural waters good conductors of electricity. Conversely, pure water has a high electrical resistance, and resistance is frequently used as a measure of its purity. The most common ions in natural waters that contribute to conductivity are listed in Table 2-1.

Table 2-1
Common Ions in Natural Waters

Cations		Anions	
Calcium	Ca^{+2}	Bicarbonate	$HCO3^{-}$
Magnesium	Mg^{+2}	Carbonate	$CO3^{-2}$
Potassium	K^{+}	Chloride	Cl^{-}
Sodium	Na^{+}	Sulfate	$SO4^{-2}$

Conductivity is measured using a calibrated probe. The conversion factor used to compute TDS concentration from the measured conductivity varies depending on the composition of the minerals in solution. For natural waters, a multiplier in the range between 0.50 and 0.90 is used to compute an approximate TDS concentration. The TCEQ typically utilizes a conversion factor of 0.65

2.2 SIGNIFICANCE OF TOTAL DISSOLVED SOLIDS

When evaluating the significance of TDS, three types of water use must be considered: municipal, industrial, and ecosystem support. The relationships between these uses and TDS concentrations are discussed below.

2.2.1 Municipal Use

When evaluating the relationship between TDS concentrations and water use as a municipal supply, there are a number of factors to be considered: the suitability of the water for drinking, aesthetic considerations, and potential physical effects on system components. The following sections summarize the regulatory requirements for TDS in municipal supplies with respect to compliance with Secondary Drinking Water Standards (TDS is not subject to Primary Drinking Water Standards) and corrosion control. The significance of the hardness constituents of TDS is also discussed. (Hardness is not subject to regulatory controls.)

2.2.1.1 Secondary Drinking Water Standards

A Secondary Drinking Water Standard of 500 mg/L TDS has been established by EPA. The objective of the standard is to control objectionable tastes (1). The TCEQ established a Secondary Constituent Level of 1,000 mg/L TDS in recognition of the reality that a number of Texas communities, particularly in West Texas, do not have access to water supplies containing less than 500 mg/L TDS.

Chloride consumption, in reasonable quantities, is not harmful to most people. However, chloride may present a problem for persons with dietary salt restrictions, if there is significant sodium present as well.

EPA has established a Secondary Drinking Water Standard of 250 mg/L for chloride (1). This standard is set to avoid the salty taste associated with higher concentration. The TCEQ Secondary Constituent Level identified in Texas Administrative Code (TAC) 290.118 (Public Drinking Water Standards) is 300 mg/L.

In their 1980 Amendments to the Interim Primary Drinking Water Regulations, the EPA suggested an optimum sodium concentration for all drinking water supplies of 20 mg/L(2). This recommendation was based on evidence linking high sodium intake to hypertension and a National Academy of Sciences suggested limit of 20 mg/L based on a body of research evidence(5). However, a limit for sodium has not been adopted as either a Primary or a Secondary standard.

Sulfur is present in natural waters primarily as the sulfate ion. The taste threshold for sulfate has generally been established to be 300 to 400 mg/L, with some individuals detecting it as low as 200 mg/L. Sulfate concentrations above 300 mg/L, in association with significant concentrations of sodium, have been found to be responsible for laxative effects in humans. In response, EPA has set the Secondary Drinking Water Standard for sulfate at 250 mg/L (1). TCEQ has set a Secondary Constituent Level of 300 mg/L.

2.2.1.2 Corrosion Control

The corrosive properties of natural waters are a function of the mineral composition of the TDS. High levels of specific ions, such as sodium and chloride, promote corrosion. Corrosive waters are usually treated by the addition of caustic. Overcorrection can cause excessive scaling.

Water that is corrosive can react with the household plumbing and metal fixtures resulting in the deterioration of pipes and increased metal content of the water. This reaction can result in aesthetic problems, such as bitter water and stains around basins and sinks. Another potential risk of corrosion is the release of metal ions into solution that could be harmful to human health in water for human consumption.

EPA promulgated the Lead and Copper Rule to address these issues. The Lead and Copper Rule establishes Action Levels (ALs) for copper and lead. The AL for lead is 0.015 mg/L. The AL for copper is 1.3 mg/L. An AL exceedence is not a regulatory violation, but it can trigger other requirements, including additional water quality monitoring, additional treatment for corrosion control, public education, and lead service line replacement.

2.2.1.3 Hardness

As water moves through soil and rock, it dissolves small amounts of minerals. Calcium and magnesium dissolved in water are the two most common minerals that make water "hard." The degree of hardness becomes greater as the calcium and magnesium content increases. Because it is less abundant in rocks than calcium, magnesium concentrations typically are lower than calcium concentrations even though it has a higher solubility. The standard measure of hardness is as an equivalent concentration of calcium carbonate ($CaCO_3$).

While not a health risk, water hardness can interfere with the performance of soap and/or detergent and cause a build-up of mineral deposits in pipes, on fixtures, and on glass surfaces. A thin film of $CaCO_3$ in pipes is beneficial for corrosion protection. In severe cases, pipes and water-using appliances can become clogged with the scale deposits, requiring their replacement.

Water is classified as “hard” when the concentration is between 150 and 300 mg/L, expressed as $CaCO_3$. Water with hardness in excess of 300 mg/L as $CaCO_3$ is classified as “very hard”.

2.2.2 Industrial Use

The TDS concentration required for use of water in industrial processes depends on the specific industrial process needs and the mineral species present in the water. As was discussed under the municipal use section, corrosion control and water hardness issues may require correction to avoid equipment fouling. Cooling water can generally tolerate higher TDS concentrations than water for manufacturing processes. For example, process water for circuit board manufacture must be of almost distilled water quality, and boiler water feed must have hardness near zero. Examples of typical required TDS and TDS constituent concentrations for a variety of water-using industries are shown in Table 2-2.

Table 2-2 [(4)]
Typical Industrial Process Water Quality Requirements

Industry	TDS (mg/L)	Hardness (mg/L as $CaCO_3$)	Cl (mg/L)
Cement	600		250
Chemical Plants	1,000	250	500
Textiles	100	25	
Petrochemical and Coal	1,000	350	300
Paper Mills (chemical)		100	200

2.2.3 Ecosystem Support

Potential ecosystem impacts attributable to changes in TDS concentrations are not well-defined, and no general guidelines exist for predicting impacts in complex natural ecosystems. The potential extent of change will depend on the ecosystem organisms that are already present and the magnitude of the proposed change. These effects must be evaluated on a case-by-case basis.

Organisms that have established their place in an ecosystem thrive because their particular needs are met by the environmental conditions. Most organisms can withstand a range of conditions without significant impacts. However, the tolerance range is different for different organisms; and, for any species, there is a magnitude of change in TDS concentrations that will have adverse effects.

2.3 SURFACE WATER QUALITY STANDARDS FOR TOTAL DISSOLVED SOLIDS

Under the Clean Water Act and Chapter 26 of the Texas Water Code, the TCEQ has the authority to develop and amend the Texas Surface Water Quality Standards (TSWQS) for the state. The TCEQ applies the TSWQS criteria when issuing permits for wastewater discharges and in other regulatory actions that may affect waters of the state. TSWQS criteria are subject to periodic review and revision. During the revision process, TCEQ solicits input from the general public, other governmental agencies, industries, municipalities, environmental groups, and others. The revised TSWQS criteria are subject to approval by EPA. Adopted TSWQS criteria are codified in Chapter 307 of the Texas Administrative Code (TAC). TAC 307 includes a statement regarding the purpose of the TSWQS criteria (6):

> *"…to maintain the quality of water in the state consistent with public health and enjoyment, propagation and protection of terrestrial and aquatic life, operation of existing industries, and economic development of the state;"*

There are three components to the TSWQS criteria: (1) designated uses, (2) chemical and physical criteria to protect those uses, and (3) an anti-degradation policy. The anti-degradation policy prohibits lowering of water quality in segments that have quality exceeding the TSWQS criteria by more than a *de minimus* extent unless certain criteria are met. The term *de minimus* is not officially defined. However, in practice, a change greater than 10% is frequently considered more than *de minimus*. The anti-degradation policy prohibits lowering water quality in any segment to the extent that an existing use is impaired.

TDS is one of the parameters for which TSWQS criteria have been developed. Numerical criteria for TDS are established for specific waterbodies that are identified in Appendix A of the TSWQS. These waterbodies are referred to as "classified" segments. In the Trinity River Basin, there are 41 classified segments.

Waterbodies that are not specifically listed in TSWQS Appendix A are referred to as "unclassified" segments. There are no TDS TSWQS criteria applicable to unclassified segments. However, the TCEQ requires an assessment of the potential effects of proposed discharges on TDS concentrations in unclassified waterbodies and provides guidance on how the assessment is to be performed (7).

Table 2-3 identifies the classified segments in the Trinity River Basin and the current and proposed TDS TSWQS criteria for each segment. As part of the current process to revise the TSWQS criteria, the TCEQ has proposed revisions to the TDS TSWQS criteria for three classified segments: A new standard of 990 mg/L TDS is being proposed for Segment 0812 (West Fork Trinity River above Bridgeport Reservoir). The new standard proposed for Segment 0819 (East Fork Trinity River) is 530 mg/L. A standard of 500 mg/L is being proposed for Segment 0821 (Lake Lavon).

These TSWQS criteria set the maximum allowable annual median TDS concentration for each segment. With regard to standards attainment, the proposed TAC 307 states the following:

> *"Standards attainment determinations shall be based on the median of measurements taken over a period of at least one year. Results from all monitoring stations within the segment will be used to allow for reasonable parametric gradients."*

Table 2-3 (6)

Texas Surface Water Quality Standards for Total Dissolved Solids in the Trinity River Basin

Segment Number	Segment Name	Current Criteria (mg/L)	Proposed [1] Criteria (mg/L)
0801	Trinity River Tidal	See Note 2	
0802	Trinity River Below Lake Livingston	600	
0803	Lake Livingston	500	
0804	Trinity River Above Lake Livingston	600	
0805	Upper Trinity River	850	
0806	West Fork Trinity River Below Lake Worth	500	
0807	Lake Worth	500	
0808	West Fork Trinity River Below Eagle Mountain Reservoir	500	
0809	Eagle Mountain Reservoir	300	
0810	West Fork Trinity River Below Bridgeport Reservoir	500	
0811	Bridgeport Reservoir	300	
0812	West Fork Trinity River Above Bridgeport Reservoir	500	990
0813	Houston County Lake	300	
0814	Chambers Creek Above Richland-Chambers Reservoir	500	
0815	Bardwell Reservoir	300	
0816	Lake Waxahachie	300	
0817	Navarro Mills Lake	300	
0818	Cedar Creek Reservoir	200	
0819	East Fork Trinity River	500	530
0820	Lake Ray Hubbard	500	
0821	Lavon Lake	400	500
0822	Elm Fork Trinity River Below Lewisville Lake	500	
0823	Lewisville Lake	500	
0824	Elm Fork Trinity River Above Ray Roberts Lake	700	
0825	Denton Creek	500	
0826	Grapevine Lake	500	
0827	White Rock Lake	400	
0828	Lake Arlington	300	
0829	Clear Fork Trinity River Below Benbrook Lake	500	
0830	Benbrook Lake	300	
0831	Clear Fork Trinity River Below Lake Weatherford	500	
0832	Lake Weatherford	500	
0833	Clear Fork Trinity River Above Lake Weatherford	750	
0834	Lake Amon G. Carter	400	
0835	Richland Creek Below Richland-Chambers Reservoir	500	
0836	Richland-Chambers Reservoir	400	
0837	Richland Creek Above Richland-Chambers Reservoir	500	
0838	Joe Pool Lake	500	
0839	Elm Fork Trinity River Below Ray Roberts Lake	500	
0840	Ray Roberts Lake	500	
0841	Lower West Fork Trinity River	850	

1 Proposed standard revision currently under consideration by TCEQ

2 No TDS criteria are established for tidal segments

2.4 SOURCES OF TOTAL DISSOLVED SOLIDS

As noted briefly at the beginning of this chapter, TDS are introduced to surface waters from natural sources and from discharges that are a result of human activities. This discussion describes the TDS contributions from specific human sources. Potential antropogenic sources of TDS increases in surface waters in the Trinity River Basin include the following:

1. Municipal wastewater treatment plants.
2. Evaporative cooling processes, such as power plants, that rely on water evaporation for cooling.
3. Other industrial facilities with processes such as pH neutralization.
4. Brine reject wastes from industrial or municipal water treatment systems to reduce TDS concentrations, and regeneration wastes from home water softeners.
5. Brines associated with oil and gas production.

These sources are discussed in more detail below.

2.4.1 Municipal Wastewater Treatment Plants

TDS concentrations in effluents from municipal wastewater treatment plants are influenced by the following factors, if present:

- Potable water supplies that rely on groundwater sources with higher TDS concentrations than surface waters in the area.
- Salts excreted in human waste and released as metabolic bacterial byproducts in the sewage treatment process contribute TDS that are not removed in conventional biological treatment processes (8).
- Home water softeners that discharge regeneration wastes to the sewerage system.
- Industrial wastewater discharges to the sewerage system. The nature of industrial wastewaters is discussed further in sections included below.

Limited investigations by APAI using data from some of the wastewater treatment plants serving the Dallas-Fort Worth Metroplex identified increases of 300 to 350 mg/L TDS in the effluent discharge compared to the potable water supply TDS concentrations.

2.4.2 Evaporative Cooling

Recirculating evaporative cooling water systems are used in a number of industrial processes. Because water is evaporated, the concentration of dissolved minerals in the cooling water increases over time. When TDS concentrations exceed desirable operating levels, a portion of the recirculating water is discharged and replaced with water from the water supply.

The concentration increase in the discharged water, compared to the water supply, is determined by the cycles of concentration (COC) employed by the particular process. A COC of 4 would increase the dissolved mineral concentration of the supply water by four times. The TDS concentration of the cooling water discharge is, therefore, dependent on the concentration in the water supply and the COC used in the cooling process. Typical COCs used in various industries are shown in Table 2-4.

Table 2-4 (4)
Typical Industry Cycles of Concentration

Industry	Typical COC
Utilities	
Fossil	5 - 8
Nuclear	6 - 10
Petroleum Refineries	6 - 8
Chemical Plants	8 - 10
Steel Mills	3 - 5
HVAC	3 - 5
Paper Mills	5 - 8

2.4.3 Industrial Processes

There are a number of industrial processes that can result in a wastewater discharge that contains high TDS concentrations. If high purity water is needed for manufacturing processes, treatment may be achieved by a membrane technique, such as reverse osmosis, which produces a reject stream containing high concentrations of TDS. If a manufacturing process requires the use of an acid or base, neutralization will be required at some point in the process, which will produce a stream with high TDS concentrations. Some food processing plants create waste streams with high TDS concentrations. Rinse tanks can contain significant TDS concentrations.

2.4.4 Oil and Gas Production

Regulations have been established to require exploration and production companies to manage drilling chemicals and the produced brine water so that they do not contaminate surface waters. However, there may be regions that are still impacted by practices that were followed before these regulations were placed in effect.

2.5 REFERENCES

1. Environmental Protection Agency, “National Secondary Drinking Water Regulations,” Fed. Reg., 44, 153, 42195-42202 (July 19, 1979) (EPA, 1979a).
2. Environmental Protection Agency, “Interim Primary Drinking Water Regulations; Amendments,” Fed. Reg., 45, (168), 57332-57357 (August 27, 1980).
3. Environmental Protection Agency, “2006 Edition of the Drinking Water Standards and Health Advisories,” EPA 822-R-06-013 (August, 2006).
4. Environmental Protection Agency, “Guidelines for Water Reuse,” EPA 625-R-04-108 (September, 2004).
5. National Academy of Sciences, Safe Drinking Water Committee, “Drinking Water and Health,” Washington DC (1977).
6. Texas Administrative Code, Chapter 307: Texas Surface Water Quality Standards §§307.1-307.10 Effective August 17, 2000.
7. Texas Commission on Environmental Quality, “Procedures to Implement the Texas Surface Water Quality Standards,” January 2003.
8. Patoczka, Jurek, "TDS and Sludge Generation Impacts from Use of Chemicals in Wastewater Treatment," New Jersey Effluents, (Fall 2006).

CHAPTER III

DATA REVIEW

A review of the historical TDS data was conducted for waterbodies in the Trinity River Basin and for waterbodies outside of the Trinity River Basin from which water is either currently or projected to be imported into the basin to supplement existing water supplies. The evaluation was performed using available data obtained by the Trinity River Authority from the SWQM database.

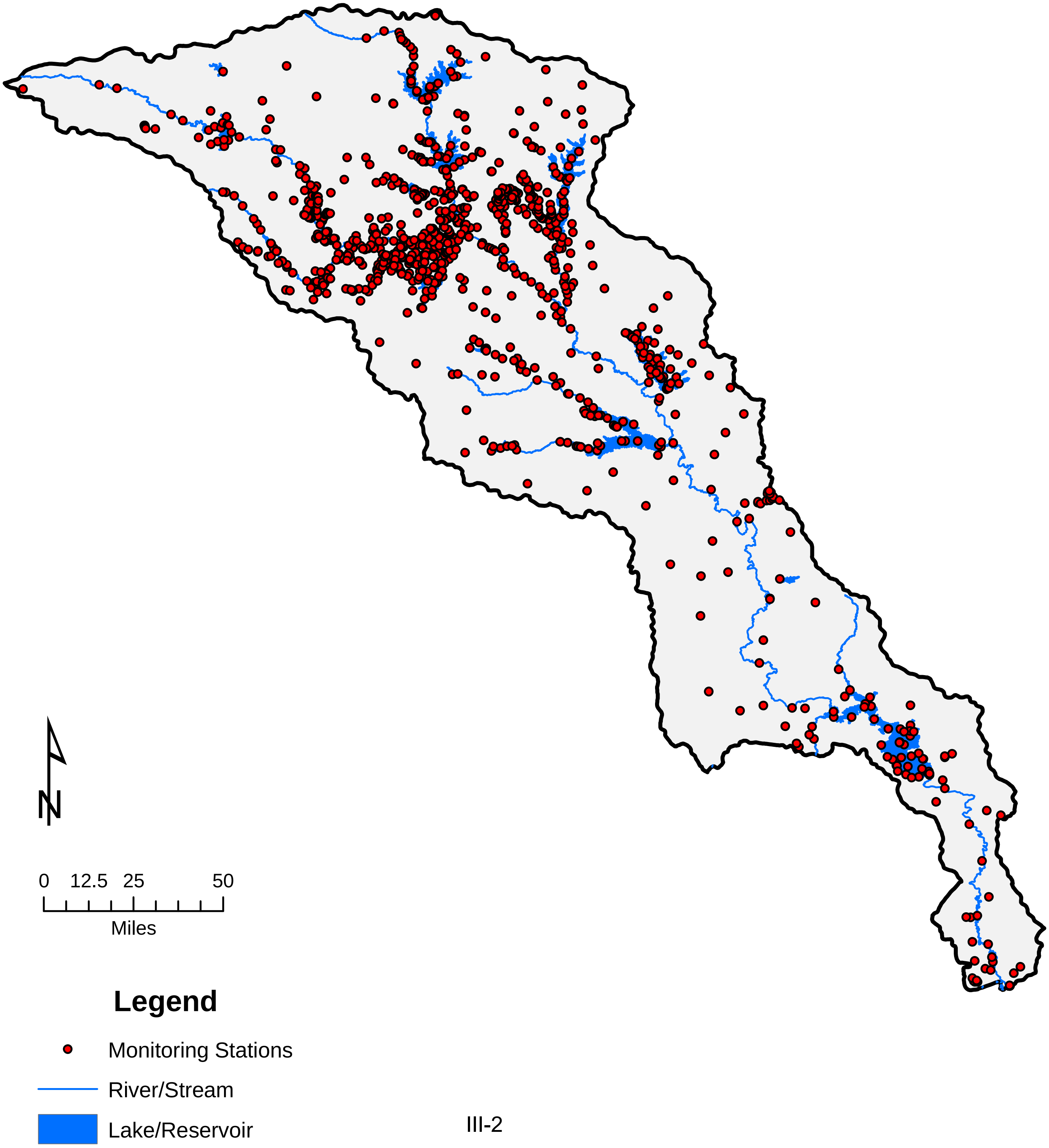
It should be noted that, for a number of reasons, the TDS summaries presented in the next section are not appropriate for use in determining TSWQ standards attainment. The TCEQ maintains specific protocol for assessing standards attainment that take into account the time periods and amount of data considered for analysis as well as the aggregation of sampling station data according to “Assessment Units.” This study did not fully research nor abide by the specific practices followed by the TCEQ in development of the 2008 Texas Water Quality Inventory and Basin Assessment for 303(d) level of support determination.

For the data analyses performed for this study, both TDS and conductivity measurements were used. Section 3-1 below describes how the conductivity data were adapted for this study.

The dataset used to evaluate waterbodies in the Trinity River Basin consists of over 97,000 raw data records. The data were collected over the time period 1968 to 2009 and include samples collected from over 750 different sampling stations. Of these stations, 580 were on classified segments, and 178 were on unclassified waterbodies. Figure 3-1 depicts the density of SWQM sampling stations throughout the basin. Larger scale maps are provided in Appendix A on which the specific sampling station locations on the various stream segments may be seen. The results of the evaluations of TDS concentrations in the Trinity River Basin are presented in Section 3.2.

An evaluation was also performed of the TDS data from sampling stations outside the Trinity River Basin that are located on waterbodies from which water is, or may be, imported. Summaries of these results are presented in Section 3.3 of this report.

Figure 3-1
Surface Water Quality Monitoring Stations
Trinity River Basin



3.1 USE OF CONDUCTIVITY DATA

Both TDS and conductivity data were obtained for use in this study. Table 3-1 presents a brief summary of the available data in the Trinity River Basin for each of the parameters of interest. The results reported in Table 3-1 are based on the daily average values for each parameter; i.e., daily measurements at multiple depths in a reservoir station were averaged to produce a single value for that location, and multiple measurements taken at any sampling station during a 24-hour period were averaged to produce a daily average. As seen by the data counts listed in Table 3-1, approximately 43,000 daily average valves were generated from the 97,000 or so records of raw measurements.

Table 3-1
Summary of Historical Daily Average Total Dissolved Solids and Conductivity Data for the Trinity River Basin

Parameter Code	Description	Period of Record	Data Count	Measured Values		
				Min	Max	Avg
70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	1976 - 2009	9,603	38	9,000	313
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	1972 - 2009	20,262	30	27,500	498
00095	SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	1968 - 2007	13,097	30	8,109	484

Conductivity measurements can be used to estimate TDS concentrations. When TCEQ makes this conversion, they use an empirical conversion factor of 0.65, which they derived from data collected statewide. As part of this study, an analysis was made of the relationship between conductivity and gravimetric TDS measurements in waters in the Trinity River Basin to determine if this conversion factor applies to waters in the Trinity River Basin.

This evaluation analyzed the data for the entire Trinity River Basin as a single dataset. Different results might be obtained if the analysis were performed on an individual waterbody.

The evaluation was based on paired values from the dataset of the average daily results for conductivity and TDS (i.e., both conductivity and TDS measurements were available at the same location on the same day). At each sampling station, measurements at multiple depths were averaged, and multiple measurements over a 24-hour period were averaged. The resulting dataset consisted of 9,397 data pairs.

The data from these data pairs were then plotted with TDS measurements as the y-axis and conductivity measurements as the x-axis. Linear regression was used to fit a straight line through the data points. The slope of the resultant line is the appropriate conversion factor for that dataset.

Conversion factors were computed for four subsets of the paired dataset. The data subsets used and the results of each evaluation are as follows:

- Field conductivity data (Figure 3-2) - All data pairs in which the conductivity measurement was measured in the field were included in this evaluation. There were 7,180 data pairs in this evaluation. The conversion factor based on this data set is 0.57, and the R^2 value is 0.66.
- Field conductivity data, not including conductivity measurements greater than 3,000 umhos/cm (Figure 3-3) - The field conductivity data included values up to 17,000 umhos/cm. For this evaluation, the conductivity measurements greater than 3,000 umhos/cm were visually judged to be outliers and were excluded from the analysis. This resulted in 13 out of the 7,180 data pairs being eliminated. The conversion factor for this data set is 0.65, and the R^2 value is 0.71.
- Laboratory conductivity data (Figure 3-4) - There were 2,217 data pairs in this dataset. The conversion factor for this dataset is 0.59, and the R^2 value is 0.85.
- Field and laboratory conductivity data combined, not including conductivity measurements greater than 3,000 umhos/cm (Figure 3-5) - There were 9,383 data pairs in this dataset. The conversion factor for this dataset is 0.63, and the R^2 value is 0.72.

All of the conversion factors are similar to that used by TCEQ, 0.65. In addition, the small differences that would be exhibited if a different conversion factor were used are not significant for the purposes of this study. Therefore, for subsequent evaluations for this study, conductivity measurements were converted to estimated TDS values by multiplying the conductivity measurement by 0.65. This produced an additional 21,278 daily average TDS values for use in this study. For those cases where both TDS and conductivity measurements were available at the same location on the same day, only the TDS measurement was used.

Figure 3-2

Comparison of Total Dissolved Solids and Field Measurements of Conductivity Trinity River Basin, 1968-2009

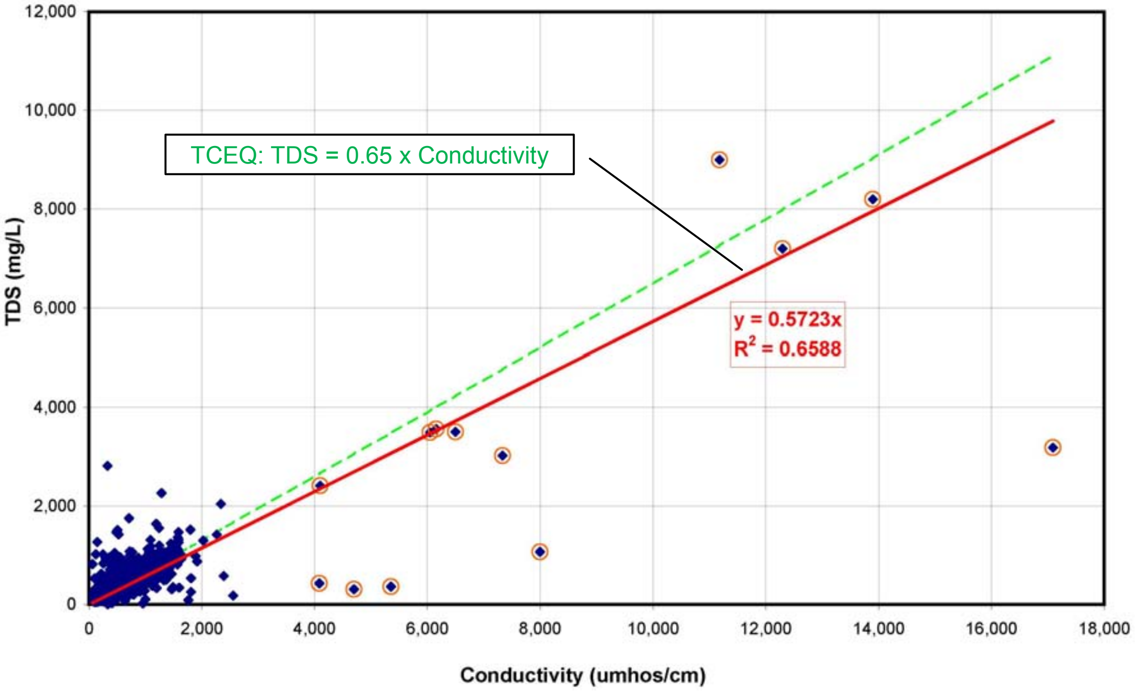
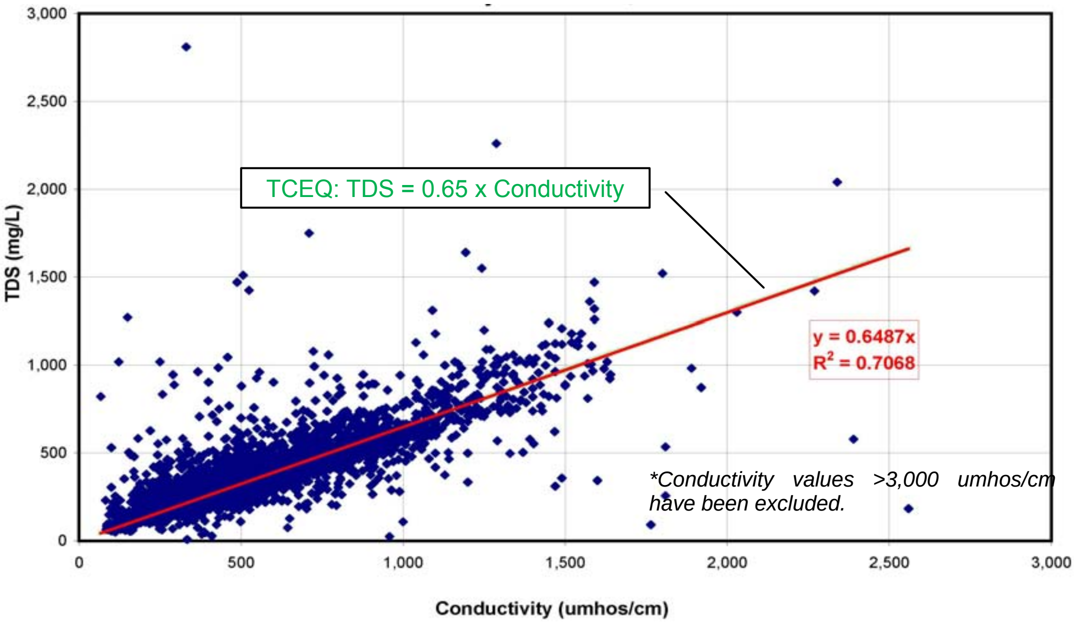


Figure 3-3

Comparison of Total Dissolved Solids and Field Measurements of Conductivity with High Conductivity Measurements Excluded* for the Trinity River Basin, 1968-2009



*Conductivity values >3,000 umhos/cm have been excluded.

Figure 3-4
Comparison of Total Dissolved Solids and Laboratory Measurements of Conductivity for the Trinity River Basin, 1968-2009

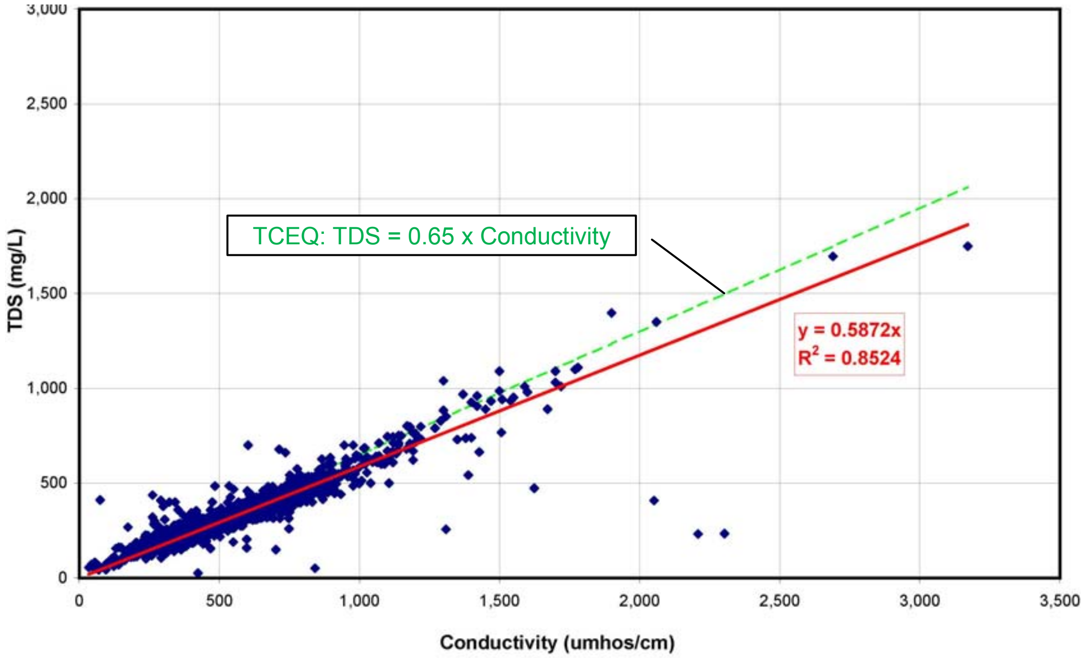
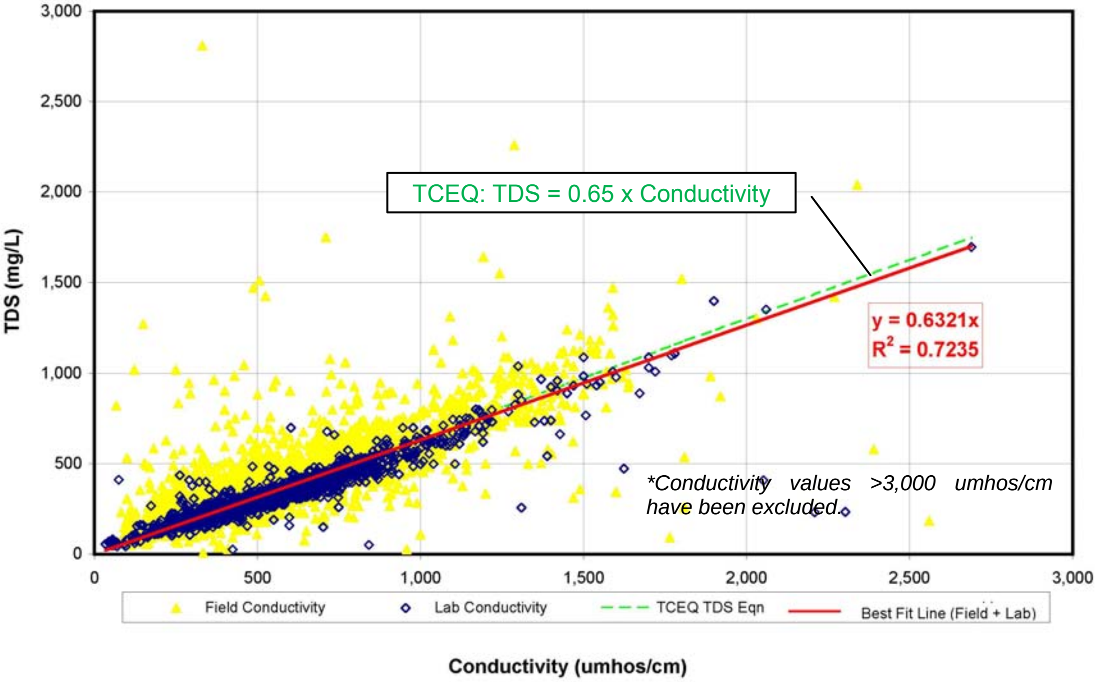


Figure 3-5
Comparison of Total Dissolved Solids and Combined Field and Laboratory Measurements of Conductivity*
for the Trinity River Basin, 1968-2009



*Conductivity values >3,000 umhos/cm have been excluded.

3.2 TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN THE TRINITY RIVER BASIN

As discussed in Chapter II, the TCEQ has established 41 classified segments in the Trinity River Basin. The basis of the evaluations presented in this report is by classified segment. The TDS data for unclassified waterbodies were also evaluated in this study. We have utilized the same identifiers for these unclassified waterbodies that the TCEQ uses in their "Texas Water Quality Inventory and 303(d) List," which is to refer to them by the number of the classified segment to which they are tributary and a letter designation (e.g., 0841A, 0841B, etc.).

To further organize some of the data presentations, the segments have been grouped by major watershed. The major watersheds are as follows:

- Clear Fork of the Trinity River
- West Fork of the Trinity River
- Village creek and Mountain Creek
- Elm, Fork of the Trinity River
- East Fork of the Trinity River
- Upper Main Stem Trinity River
- Richland-Chambers Reservoir and Cedar Creek Reservoir
- Lower Main Stem Trinity River, and
- Trinity River below Lake Livingston

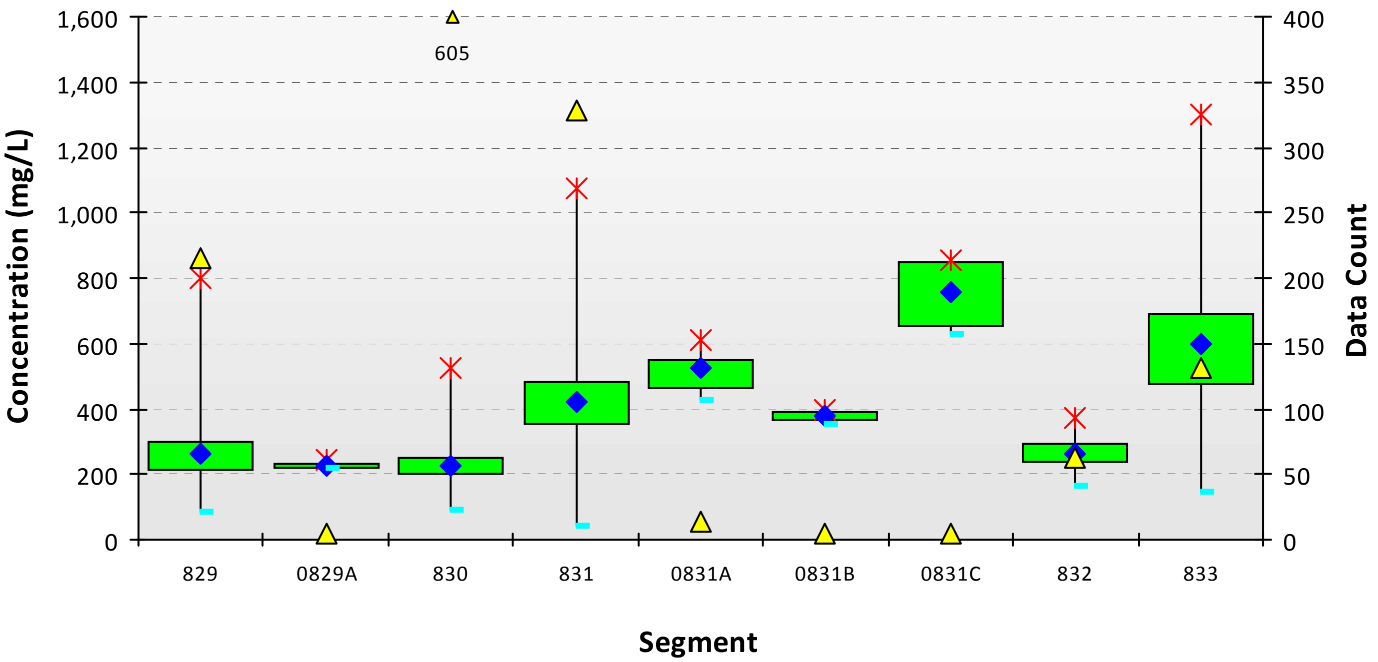
Historical TDS concentrations (based on both TDS and conductivity data) for the Trinity River Basin are summarized in two forms in this report.

- The historical median, maximum, minimum, 25th percentile, and 75th percentile TDS concentrations for each classified segment in the Trinity River Basin, and for those unclassified waterbodies for which data are available, are summarized on Figure 3-6. These plots organize the segment summaries by major watershed and provide information of spatial trends.
- Annual average concentrations, by year, for each classified segment for the period of record are presented on Figure 3-7. These plots provide information on temporal trends.

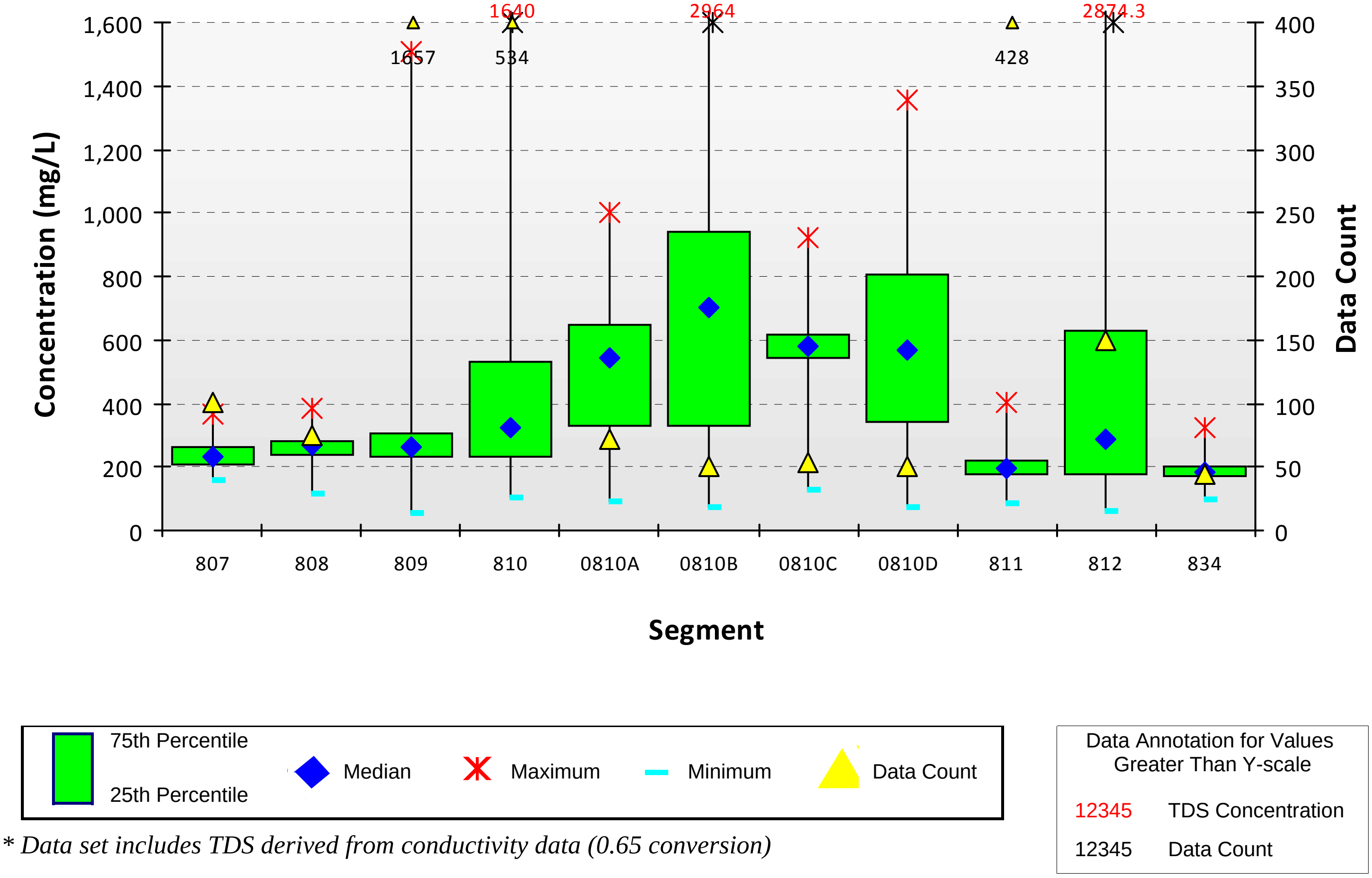
Shown in Figure 3-6 are box and whisker plots of the data quartiles for each classified segment and unclassified waterbody. The median TDS concentration for each waterbody is represented by a blue diamond. The green boxes represent the interquartile range, and the whiskers denote the minimum and maximum observed values. The number of data values for each segment, scaled according to the right y-axis, is shown by a yellow triangle.

Figure 3-6
Historical Daily Average Total Dissolved Solids* Concentrations
Trinity River Basin

Clear Fork



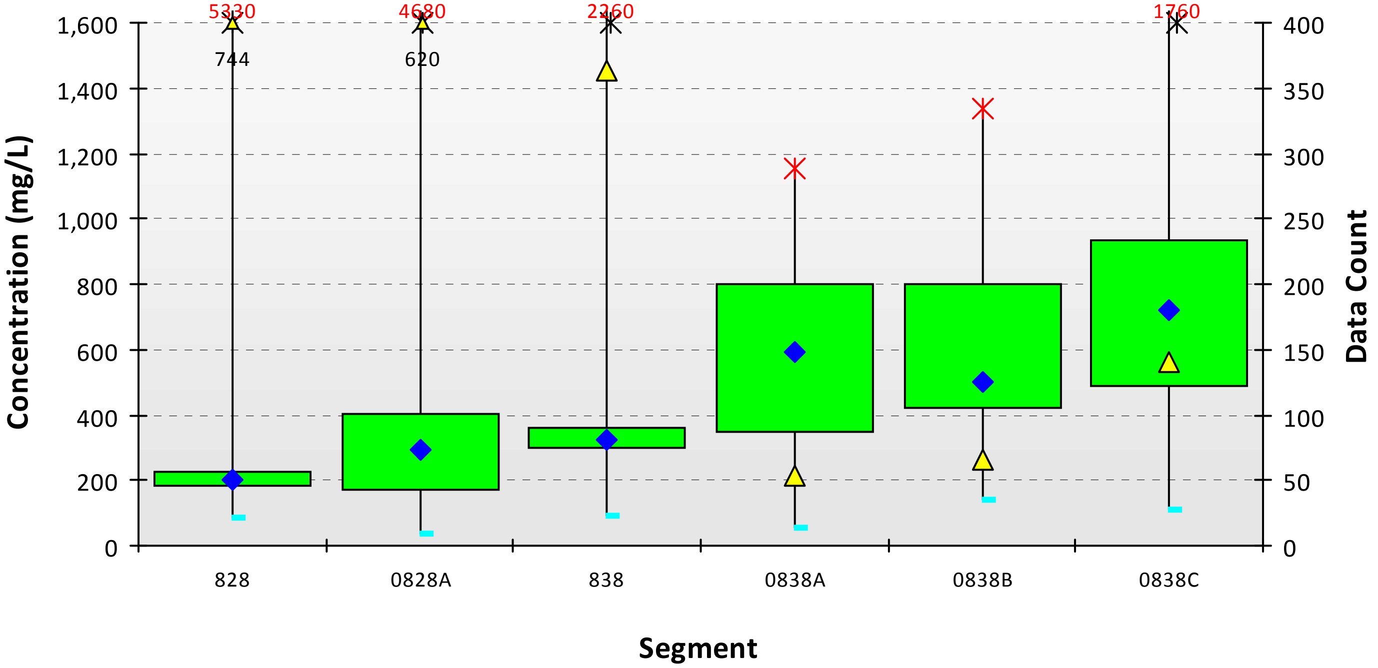
West Fork



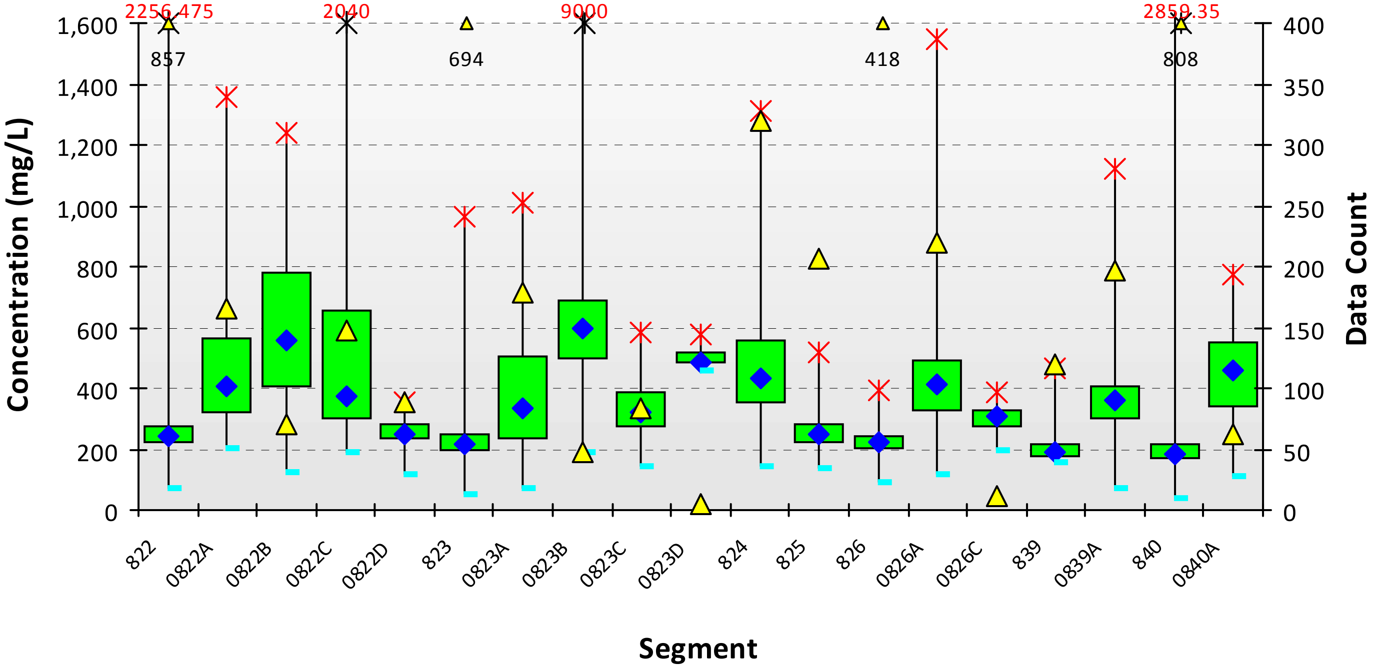
** Data set includes TDS derived from conductivity data (0.65 conversion)*

Figure 3-6 (cont.)
Historical Daily Average Total Dissolved Solids* Concentrations
Trinity River Basin

Village Creek & Mountain Creek



Elm Fork



🟩 75th Percentile / 25th Percentile ◆ Median ✕ Maximum – Minimum ▲ Data Count

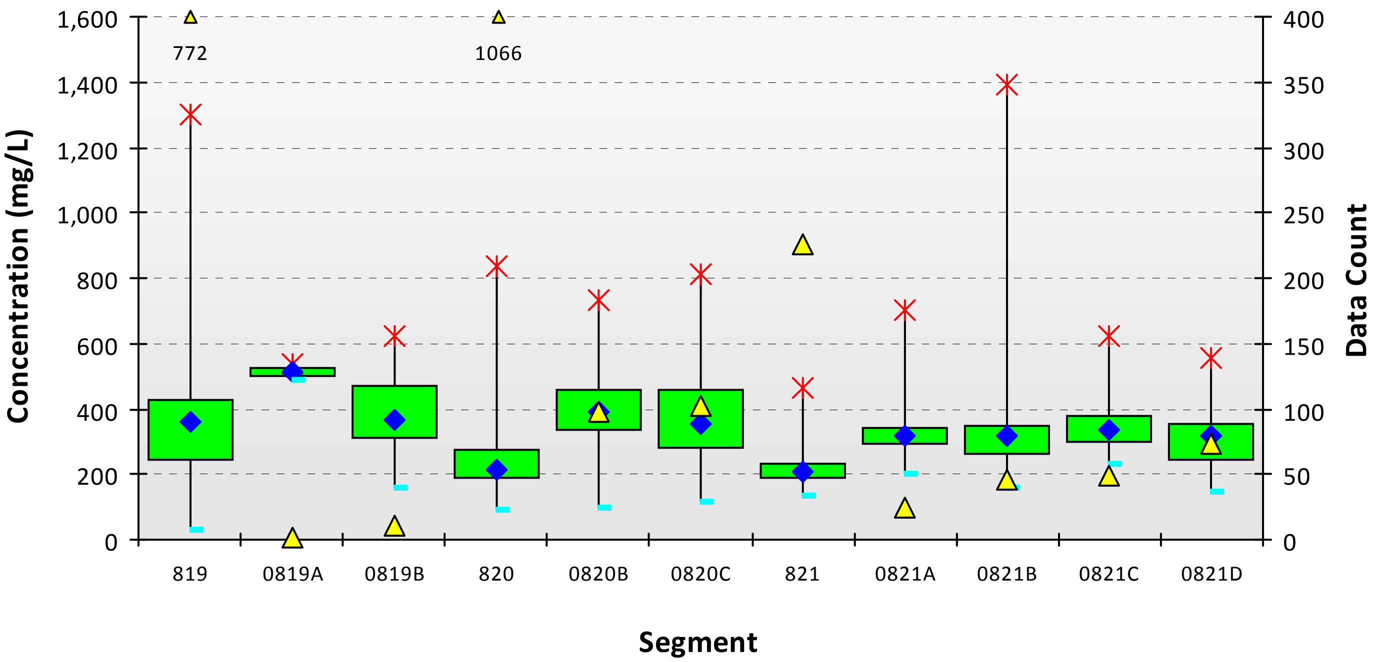
Data Annotation for Values Greater Than Y-scale

12345	TDS Concentration
12345	Data Count

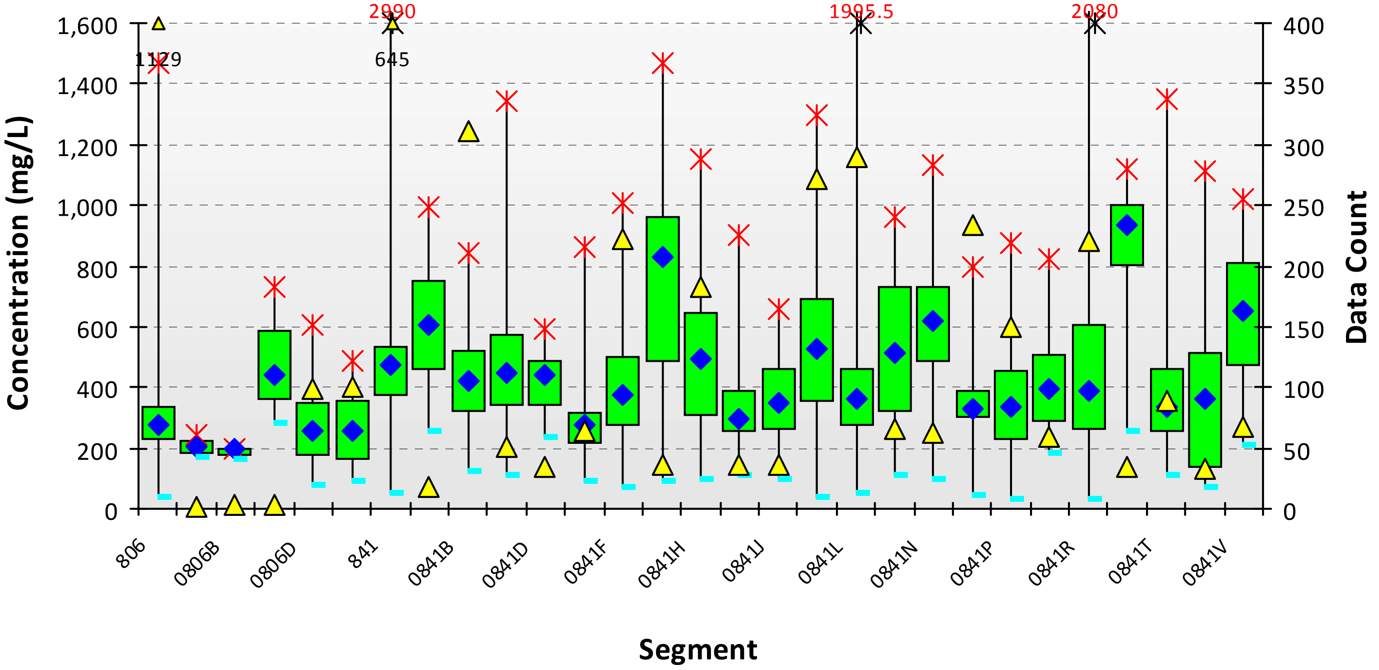
** Data set includes TDS derived from conductivity data (0.65 conversion)*

Figure 3-6 (cont.)
Historical Daily Average Total Dissolved Solids* Concentrations
Trinity River Basin

East Fork



Upper Main Stem



🟩 75th Percentile / 25th Percentile ◆ Median ✕ Maximum — Minimum ▲ Data Count

Data Annotation for Values Greater Than Y-scale

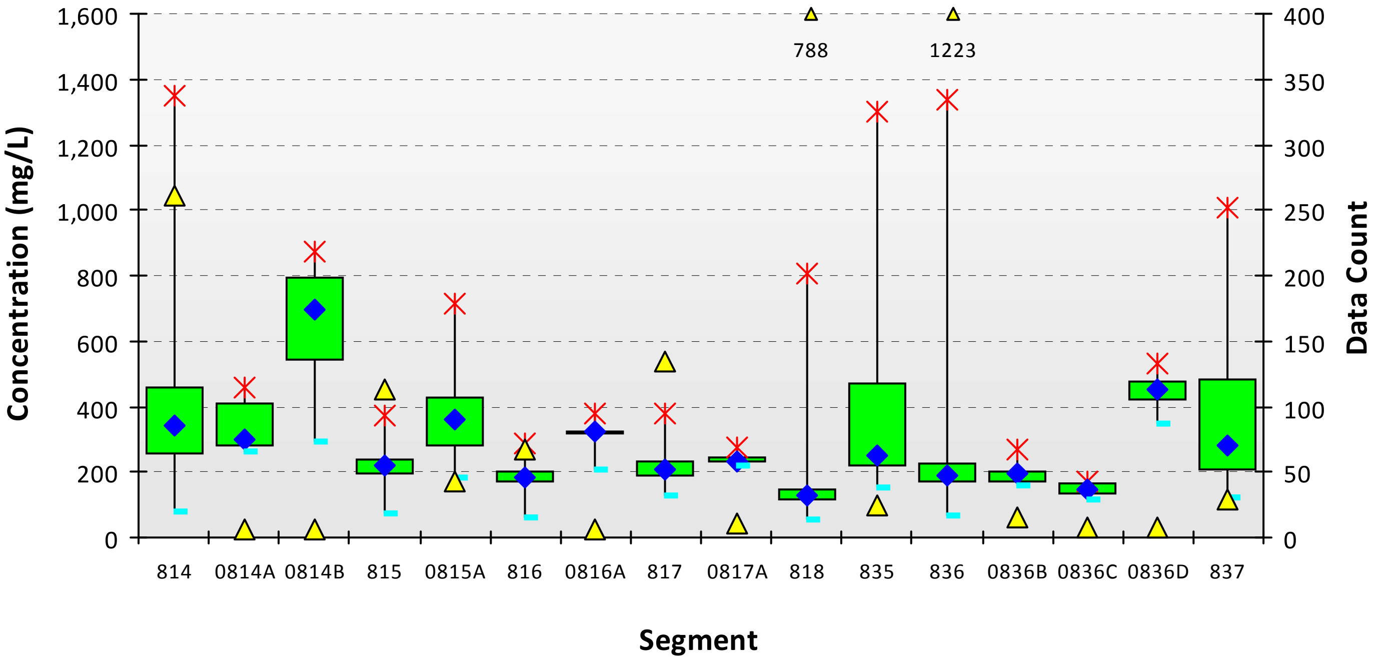
12345 TDS Concentration

12345 Data Count

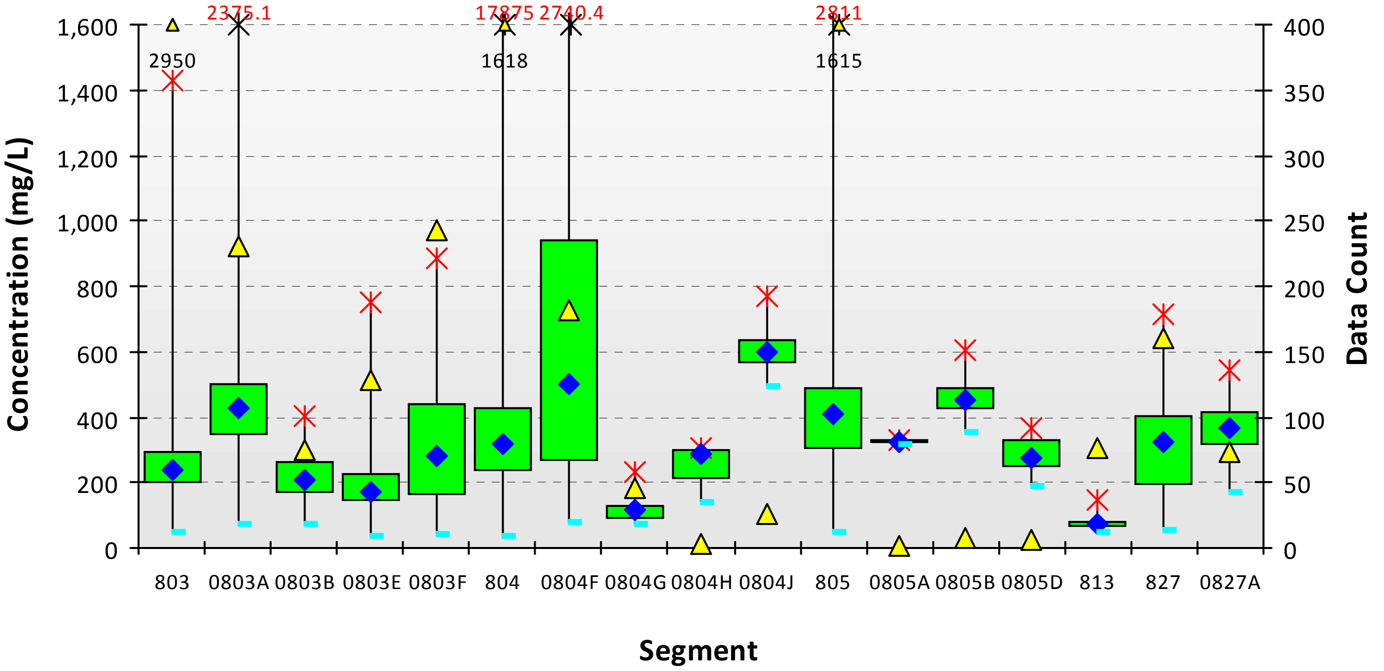
* *Data set includes TDS derived from conductivity data (0.65 conversion)*

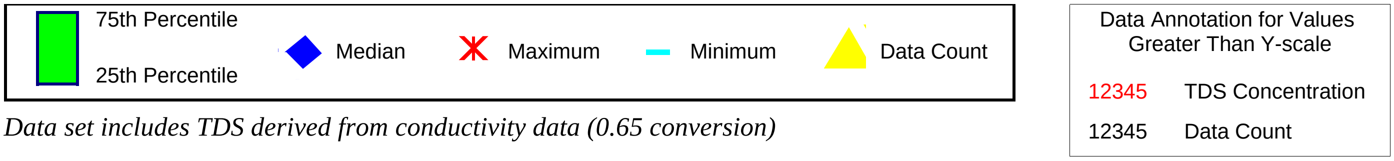
Figure 3-6 (cont.)
Historical Daily Average Total Dissolved Solids* Concentrations
Trinity River Basin

Richland-Chambers & Cedar Creek



Lower Main Stem

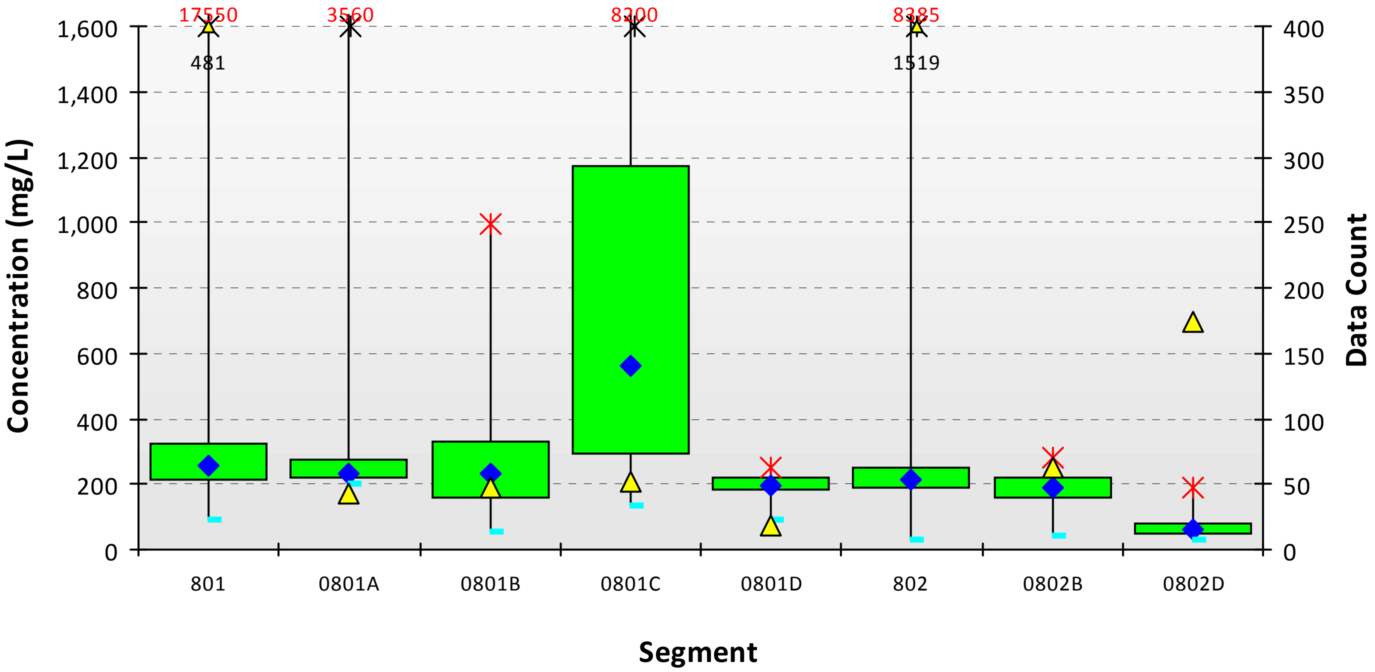




** Data set includes TDS derived from conductivity data (0.65 conversion)*

Figure 3-6 (cont.)
Historical Daily Average Total Dissolved Solids* Concentrations
Trinity River Basin

Trinity Below Livingston



** Data set includes TDS derived from conductivity data (0.65 conversion)*

Shown in Figure 3-7 are plots of annual average TDS concentrations by classified stream segment. Similar plots for the unclassified waterbodies can be found in Appendix B. Two or three horizontal lines are shown on each chart. The black line represents the TDS stream standard for the segment, and the red line indicates the 20-year average (1989 – 2008) observed TDS concentration. For segments for which a revision to the TDS water quality standard is proposed, the proposed standard is shown as a dashed, black line. The number of daily average data values for each year, scaled according to the right y-axis, is shown by a yellow triangle.

A summary of the TDS data for the classified segments is presented in Table 3-2. The segments are grouped according to major watershed. On the right side of the table are indicators of the specific years during which TDS data were collected within each segment and the average number of samples collected per year (considering only those years for which data were collected). The red/yellow/green shading shown for each Segment ID number on the left side of the table indicates the “Segment Ratio,” which is the ratio of the 20-year average (1989 – 2008) TDS concentration to the current TSWQS criteria. The Segment Ratio is less than or equal to 1.0 for all classified segments. One segment has a ratio between 0.9 and 1.0. Ten segments have a ratio between 0.7 and 0.9, and 30 segments have a ratio less than 0.7.

Figure 3-8 presents a spatial summary of the TDS data for the classified segments. The top two panes present the 20-year (1989-2008) average TDS concentrations and the number of measurements on which they are based. The bottom panes present the current TDS TSWQS criteria and the Segment Ratio.

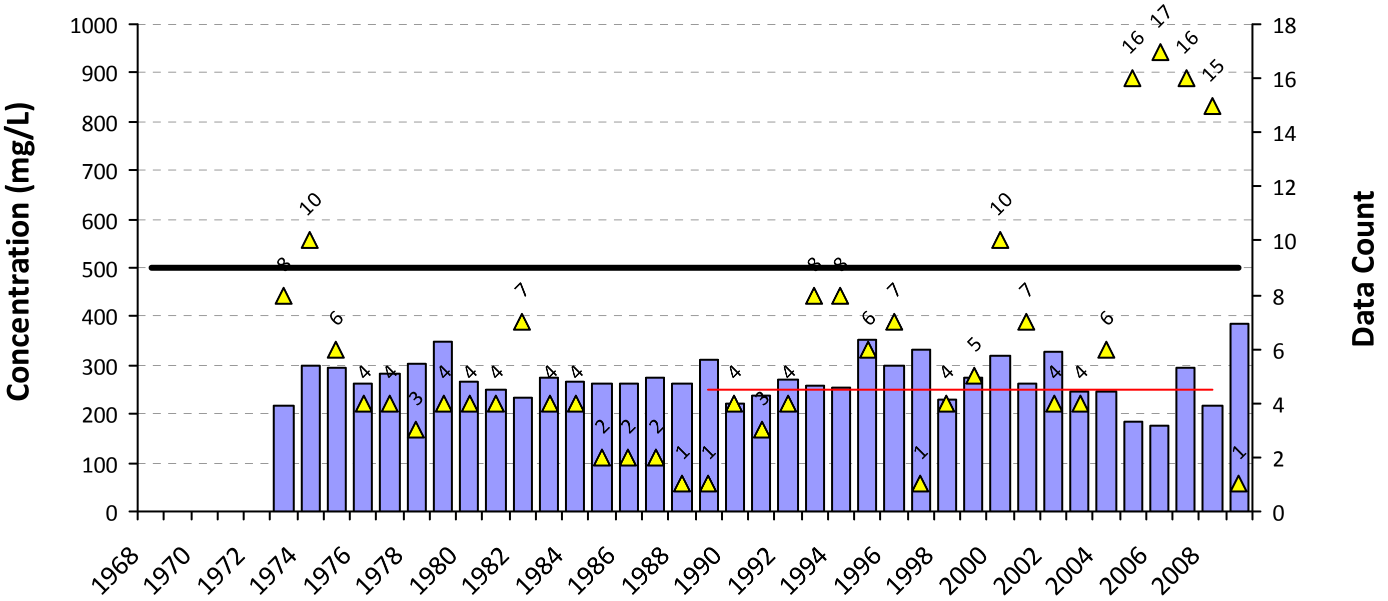
3.3 TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN EXISTING AND POTENTIAL IMPORT WATERS

This study included characterization of TDS concentrations in waters not only within the Trinity River Basin, but also in water resources that are currently imported, or planned to be imported, into the basin. Table 3-3 lists the water resources outside the Trinity River Basin that have been identified as either existing or future sources of water supply for the Trinity River Basin in the water management strategies in the Texas Water Development Board’s 2007 Regional Water Planning database.

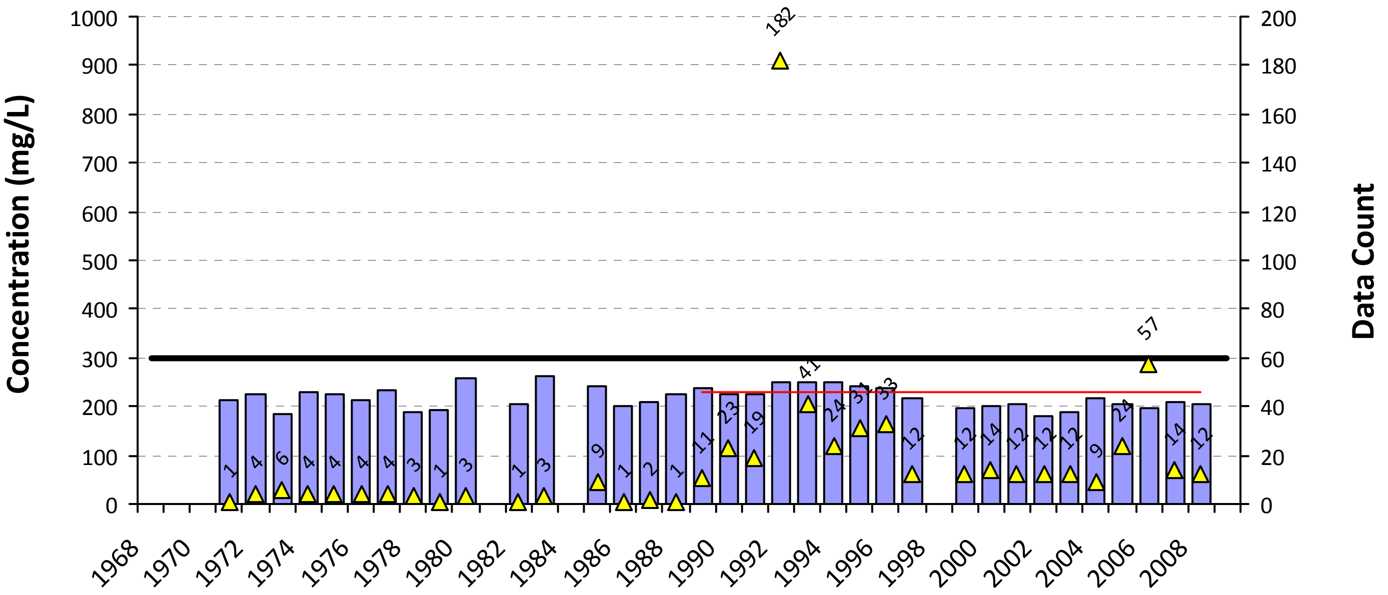
Figure 3-7
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Clear Fork

0829 Clear Fork Trinity River Below Benbrook Lake



0830 Benbrook Lake



🟦 Observed Annual Average
▲ Data Count
━ Current TSWQS Criteria
- - - Proposed TSWQS Criteria
━ Observed Avg (1989-2008)

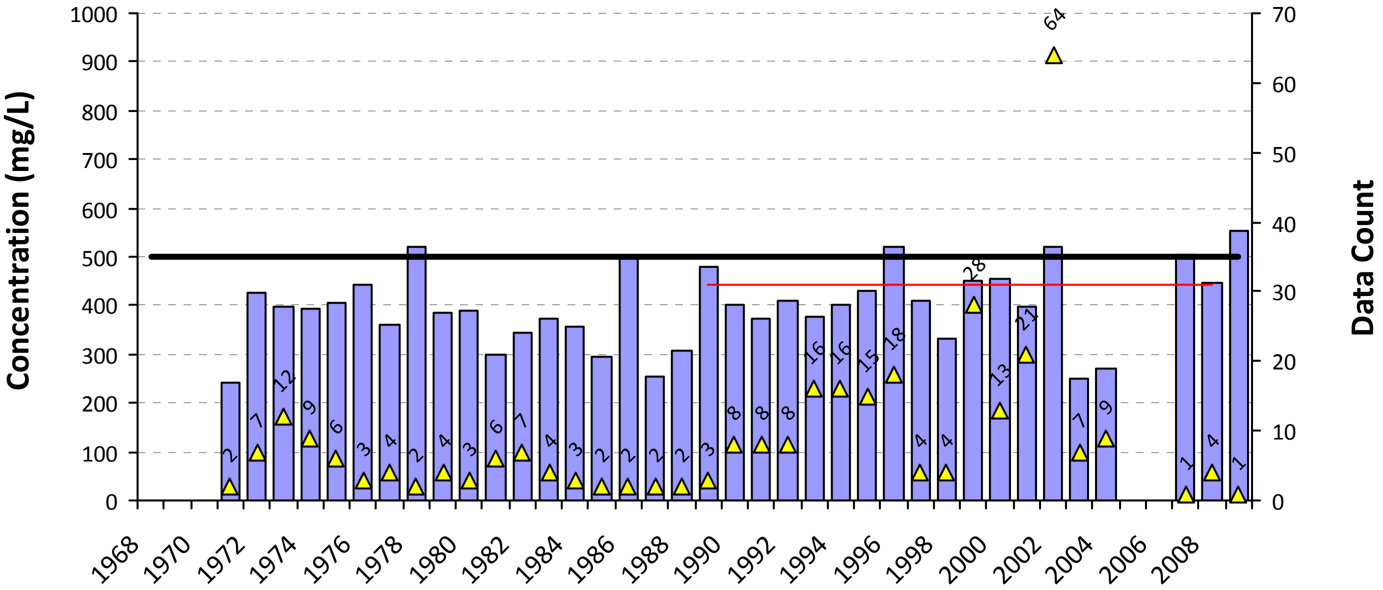
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

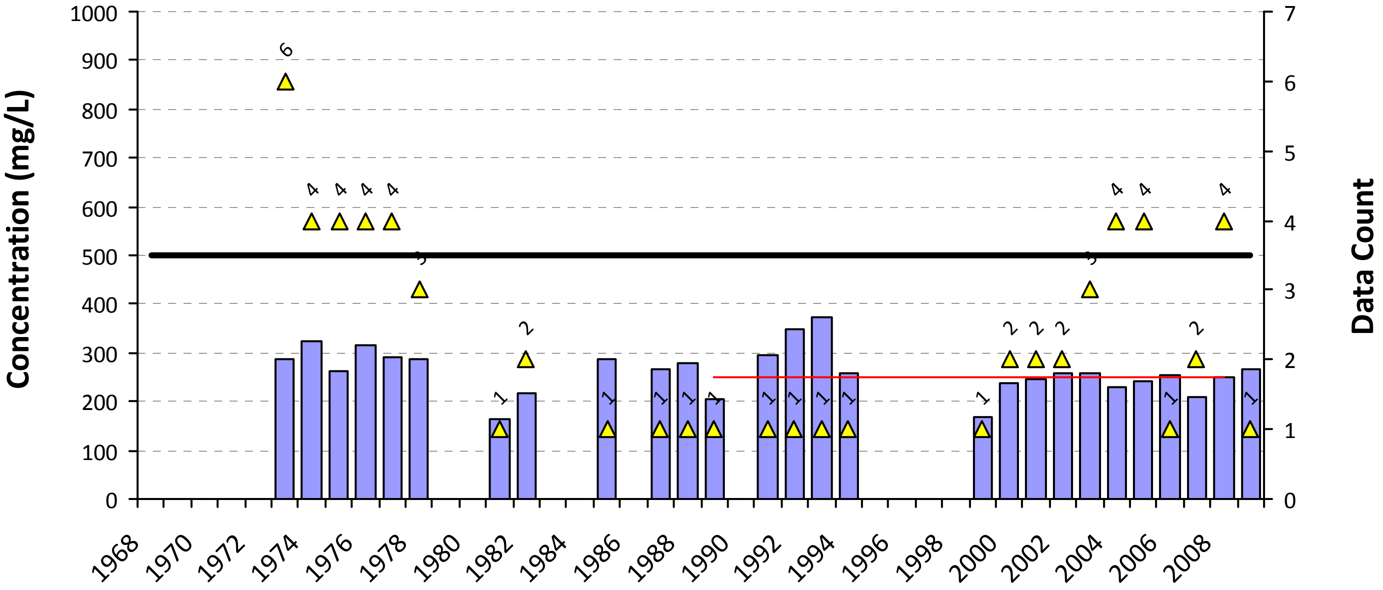
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Clear Fork

0831 Clear Fork Trinity River Below Lake Weatherford



0832 Lake Weatherford



▨ Observed Annual Average △ Data Count — Current TSWQS Criteria - - - Proposed TSWQS Criteria — Observed Avg (1989-2008)

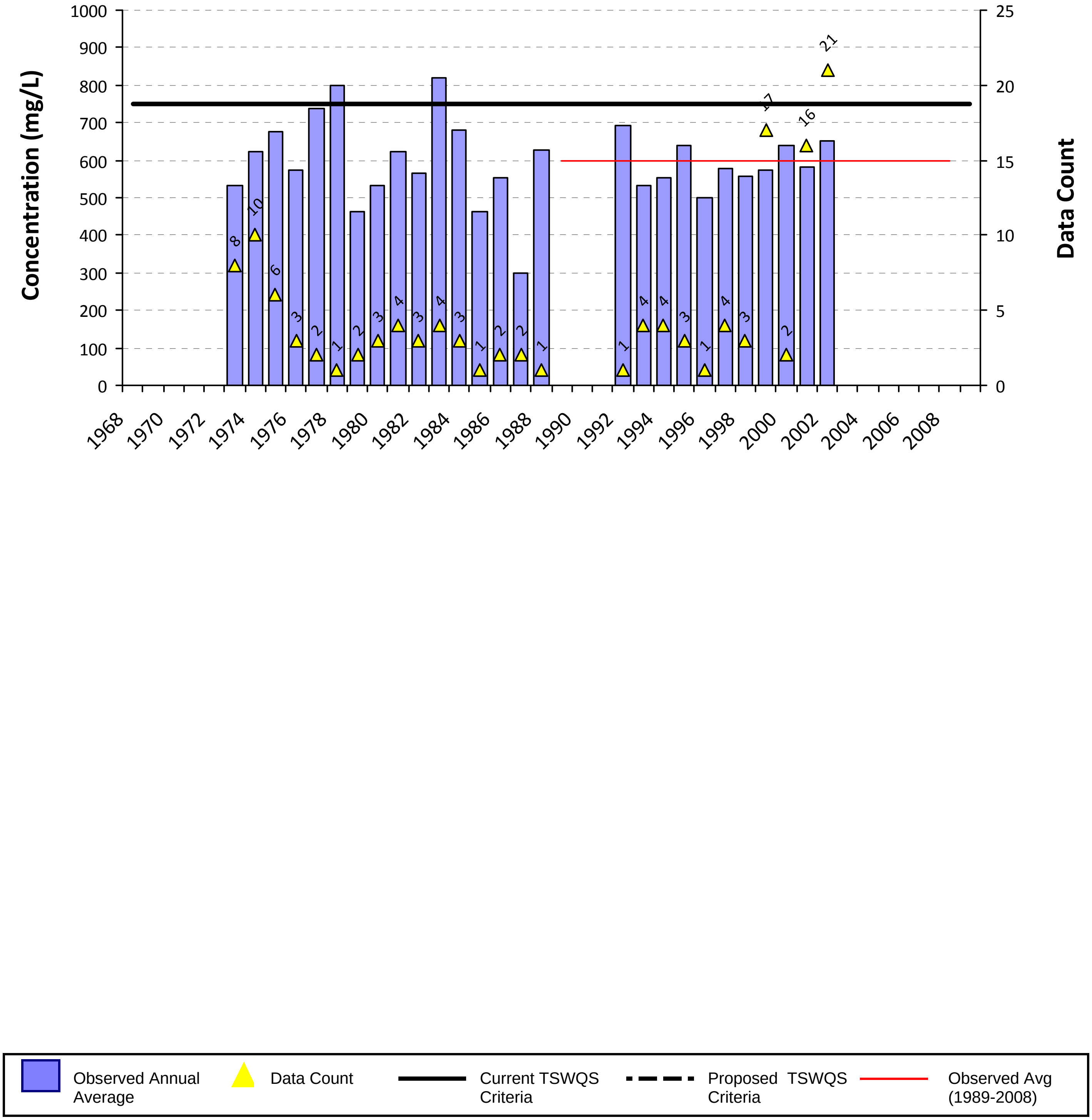
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Clear Fork

0833 Clear Fork Trinity River Above Lake Weatherford



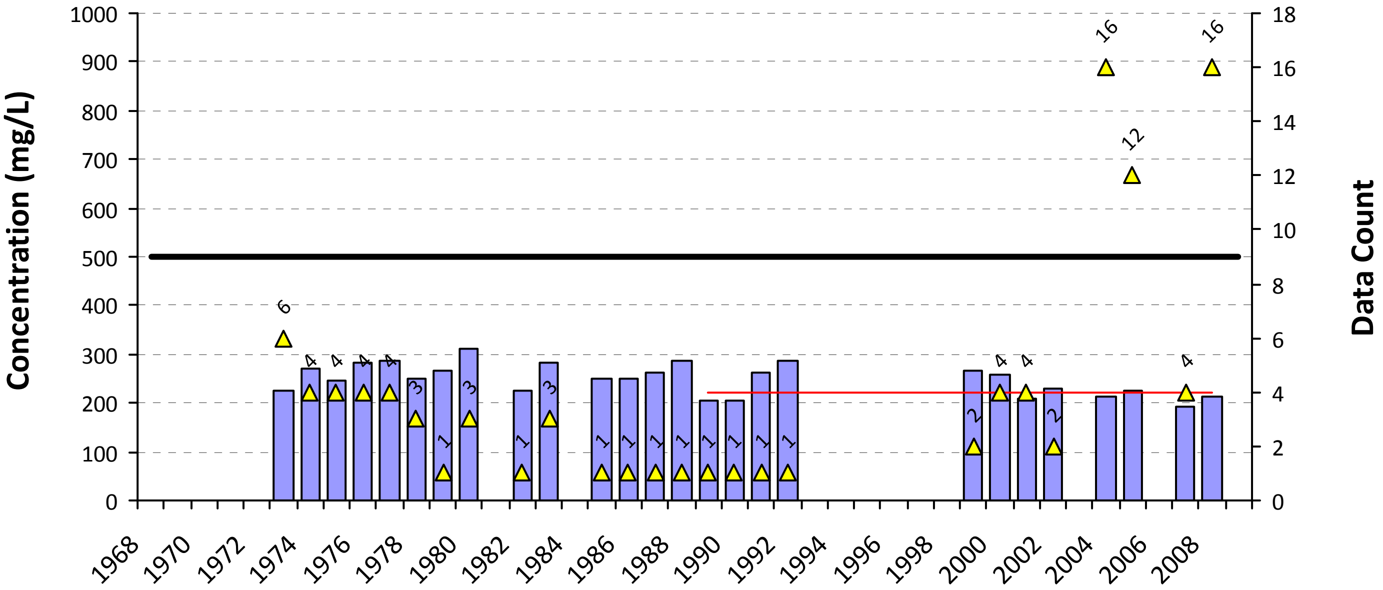
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

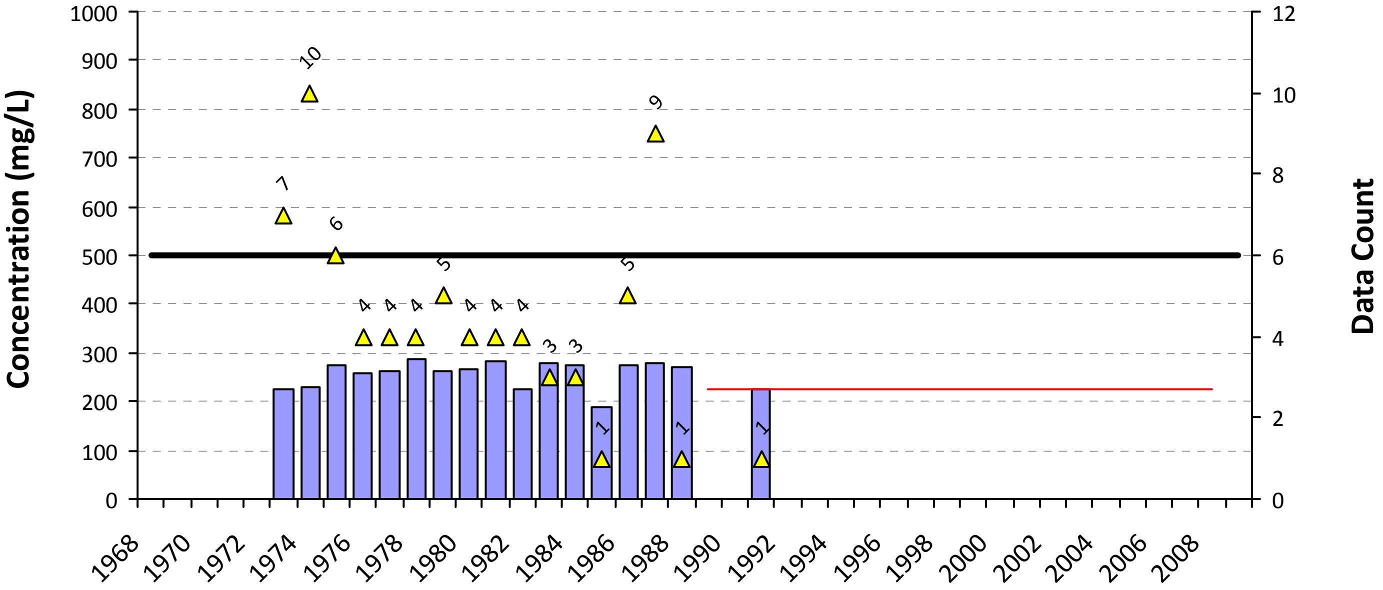
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

West Fork

0807 Lake Worth



0808 West Fork Trinity River Below Eagle Mountain Reservoir



- ■ Observed Annual Average
- ▲ Data Count
- ━ Current TSWQS Criteria
- ╍ Proposed TSWQS Criteria
- ━ Observed Avg (1989-2008)

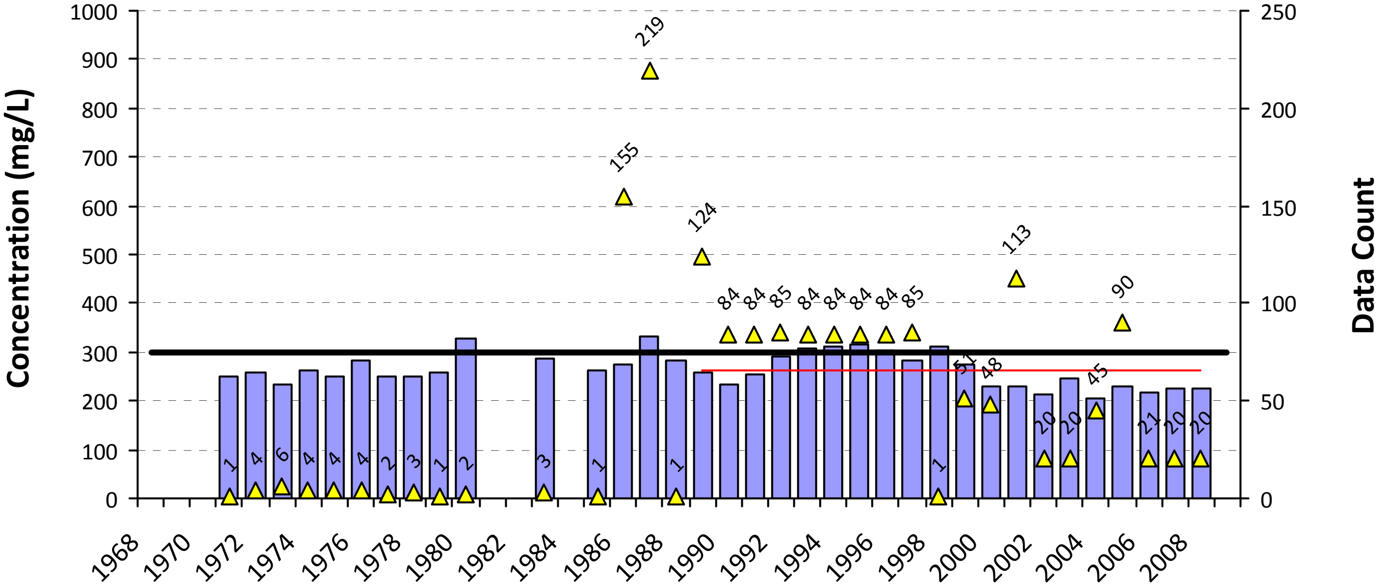
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

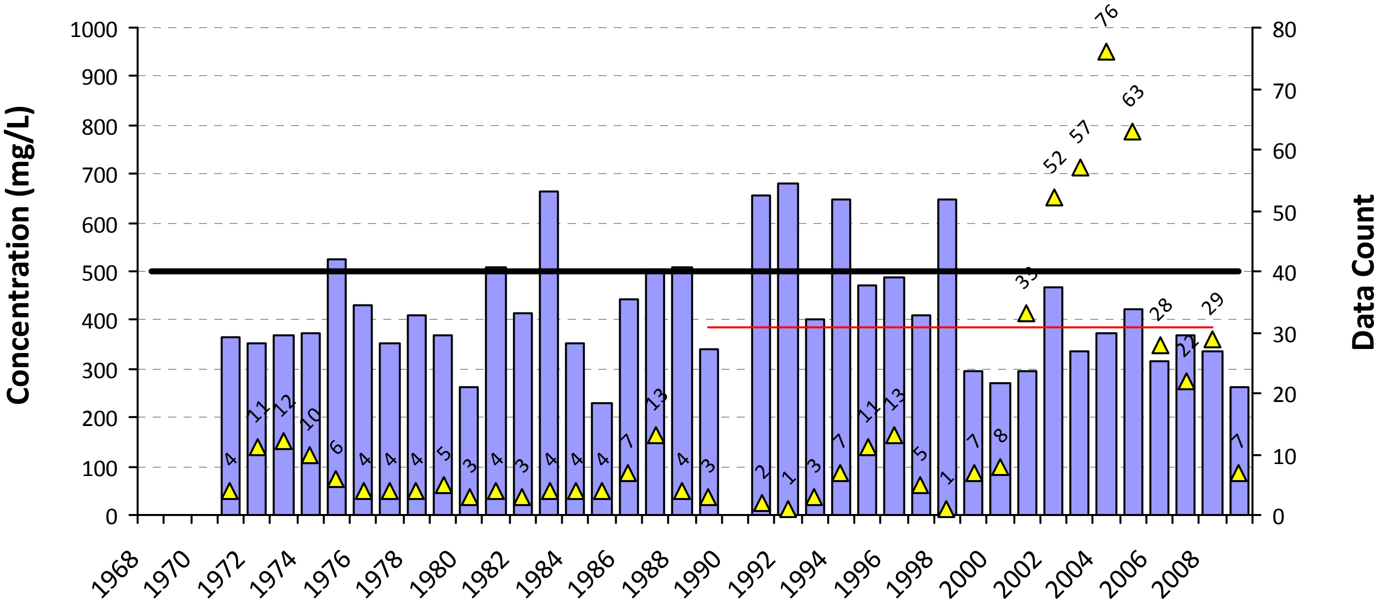
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

West Fork

0809 Eagle Mountain Reservoir



0810 West Fork Trinity River Below Bridgeport Reservoir



▨ Observed Annual Average
▲ Data Count
━━ Current TSWQS Criteria
- - - Proposed TSWQS Criteria
― Observed Avg (1989-2008)

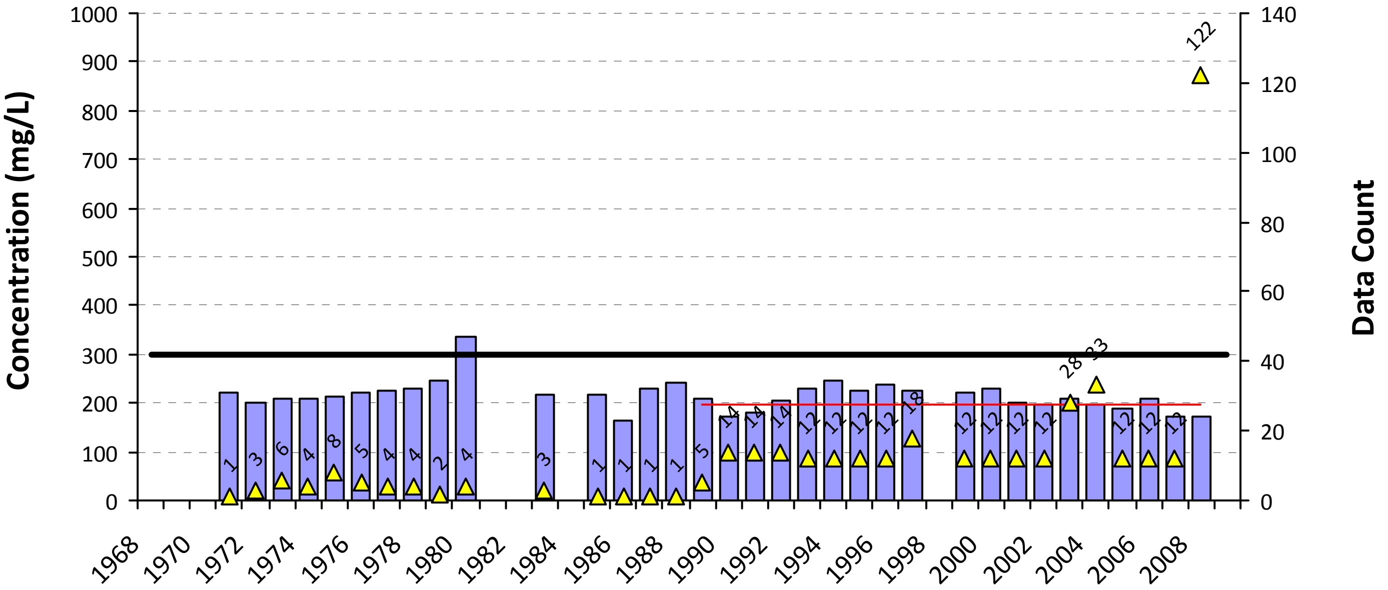
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

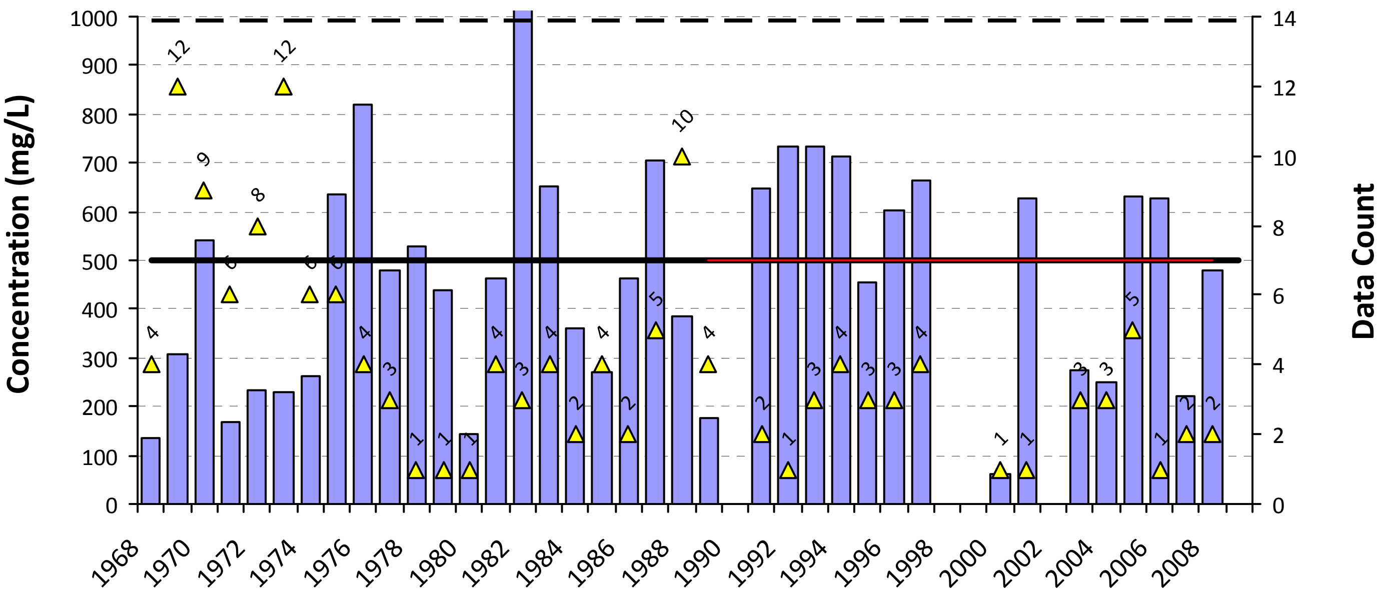
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

West Fork

0811 Bridgeport Reservoir



0812 West Fork Trinity River Above Bridgeport Reservoir



▨ Observed Annual Average
▲ Data Count
━ Current TSWQS Criteria
- - Proposed TSWQS Criteria
— Observed Avg (1989-2008)

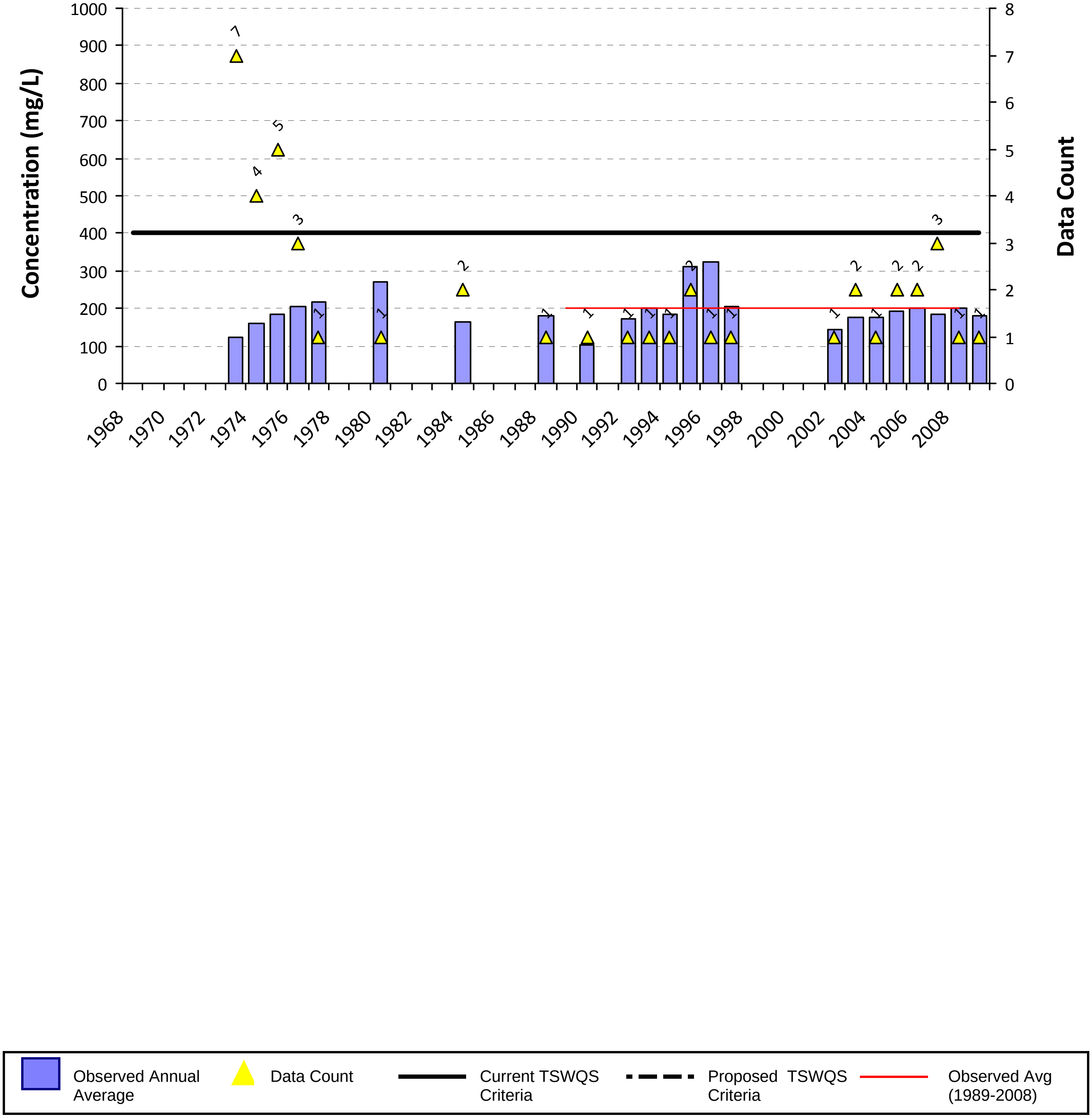
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

West Fork

0834 Lake Amon G. Carter



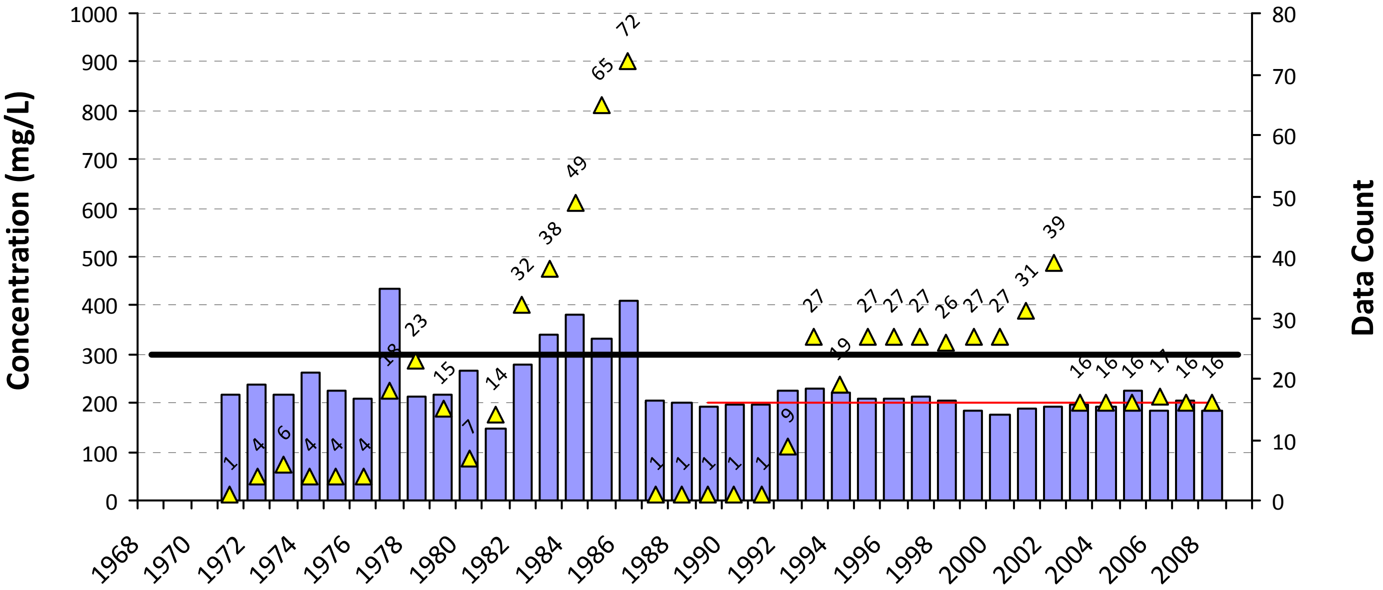
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

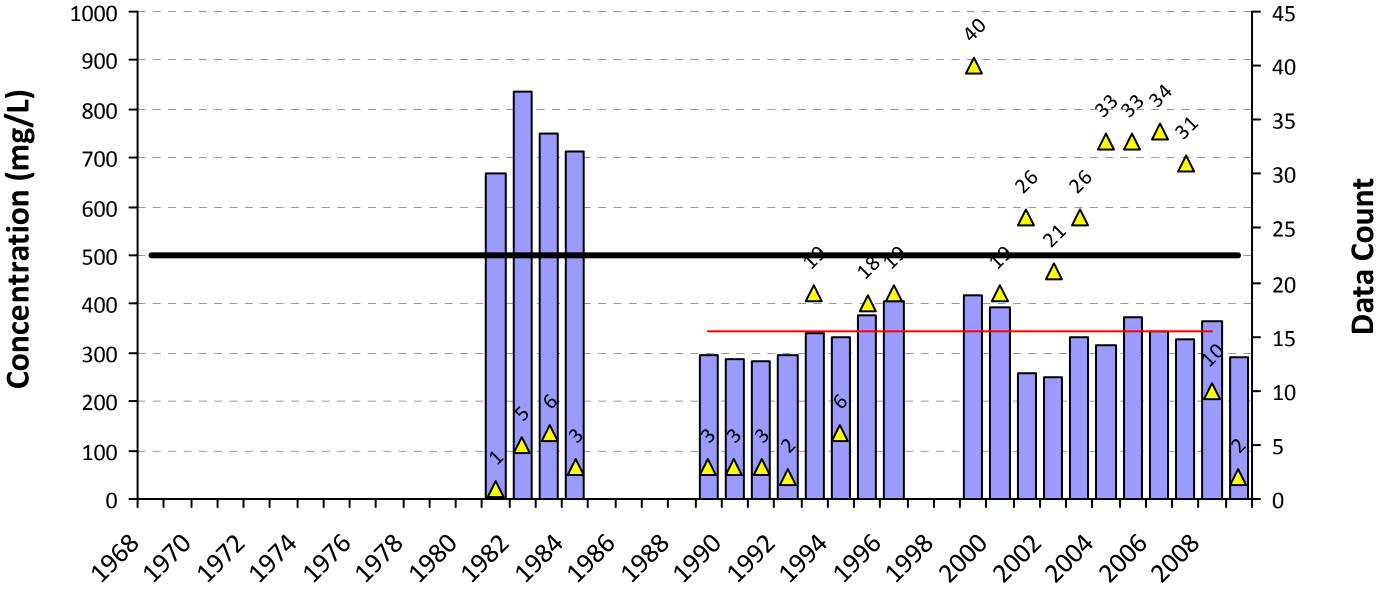
Village Creek & Mountain Creek

0828 Lake Arlington



0838 Joe Pool Lake

Joe Pool Lake was impounded in 1986 and filled by 1989.



🟦 Observed Annual Average	▲ Data Count	▬ Current TSWQS Criteria	- - - Proposed TSWQS Criteria	― Observed Avg (1989-2008)

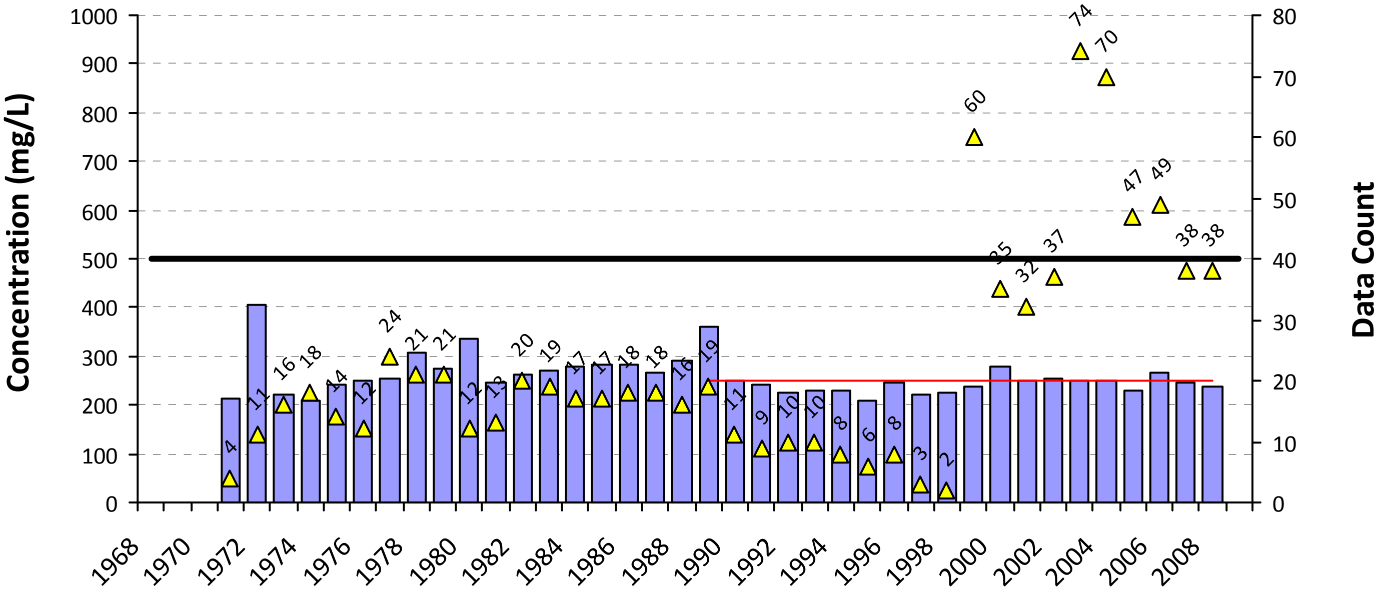
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

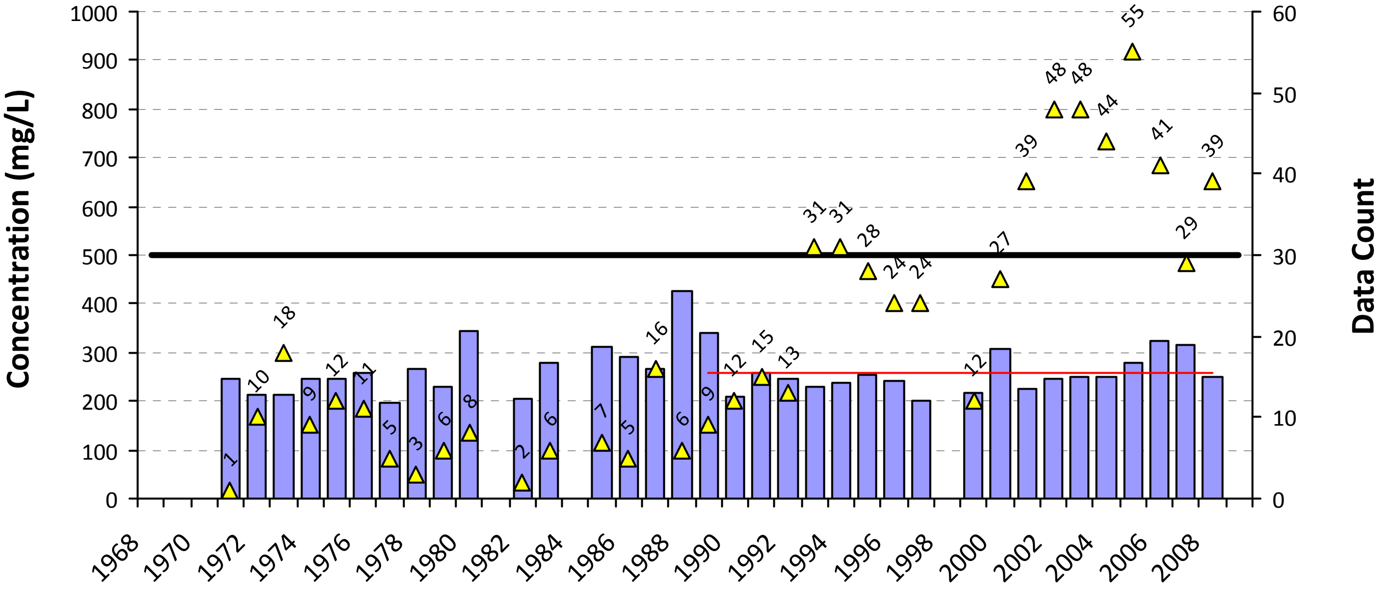
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Elm Fork

0822 Elm Fork Trinity River Below Lewisville Lake



0823 Lewisville Lake



■ Observed Annual Average	▲ Data Count	▬ Current TSWQS Criteria	‒ ‒ ‒ Proposed TSWQS Criteria	― Observed Avg (1989-2008)

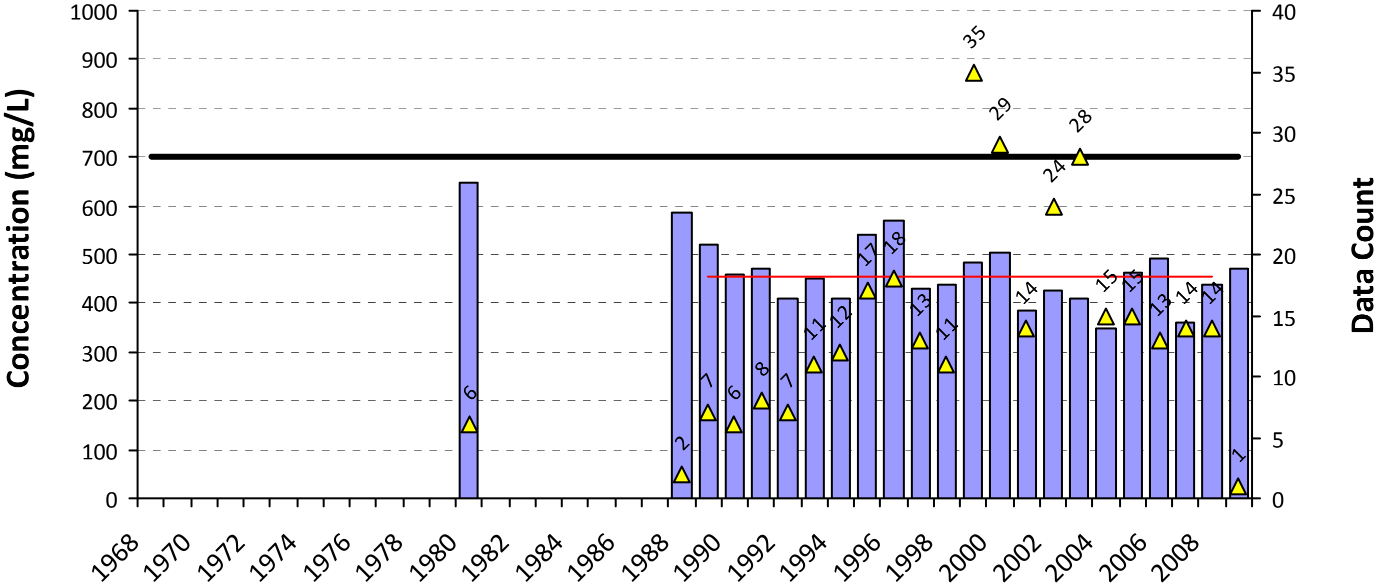
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

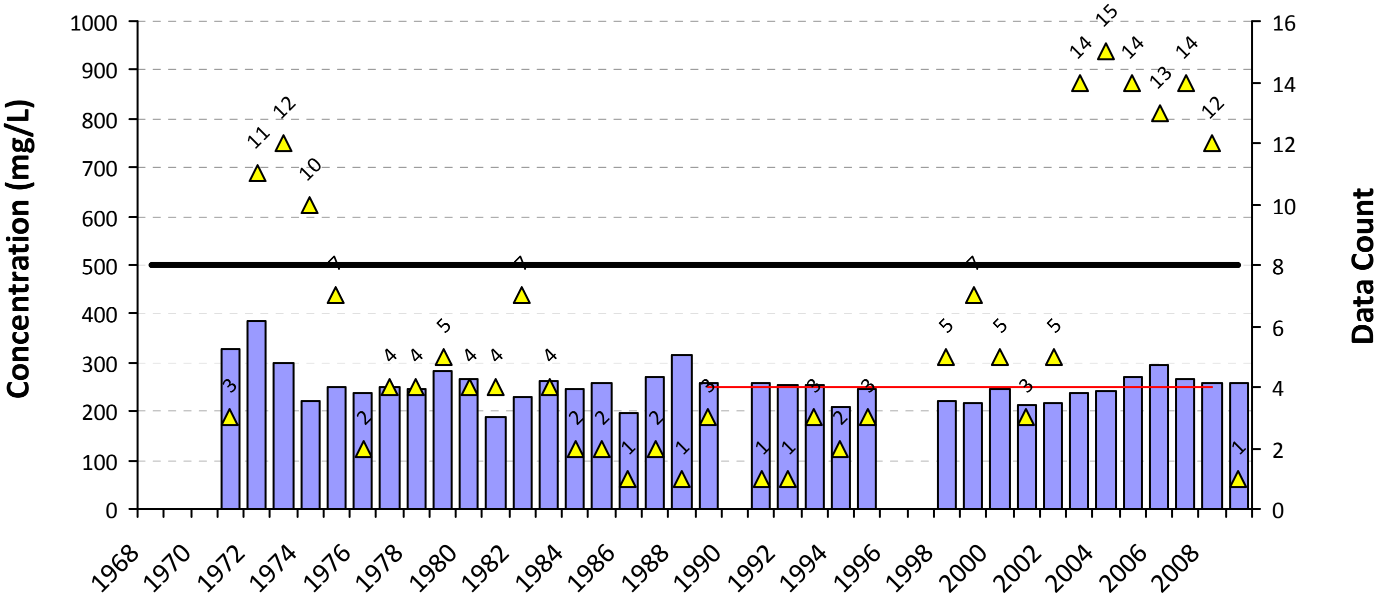
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Elm Fork

0824 Elm Fork Trinity River Above Ray Roberts Lake



0825 Denton Creek



🟦	Observed Annual Average	▲	Data Count	━━	Current TSWQS Criteria	━ ━ ━	Proposed TSWQS Criteria	━━	Observed Avg (1989-2008)

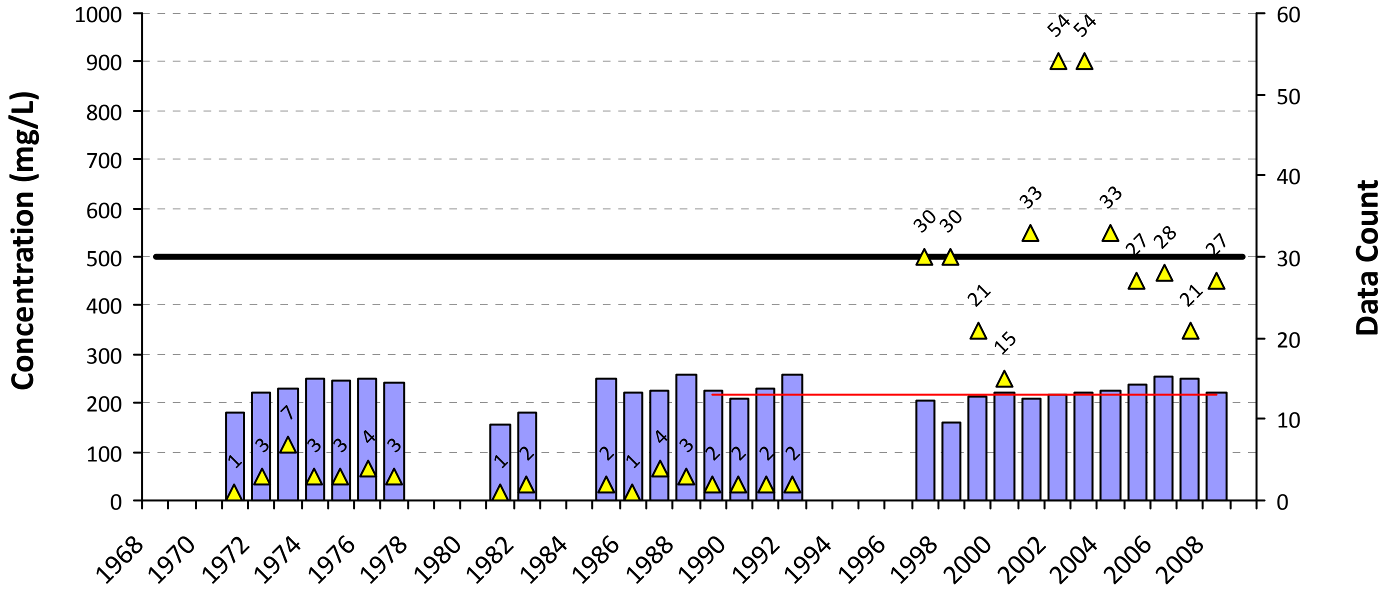
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

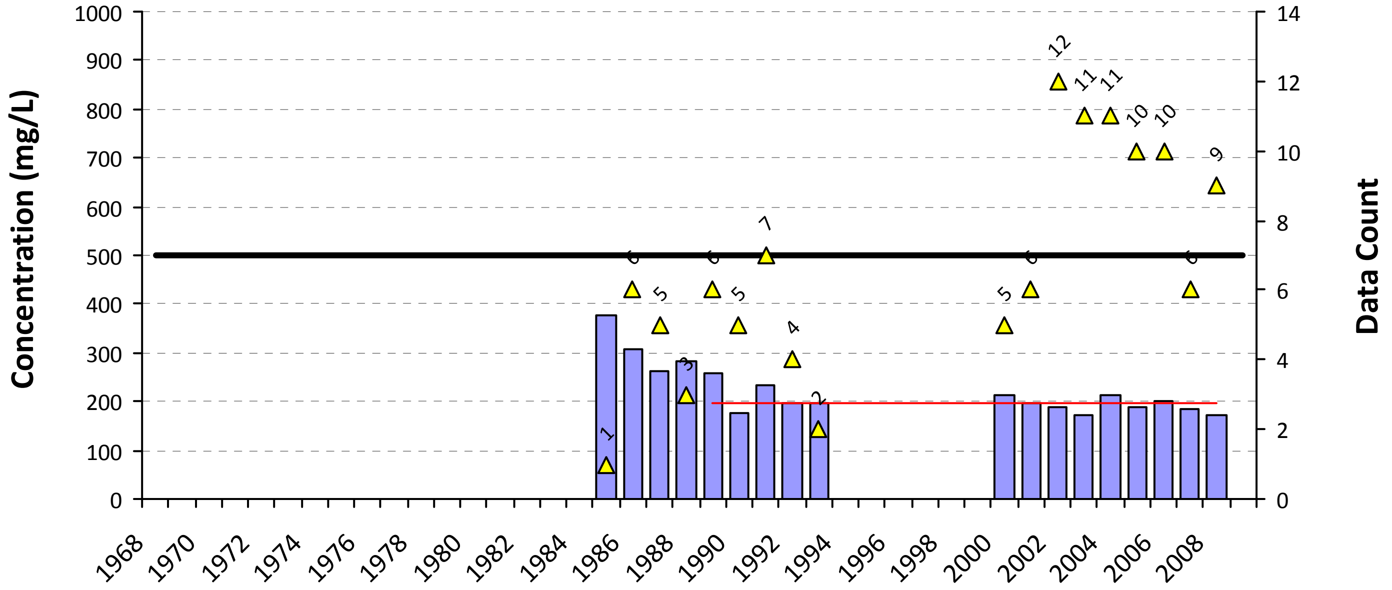
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Elm Fork

0826 Grapevine Lake



0839 Elm Fork Trinity River Below Ray Roberts Lake



🟦 Observed Annual Average
▲ Data Count
▬ Current TSWQS Criteria
- - - Proposed TSWQS Criteria
— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

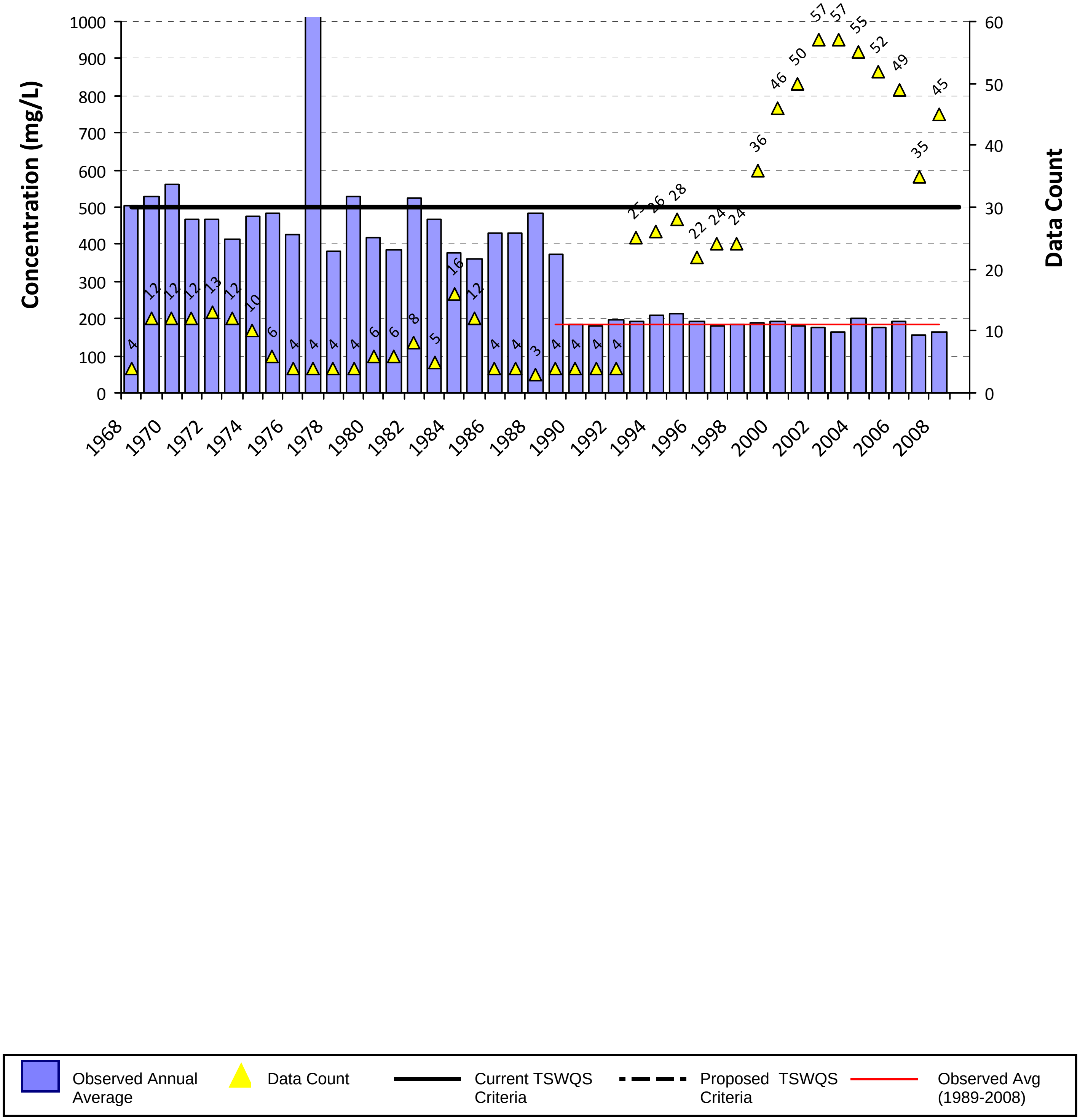
(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Elm Fork

0840 Ray Roberts Lake

Ray Roberts Lake was impounded in 1987 and filled by 1990.



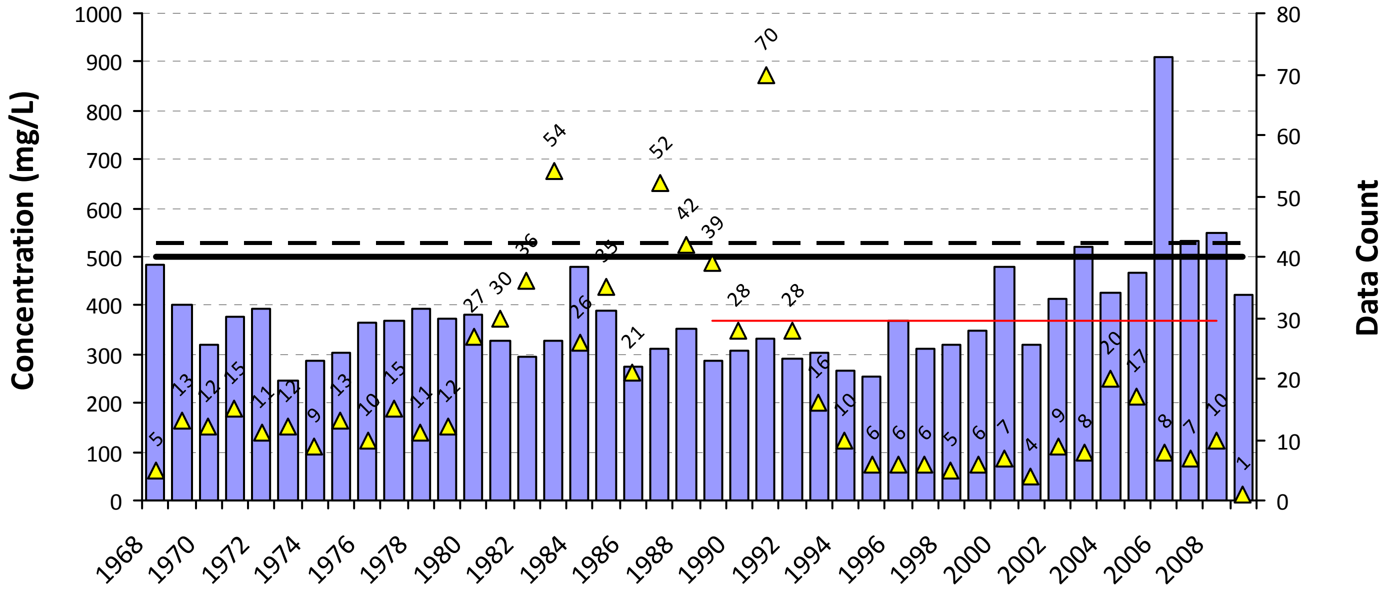
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

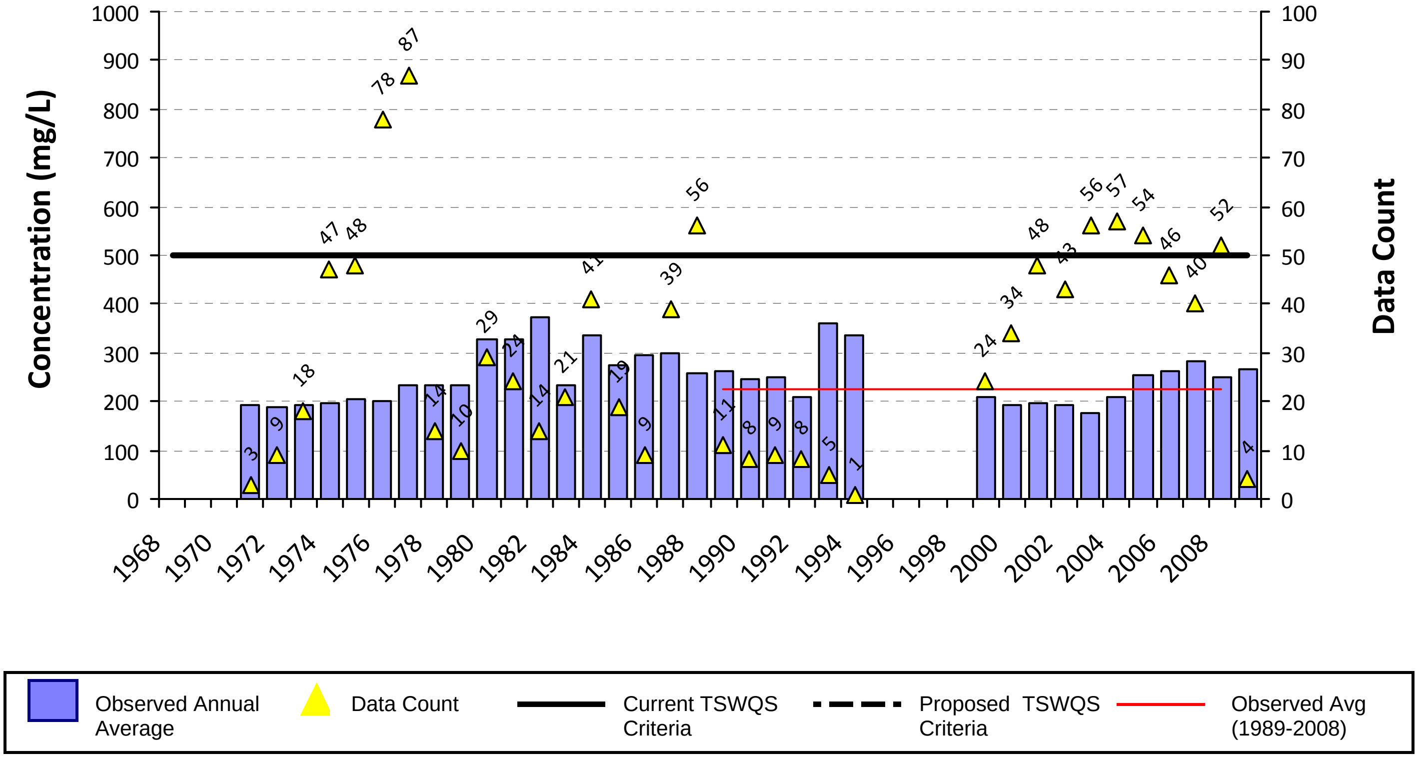
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

East Fork

0819 East Fork Trinity River



0820 Lake Ray Hubbard



(1) Data set includes TDS derived from conductivity data (0.65 conversion)

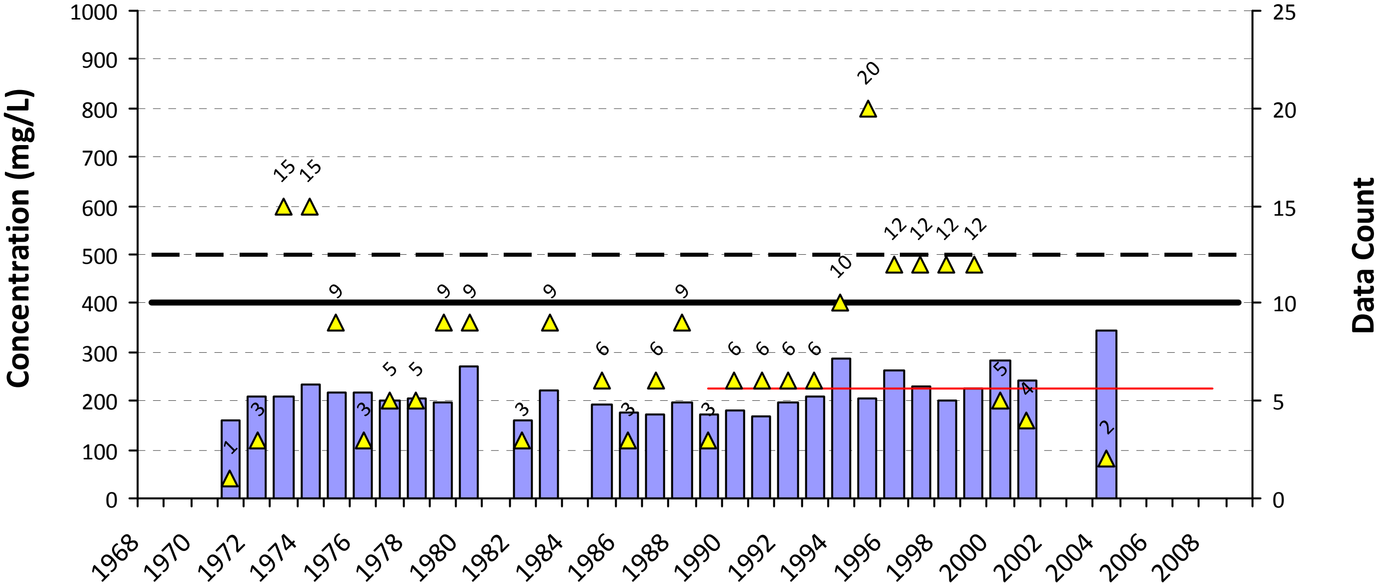
(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)

Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

East Fork

0821 Lake Lavon



🟦 Observed Annual Average ▲ Data Count ━━ Current TSWQS Criteria ━ ━ Proposed TSWQS Criteria ── Observed Avg (1989-2008)

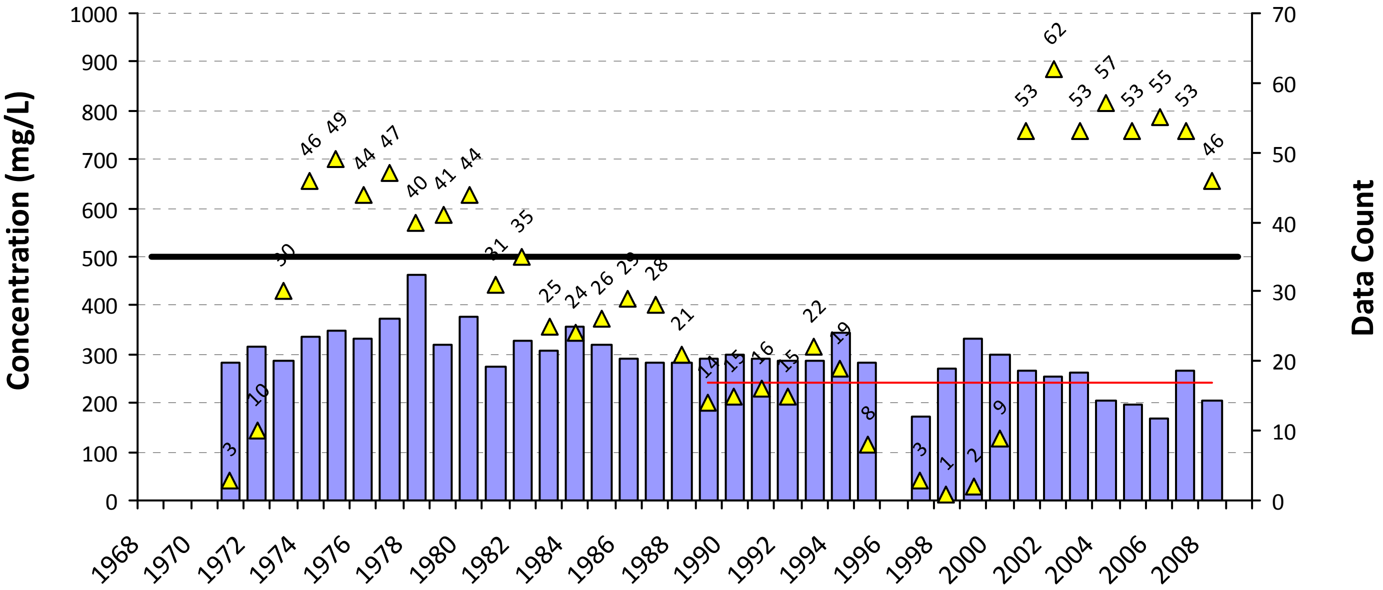
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

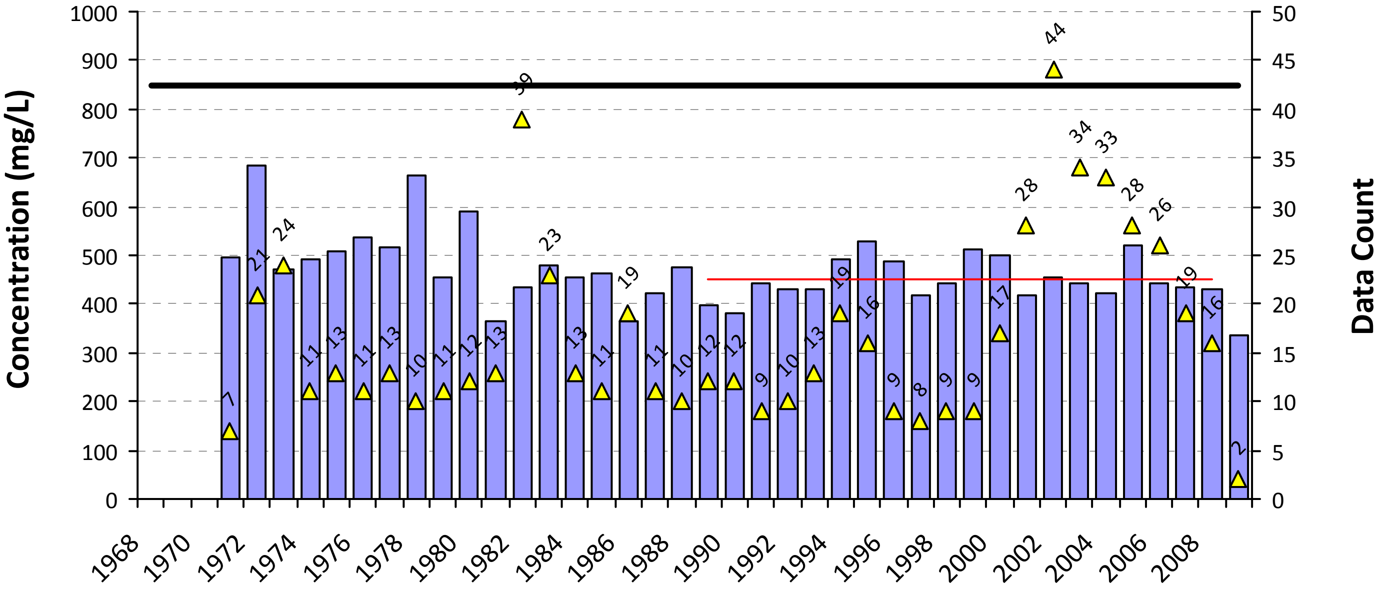
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Upper Main Stem

0806 West Fork Trinity River Below Lake Worth



0841 Lower West Fork Trinity River



🟦 Observed Annual Average	▲ Data Count	━━ Current TSWQS Criteria	‒ ‒ ‒ Proposed TSWQS Criteria	━━ Observed Avg (1989-2008)

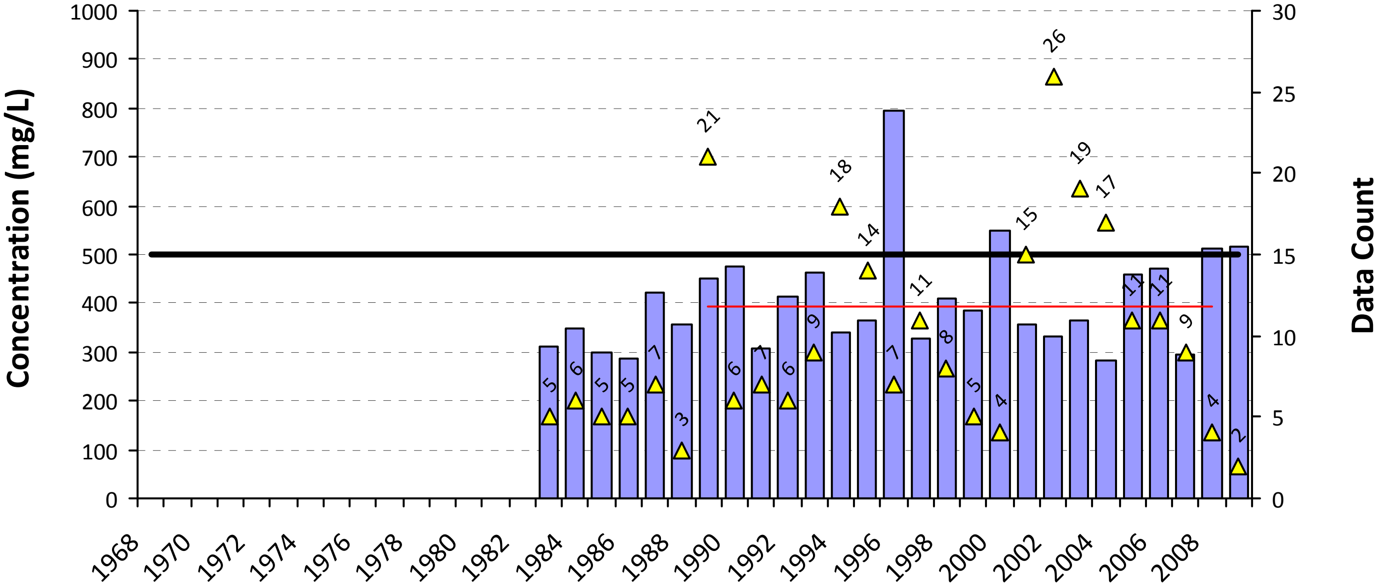
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

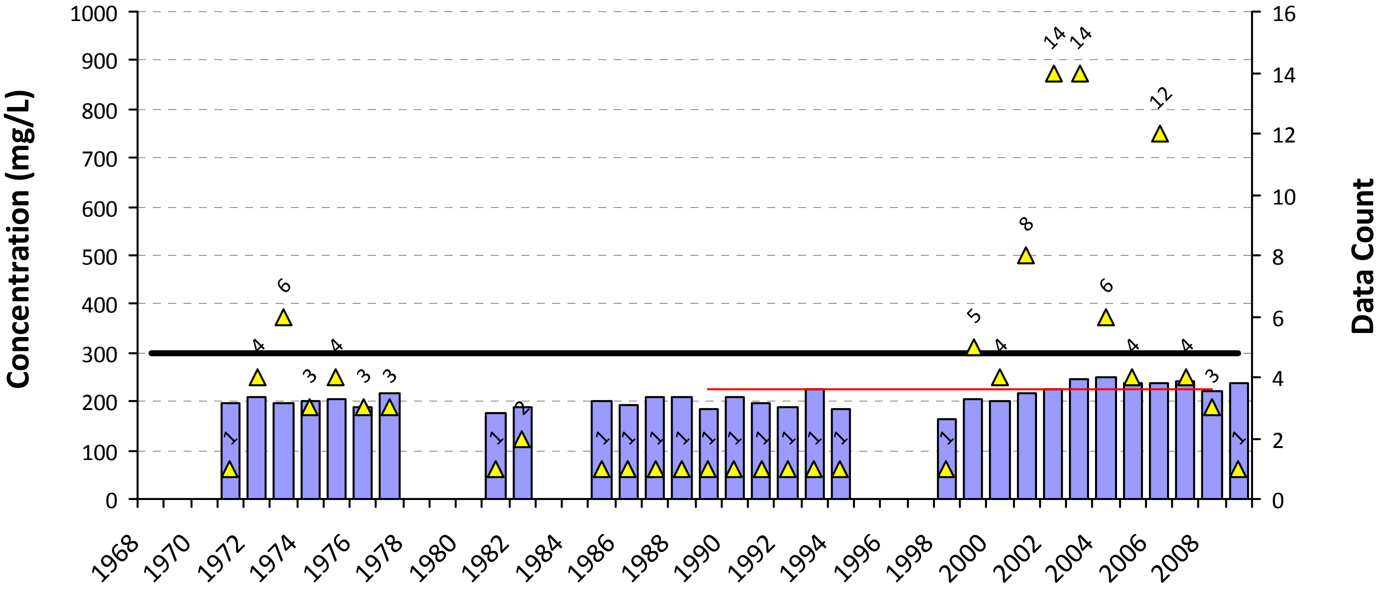
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Richland-Chambers & Cedar Creek

0814 Chambers Creek Above Richland-Chambers Reservoir



0815 Bardwell Reservoir



🟦 Observed Annual Average	▲ Data Count	━━ Current TSWQS Criteria	‒ ‒ ‒ Proposed TSWQS Criteria	━━ Observed Avg (1989-2008)

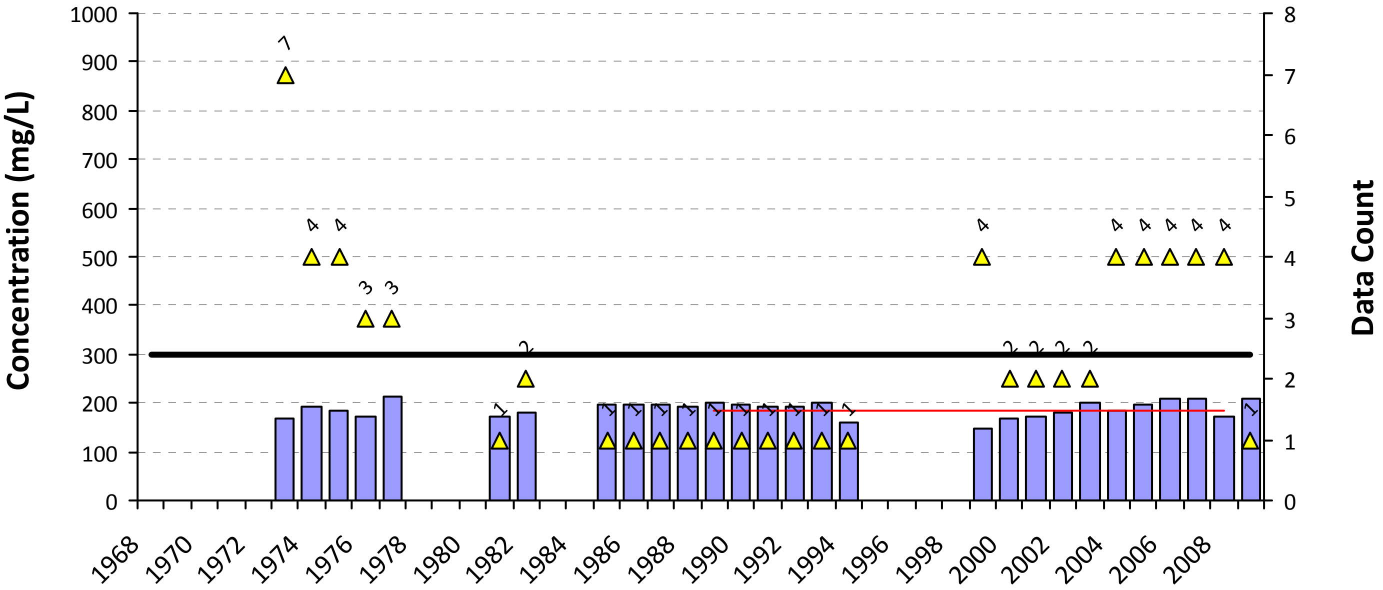
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

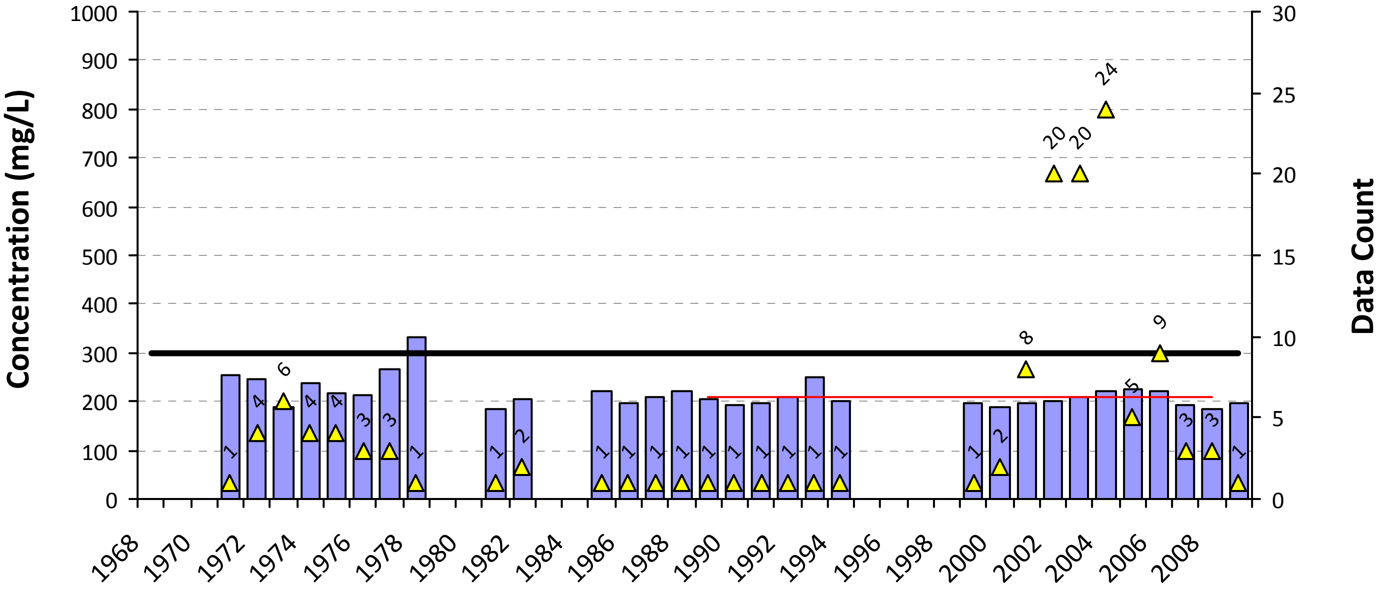
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Richland-Chambers & Cedar Creek

0816 Lake Waxahachie



0817 Navarro Mills Lake



▬ Observed Annual Average
▲ Data Count
━━ Current TSWQS Criteria
- - - Proposed TSWQS Criteria
── Observed Avg (1989-2008)

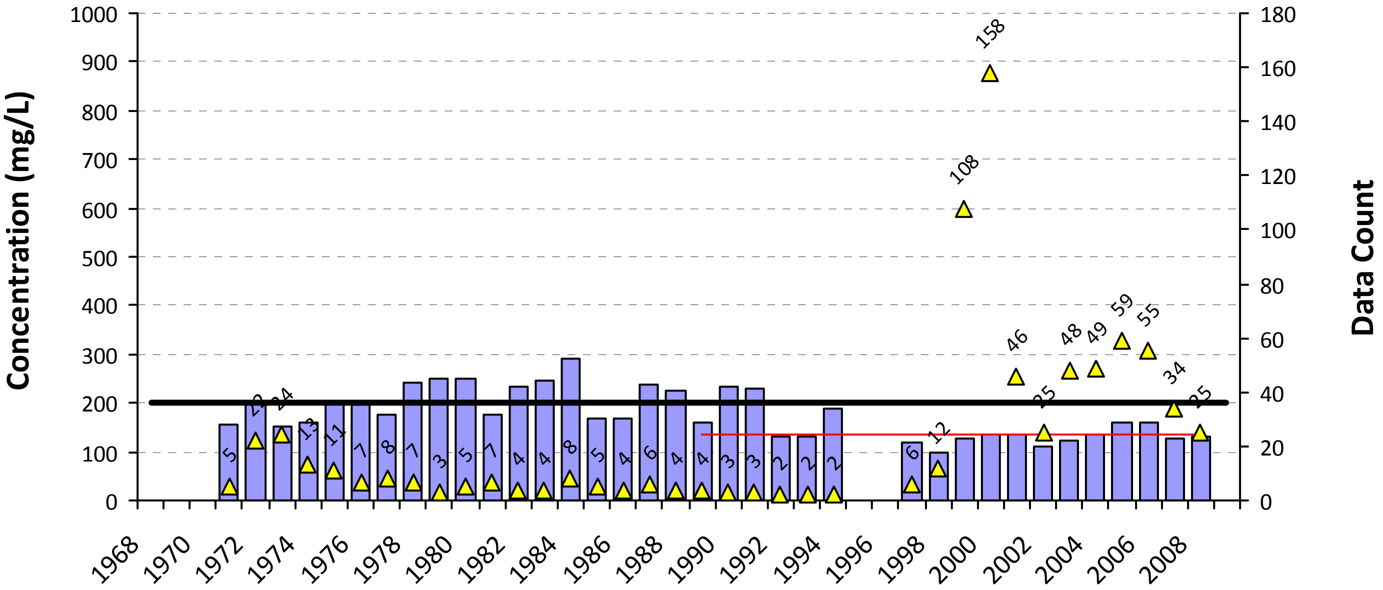
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

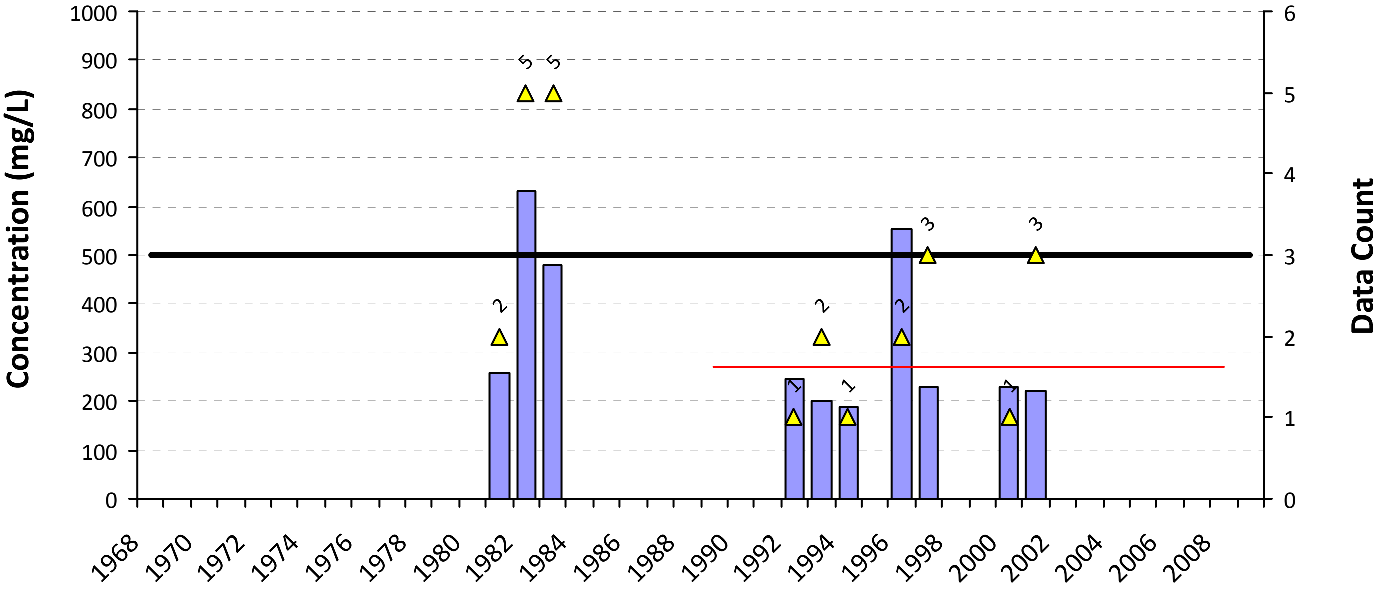
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Richland-Chambers & Cedar Creek

0818 Cedar Creek Reservoir



0835 Richland Creek Below Richland-Chambers Reservoir



🟦 Observed Annual Average	▲ Data Count	— Current TSWQS Criteria	- - Proposed TSWQS Criteria	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

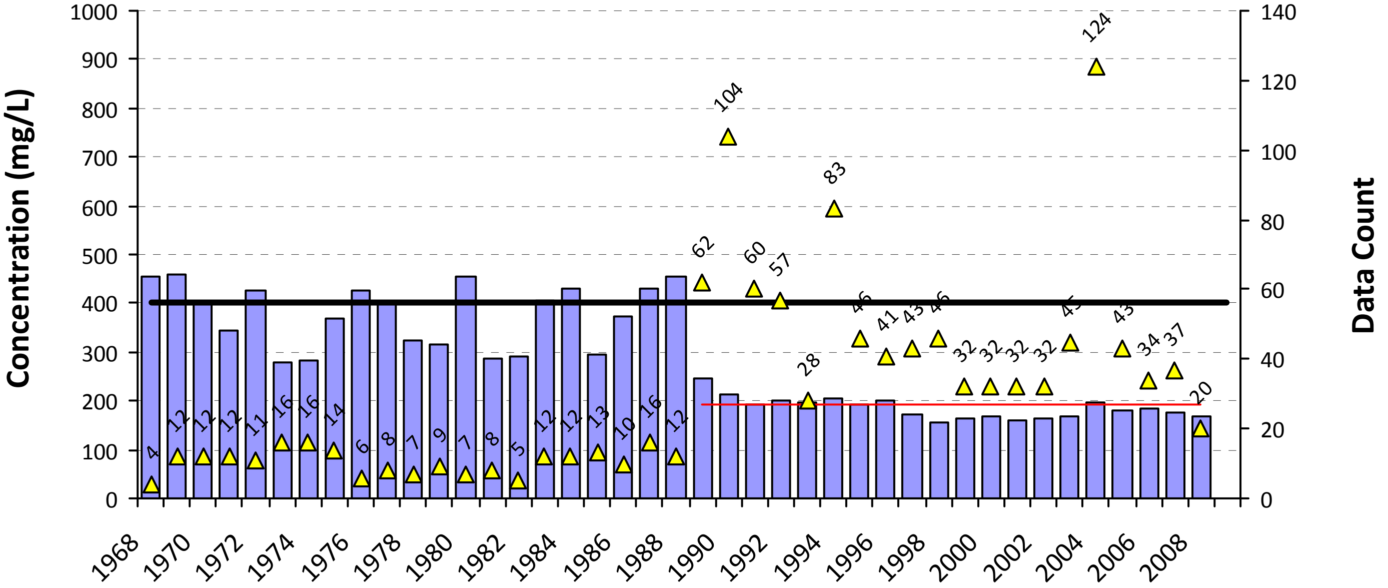
(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

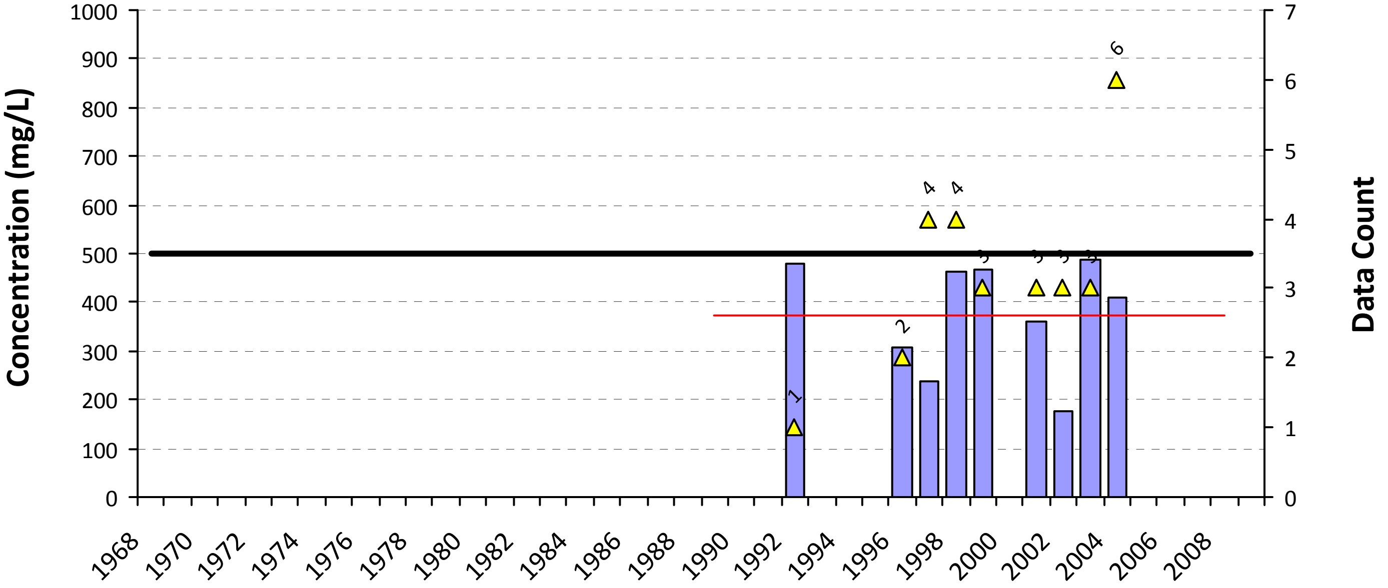
Richland-Chambers & Cedar Creek

0836 Richland-Chambers Reservoir

Richland-Chambers Reservoir was impounded in 1987 and filled by 1989.



0837 Richland Creek Above Richland-Chambers Reservoir



▬	Observed Annual Average	▲	Data Count	━━	Current TSWQS Criteria	╍╍	Proposed TSWQS Criteria	━	Observed Avg (1989-2008)

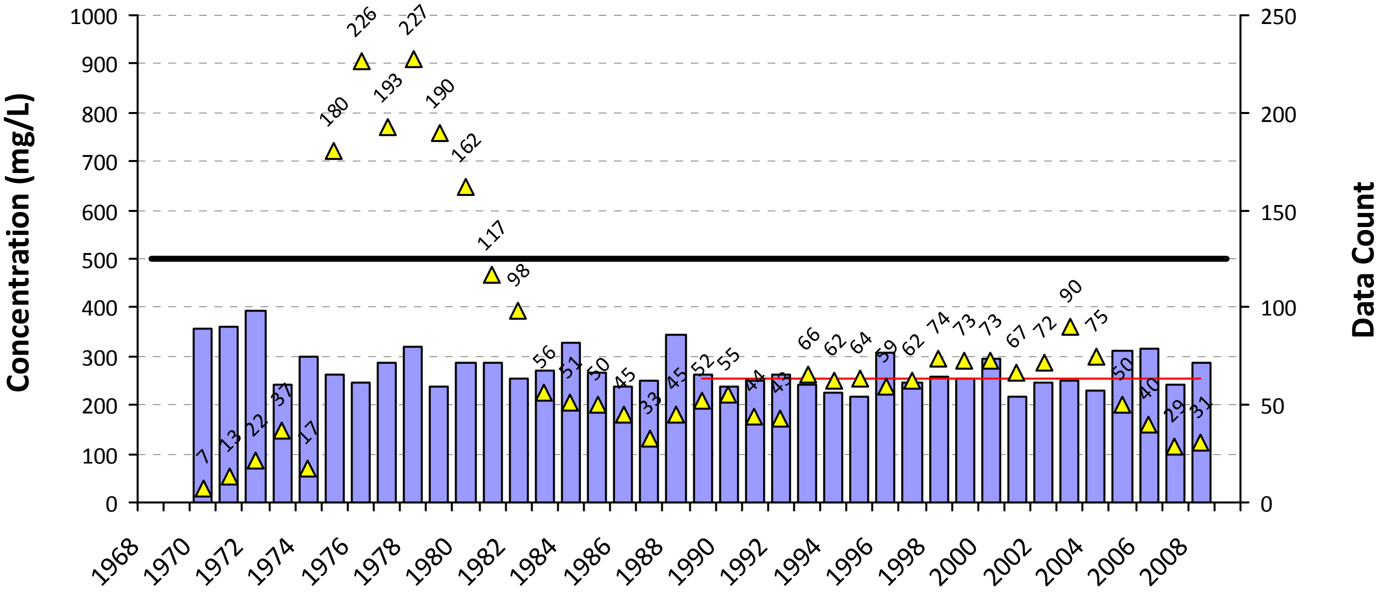
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

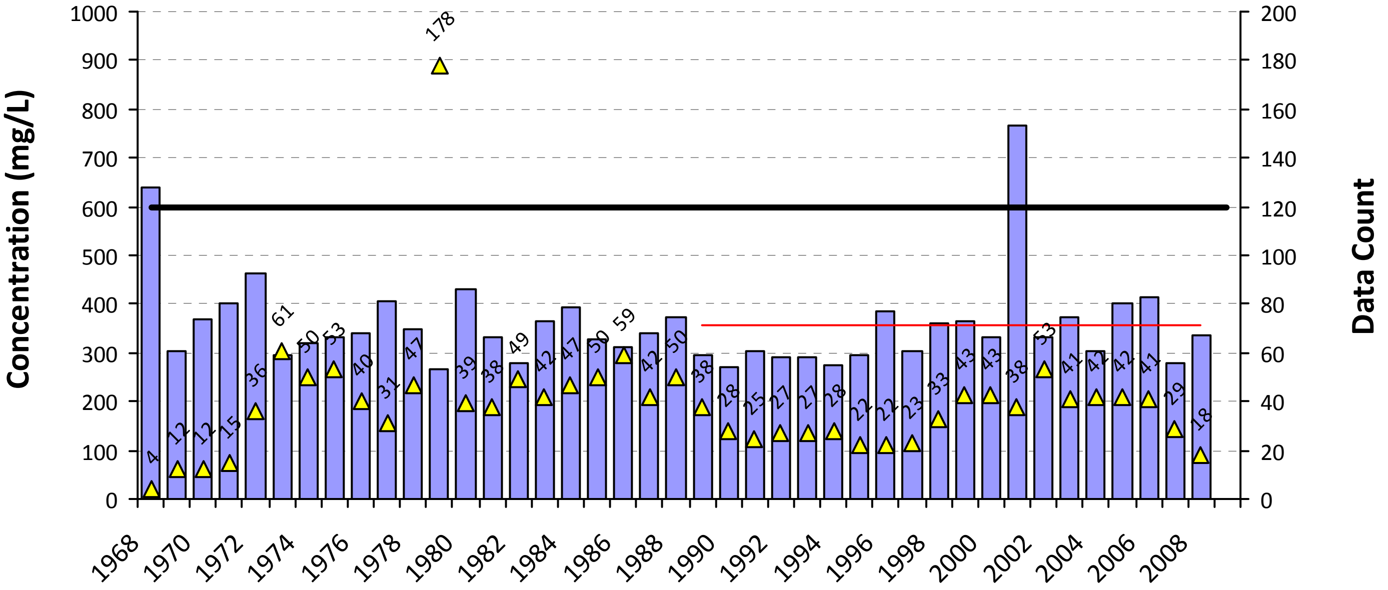
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Lower Main Stem

0803 Lake Livingston



0804 Trinity River Above Lake Livingston



🟦 Observed Annual Average
▲ Data Count
━ Current TSWQS Criteria
╍ Proposed TSWQS Criteria
— Observed Avg (1989-2008)

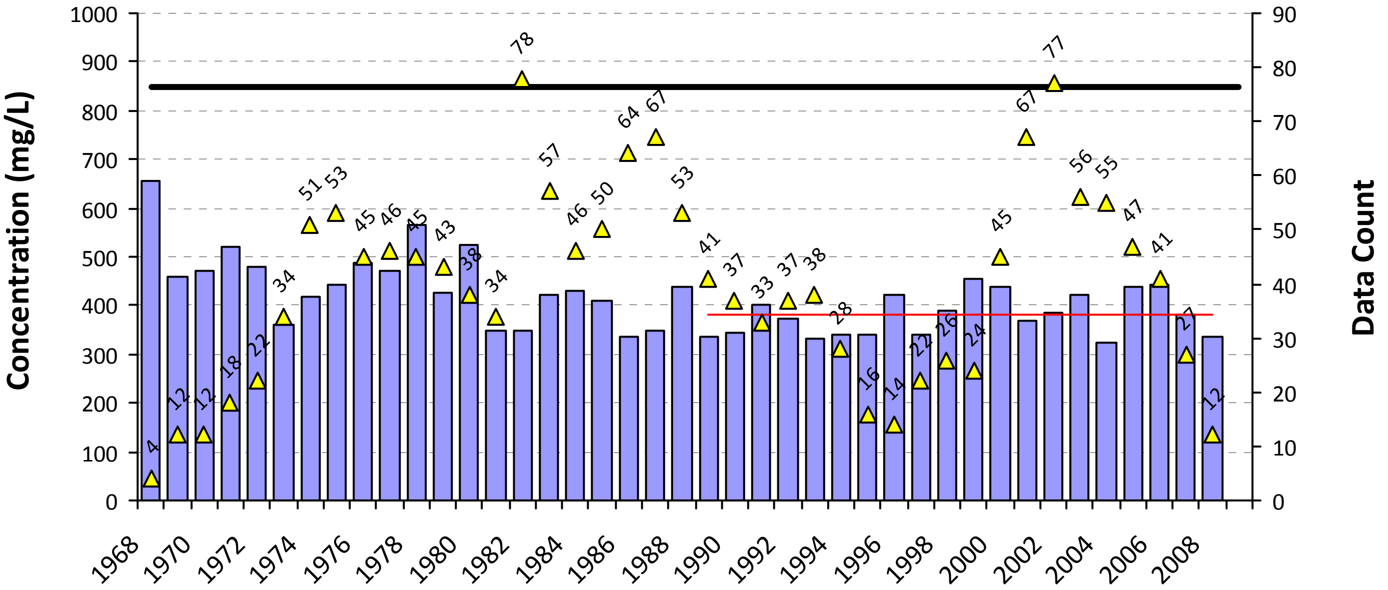
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

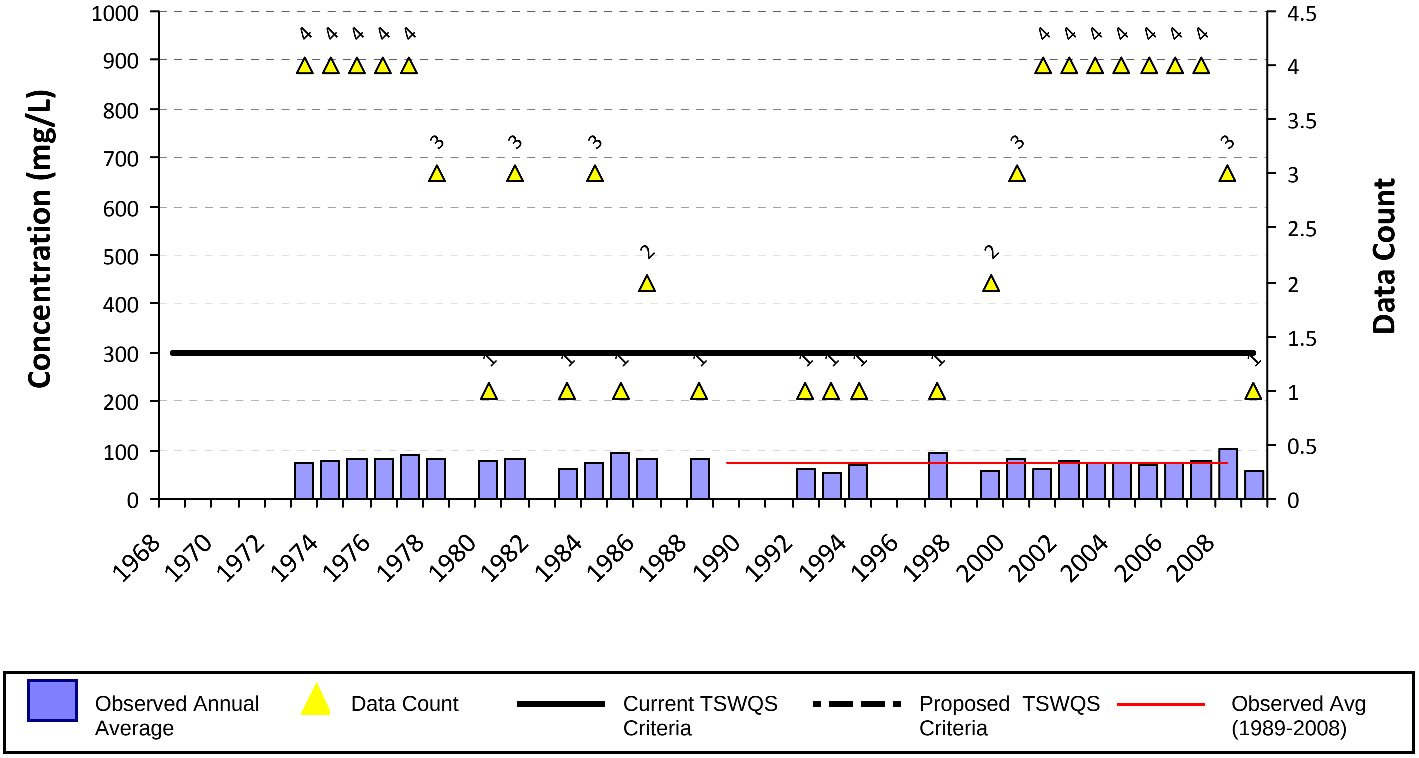
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Lower Main Stem

0805 Upper Trinity River



0813 Houston County Lake



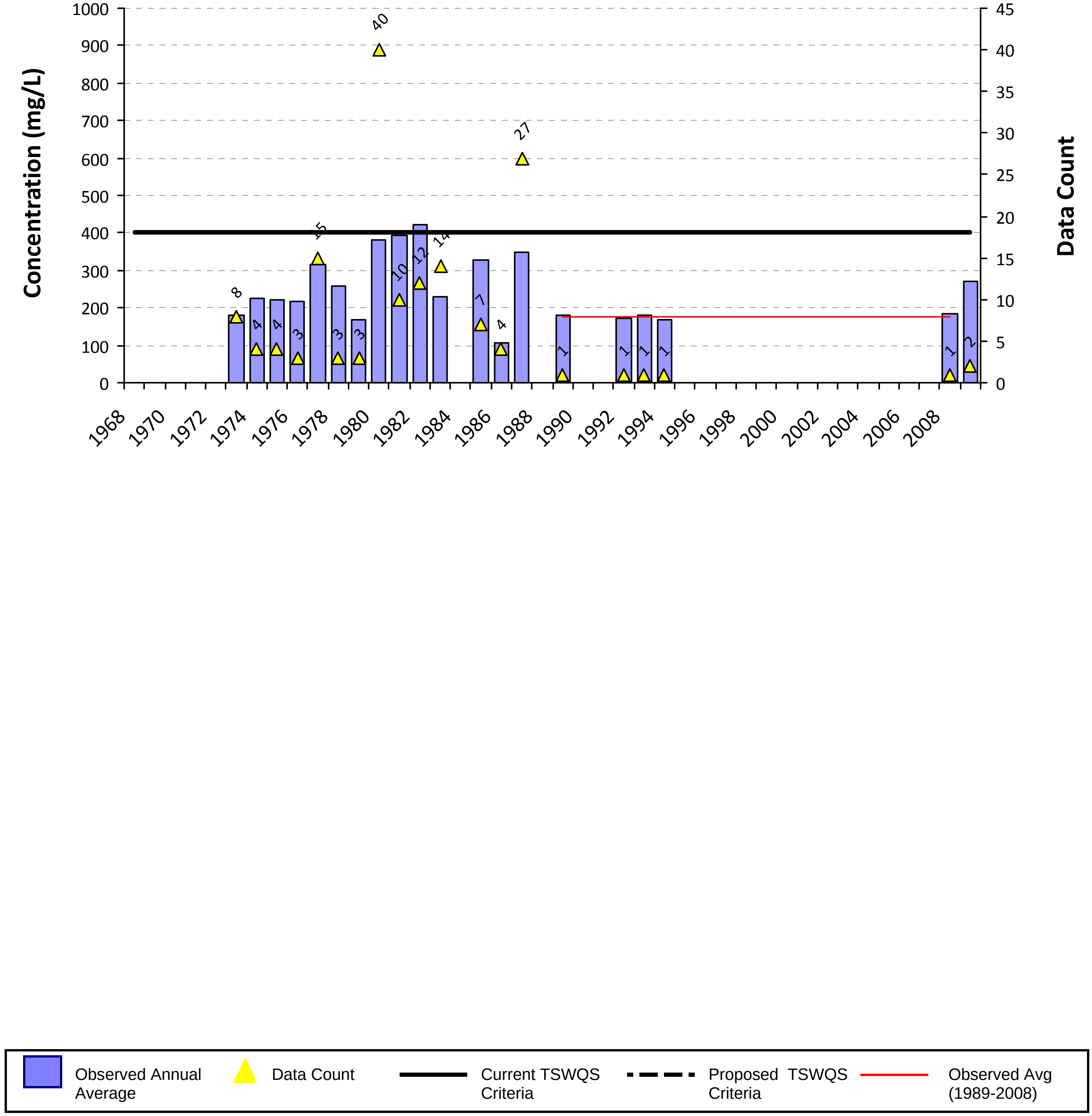
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Lower Main Stem

0827 White Rock Lake



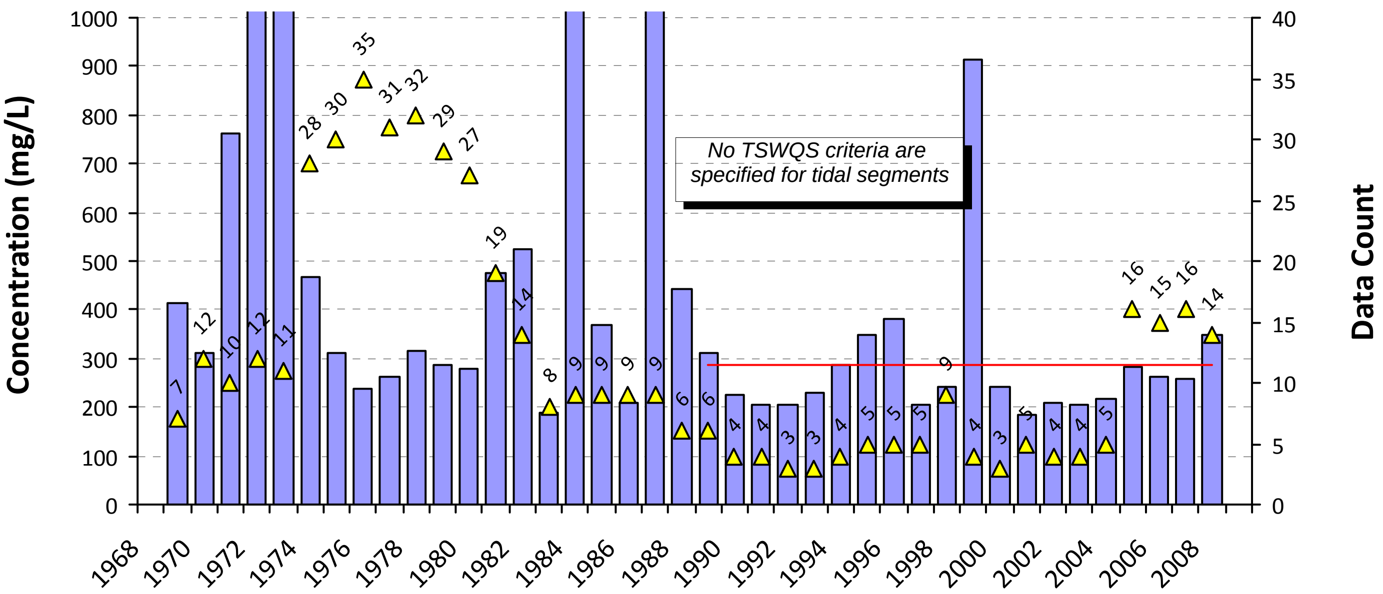
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

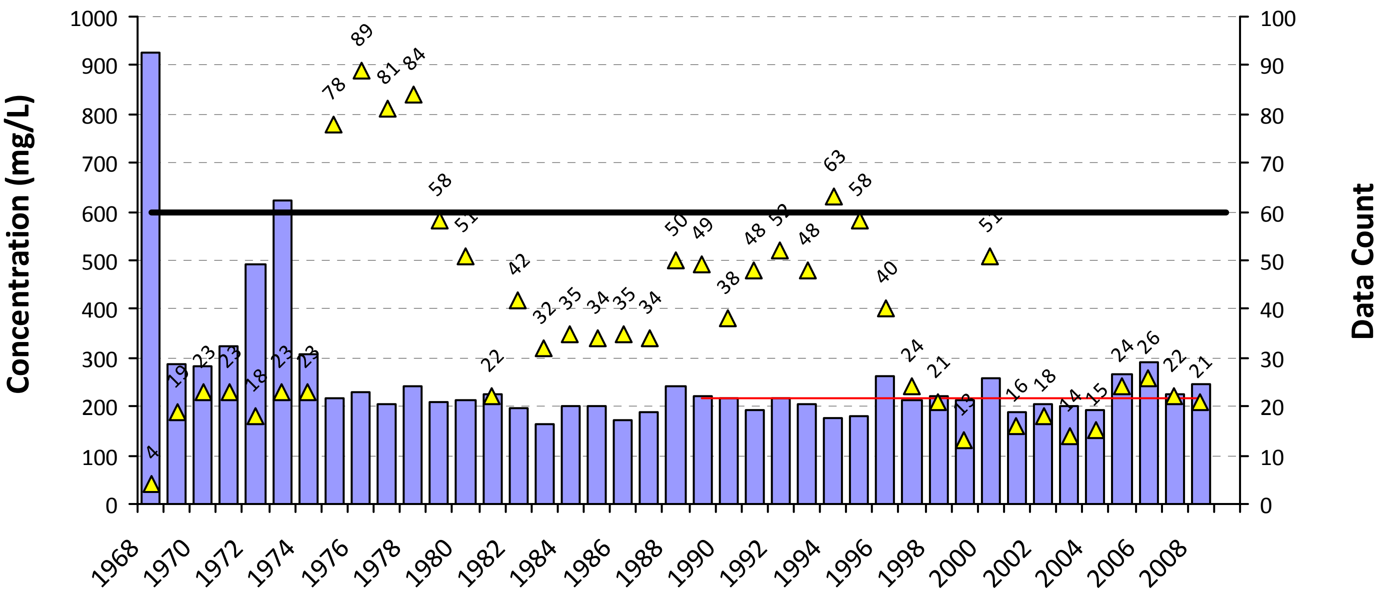
Figure 3-7 (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Classified Segments

Trinity Below Livingston

0801 Trinity River Tidal



0802 Trinity River Below Lake Livingston

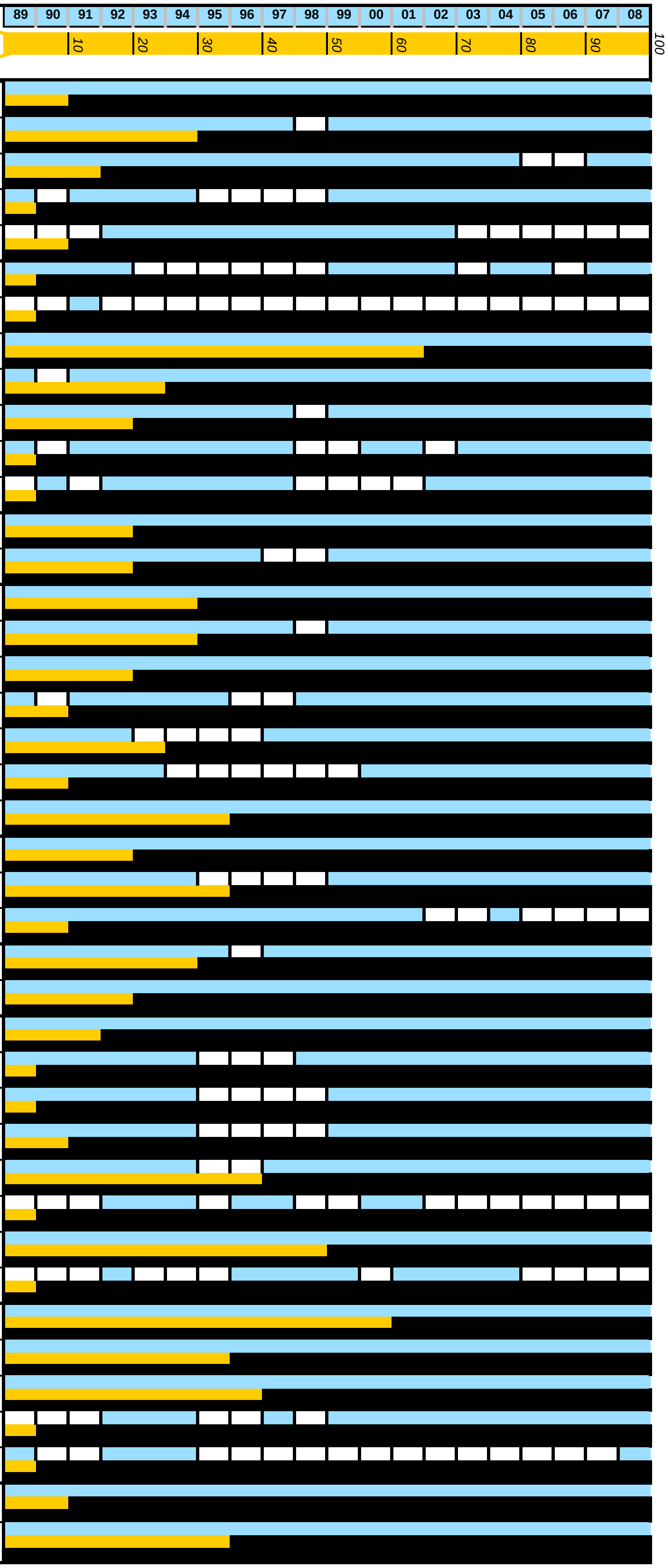


🟦	Observed Annual Average	▲	Data Count	━━	Current TSWQS Criteria	╍╍	Proposed TSWQS Criteria	━━	Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

(2) The results presented here are not technically appropriate for use in determining standards attainment. They have not been developed on an Assessment Unit basis and no qualifications have been made regarding the minimum number of values for computation of the annual average.

Table 3-2
Total Dissolved Solids Summary for Classified Stream Segments in the Trinity River Basin



Water-shed	Seg ID [1]	Stream Std. (mg/L)	Prop. Std. (mg/L)		89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
Clear Fork	🟩 0829	500		Clear Fork Trinity River Below Benbrook Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0830	300		Benbrook Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0831	500		Clear Fork Trinity River Below Lake Weatherford	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
	🟩 0832	500		Lake Weatherford	✓		✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0833	750		Clear Fork Trinity River Above Lake Weatherford				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
West Fork	🟩 0807	500		Lake Worth	✓	✓	✓	✓							✓	✓	✓	✓		✓	✓		✓	✓
	🟩 0808	500		West Fork Trinity River Below Eagle Mountain Reservoir			✓																	
	🟨 0809	300		Eagle Mountain Reservoir	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0810	500		West Fork Trinity River Below Bridgeport Reservoir	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0811	300		Bridgeport Reservoir	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟥 0812	500	990	West Fork Trinity River Above Bridgeport Reservoir	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓
	🟩 0834	400		Lake Amon G. Carter		✓		✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓
Village Creek / Mtn Crk	🟩 0828	300		Lake Arlington	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0838	500		Joe Pool Lake	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Elm Fork	🟩 0822	500		Elm Fork Trinity River Below Lewisville Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0823	500		Lewisville Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0824	700		Elm Fork Trinity River Above Ray Roberts Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0825	500		Denton Creek	✓		✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0826	500		Grapevine Lake	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0839	500		Elm Fork Trinity River Below Ray Roberts Lake	✓	✓	✓	✓	✓							✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0840	500		Ray Roberts Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
East Fork	🟨 0819	500	530	East Fork Trinity River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0820	500		Lake Ray Hubbard	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0821	400	500	Lake Lavon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓				
Upper Main Stem	🟩 0806	500		West Fork Trinity River Below Lake Worth	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0841	850		Lower West Fork Trinity River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Richland-Chambers & Cedar Creek	🟨 0814	500		Chambers Creek Above Richland-Chambers Reservoir	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0815	300		Bardwell Reservoir	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0816	300		Lake Waxahachie	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0817	300		Navarro Mills Lake	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0818	200		Cedar Creek Reservoir	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0835	500		Richland Creek Below Richland-Chambers Reservoir				✓	✓	✓		✓	✓			✓	✓							
	🟩 0836	400		Richland-Chambers Reservoir	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟨 0837	500		Richland Creek Above Richland-Chambers Reservoir				✓				✓	✓	✓	✓		✓	✓	✓	✓				
Lower Main Stem	🟩 0803	500		Lake Livingston	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0804	600		Trinity River Above Lake Livingston	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0805	850		Upper Trinity River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0813	300		Houston County Lake				✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0827	400		White Rock Lake	✓			✓	✓	✓														✓
Trinity Below Livingston	🟩 0801	no criteria		Trinity River Tidal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	🟩 0802	600		Trinity River Below Lake Livingston	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

(1) (20-yr Average) ÷ (TSWQS criteria) Legend: 🟩 0 - 0.7 🟨 0.7 - 0.9 🟥 0.9 - 1.0

(2) The blue shaded cells in table body indicate that TDS or Conductivity data exist for that segment for the indicated year

(3) The orange horizontal bar scale reflects the average number of data samples per year (considering only those years for which data exist)

(4) Proposed revision to TSWQS criteria currently under consideration by TCEQ

Figure 3-8
Trinity River Basin
Summary of Total Dissolved Solids for
Classified Stream Segments

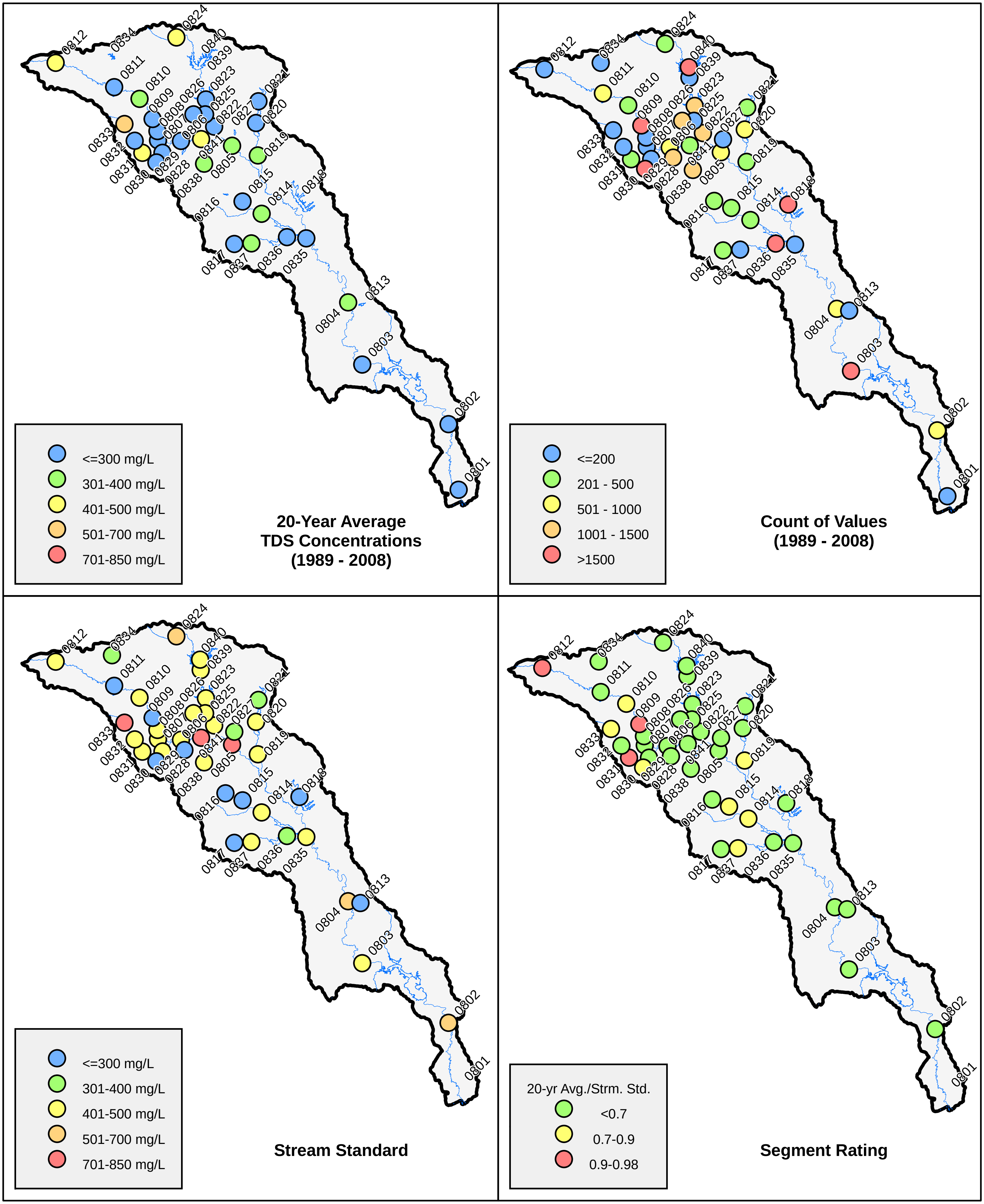
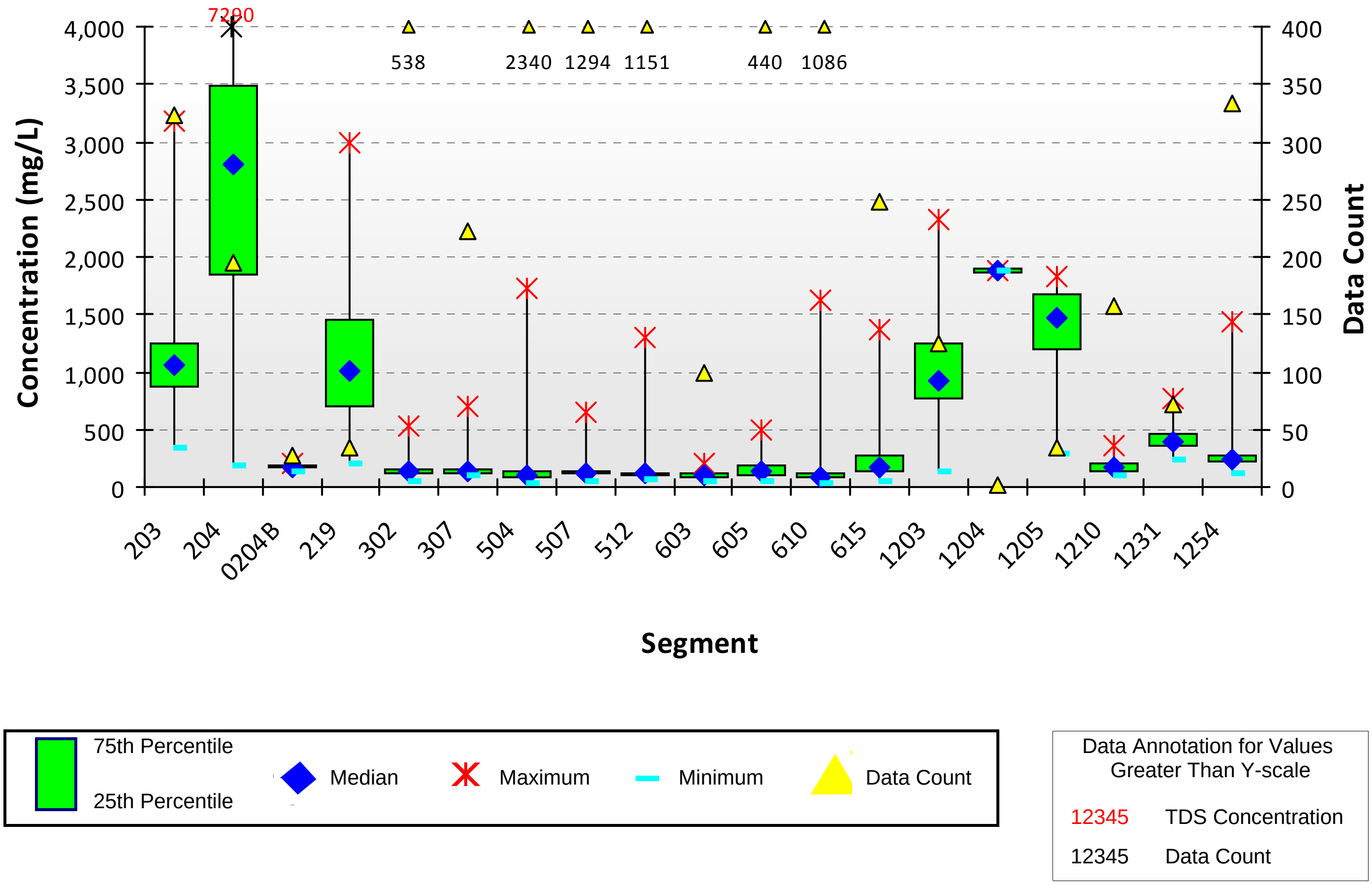


Table 3-3
Existing and Potential Water Import Sources for the Trinity River Basin

Source Name	Source Type	Existing	Future
ATHENS RESERVOIR	Surface Water	●	●
BRAZOS RIVER AUTHORITY AQUILLA RESERVOIR SYSTEM	Surface Water	●	
BRAZOS RIVER AUTHORITY MAIN STEM RESERVOIR SYSTEM	Surface Water	●	●
CHAPMAN/COOPER RESERVOIR NON-SYSTEM PORTION	Surface Water	●	●
CHAPMAN/COOPER RESERVOIR NORTH TEXAS MWD SYSTEM	Surface Water	●	
FORK RESERVOIR	Surface Water	●	●
GRAHAM/EDDLEMAN RESERVOIR	Surface Water	●	
HUBERT H MOSS RESERVOIR	Surface Water	●	●
MEXIA RESERVOIR	Surface Water	●	
MUENSTER RESERVOIR	Surface Water		●
OLNEY-COOPER RESERVOIR SYSTEM	Surface Water	●	
PALESTINE RESERVOIR	Surface Water	●	●
RED RIVER RUN-OF-RIVER DIVERSION	Surface Water		●
SAM RAYBURN-STEINHAGEN RESERVOIR SYSTEM	Surface Water	●	
TAWAKONI RESERVOIR	Surface Water	●	●
TEAGUE CITY RESERVOIR	Surface Water	●	
TEXOMA RESERVOIR NON-SYSTEM PORTION	Surface Water	●	●
TEXOMA RESERVOIR NORTH TEXAS MWD SYSTEM	Surface Water	●	
TOLEDO BEND RESERVOIR	Surface Water		●
WICHITA RESERVOIR SYSTEM	Surface Water		●
WRIGHT PATMAN RESERVOIR	Surface Water		●
INDIRECT REUSE	Reuse		●
FASTRILL RESERVOIR	Proposed Reservoir		●
LOWER BOIS D ARC RESERVOIR	Proposed Reservoir		●
MARVIN NICHOLS RESERVOIR	Proposed Reservoir		●
RALPH HALL RESERVOIR	Proposed Reservoir		●
CARRIZO-WILCOX AQUIFER	Groundwater	●	●
GULF COAST AQUIFER	Groundwater	●	
OTHER AQUIFER	Groundwater	●	
TRINITY AQUIFER	Groundwater	●	
WOODBINE AQUIFER	Groundwater		●
CONSERVATION	Conservation		●
OKLAHOMA RESERVOIR	Unspecified Source		●

The SWQM stations located on each of the waterbodies listed in Table 3-3 were identified. The TDS data for those stations were analyzed to produce the box–and-whisker data quartile plots for each segment shown in Figure 3-9. These plots can be compared to the plots presented previously in Figure 3-6 to get a general sense of the relationships between the TDS concentrations in these segments and those in the Trinity River Basin segments.

Figure 3-9
Historical Daily Average Total Dissolved Solids* Concentrations in Segments Identified as Existing or Proposed Import Water Sources for the Trinity River Basin



** Data set includes TDS derived from conductivity data (0.65 conversion)*

CHAPTER IV

REVIEW OF MODELING TOOLS

There are various mass balance models that can be applied to estimate potential effects of water management strategies on TDS concentrations in surface waters in the Trinity River Basin. The various approaches for performing TDS mass balance calculations can be thought of in the context of the following four categories:

1. Apply simple mass balance tools – The fundamental mass balance calculations are not complex and can be accomplished easily enough using a spreadsheet or a conventional programming language for annual or monthly evaluations involving two or three waterbodies.
2. Integrate a mass balance calculation into a standard reservoir operating model; e.g., Riverware – For reservoirs, there are various operating models available that perform water balance calculations, typically on a monthly time step. These models can be revised to include mass balance calculations for a conservative substance like TDS. These tools are particularly advantageous for modeling operating scenarios involving more complex water transfer schemes that may vary based on relative demand and hydrologic conditions.
3. Integrate a mass balance calculation into a water availability model; e.g., TCEQ Water Rights Analysis Package (WRAP) – The WRAP model utilized by the TCEQ is already structured to represent the waterbodies in the Trinity River Basin. The program could be revised to include a mass balance component for TDS.
4. Utilize other, more sophisticated, models with existing mass balance capabilities; e.g., WASP, CE-QUAL-W2 – There are a host of models with built-in capability for modeling conservative substances. Development of these models requires extensive physical data for the waterbody but offer increased time variable flow routing capability.

It must be noted, however, that the technical calculation to predict TDS concentrations resulting from combining characteristically different waters is the most straightforward aspect of investigations of the effects of these water management strategies. The more difficult task is evaluating the potential effects on water uses. Assessing the effects on ecosystems will be the largest challenge. However, even the significance of effects with respect to water supply has some uncertainty and tools for these evaluations are not so readily available. It is recommended that techniques for relating changes in TDS concentrations to the requirements of various water uses be agreed to before making significant investments in the development of complex mass-balance models.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

As demands on water resources increase, the quality of surface waters with respect to TDS concentrations will become a more significant issue. TDS concentrations must be maintained at levels that support existing and desired uses. The Texas Surface Water Quality Standards (TSWQS) criterion is the primary regulatory mechanism to maintain the quality of water in the state to protect designated uses. At the present time, the TSWQS criteria for TDS are set based on historical water quality: i.e., ambient quality. Since existing water uses are viable due to the existing water quality, this approach does not give consideration to the potential that existing uses can also be viable at concentrations of TDS greater than at ambient conditions.

Increasing use of surface waters in the future and implementing the strategies to meet future water demands have the potential to increase ambient TDS concentrations. It is important that water managers develop tools to identify whether or not proposed uses of surface waters and proposed water management strategies have potential to affect TDS concentrations in the long term. Also of importance is to assess the potential for establishing TSWQS criteria employing an approach that considers both ambient water quality conditions and the acceptable levels of TDS to maintain existing water uses.

This report summarizes existing and proposed TSWQS criteria for TDS in the Trinity River Basin and existing TDS concentrations in waterbodies in the basin. In addition, future activities and water management strategies that may affect TDS concentrations are identified. Based on this information, recommendations are provided for steps that can be taken to provide a stronger technical basis for future evaluations of the potential changes in TDS concentrations associated with proposed actions and the significance of those changes with respect to existing and desired water uses.

5.1 EXISTING/PROPOSED WATER QUALITY STANDARDS AND SURFACE WATER QUALITY

Table 5-1 summarizes existing and proposed TSWQS criteria for TDS and the historical, 20-year annual average TDS concentrations for the classified segments in the Trinity River Basin. The segments are grouped by major watershed. The ratio of each 20-year annual average to the applicable water quality standard is also shown as the “Segment Ratio.”

Table 5-1
Total Dissolved Solids Summary for Trinity River Basin Classified Stream Segments

Water-shed	Segment ID	Segment Name	Current TSWQS Criteria (mg/L)	Proposed TSWQS Criteria (mg/L)	20-Year Average (1989 - 2008) (mg/L)	Segment Ratio [1]
Clear Fork	0829	Clear Fork Trinity River Below Benbrook Lake	500		251	0.50
	0830	Benbrook Lake	300		229	0.76
	0831	Clear Fork Trinity River Below Lake Weatherford	500		441	0.88
	0832	Lake Weatherford	500		249	0.50
	0833	Clear Fork Trinity River Above Lake Weatherford	750		598	0.80
West Fork	0807	Lake Worth	500		221	0.44
	0808	West Fork Trinity River Below Eagle Mountain Reservoir	500		227	0.45
	0809	Eagle Mountain Reservoir	300		264	0.88
	0810	West Fork Trinity River Below Bridgeport Reservoir	500		386	0.77
	0811	Bridgeport Reservoir	300		197	0.66
	0812	West Fork Trinity River Above Bridgeport Reservoir	500	990	501	1.00
	0834	Lake Amon G. Carter	400		201	0.50
Vlg. & Mtn. Cks.	0828	Lake Arlington	300		201	0.67
	0838	Joe Pool Lake	500		345	0.69
Elm Fork	0822	Elm Fork Trinity River Below Lewisville Lake	500		251	0.50
	0823	Lewisville Lake	500		257	0.51
	0824	Elm Fork Trinity River Above Ray Roberts Lake	700		454	0.65
	0825	Denton Creek	500		252	0.50
	0826	Grapevine Lake	500		219	0.44
	0839	Elm Fork Trinity River Below Ray Roberts Lake	500		197	0.39
	0840	Ray Roberts Lake	500		185	0.37
East Fork	0819	East Fork Trinity River	500	530	367	0.73
	0820	Lake Ray Hubbard	500		226	0.45
	0821	Lake Lavon	400	500	225	0.56
Upper Main Stem	0806	West Fork Trinity River Below Lake Worth	500		243	0.49
	0841	Lower West Fork Trinity River	850		452	0.53
Richland-Chambers & Cedar Creek	0814	Chambers Creek Above Richland-Chambers Reservoir	500		393	0.79
	0815	Bardwell Reservoir	300		227	0.76
	0816	Lake Waxahachie	300		185	0.62
	0817	Navarro Mills Lake	300		209	0.70
	0818	Cedar Creek Reservoir	200		137	0.68
	0835	Richland Creek Below Richland-Chambers Reservoir	500		271	0.54
	0836	Richland-Chambers Reservoir	400		191	0.48
	0837	Richland Creek Above Richland-Chambers Reservoir	500		373	0.75
Lower Main Stem	0803	Lake Livingston	500		255	0.51
	0804	Trinity River Above Lake Livingston	600		357	0.60
	0805	Upper Trinity River	850		383	0.45
	0813	Houston County Lake	300		74	0.25
	0827	White Rock Lake	400		177	0.44
Below Livingston	0801	Trinity River Tidal	(see Note 2)		287	
	0802	Trinity River Below Lake Livingston	600		218	0.36

Notes:

(1) Segment Ratio = (20-yr Average) ÷ (TSWQS criteria)

(2) No TDS criteria are established for tidal segments

Legend

0 - 0.7

0.7 - 0.9

0.9 - 1.0

The following can be observed in Table 5-1:

- The 20-year average concentrations in the classified segments range from 74 mg/L to 598 mg/L.
- The current TSWQS criteria for the classified stream segments range from 200 mg/L to 850 mg/L.
- The ratio of the 20-year annual average segment concentration to the segment TSWQS criteria is less than or equal to 1.0 for all classified segments.
  - One segment has a ratio between 0.9 and 1.0.
  - Ten segments have a ratio between 0.7 and 0.9.
  - Thirty segments have a ratio less than 0.7.
- The following revisions to the TDS standard are currently being proposed by the TCEQ:
  - Segment 0812 (West Fork of the Trinity River Above Lake Bridgeport) – from 500 mg/L to 990 mg/L
  - Segment 0819 (East Fork of the Trinity River) – from 500 mg/L to 530 mg/L
  - Segment 0821 (Lake Lavon) – from 400 mg/L to 500 mg/L.

5.2 ACTIVITIES THAT MAY AFFECT TOTAL DISSOLVED SOLIDS CONCENTRATIONS

Increases in the following activities have the potential to change TDS concentrations in receiving waters in the Trinity River Basin:

- Industrial production – Many industrial wastewater streams have high TDS concentrations. Alternatives to reduce the TDS concentrations in the wastewater prior to discharge are limited and, frequently, simply not available.
- Power production – The primary use of water at most power plants is for cooling in recirculating systems. Evaporative losses substantially increase the TDS concentrations in these waters; and, periodically, a portion of the cooling water has to be discharged so that it can be replaced with water with lower TDS concentrations.
- Wastewater treatment at publicly owned treatment works – The combined effects of human wastes, industrial discharges, and treatment processes increase the TDS concentration in the effluent from publicly owned treatment works, compared to the TDS concentration in the water supply.
- Home water softeners – In regions with high hardness in the water supply, many homeowners install home water softeners. These water softeners are typically regenerated using a solution containing high concentrations of sodium chloride. The discharge of the regeneration waste to the wastewater collection system substantially increases TDS concentrations in the effluents of wastewater treatment plants serving those areas.
- Water supply strategies – Depending on the water supply strategy implemented, TDS concentrations in the receiving stream may increase or decrease.

- Importing water from another basin – TDS data were reviewed for waterbodies outside the Trinity River Basin from which waters are currently, or are proposed to be, imported to supplement existing water supplies. Median concentrations of TDS in these waters range from 90 mg/L to 2,800 mg/L. In some cases, importing water from other basins will result in a decrease in TDS concentrations in waters in the Trinity River Basin. In other cases, it will result in an increase in TDS concentrations. For some imported waters, management strategies to control changes in TDS concentrations may be required.
- Reusing effluent – As previously noted, using water in a municipal system results in an increase the TDS concentrations in the wastewater effluent from that municipality, when compared to the TDS concentrations in the water supply. As municipalities increase their use of effluent to supplement their water supplies, the TDS concentrations in the discharges from their wastewater treatment plants will increase proportionately.
- Supplementing water supplies with groundwater – The TDS concentrations in groundwaters can be significantly different than TDS concentrations is the surface waters currently used as municipal supplies.
- Desalinating waters to increase their suitability for use – There are surface and groundwaters that are not suitable for municipal or industrial uses because of the TDS concentrations. Treatment technology exists (for example, reverse osmosis) that can produce water of suitable quality. However, these treatments have, as a byproduct, a high brine wastewater that has to be managed. If these brines are discharged to surface waters, the TDS concentrations in the surface waters will increase
- Modifying reservoir operations - Changing reservoir operations to increase yield may affect TDS concentrations in waters in the reservoir. Evaporative losses can increase the TDS concentration of waters in the reservoir. Therefore, changes in operations that decrease detention time or otherwise reduce evaporative losses could decrease TDS concentrations, and changes that result in increased evaporative losses may increase TDS concentrations.

5.3 USES AFFECTED BY TOTAL DISSOLVED SOLIDS CONCENTRATION

The uses that may be affected by changes in TDS concentrations are water supply, industrial supply and aquatic life:

- Water Supply - When evaluating the effects of changes on water supplies, potential impacts to be considered include compliance with State and Federal requirements, potential for human health impacts, effects on the taste (aesthetic quality) of drinking water, potential for corrosion or calcium build-up, and cost of changes in treatment techniques for water supplies. Suitable guidelines and criteria do not exist for all of these areas. For example, additional scientific studies on the potential health effects of specific types of dissolved salts are needed; and the TDS concentration at which taste becomes objectionable varies between individuals and changes as users become acclimated to specific TDS concentrations.

- Industrial Supply - Industrial operations frequently have internal water treatment systems to produce water of suitable quality for use in the production processes or other operations, such as boilers. These systems are designed to treat a water supply of a specified quality. If the qualities of the water supply changes, the treatment system must be modified accordingly.
- Aquatic Life - There is very limited information at the present time with respect to how aquatic ecosystems may be affected by changes in TDS concentrations. Aquatic ecosystems are found in waters covering a very wide range of TDS concentrations. However, the composition of the community is different in waters with high TDS concentrations than the composition of the community in waters with low TDS concentrations. Furthermore, there is virtually no information on how great a change in TDS concentration can be tolerated by a specific type of aquatic ecosystem without adversely affecting the ecosystem.

5.4 RECOMMENDATIONS

Recommendations are provided in three areas: data collection; modeling; and investigations of impacts on uses. The recommendations are set forth below:

5.4.1 Monitoring

The following types of additional data are desirable:

- Concurrent data on conductivity and gravimetric TDS measurements for specific waterbodies so that site-specific conversion factors can be developed.
- Additional data on unclassified waterbodies so there is a sounder technical basis for evaluating actions that may affect those waterbodies.
- Recognize that some type of biological monitoring may be warranted in the future. The particular nature of this type of monitoring will not be known until more research is performed regarding impacts on aquatic ecosystems (see Section 5.4.3).

5.4.2 Modeling

Available models could be utilized to improve the understanding of TDS conditions under a variety of natural and man-induced scenarios. The following steps are suggested:

- Select a model that would be appropriate for assessing TDS conditions in the Trinity River Basin and calibrate the model with observed data.
- Apply the model to assess the affect of drought conditions (e.g., 1950's) on ambient water quality in specific segments as appropriate.

5.4.3 Impacts on Uses

Better information is needed on how incremental changes in TDS concentrations in surface waters affect water uses. A recommended first step is to perform comprehensive literature research regarding (1) effects on aquatic ecosystems to identify acceptable levels and changes of TDS, and (2) suitability for drinking water supply from both an aesthetic and a public health perspective. Recognizing that existing literature will not provided all the information that is needed, a second step might involve developing a collaborative research effort with TCEQ and appropriate research organizations (e.g., AWWARF, etc.).

5.4.4 TSWQS Criteria

With regard to the TSWQS criteria, it is recommended that an effort be coordinated with the TCEQ to develop a long term approach for establishing criteria for TDS that employs both ambient water quality and acceptable levels of TDS that protect water uses. It is imperative that there be provisions in the TSWQS criteria to account for drought conditions. Consideration should be given to adjusting the existing numerical criteria or providing for an exemption during specified drought conditions.

APPENDIX A

Trinity River Basin Surface Water Quality Monitoring Stations

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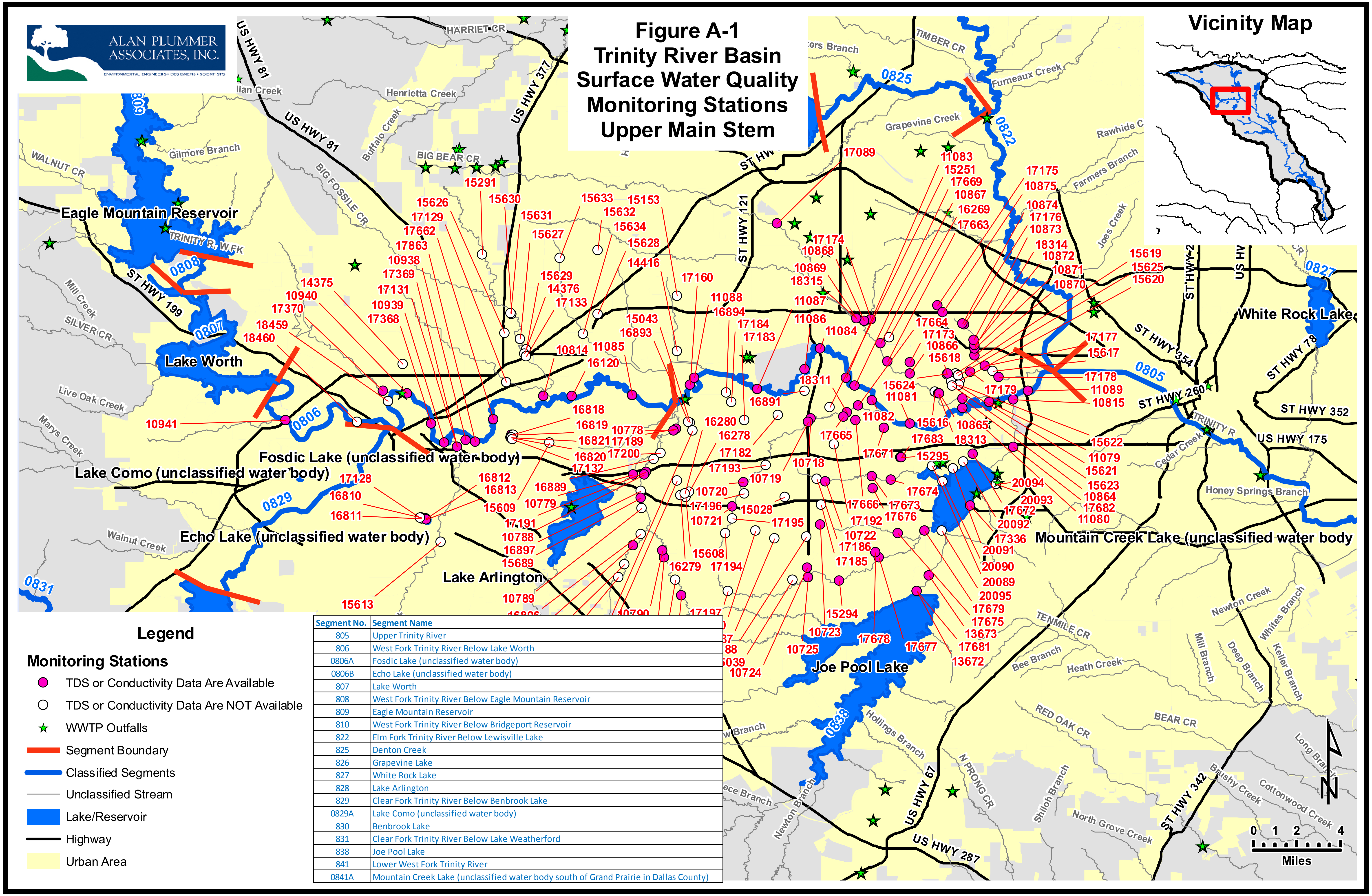
Figure A-1
Trinity River Basin Surface Water Quality Monitoring Stations Upper Main Stem



Legend

Monitoring Stations

● TDS or Conductivity Data Are Available

○ TDS or Conductivity Data Are NOT Available

★ WWTP Outfalls

— Segment Boundary

— Classified Segments

— Unclassified Stream

■ Lake/Reservoir

— Highway

■ Urban Area

Segment No.	Segment Name
805	Upper Trinity River
806	West Fork Trinity River Below Lake Worth
0806A	Fosdic Lake (unclassified water body)
0806B	Echo Lake (unclassified water body)
807	Lake Worth
808	West Fork Trinity River Below Eagle Mountain Reservoir
809	Eagle Mountain Reservoir
810	West Fork Trinity River Below Bridgeport Reservoir
822	Elm Fork Trinity River Below Lewisville Lake
825	Denton Creek
826	Grapevine Lake
827	White Rock Lake
828	Lake Arlington
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
830	Benbrook Lake
831	Clear Fork Trinity River Below Lake Weatherford
838	Joe Pool Lake
841	Lower West Fork Trinity River
0841A	Mountain Creek Lake (unclassified water body south of Grand Prairie in Dallas County)

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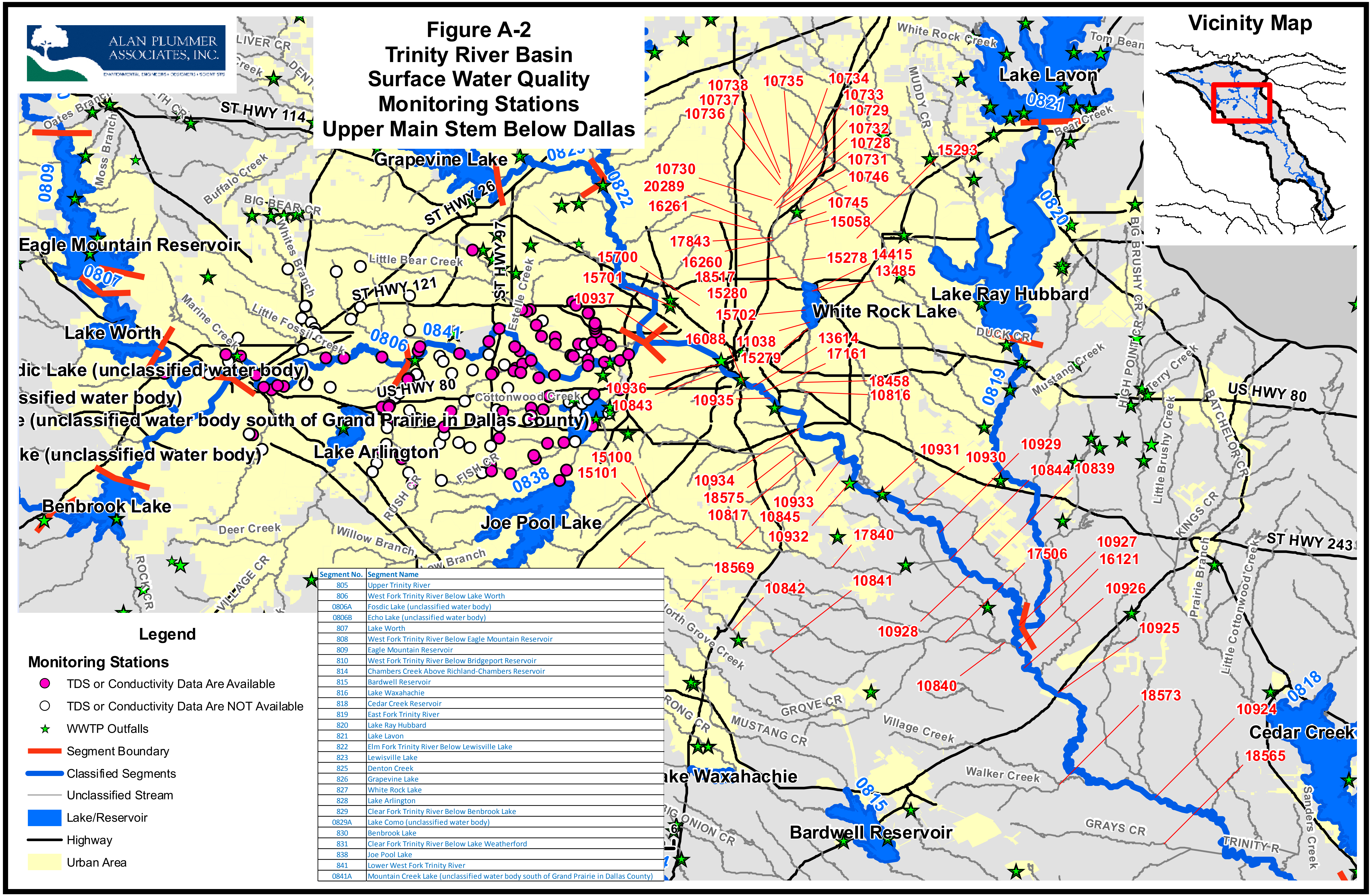
Figure A-2
Trinity River Basin
Surface Water Quality
Monitoring Stations
Upper Main Stem Below Dallas



Segment No.	Segment Name
805	Upper Trinity River
806	West Fork Trinity River Below Lake Worth
0806A	Fosdic Lake (unclassified water body)
0806B	Echo Lake (unclassified water body)
807	Lake Worth
808	West Fork Trinity River Below Eagle Mountain Reservoir
809	Eagle Mountain Reservoir
810	West Fork Trinity River Below Bridgeport Reservoir
814	Chambers Creek Above Richland-Chambers Reservoir
815	Bardwell Reservoir
816	Lake Waxahachie
818	Cedar Creek Reservoir
819	East Fork Trinity River
820	Lake Ray Hubbard
821	Lake Lavon
822	Elm Fork Trinity River Below Lewisville Lake
823	Lewisville Lake
825	Denton Creek
826	Grapevine Lake
827	White Rock Lake
828	Lake Arlington
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
830	Benbrook Lake
831	Clear Fork Trinity River Below Lake Weatherford
838	Joe Pool Lake
841	Lower West Fork Trinity River
0841A	Mountain Creek Lake (unclassified water body south of Grand Prairie in Dallas County)

Legend

Monitoring Stations

●	TDS or Conductivity Data Are Available
○	TDS or Conductivity Data Are NOT Available
★	WWTP Outfalls
🟥	Segment Boundary
🟦	Classified Segments
—	Unclassified Stream
🟦	Lake/Reservoir
—	Highway
🟨	Urban Area

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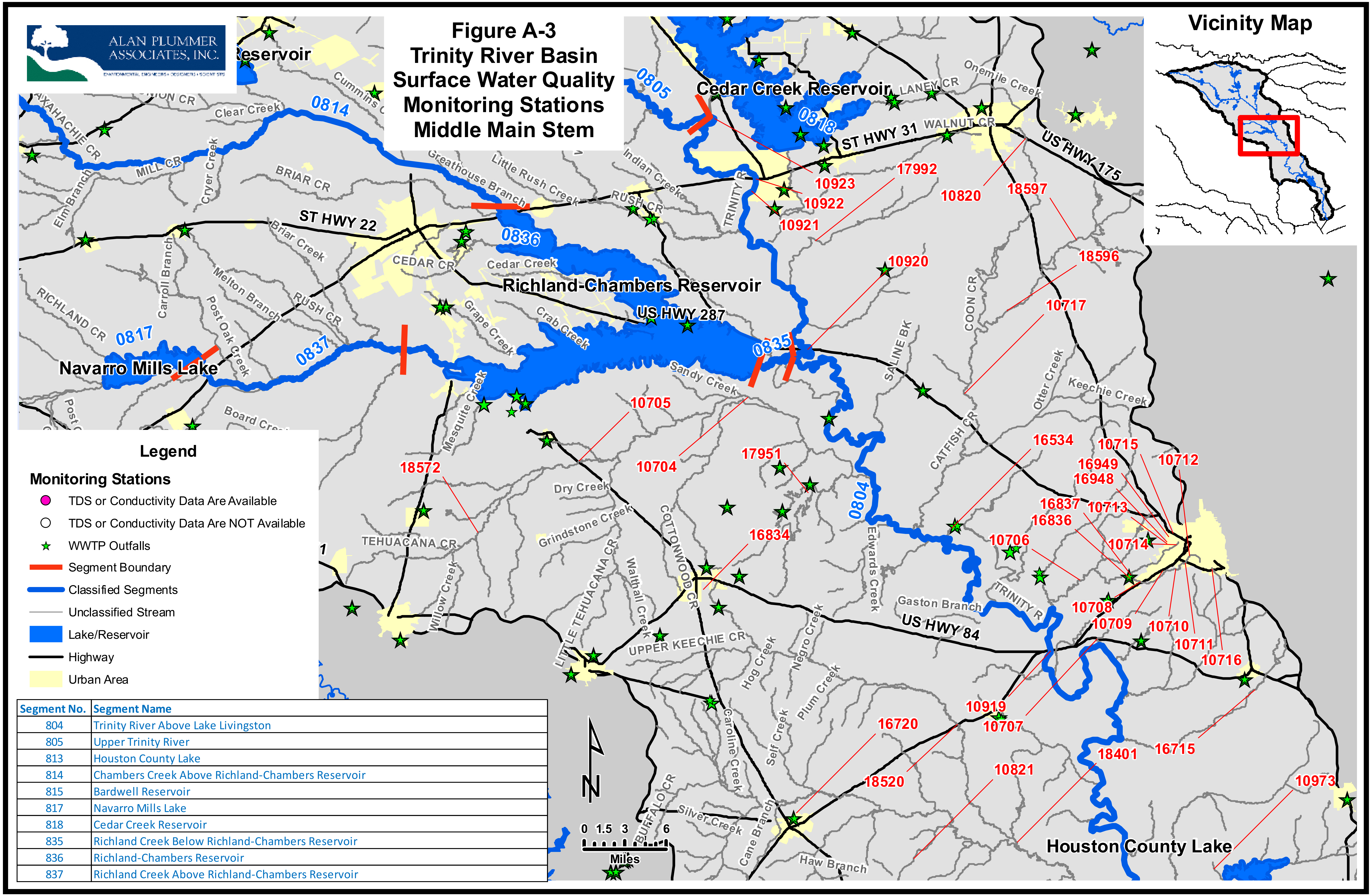
Figure A-3
Trinity River Basin Surface Water Quality Monitoring Stations Middle Main Stem



Segment No.	Segment Name
804	Trinity River Above Lake Livingston
805	Upper Trinity River
813	Houston County Lake
814	Chambers Creek Above Richland-Chambers Reservoir
815	Bardwell Reservoir
817	Navarro Mills Lake
818	Cedar Creek Reservoir
835	Richland Creek Below Richland-Chambers Reservoir
836	Richland-Chambers Reservoir
837	Richland Creek Above Richland-Chambers Reservoir

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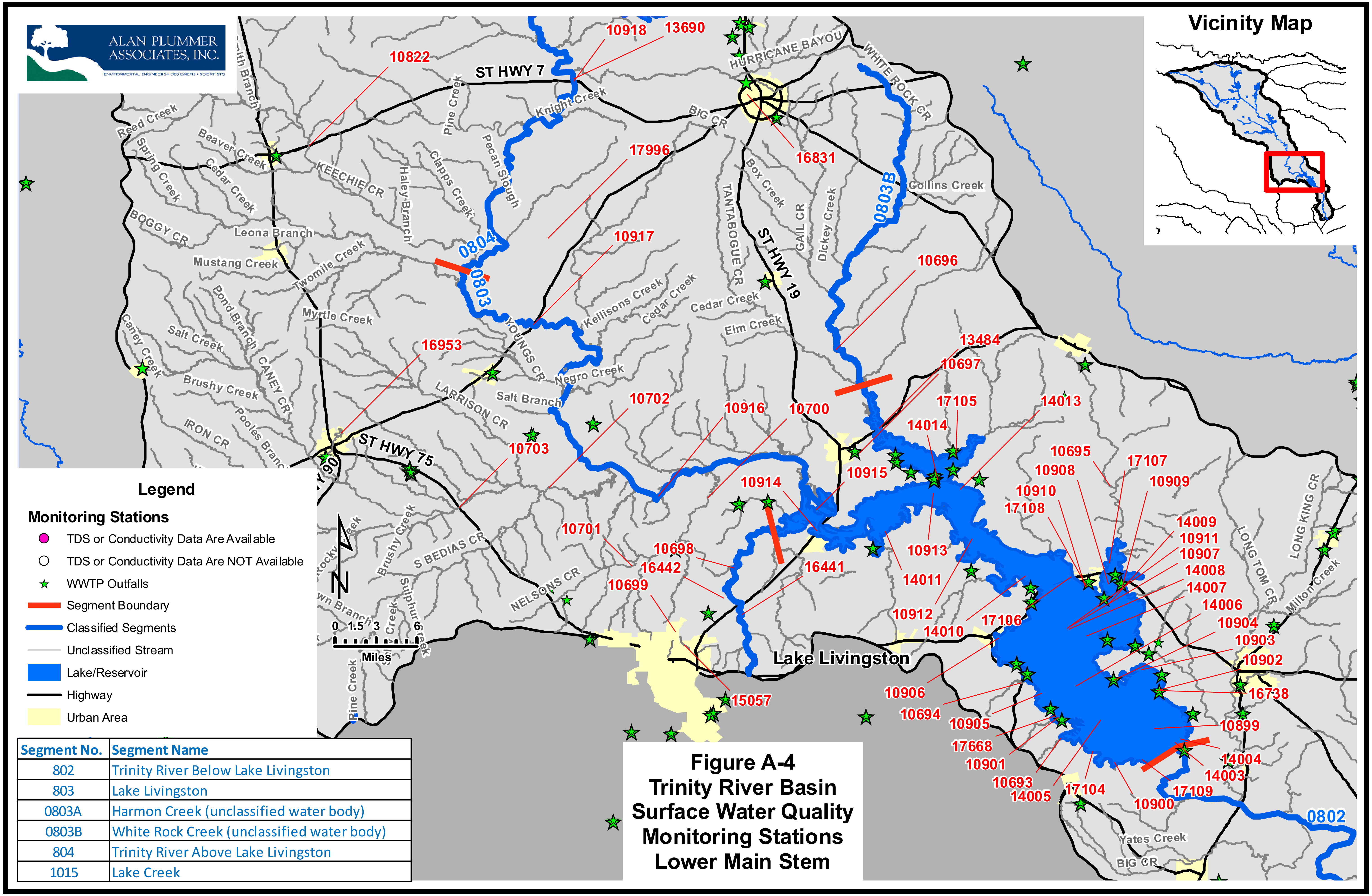

Legend

Monitoring Stations

- ● TDS or Conductivity Data Are Available
- ○ TDS or Conductivity Data Are NOT Available
- ★ WWTP Outfalls
- 🟥 Segment Boundary
- 🟦 Classified Segments
- Unclassified Stream
- 🟦 Lake/Reservoir
- Highway
- 🟨 Urban Area

Segment No.	Segment Name
802	Trinity River Below Lake Livingston
803	Lake Livingston
0803A	Harmon Creek (unclassified water body)
0803B	White Rock Creek (unclassified water body)
804	Trinity River Above Lake Livingston
1015	Lake Creek

Figure A-4
Trinity River Basin Surface Water Quality Monitoring Stations Lower Main Stem

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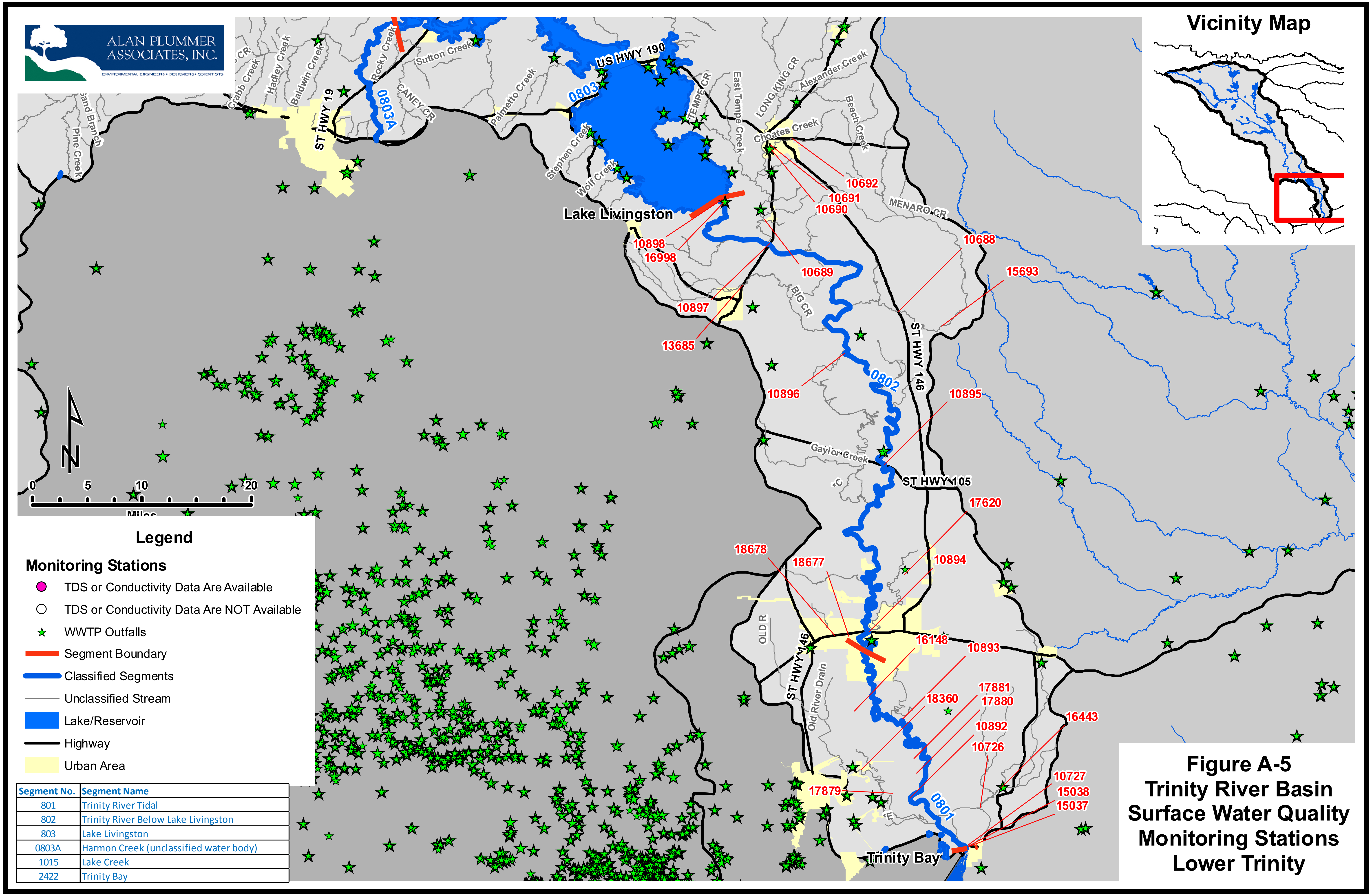

Legend

Monitoring Stations

● TDS or Conductivity Data Are Available

○ TDS or Conductivity Data Are NOT Available

★ WWTP Outfalls

🟥 Segment Boundary

🟦 Classified Segments

— Unclassified Stream

🟦 Lake/Reservoir

— Highway

🟨 Urban Area

Segment No.	Segment Name
801	Trinity River Tidal
802	Trinity River Below Lake Livingston
803	Lake Livingston
0803A	Harmon Creek (unclassified water body)
1015	Lake Creek
2422	Trinity Bay

Figure A-5
Trinity River Basin
Surface Water Quality
Monitoring Stations
Lower Trinity

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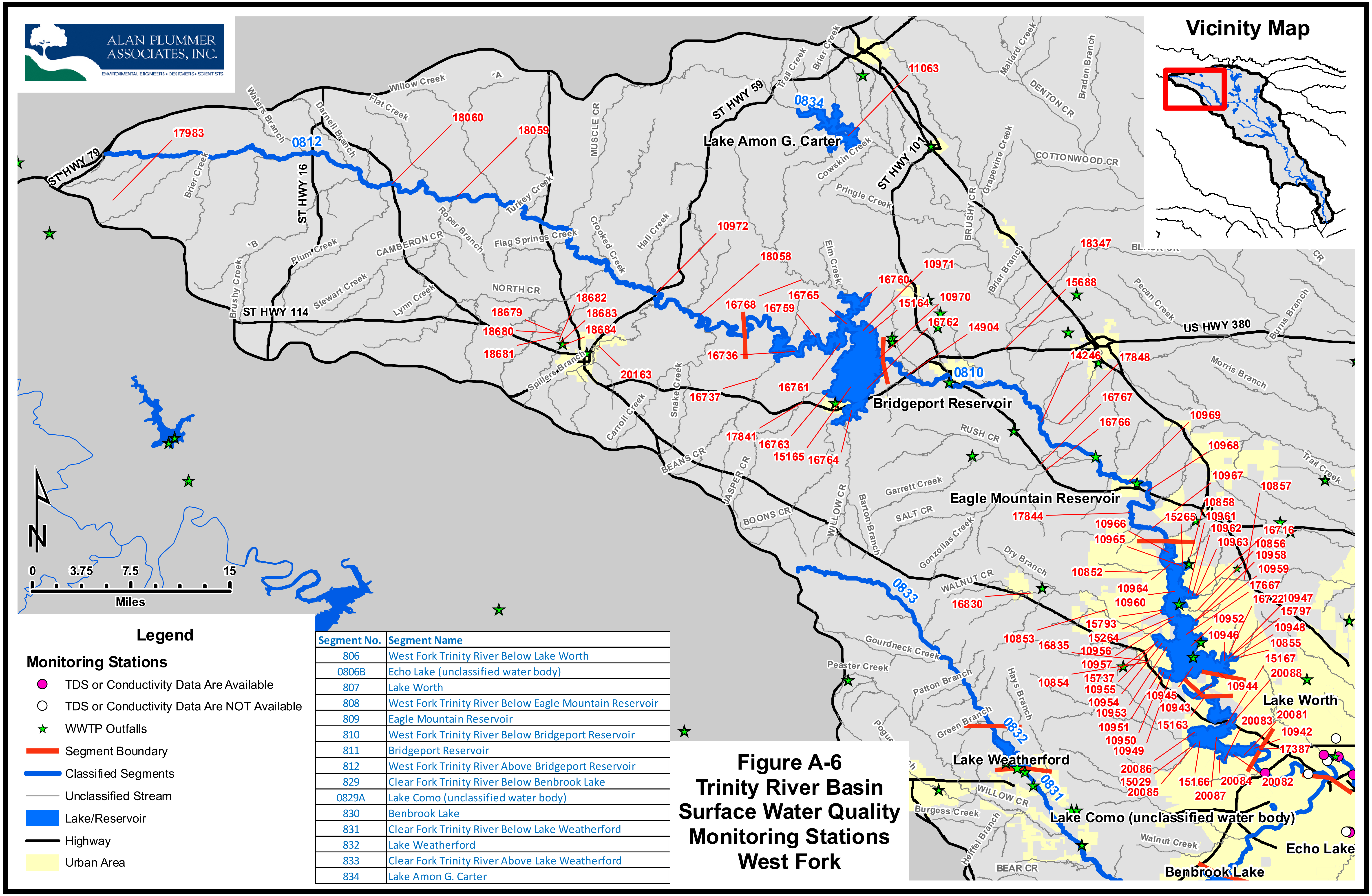

Figure A-6
Trinity River Basin
Surface Water Quality
Monitoring Stations
West Fork

Segment No.	Segment Name
806	West Fork Trinity River Below Lake Worth
0806B	Echo Lake (unclassified water body)
807	Lake Worth
808	West Fork Trinity River Below Eagle Mountain Reservoir
809	Eagle Mountain Reservoir
810	West Fork Trinity River Below Bridgeport Reservoir
811	Bridgeport Reservoir
812	West Fork Trinity River Above Bridgeport Reservoir
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
830	Benbrook Lake
831	Clear Fork Trinity River Below Lake Weatherford
832	Lake Weatherford
833	Clear Fork Trinity River Above Lake Weatherford
834	Lake Amon G. Carter

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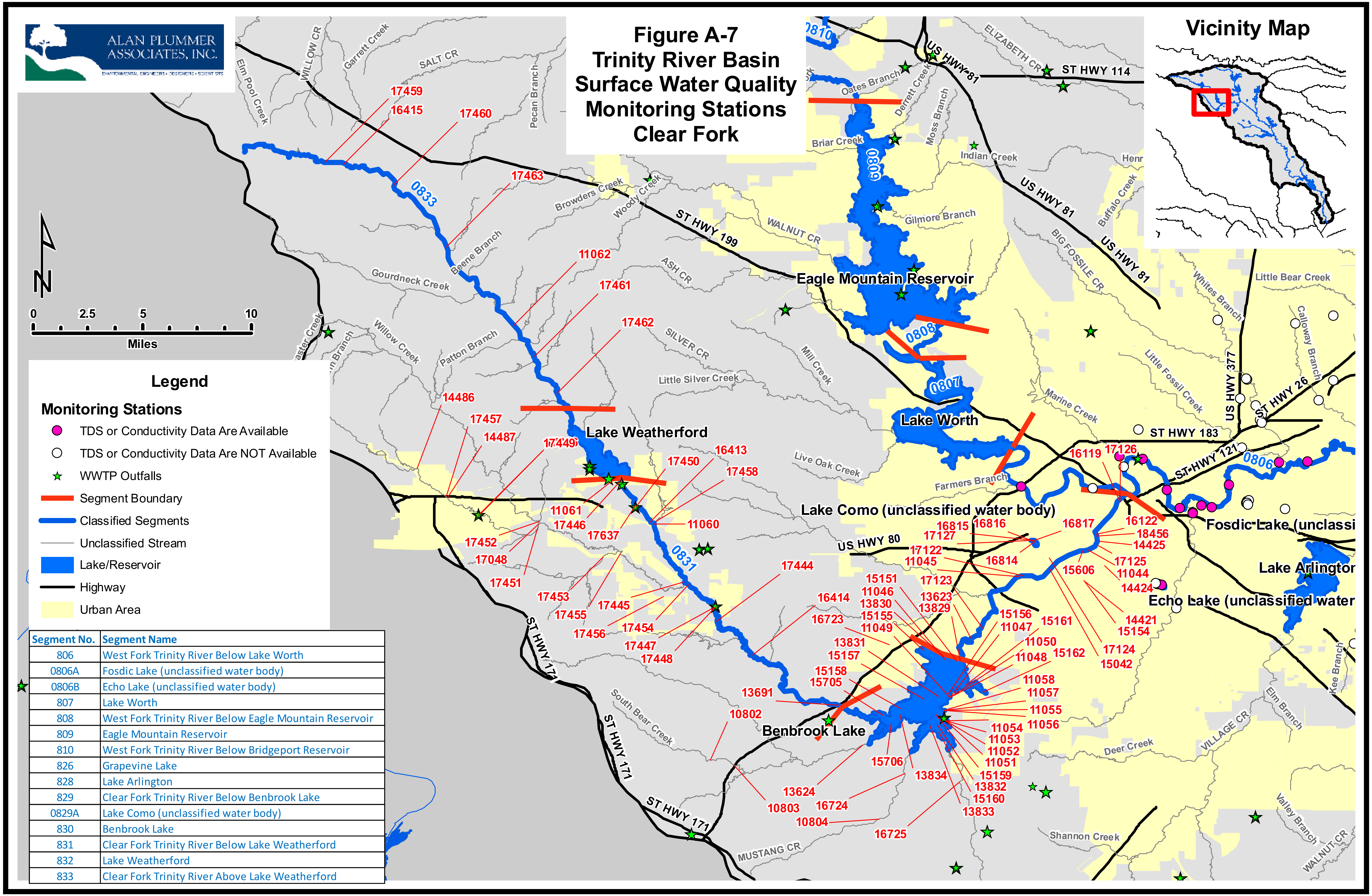
Figure A-7
Trinity River Basin Surface Water Quality Monitoring Stations Clear Fork



Legend

Monitoring Stations

- ● TDS or Conductivity Data Are Available
- ○ TDS or Conductivity Data Are NOT Available
- ★ WWTP Outfalls
- ▬ Segment Boundary
- ▬ Classified Segments
- ─ Unclassified Stream
- ■ Lake/Reservoir
- ▬ Highway
- ■ Urban Area

Segment No.	Segment Name
806	West Fork Trinity River Below Lake Worth
0806A	Fosdic Lake (unclassified water body)
0806B	Echo Lake (unclassified water body)
807	Lake Worth
808	West Fork Trinity River Below Eagle Mountain Reservoir
809	Eagle Mountain Reservoir
810	West Fork Trinity River Below Bridgeport Reservoir
826	Grapevine Lake
828	Lake Arlington
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
830	Benbrook Lake
831	Clear Fork Trinity River Below Lake Weatherford
832	Lake Weatherford
833	Clear Fork Trinity River Above Lake Weatherford

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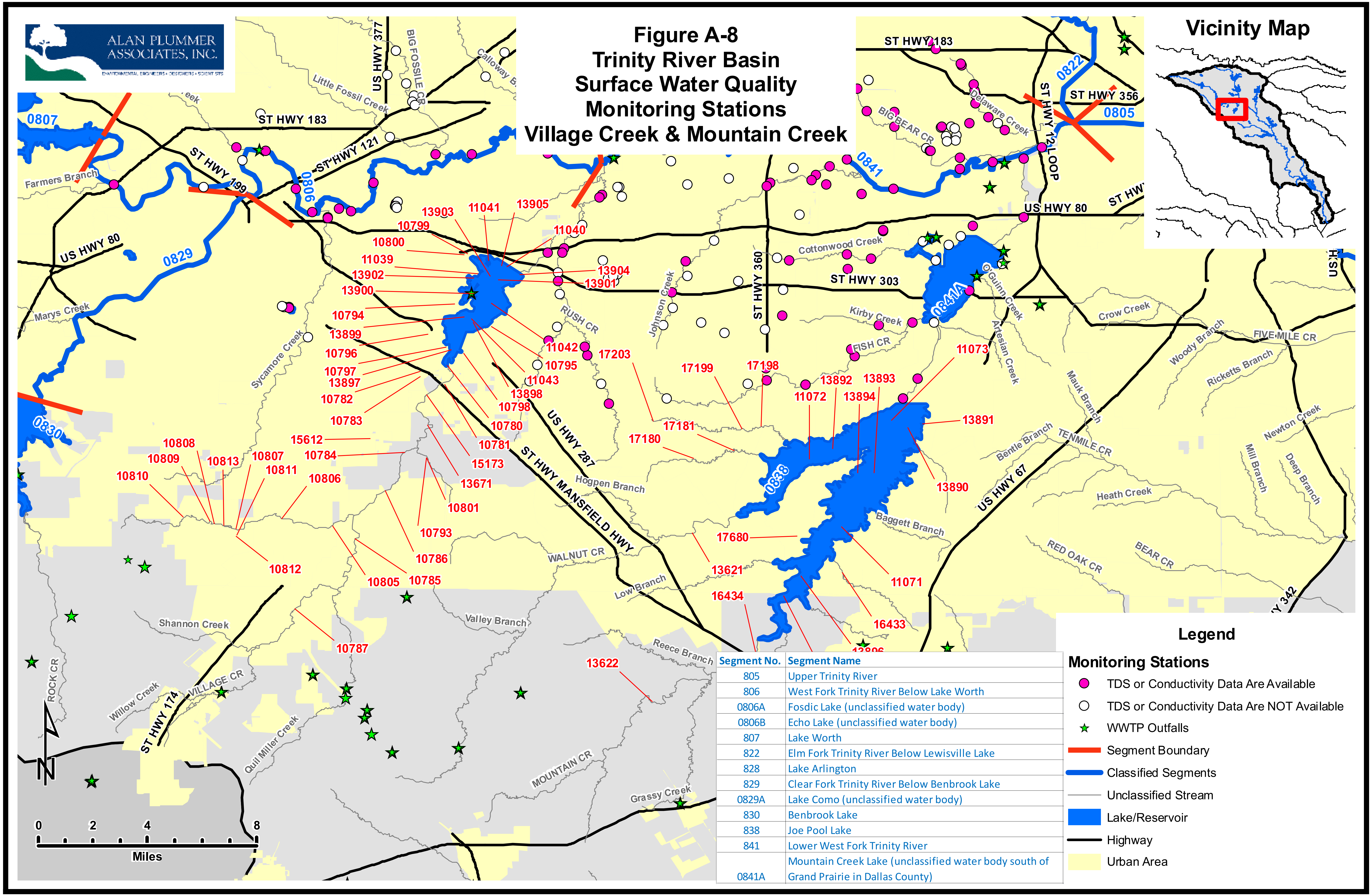
Figure A-8
Trinity River Basin
Surface Water Quality
Monitoring Stations
Village Creek & Mountain Creek



Segment No.	Segment Name
805	Upper Trinity River
806	West Fork Trinity River Below Lake Worth
0806A	Fosdic Lake (unclassified water body)
0806B	Echo Lake (unclassified water body)
807	Lake Worth
822	Elm Fork Trinity River Below Lewisville Lake
828	Lake Arlington
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
830	Benbrook Lake
838	Joe Pool Lake
841	Lower West Fork Trinity River
0841A	Mountain Creek Lake (unclassified water body south of Grand Prairie in Dallas County)

Legend

Monitoring Stations

- ● TDS or Conductivity Data Are Available
- ○ TDS or Conductivity Data Are NOT Available
- ★ WWTP Outfalls
- 🟥 Segment Boundary
- 🟦 Classified Segments
- Unclassified Stream
- 🟦 Lake/Reservoir
- Highway
- 🟨 Urban Area

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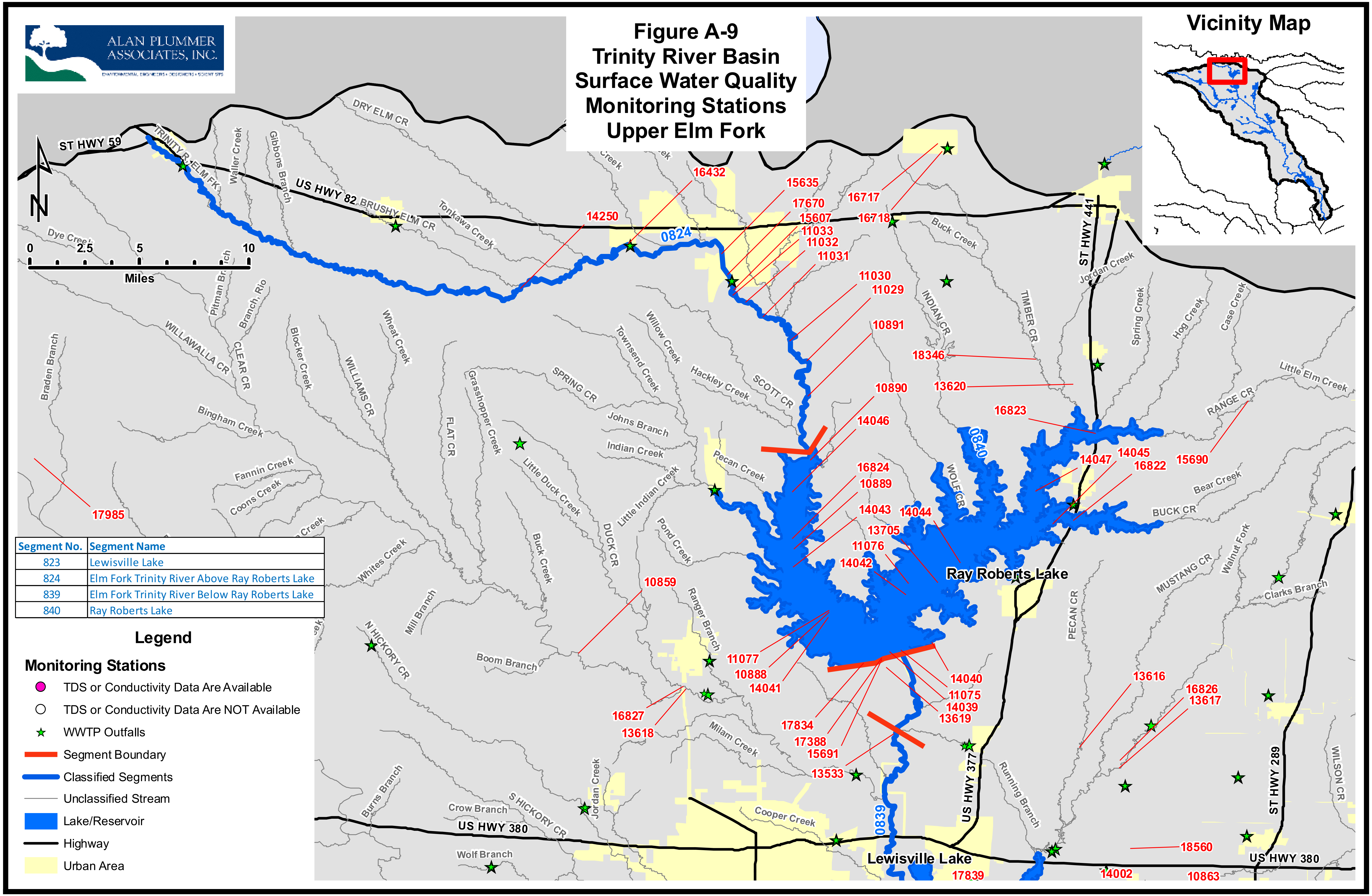
Figure A-9
Trinity River Basin Surface Water Quality Monitoring Stations Upper Elm Fork



Segment No.	Segment Name
823	Lewisville Lake
824	Elm Fork Trinity River Above Ray Roberts Lake
839	Elm Fork Trinity River Below Ray Roberts Lake
840	Ray Roberts Lake

Legend

Monitoring Stations

- ● TDS or Conductivity Data Are Available
- ○ TDS or Conductivity Data Are NOT Available
- ★ WWTP Outfalls
- — Segment Boundary
- — Classified Segments
- — Unclassified Stream
- 🟦 Lake/Reservoir
- — Highway
- 🟨 Urban Area

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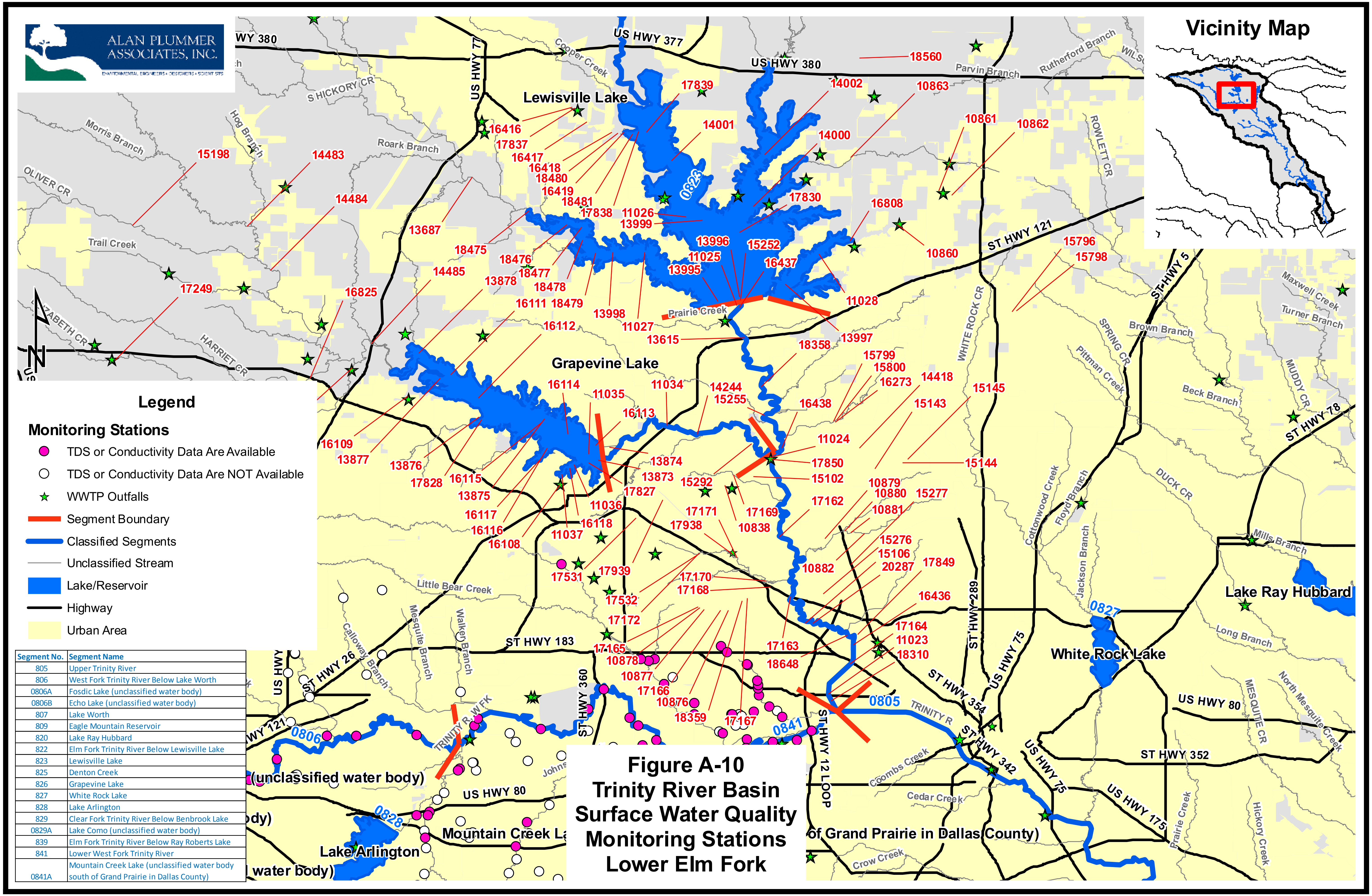

Legend

Monitoring Stations

● TDS or Conductivity Data Are Available

○ TDS or Conductivity Data Are NOT Available

★ WWTP Outfalls

▬ Segment Boundary

▬ Classified Segments

― Unclassified Stream

■ Lake/Reservoir

▬ Highway

■ Urban Area

Segment No.	Segment Name
805	Upper Trinity River
806	West Fork Trinity River Below Lake Worth
0806A	Fosdic Lake (unclassified water body)
0806B	Echo Lake (unclassified water body)
807	Lake Worth
809	Eagle Mountain Reservoir
820	Lake Ray Hubbard
822	Elm Fork Trinity River Below Lewisville Lake
823	Lewisville Lake
825	Denton Creek
826	Grapevine Lake
827	White Rock Lake
828	Lake Arlington
829	Clear Fork Trinity River Below Benbrook Lake
0829A	Lake Como (unclassified water body)
839	Elm Fork Trinity River Below Ray Roberts Lake
841	Lower West Fork Trinity River
0841A	Mountain Creek Lake (unclassified water body south of Grand Prairie in Dallas County)

Figure A-10
Trinity River Basin Surface Water Quality Monitoring Stations Lower Elm Fork

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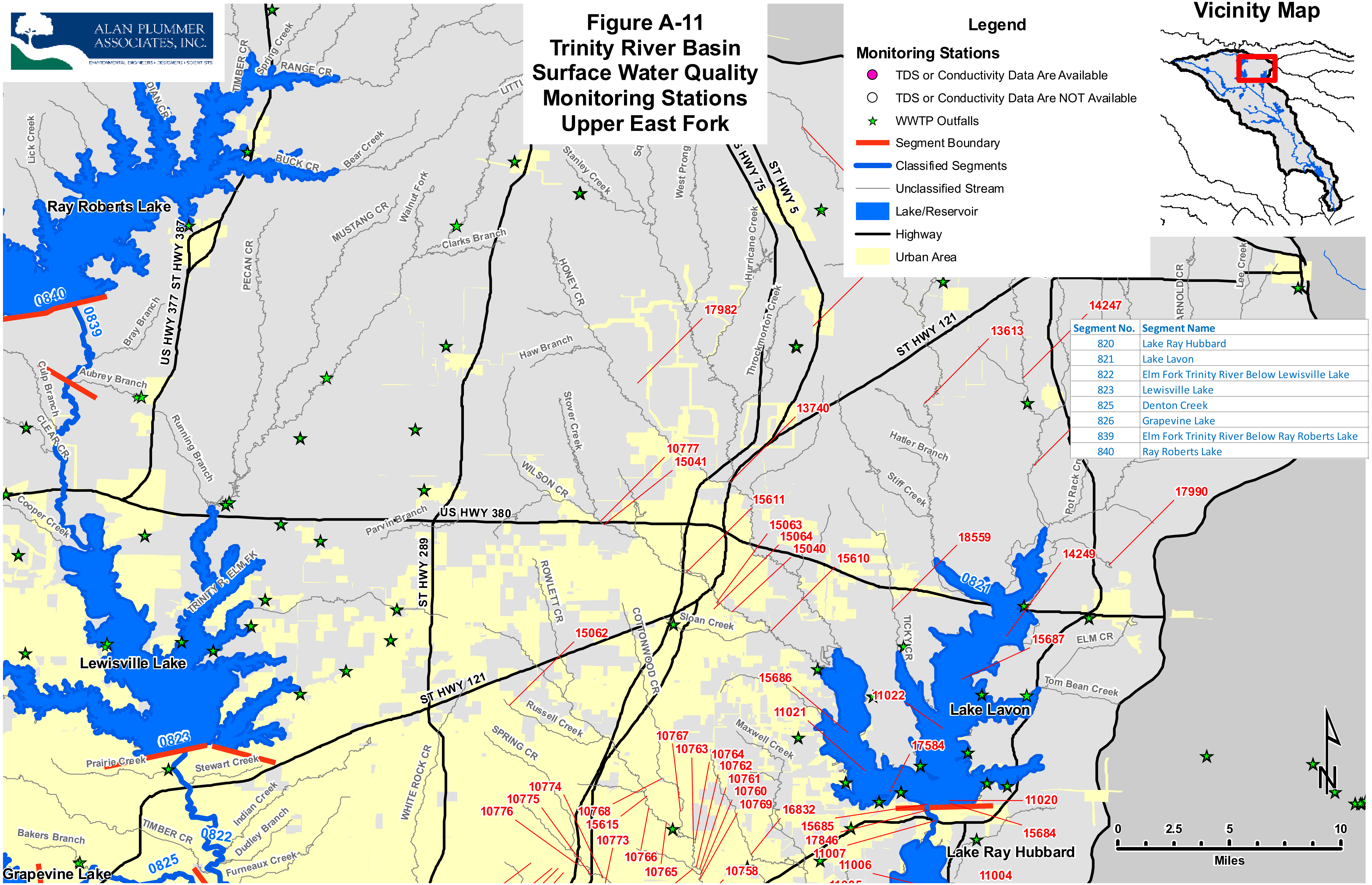
Figure A-11
Trinity River Basin Surface Water Quality Monitoring Stations Upper East Fork



Legend

Monitoring Stations

- ● TDS or Conductivity Data Are Available
- ○ TDS or Conductivity Data Are NOT Available
- ★ WWTP Outfalls
- Segment Boundary
- Classified Segments
- Unclassified Stream
- Lake/Reservoir
- Highway
- Urban Area

Vicinity Map

Segment No.	Segment Name
820	Lake Ray Hubbard
821	Lake Lavon
822	Elm Fork Trinity River Below Lewisville Lake
823	Lewisville Lake
825	Denton Creek
826	Grapevine Lake
839	Elm Fork Trinity River Below Ray Roberts Lake
840	Ray Roberts Lake

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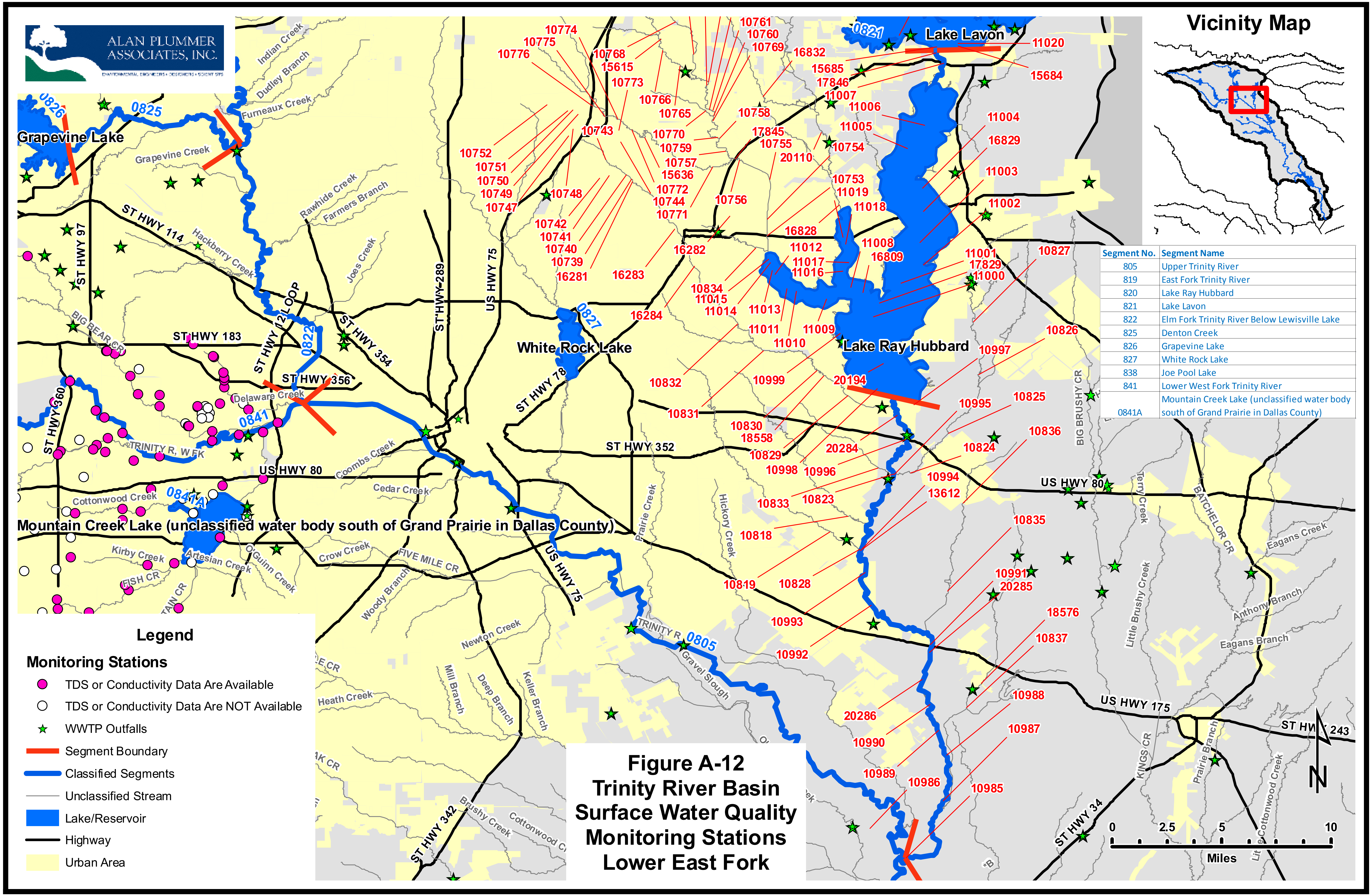

Segment No.	Segment Name
805	Upper Trinity River
819	East Fork Trinity River
820	Lake Ray Hubbard
821	Lake Lavon
822	Elm Fork Trinity River Below Lewisville Lake
825	Denton Creek
826	Grapevine Lake
827	White Rock Lake
838	Joe Pool Lake
841	Lower West Fork Trinity River
0841A	Mountain Creek Lake (unclassified water body south of Grand Prairie in Dallas County)

Figure A-12
Trinity River Basin Surface Water Quality Monitoring Stations Lower East Fork

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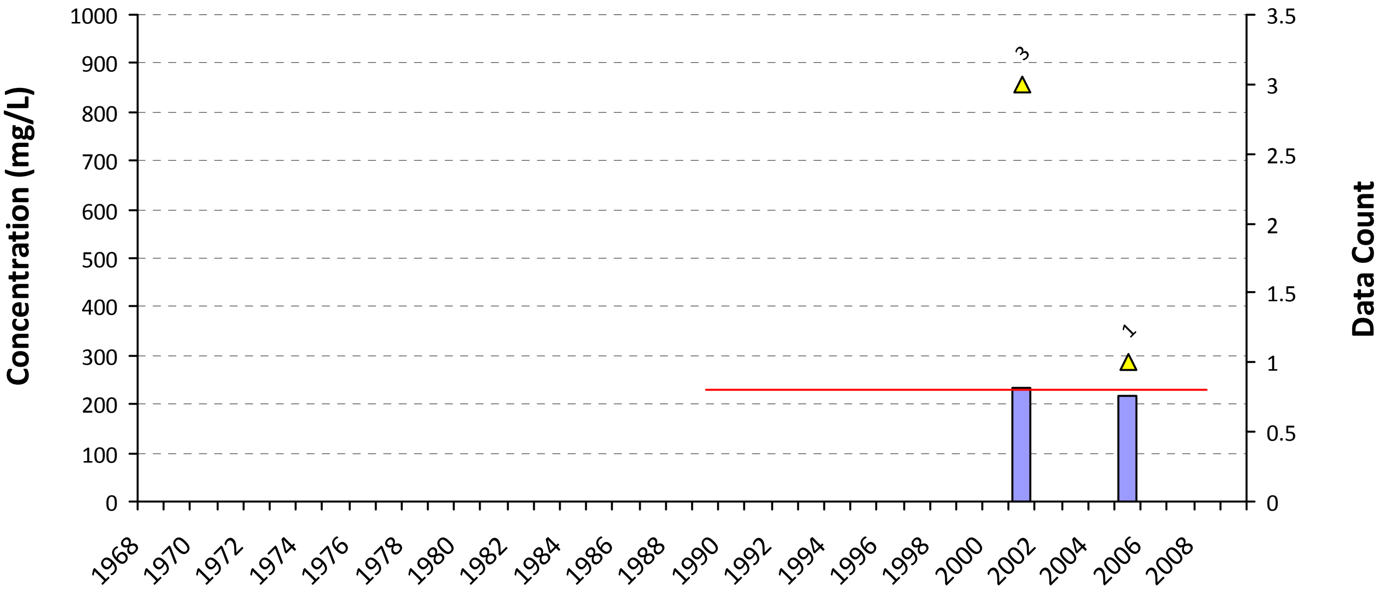
APPENDIX B

Historical Annual Average Total Dissolved Concentrations for Trinity River Basin Unclassified Waterbodies

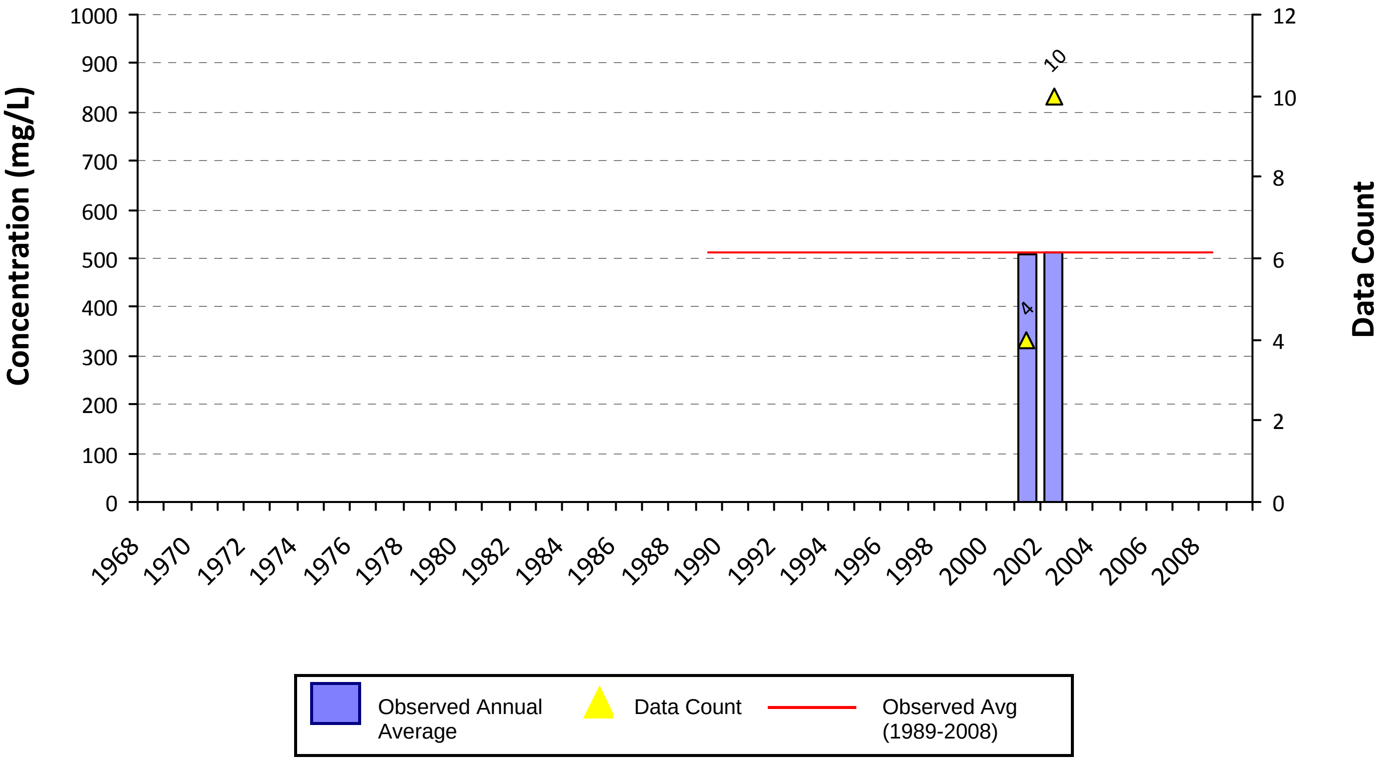
Appendix B
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Clear Fork

0829A Lake Como



0831A South Fork Trinity River

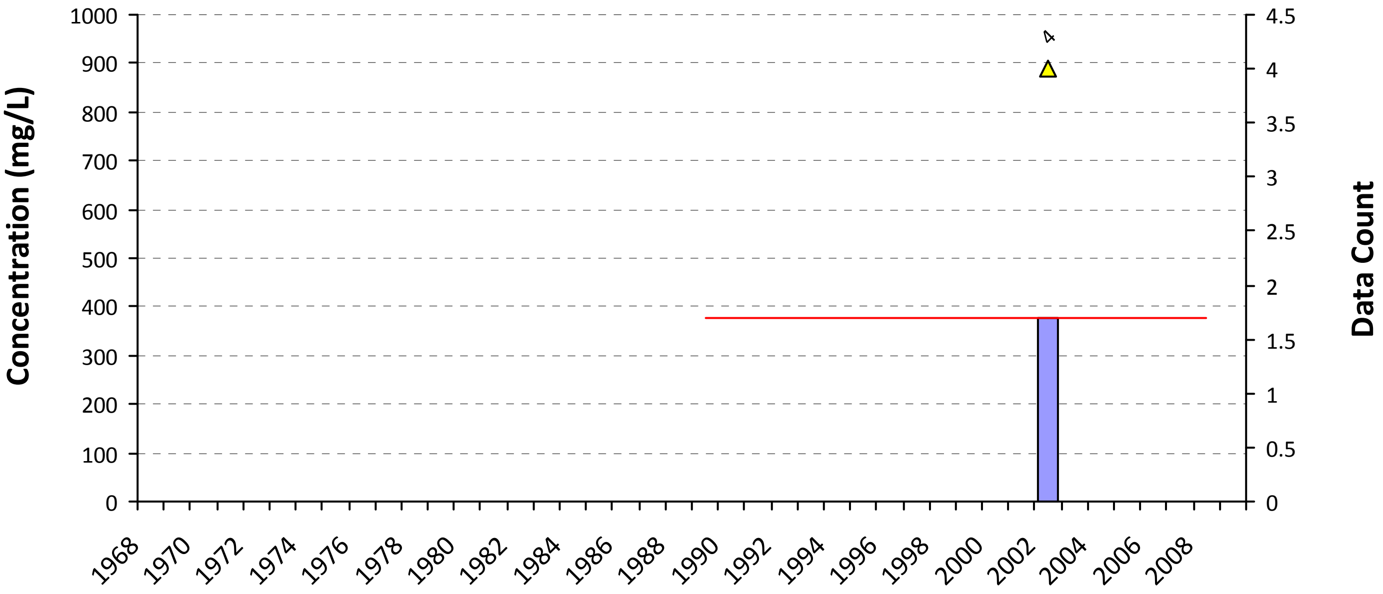


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

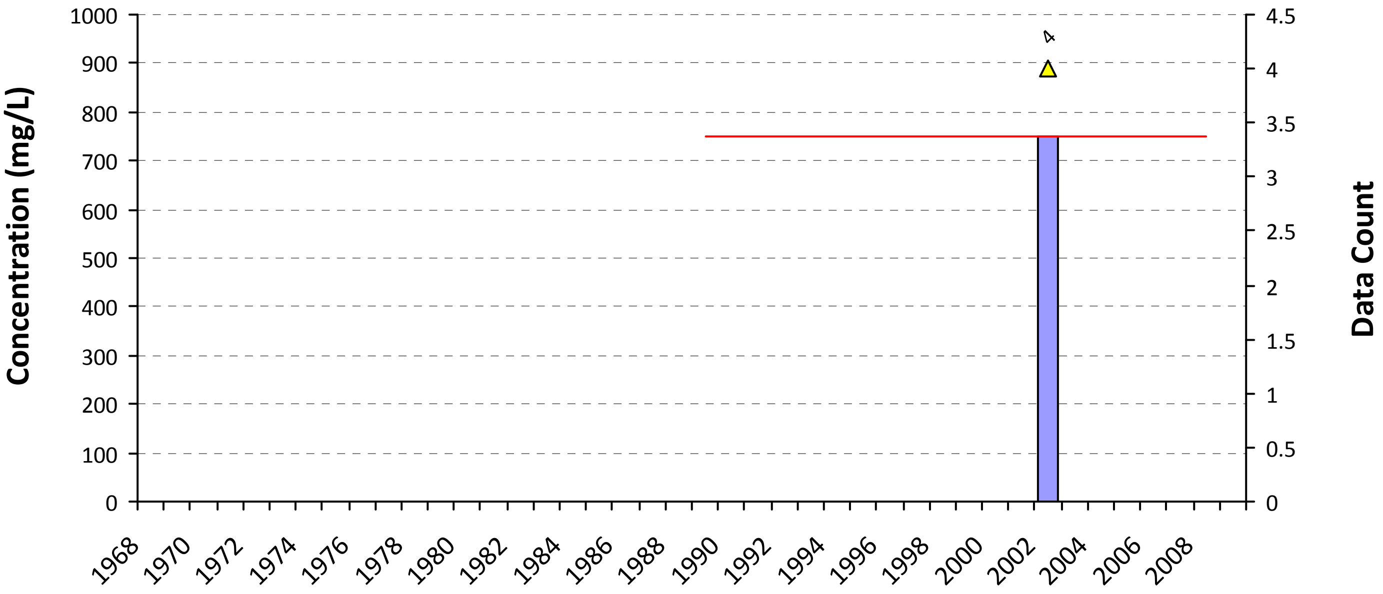
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Clear Fork

0831B



0831C



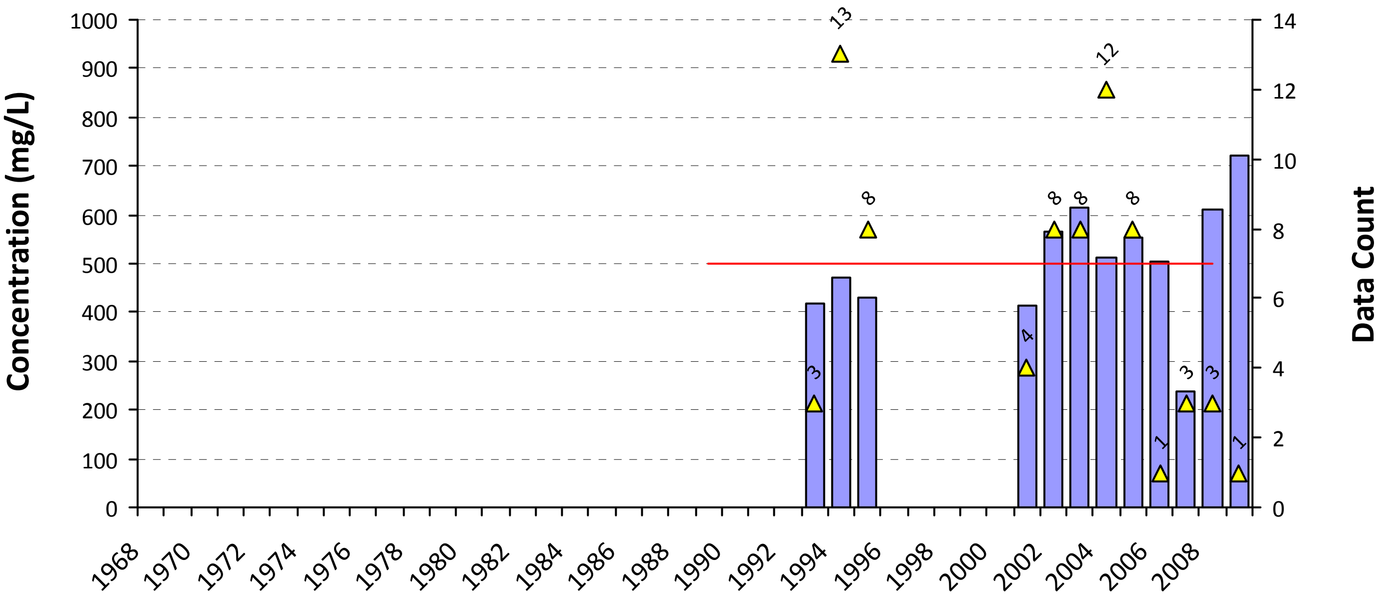
▇ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

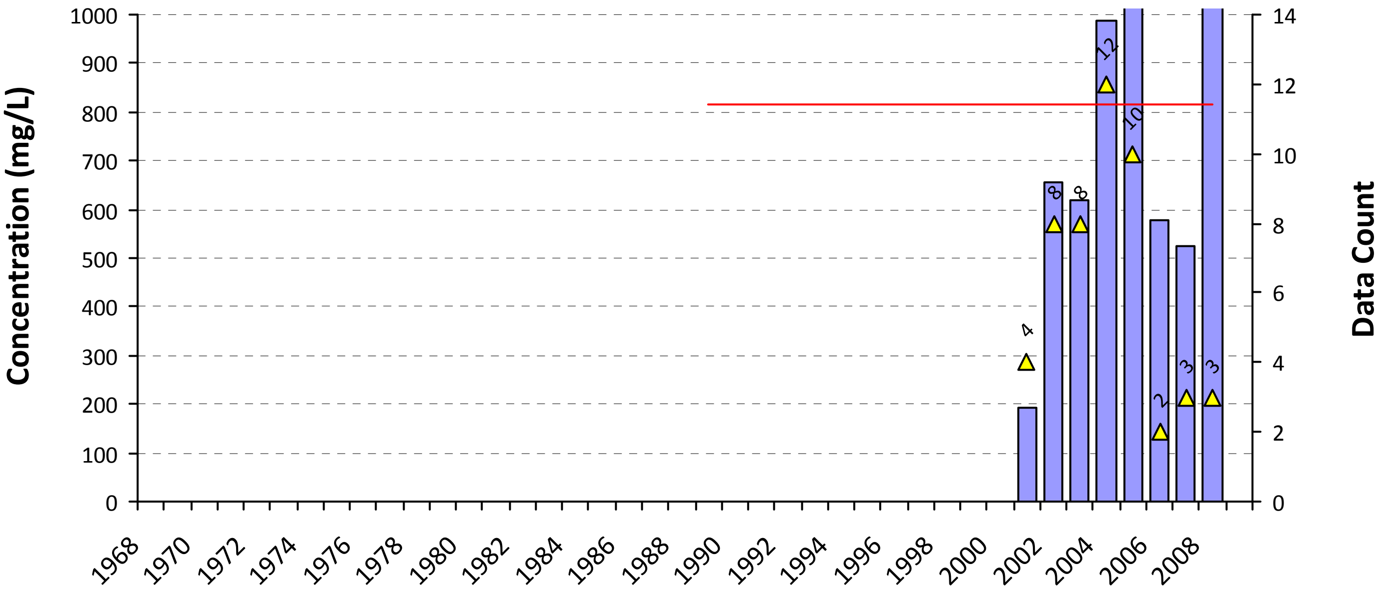
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

West Fork

0810A Big Sandy Creek



0810B Garrett Creek



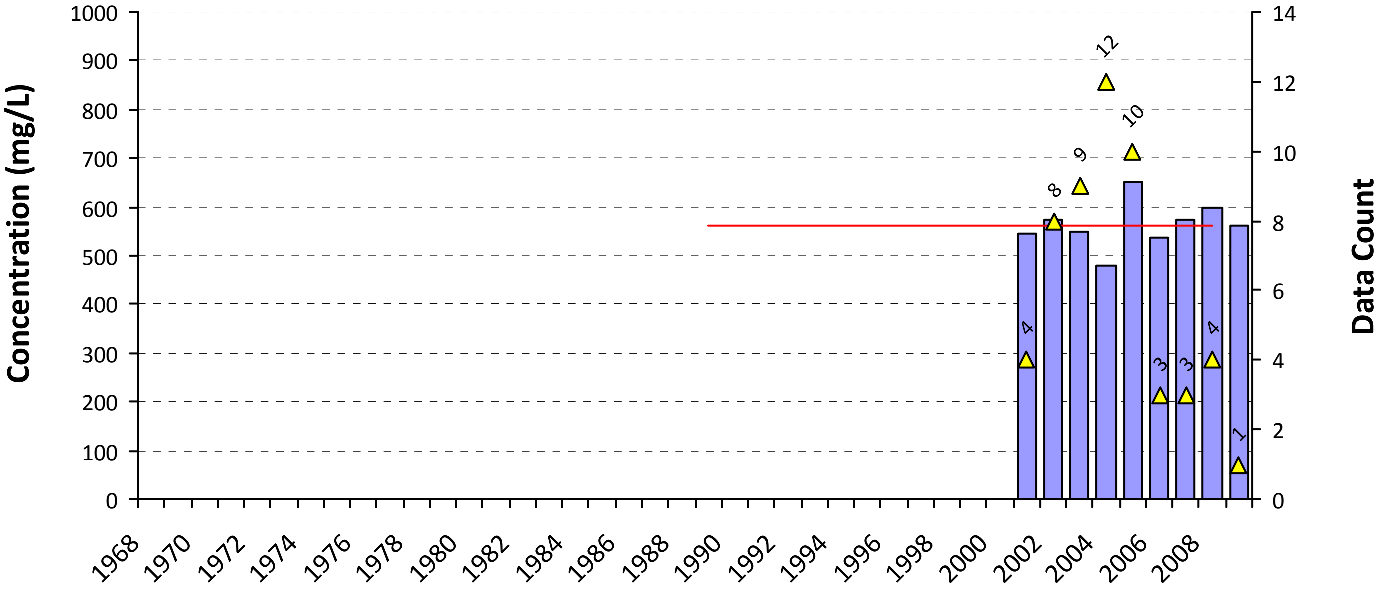
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

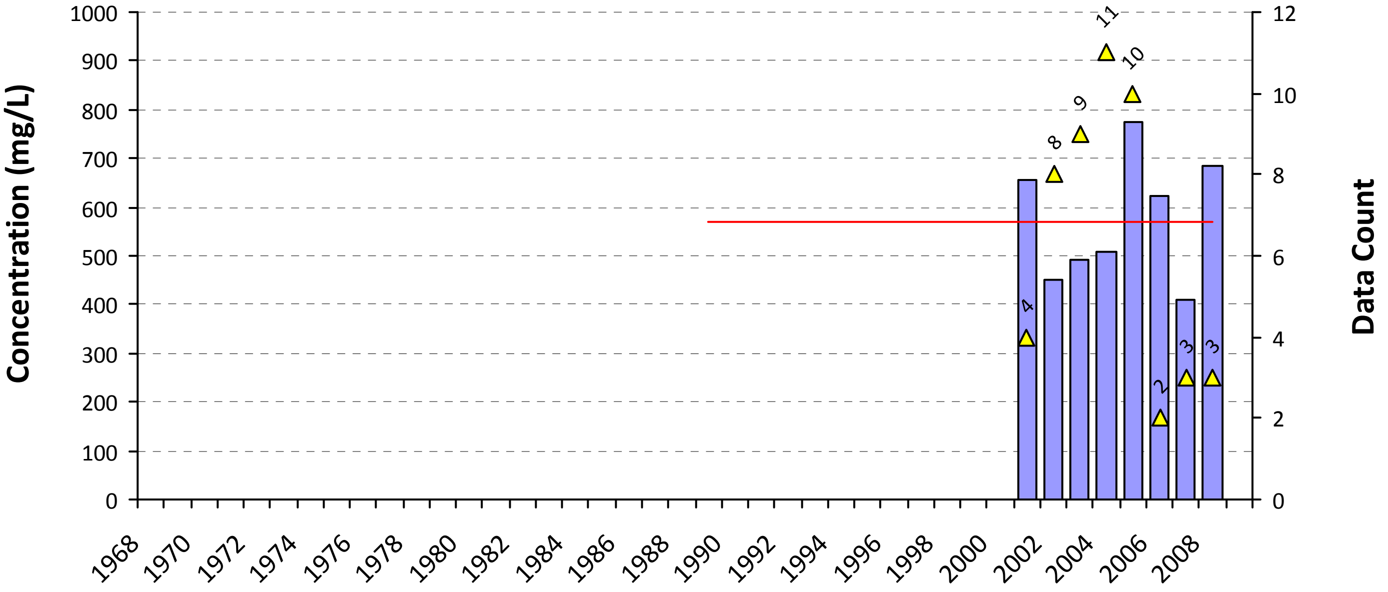
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

West Fork

0810C Martin Branch



0810D Salt Creek



🟦 Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

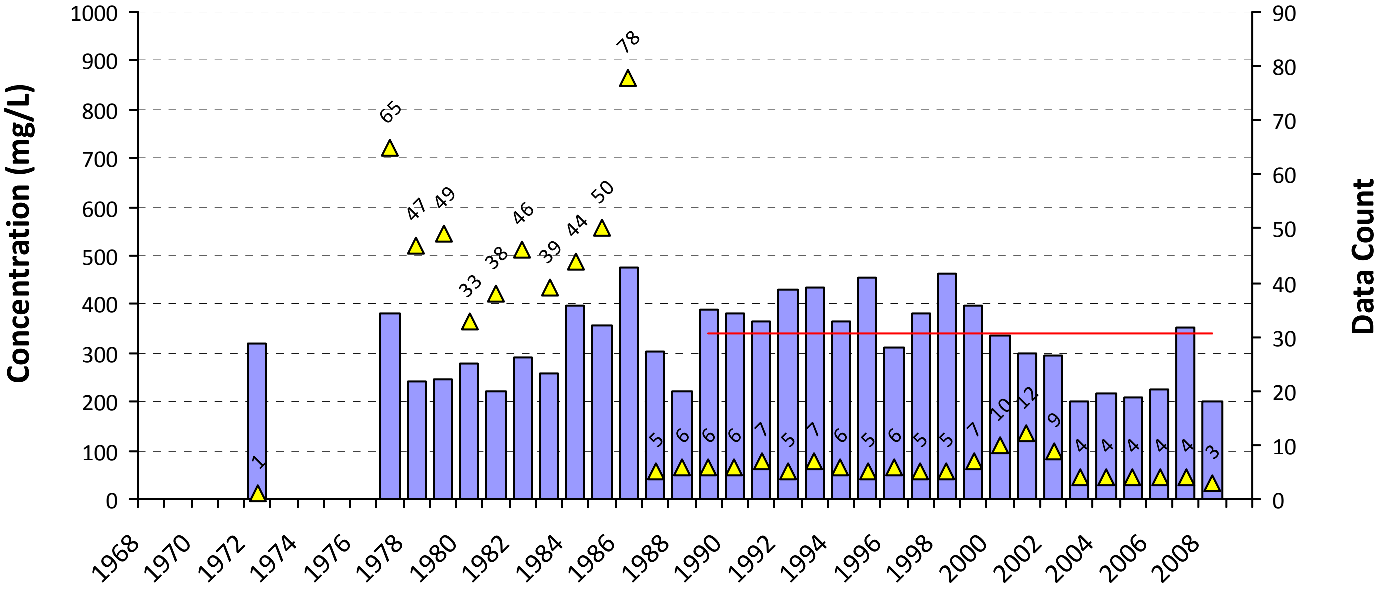
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

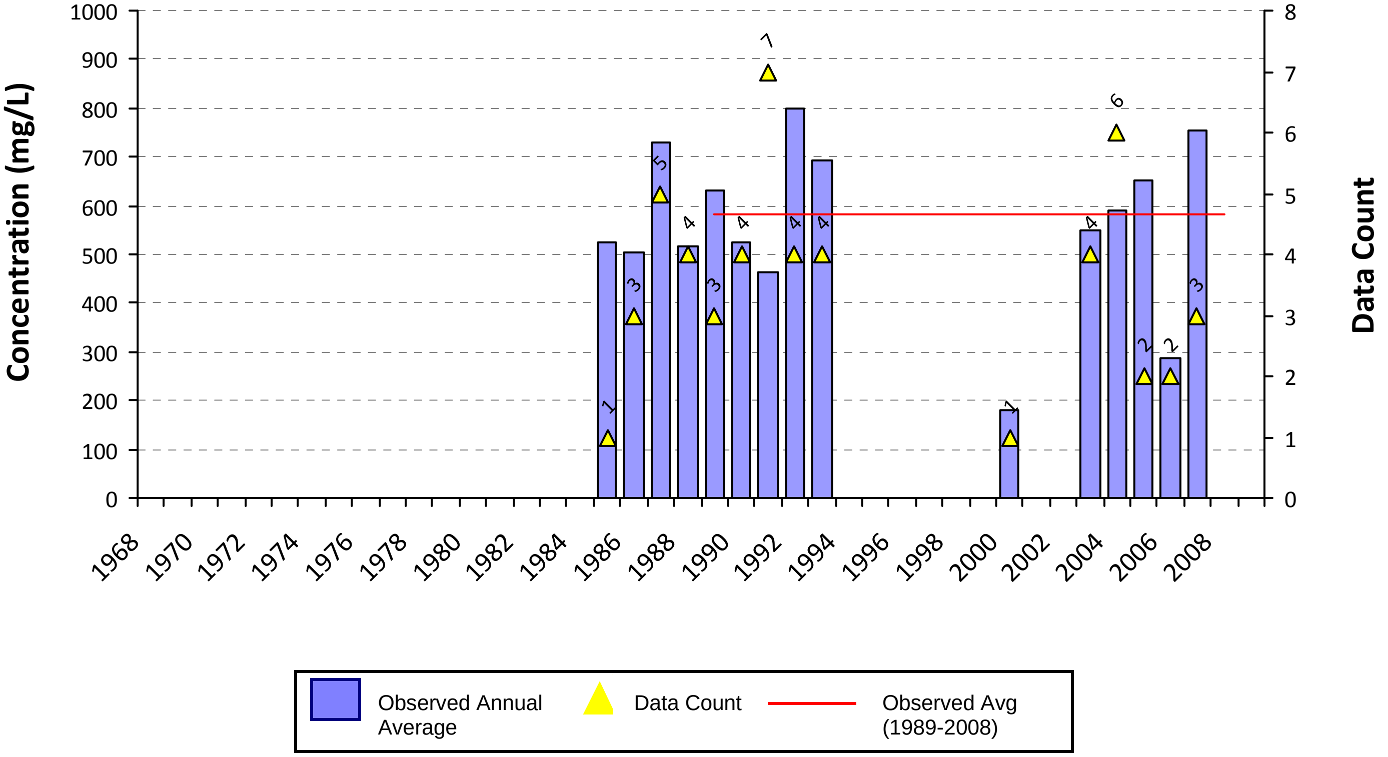
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Village Creek & Mountain Creek

0828A Village Creek



0838A Mountain Creek

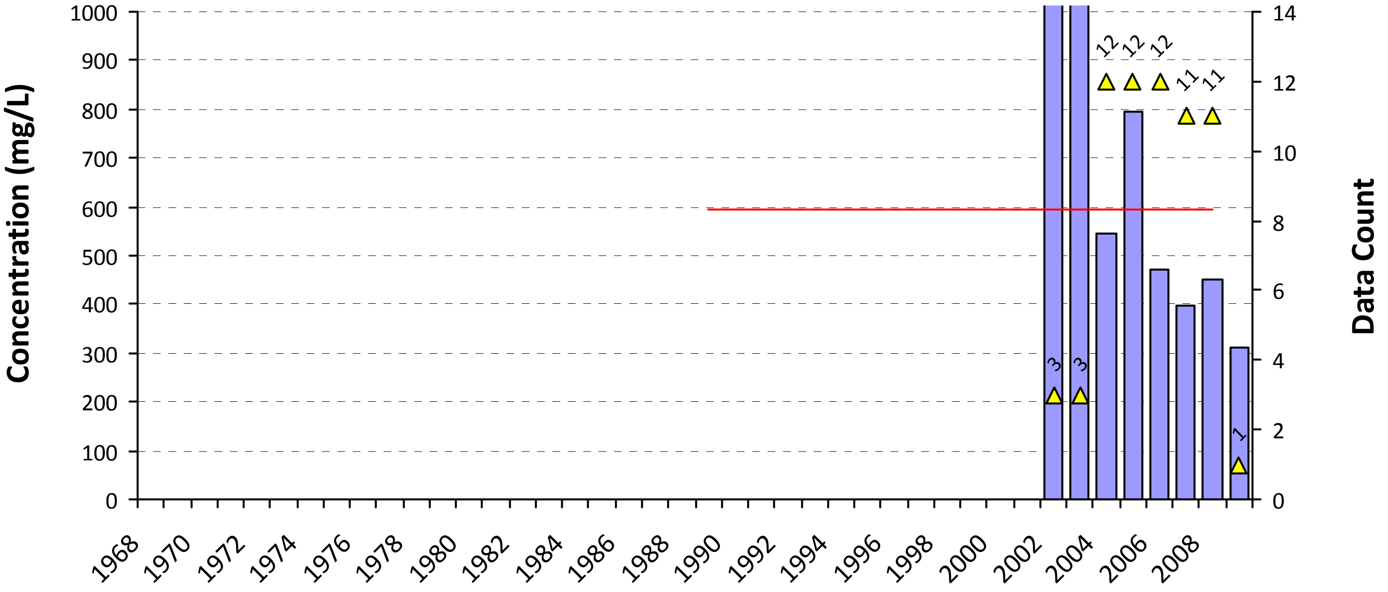


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

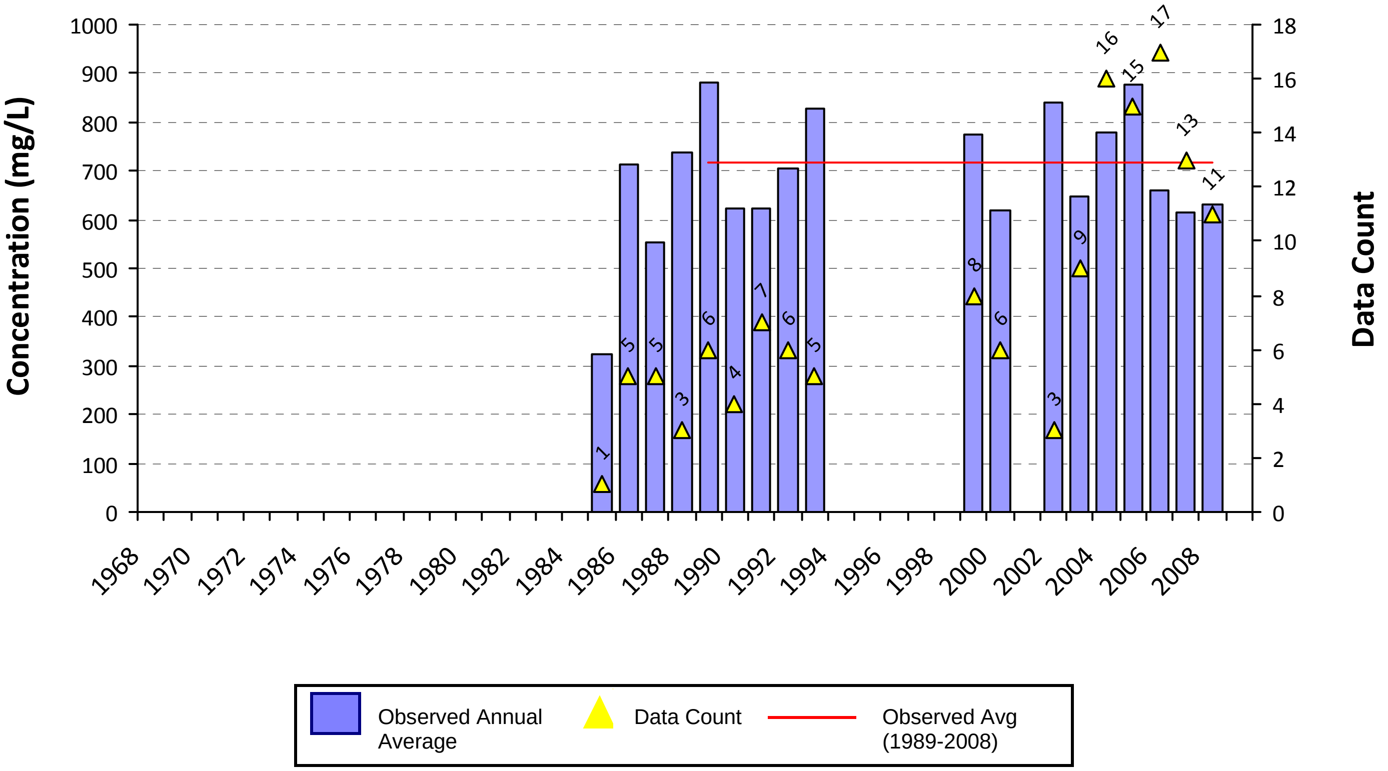
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Village Creek & Mountain Creek

0838B Sugar Creek



0838C Walunt Creek

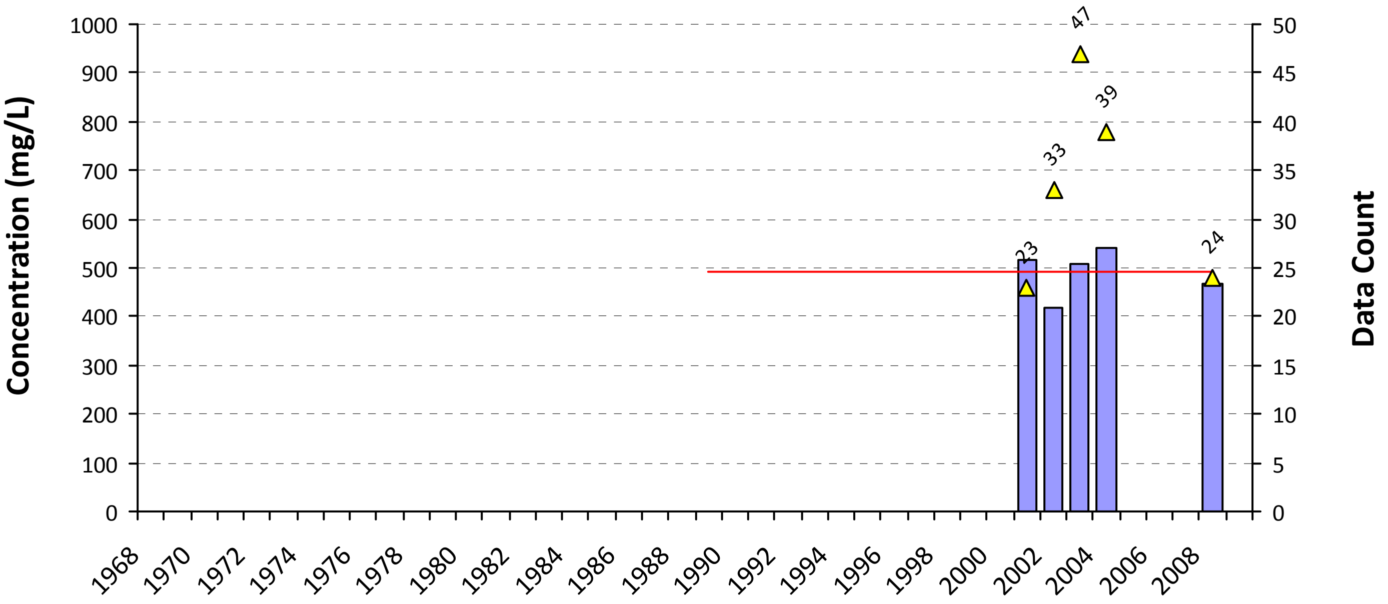


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

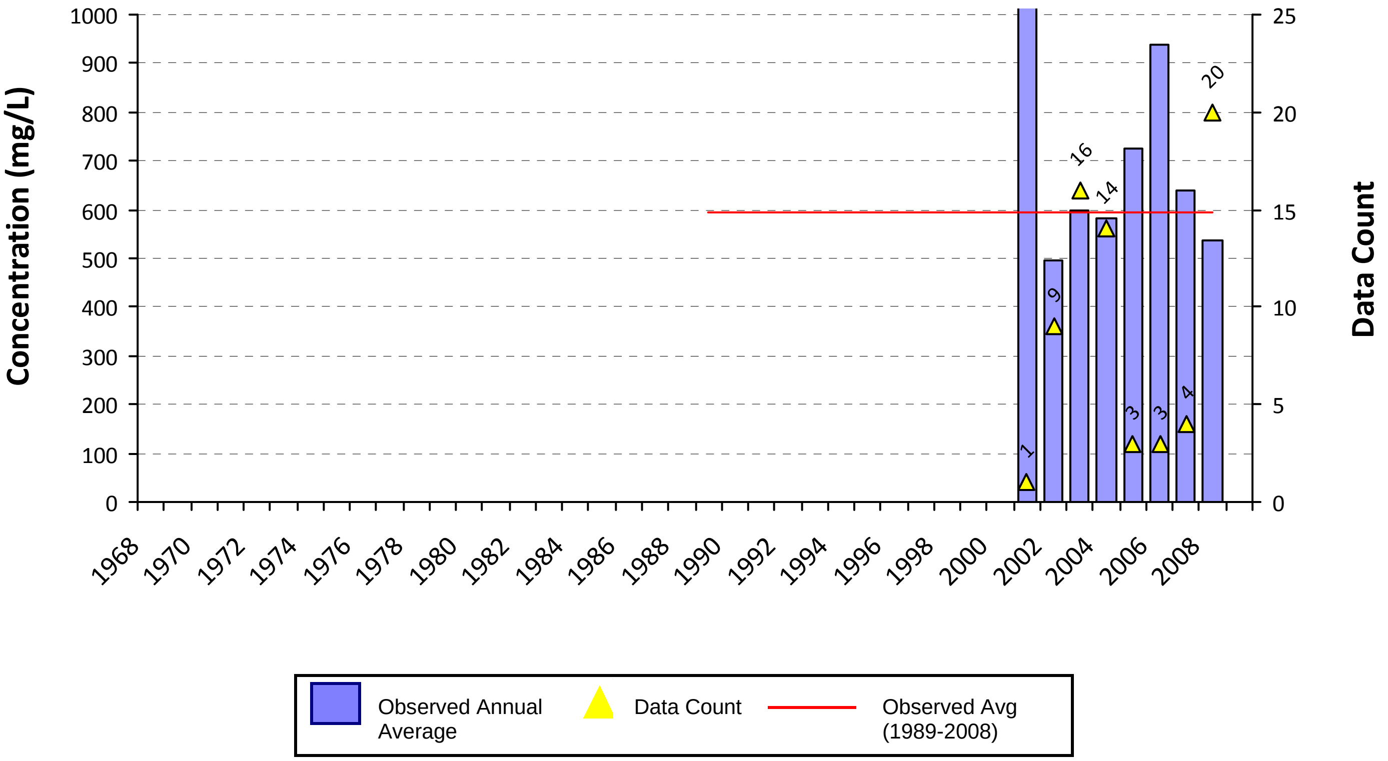
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0822A Cottonwood Branch



0822B Grapevine Creek

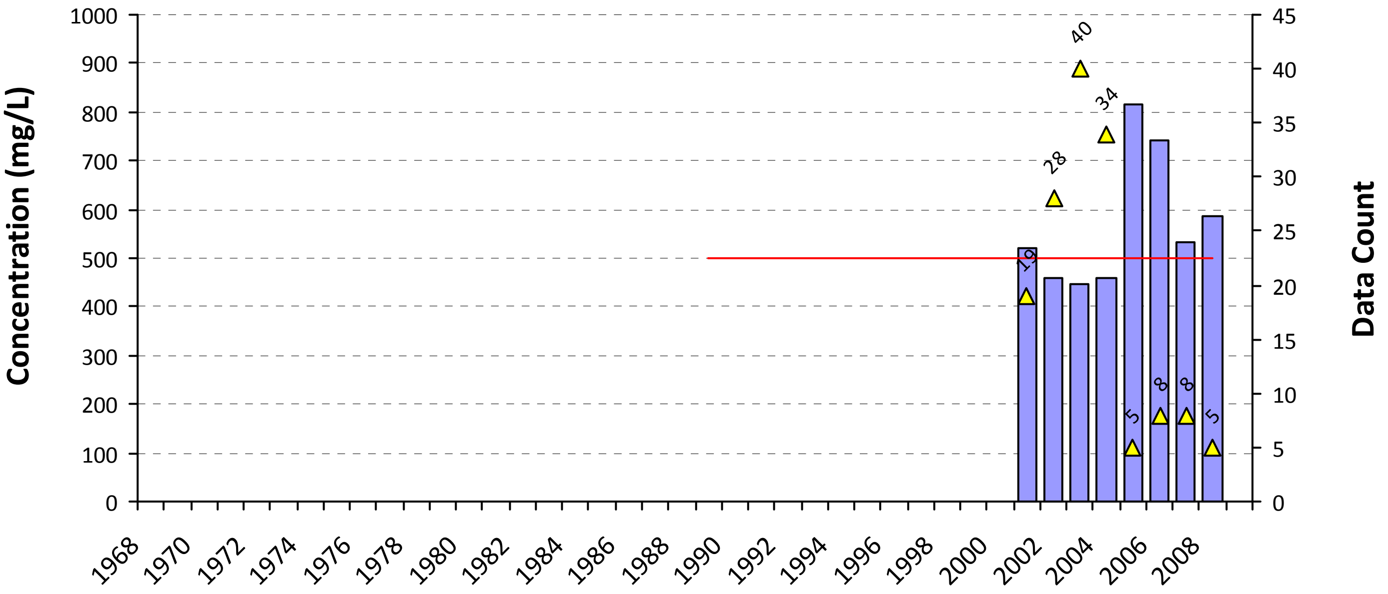


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

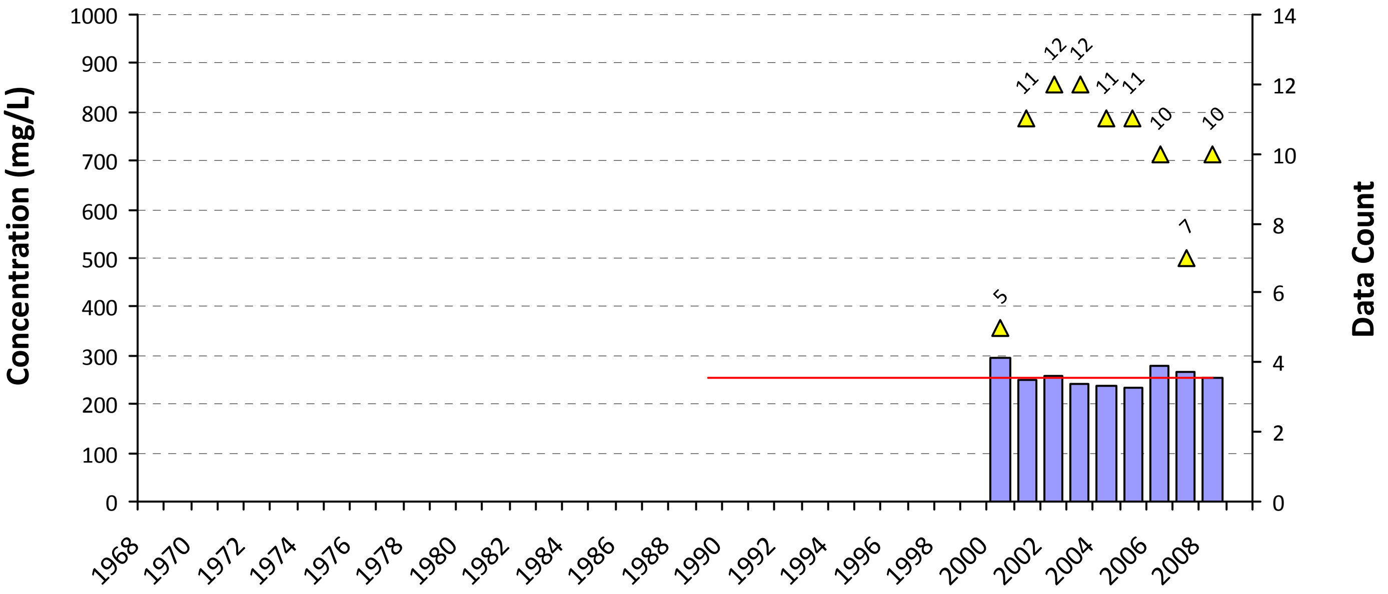
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0822C Hackberry Creek



0822D Ski Lake

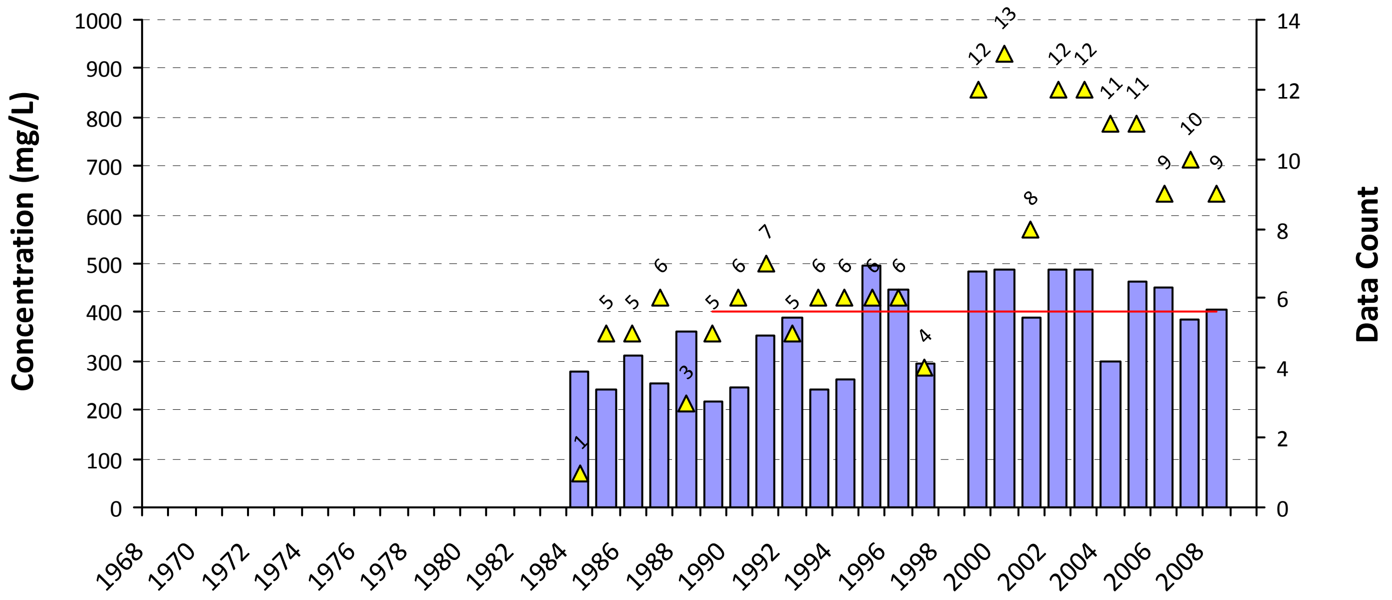


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

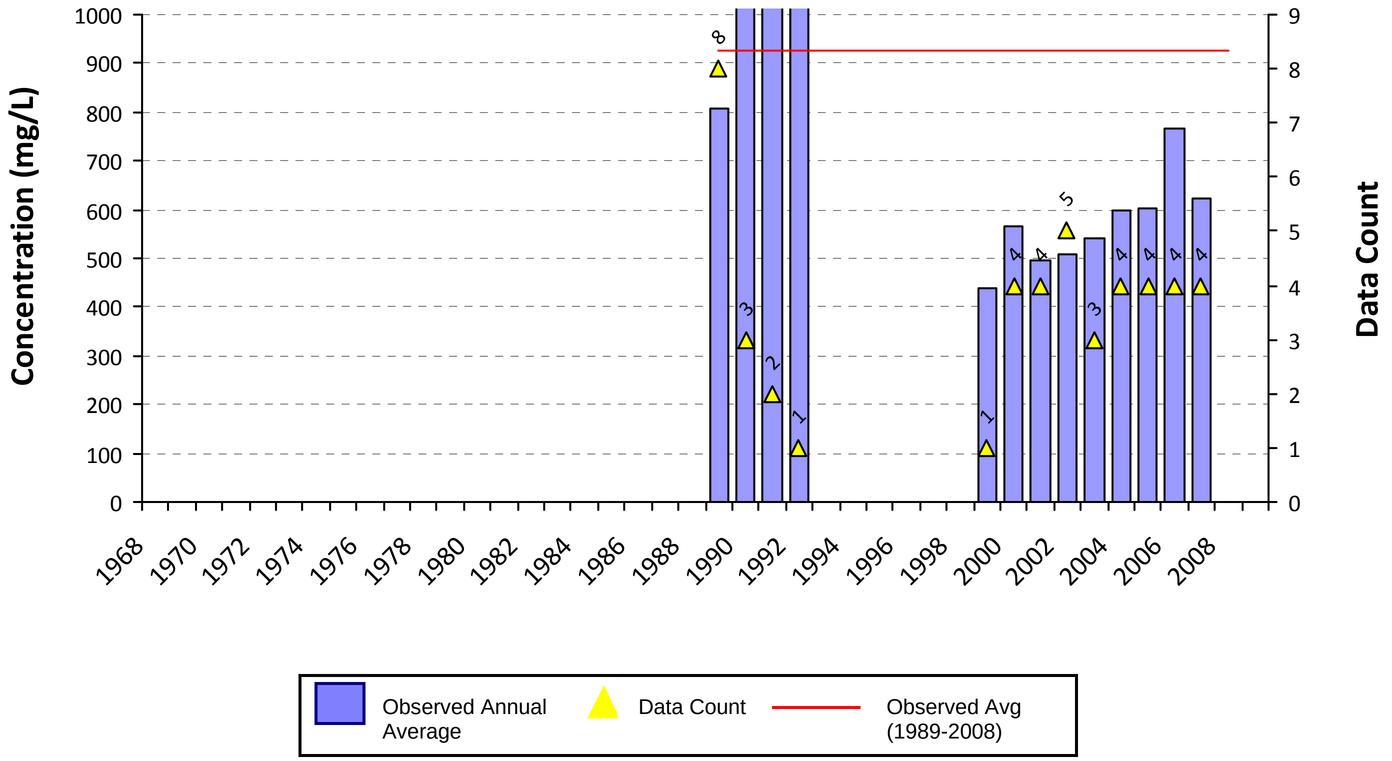
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0823A Little Elm Creek



0823B Stewart Creek

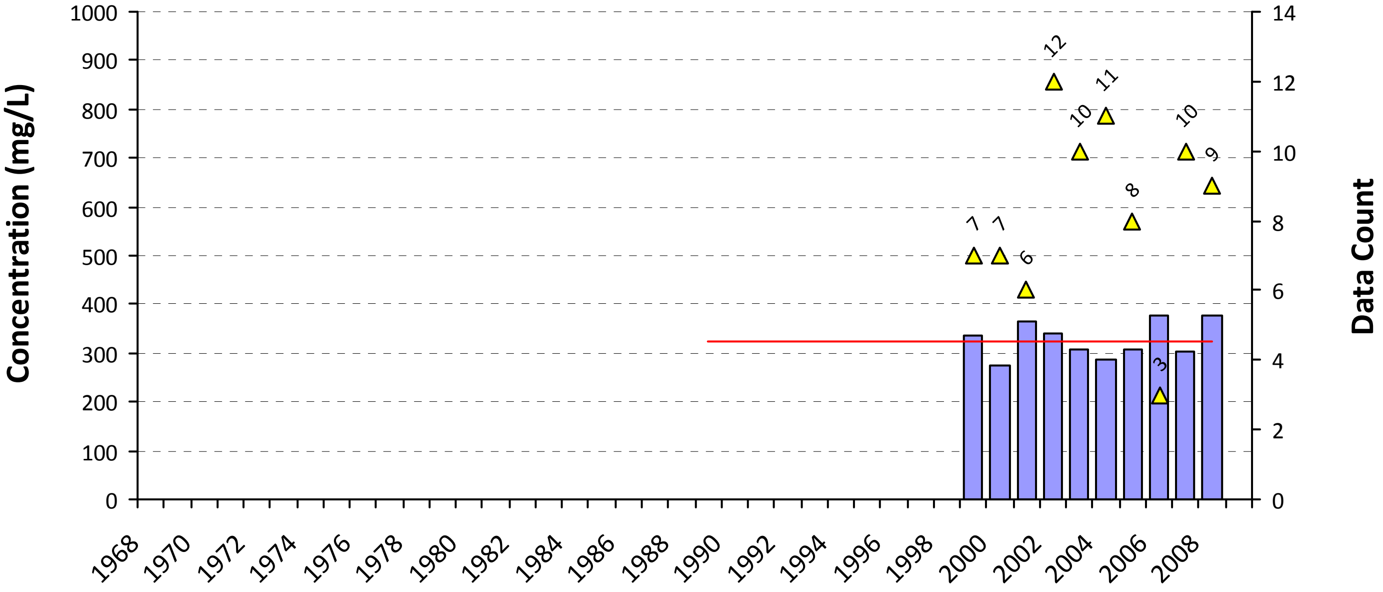


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

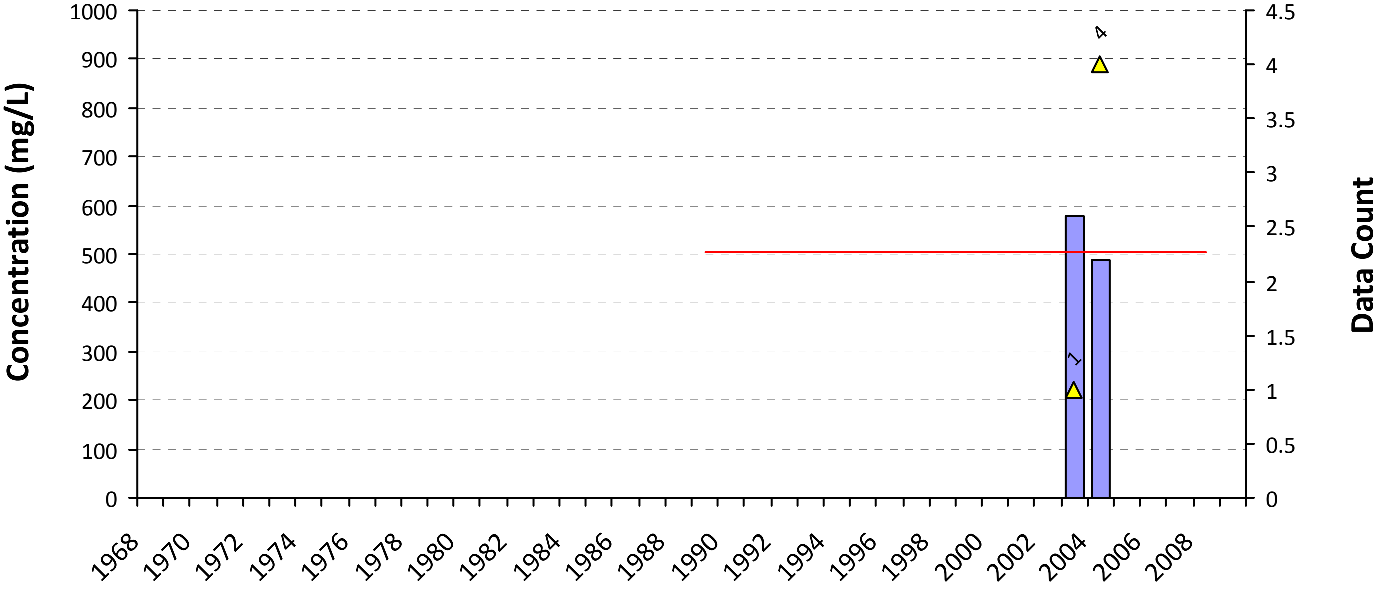
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0823C Clear Creek



0823D

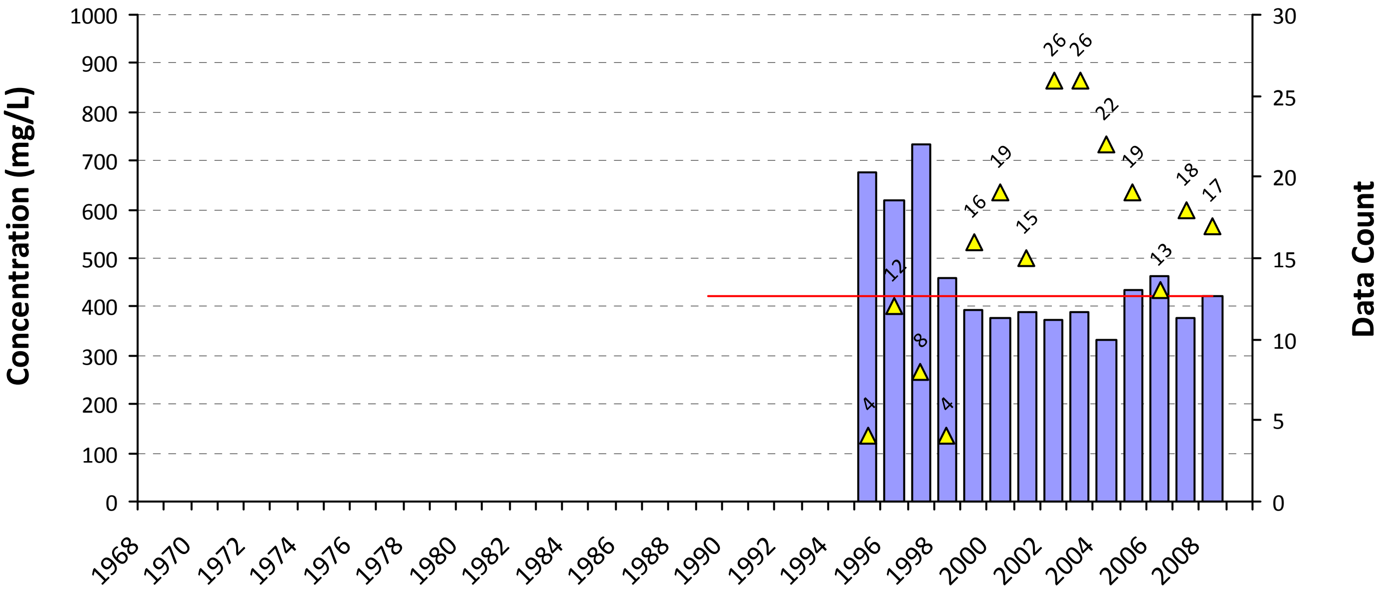


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

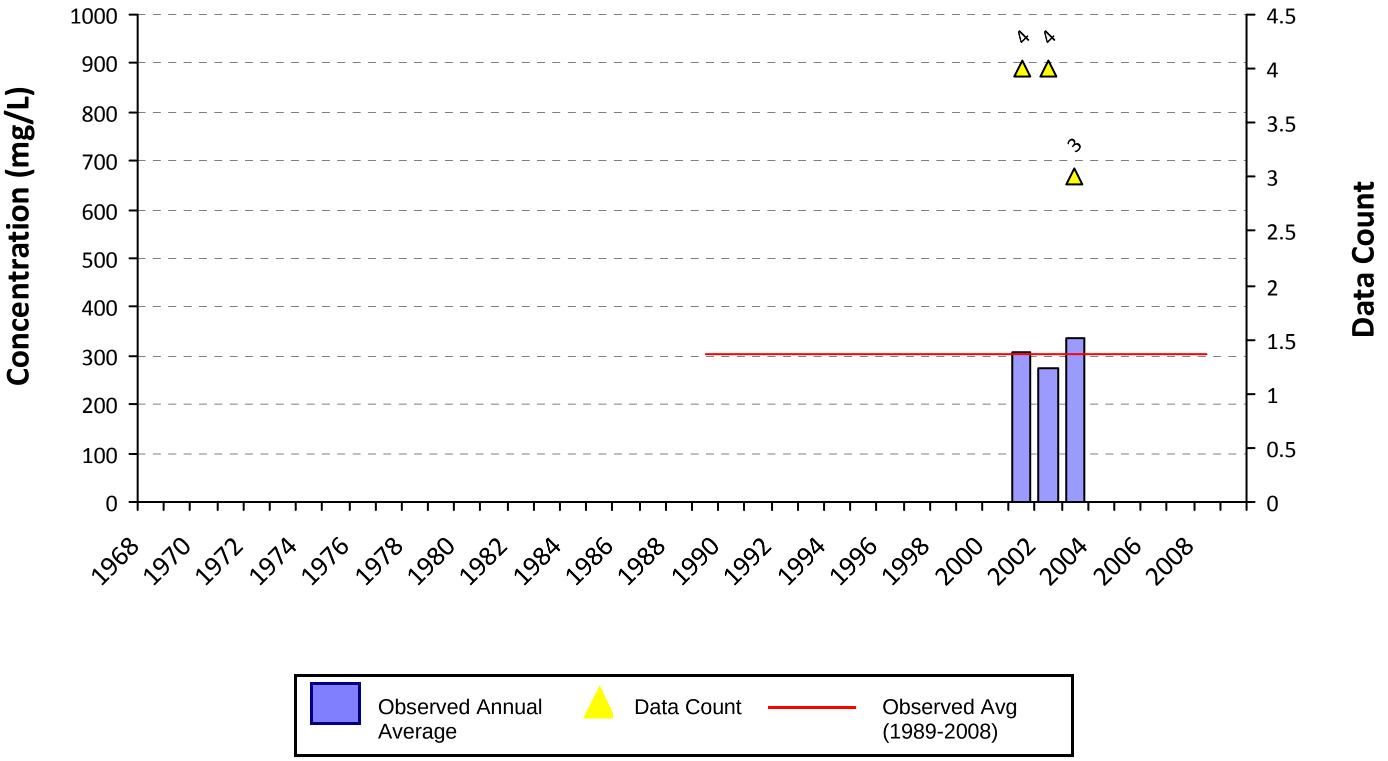
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0826A Denton Creek



0826C Henrietta Creek

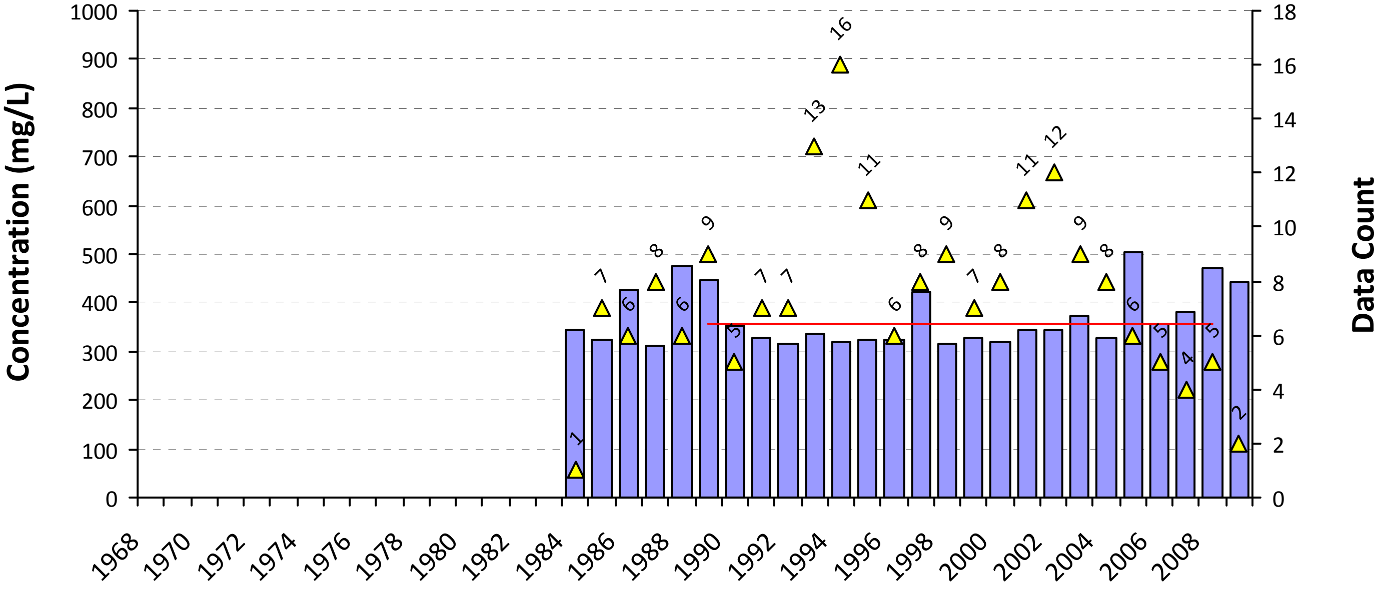


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

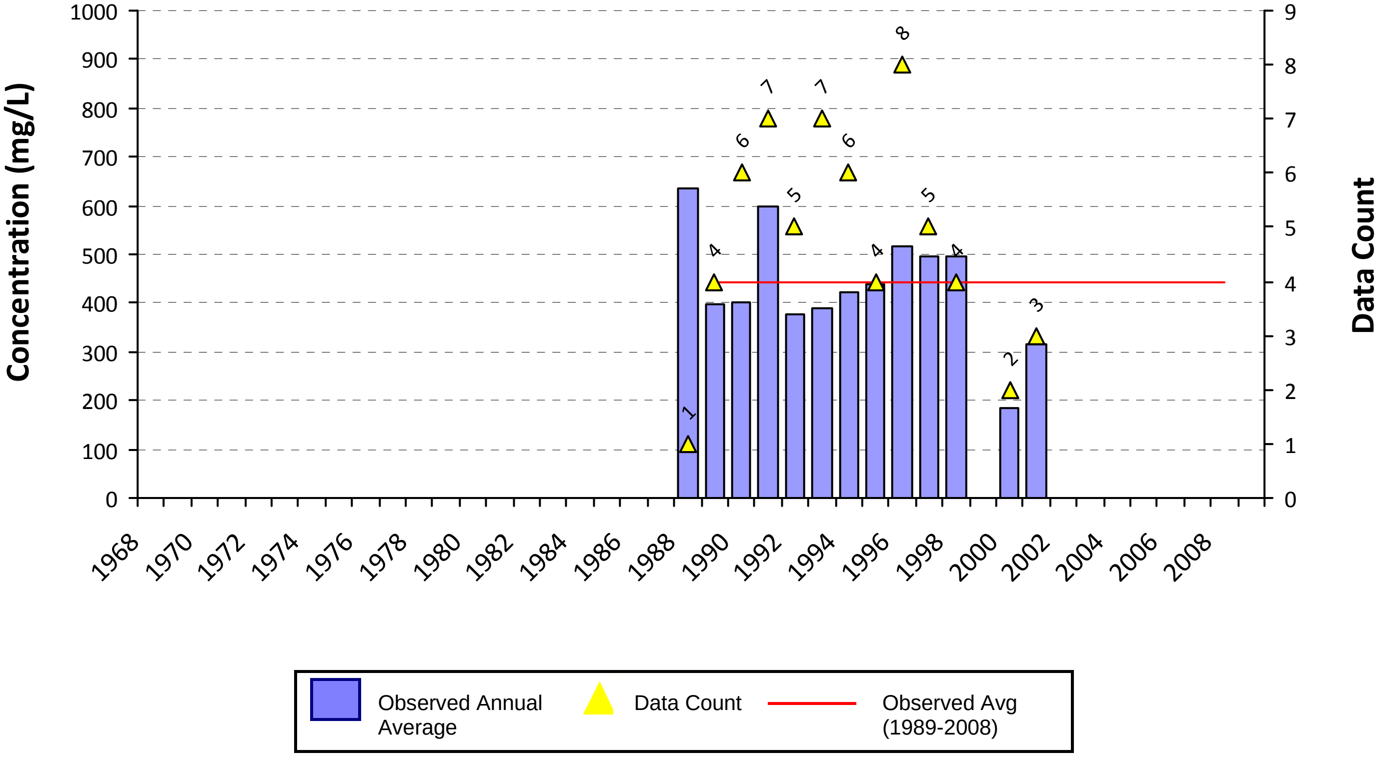
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Elm Fork

0839A Clear Creek



0840A Unnamed Tributary of Jordan Creek



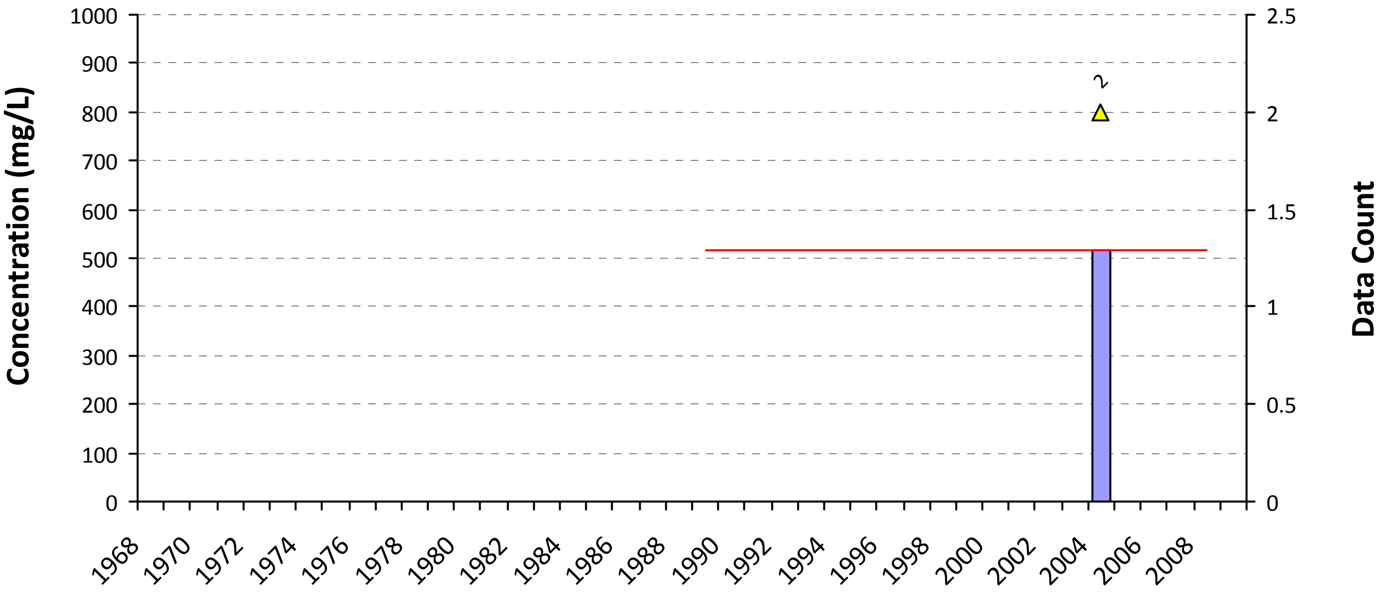
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

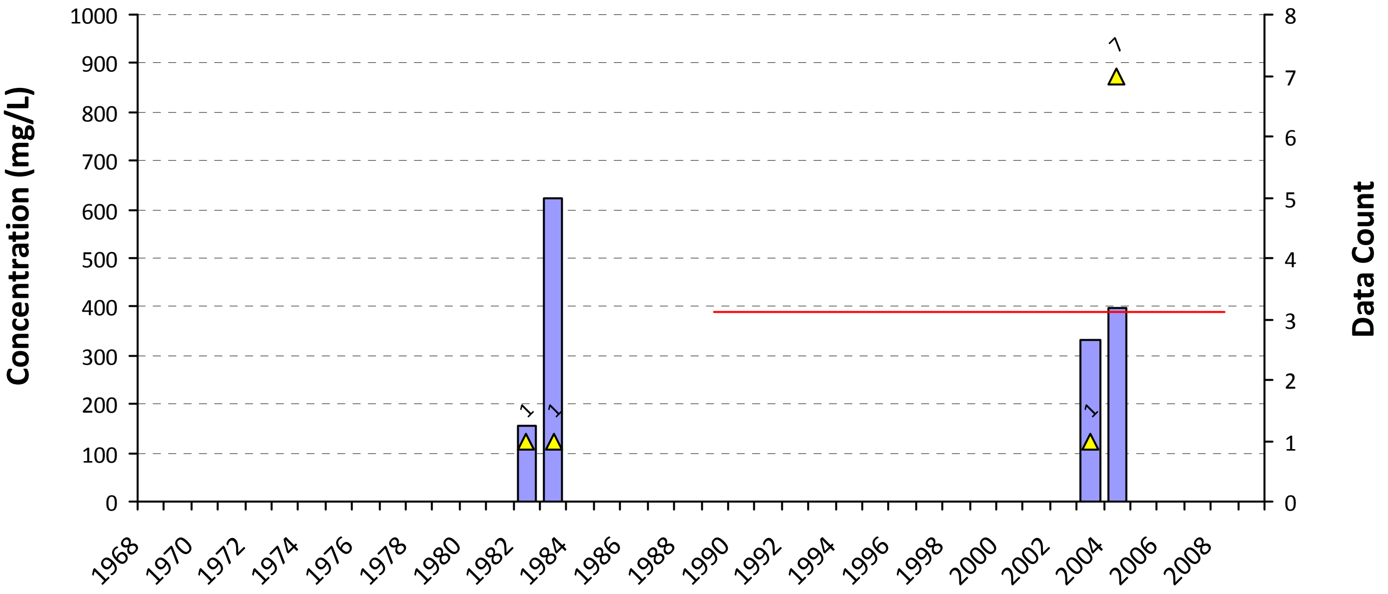
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

East Fork

0819A



0819B



▭ Observed Annual Average

▲ Data Count

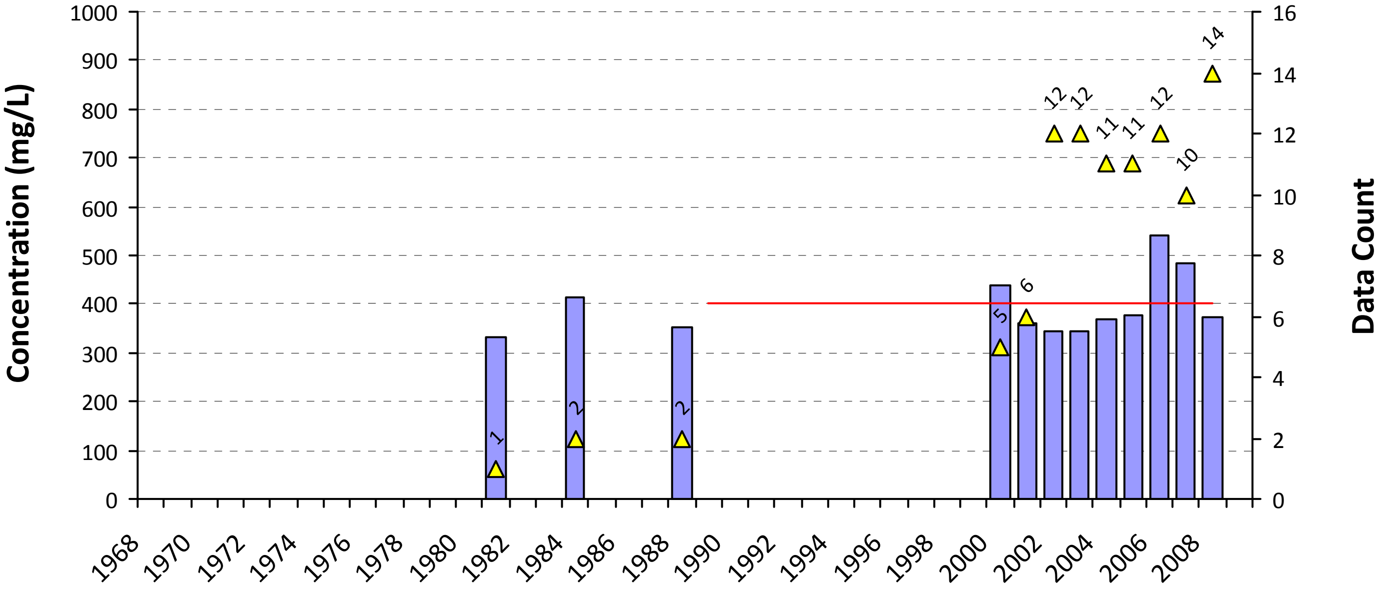
— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

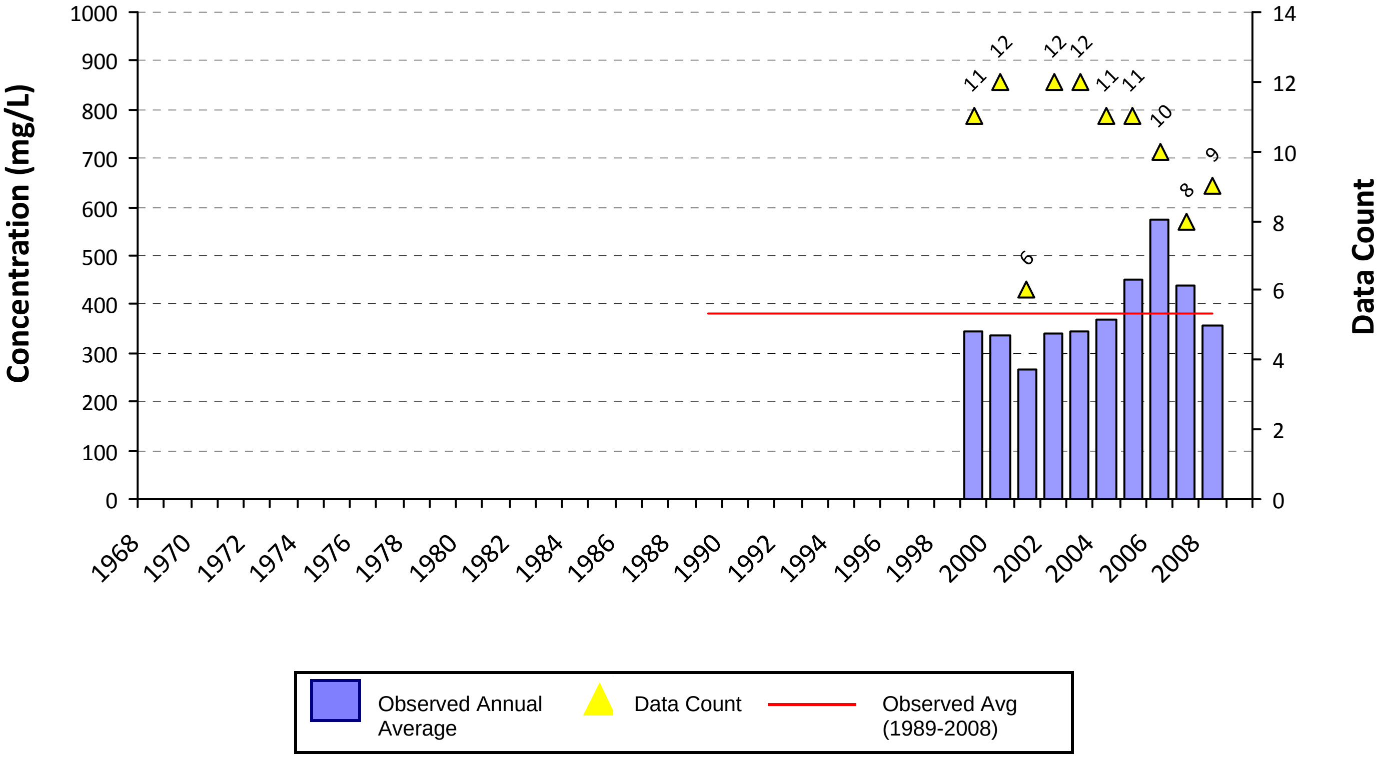
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

East Fork

0820B



0820C Muddy Creek



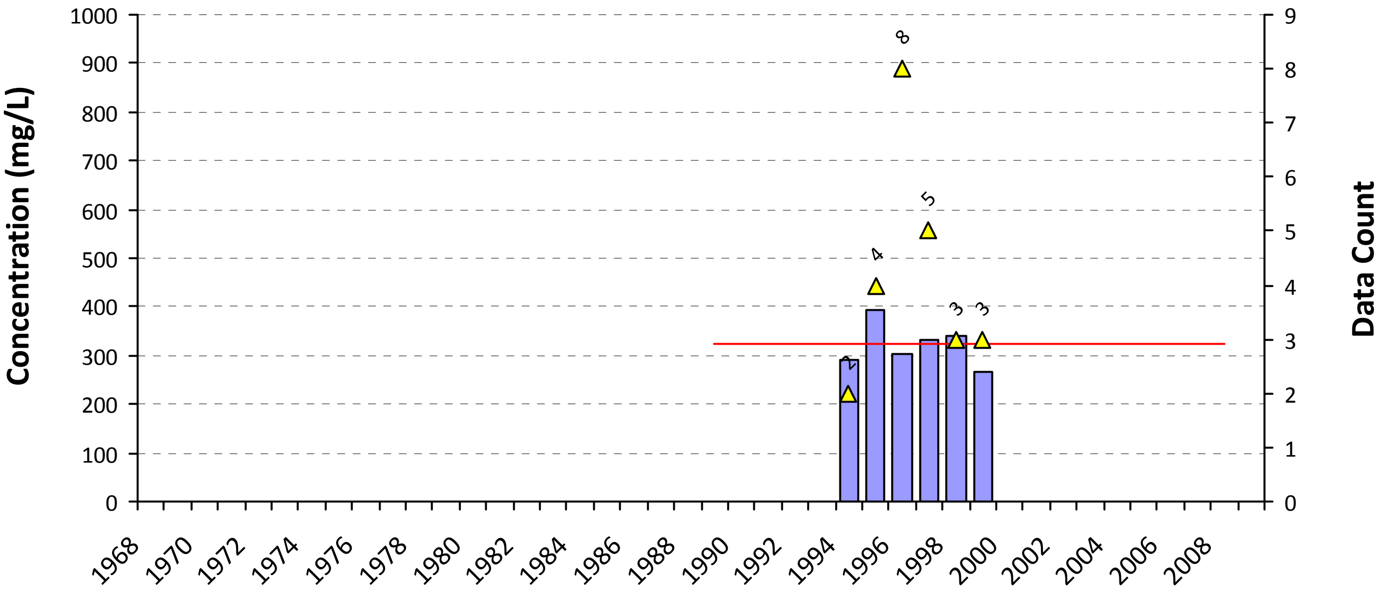
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

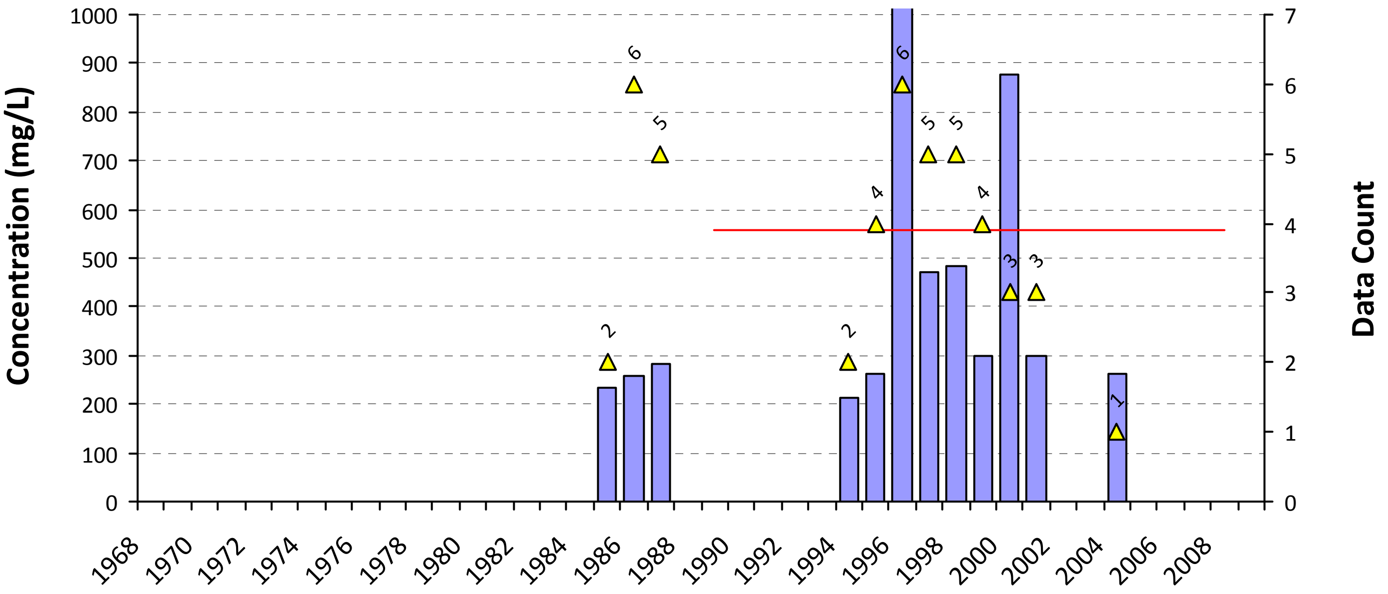
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

East Fork

0821A Pilot Grove Creek



0821B Sister Grove Creek

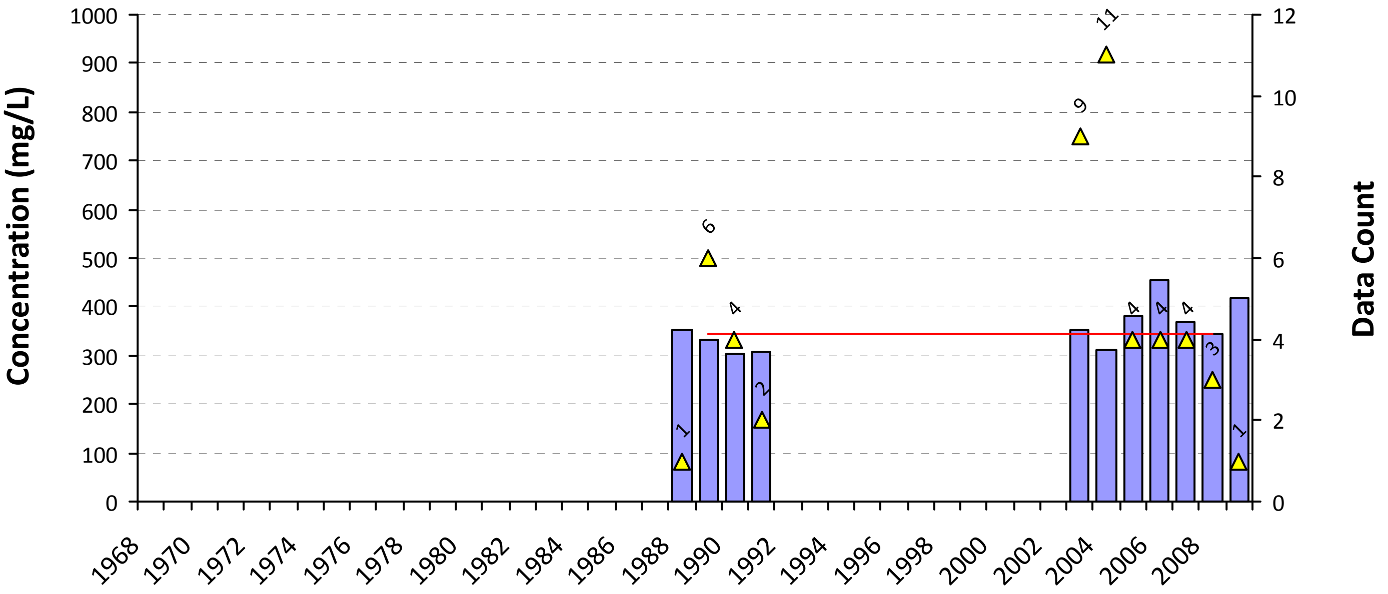


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

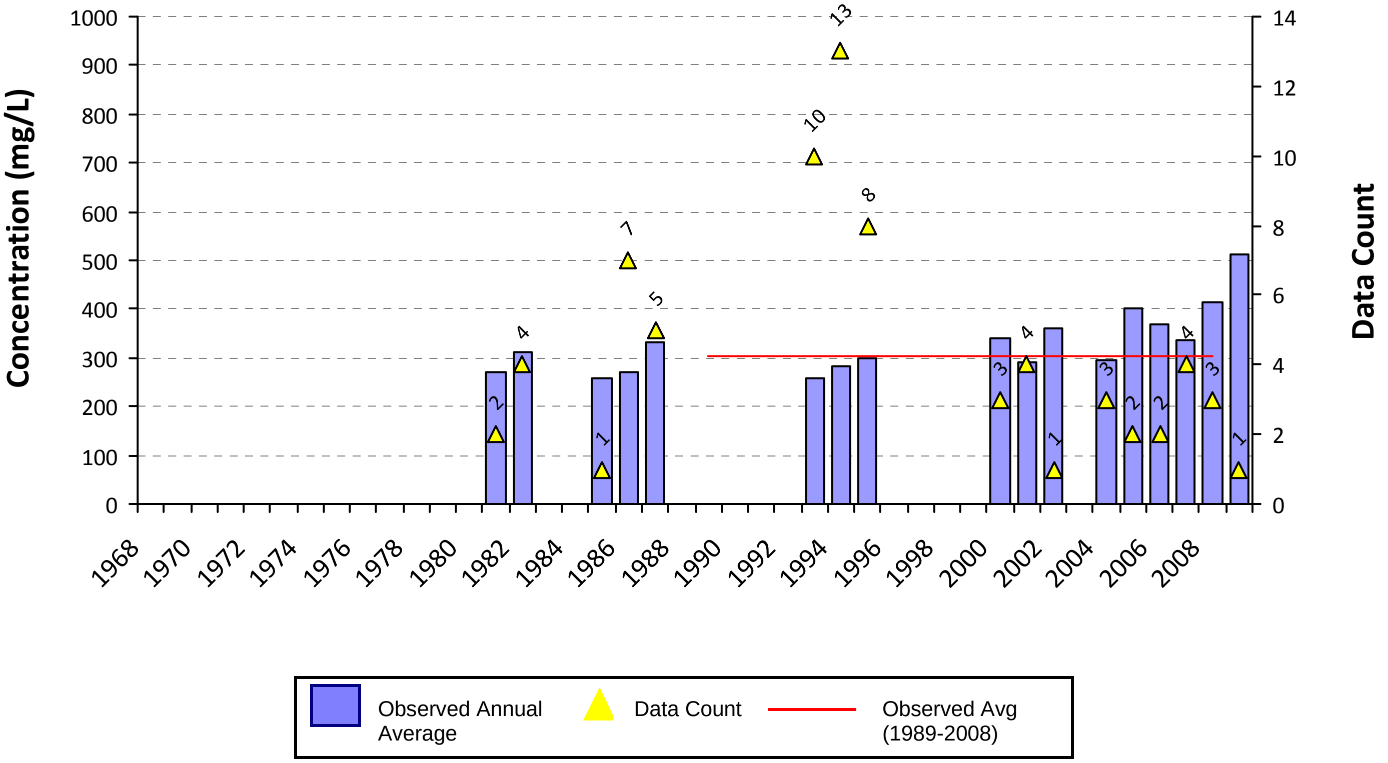
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

East Fork

0821C



0821D

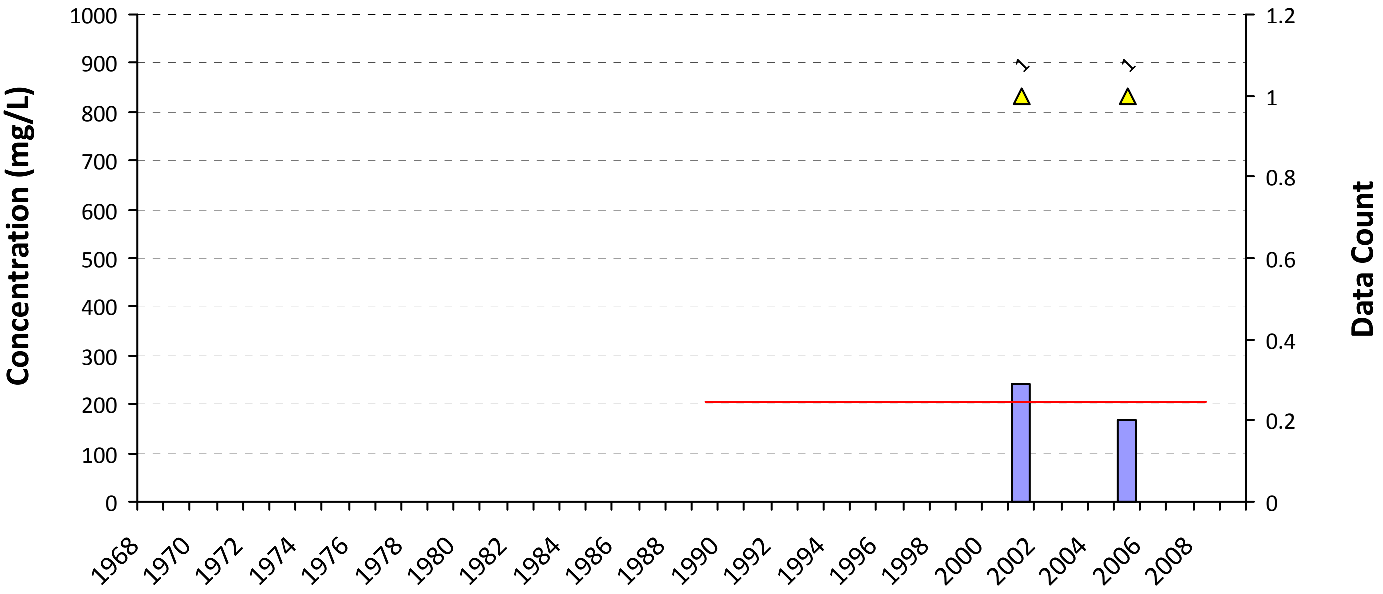


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

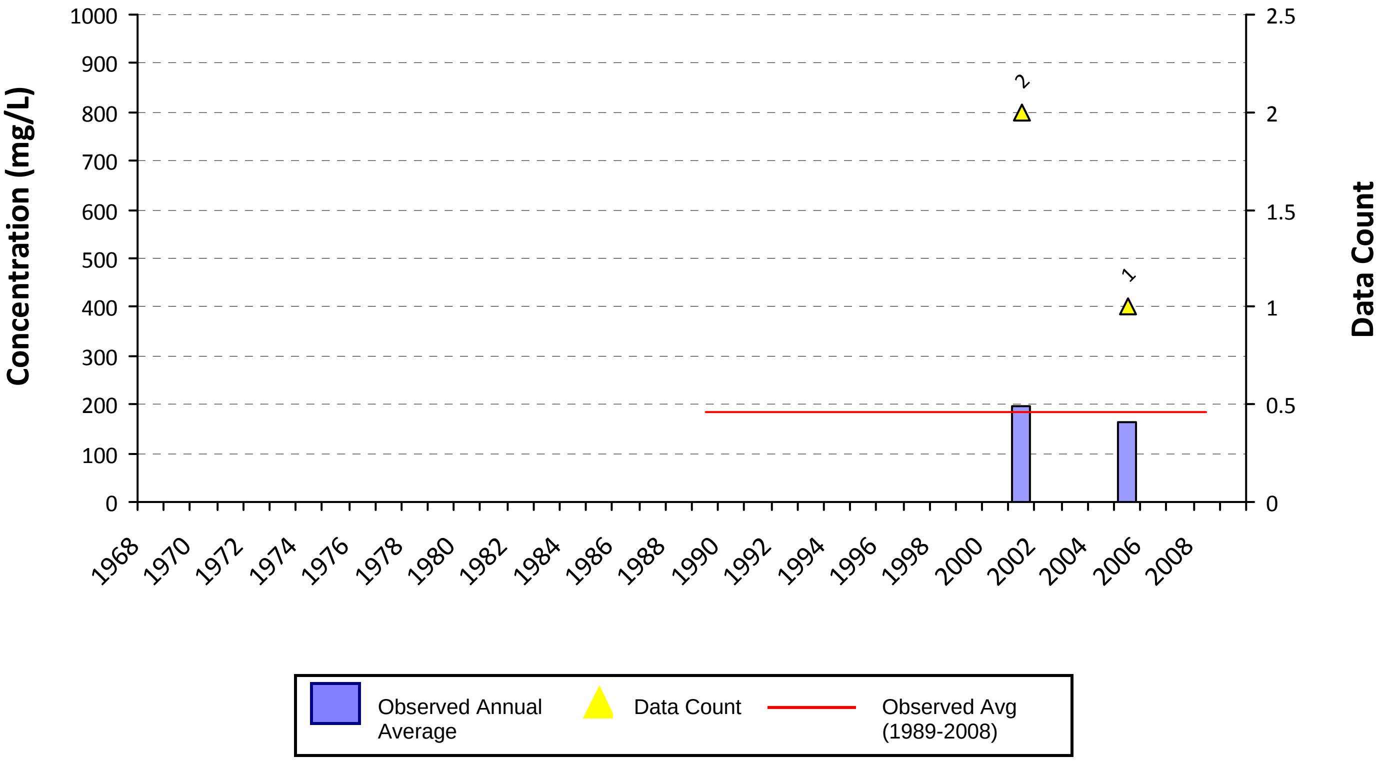
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0806A Fosdic Lake



0806B Echo Lake

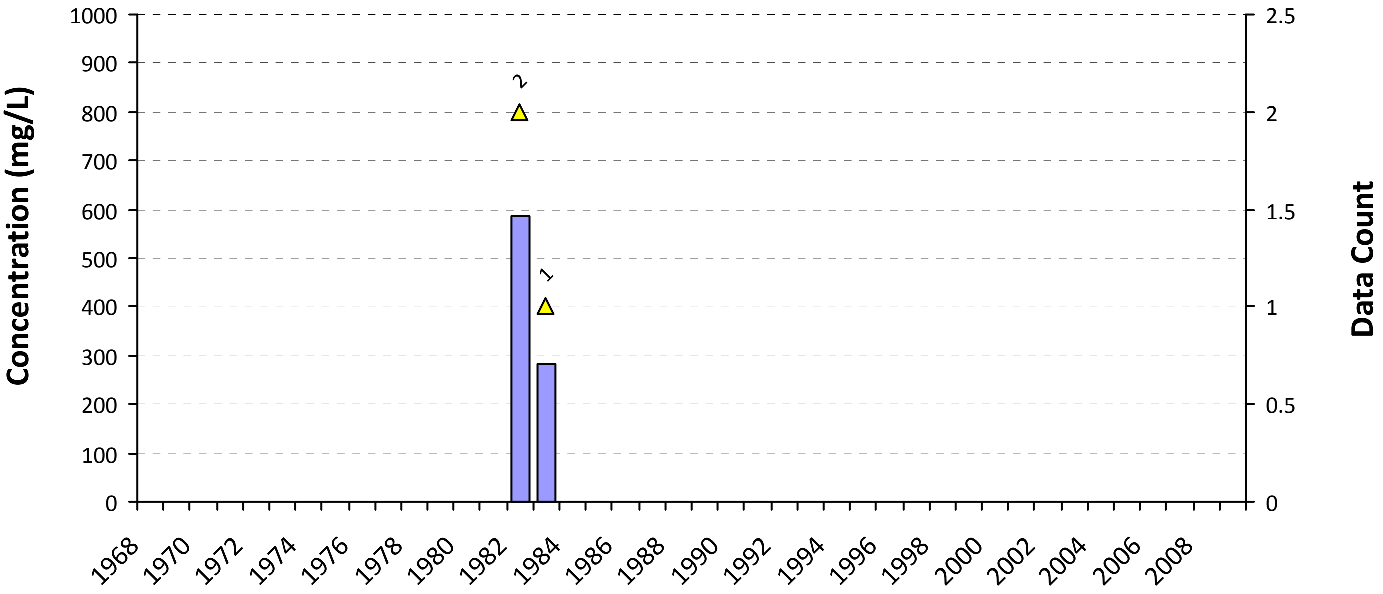


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

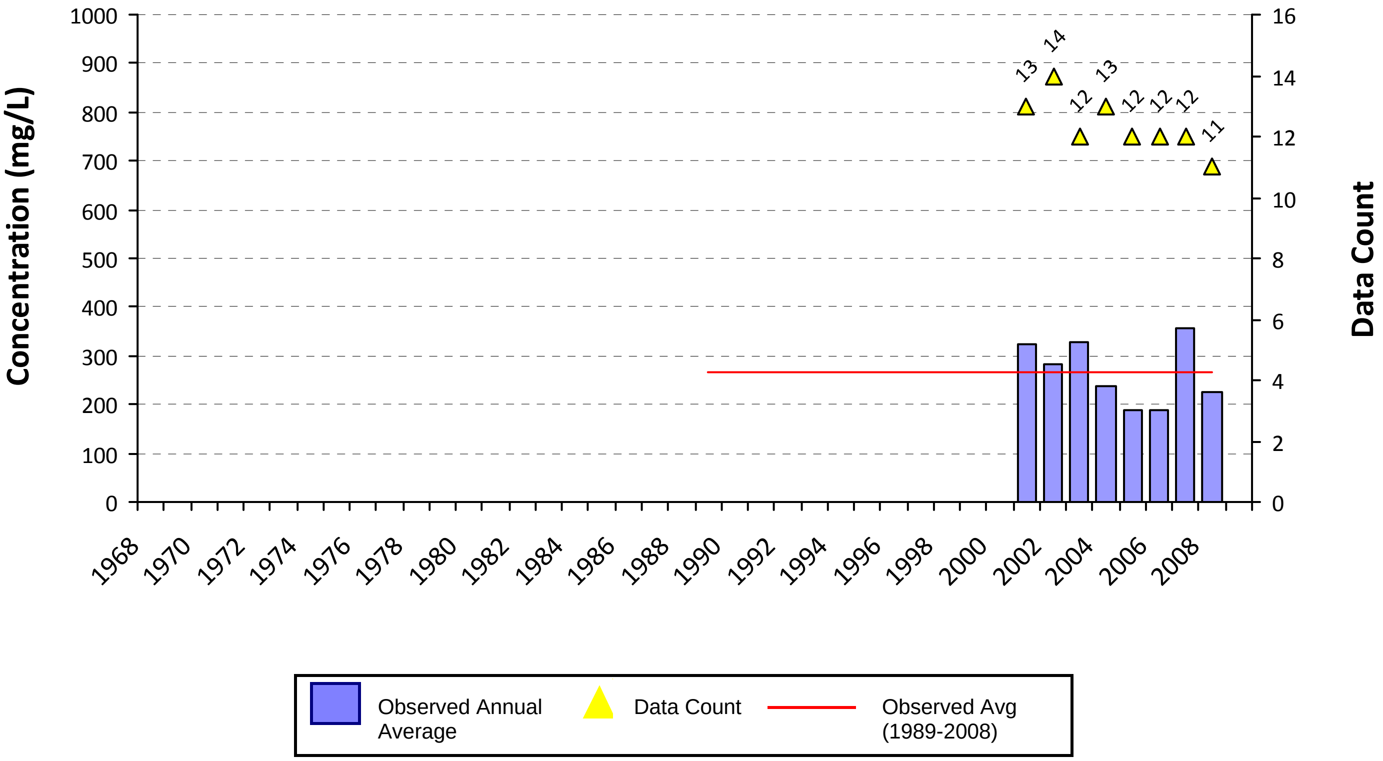
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0806C Big Fossil Creek



0806D Marine Creek

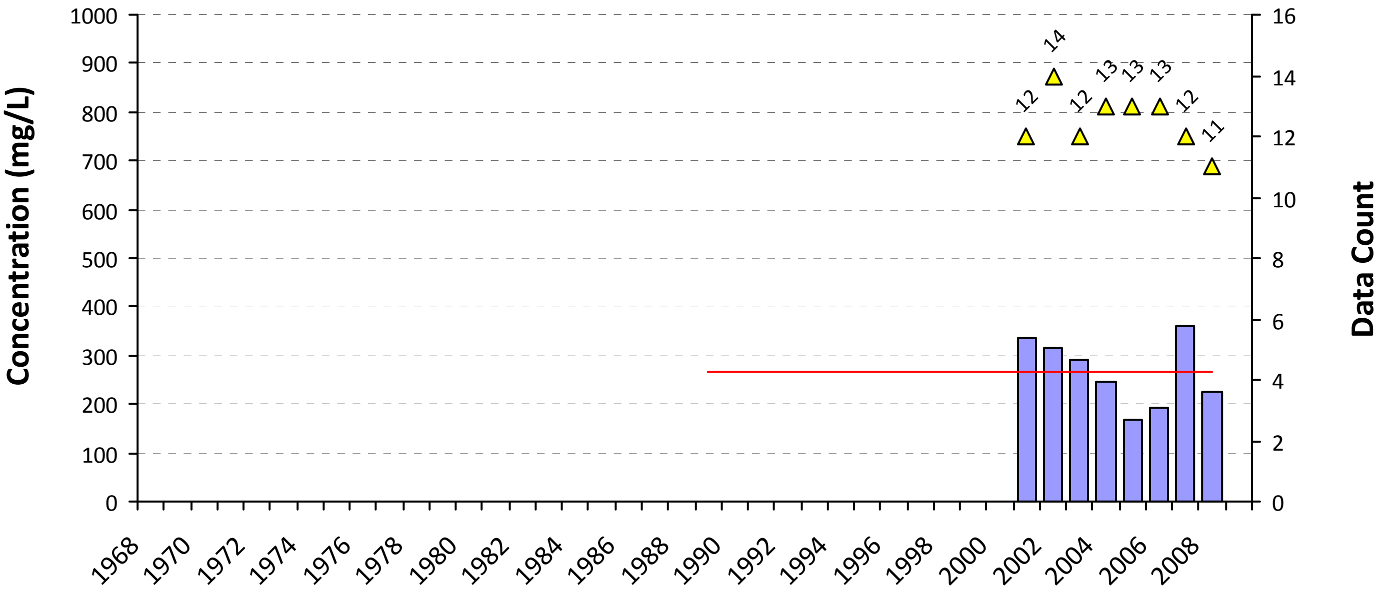


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

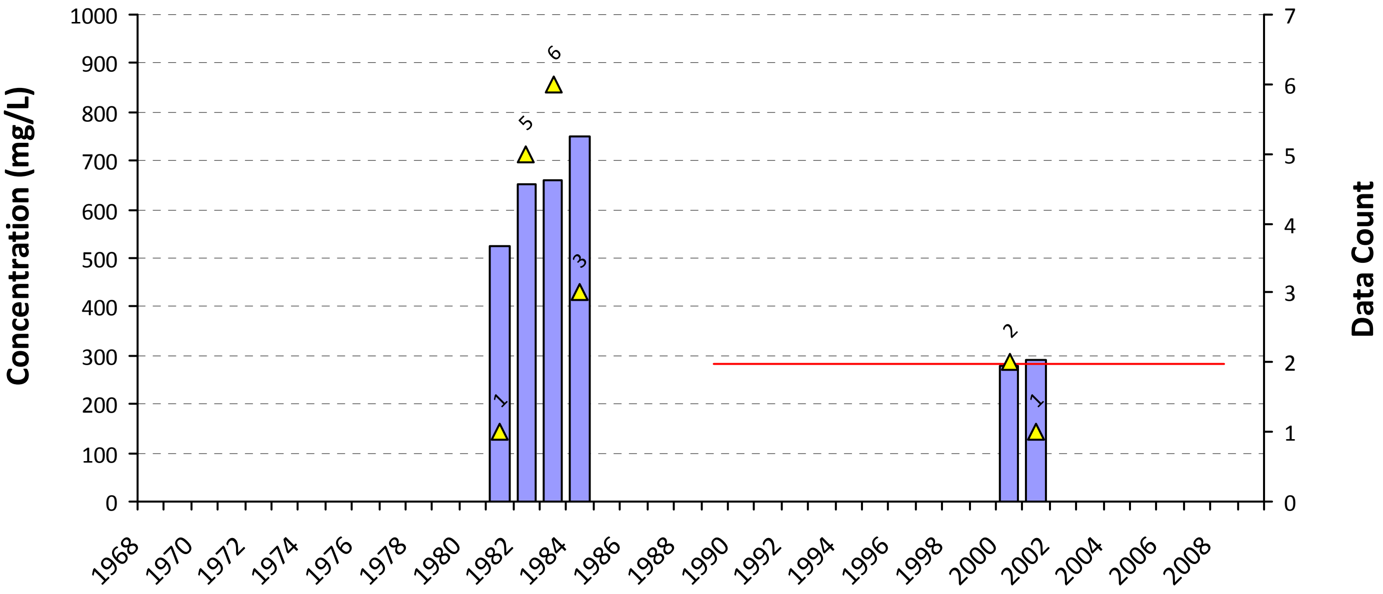
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0806E Sycamore Creek



0841A Mountain Creek Lake



🟦 Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

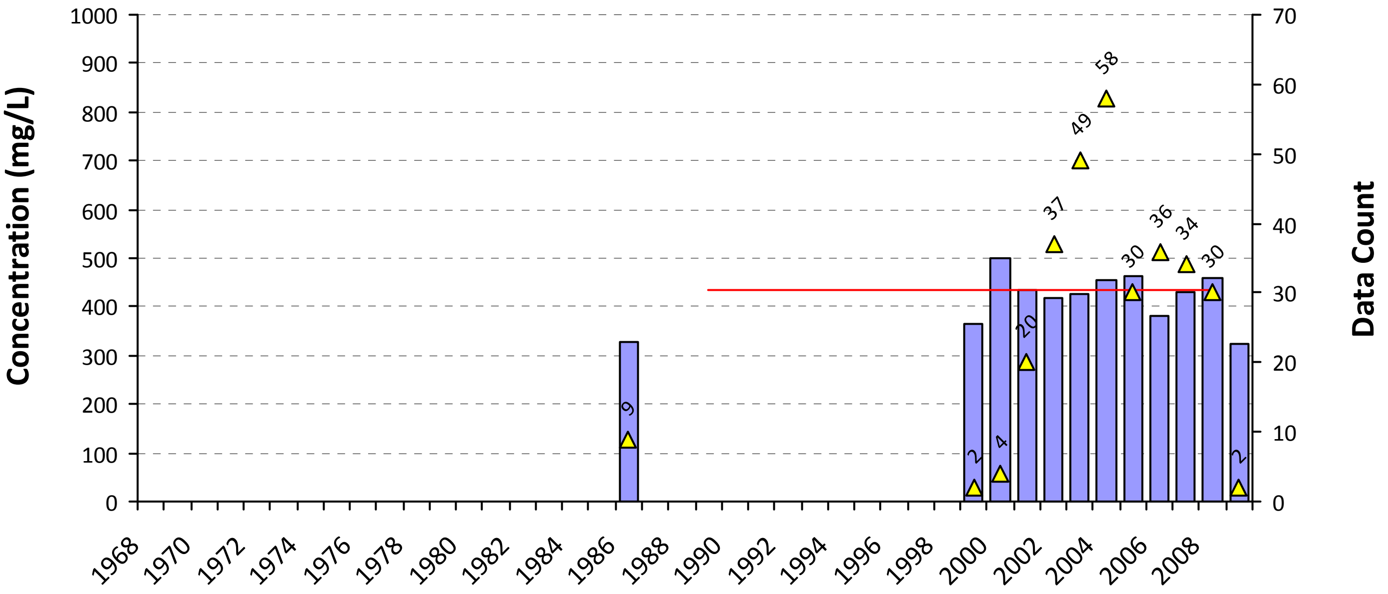
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

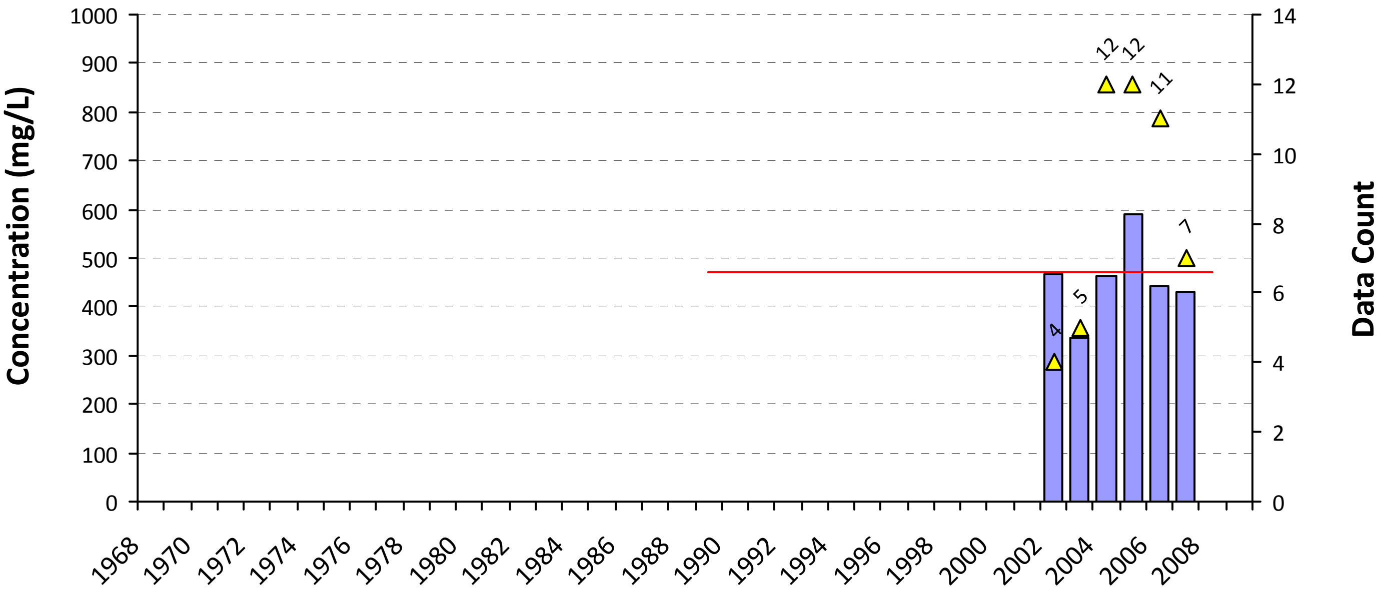
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841B Bear Creek



0841C Arbor Creek



🟦 Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

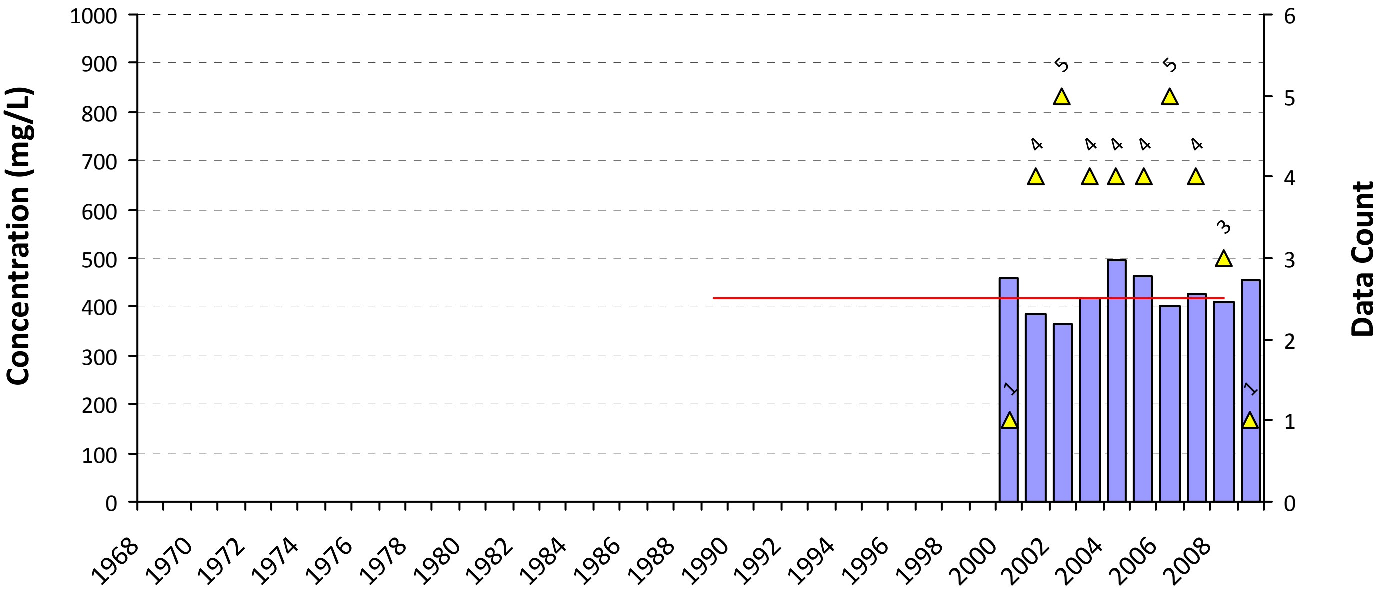
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

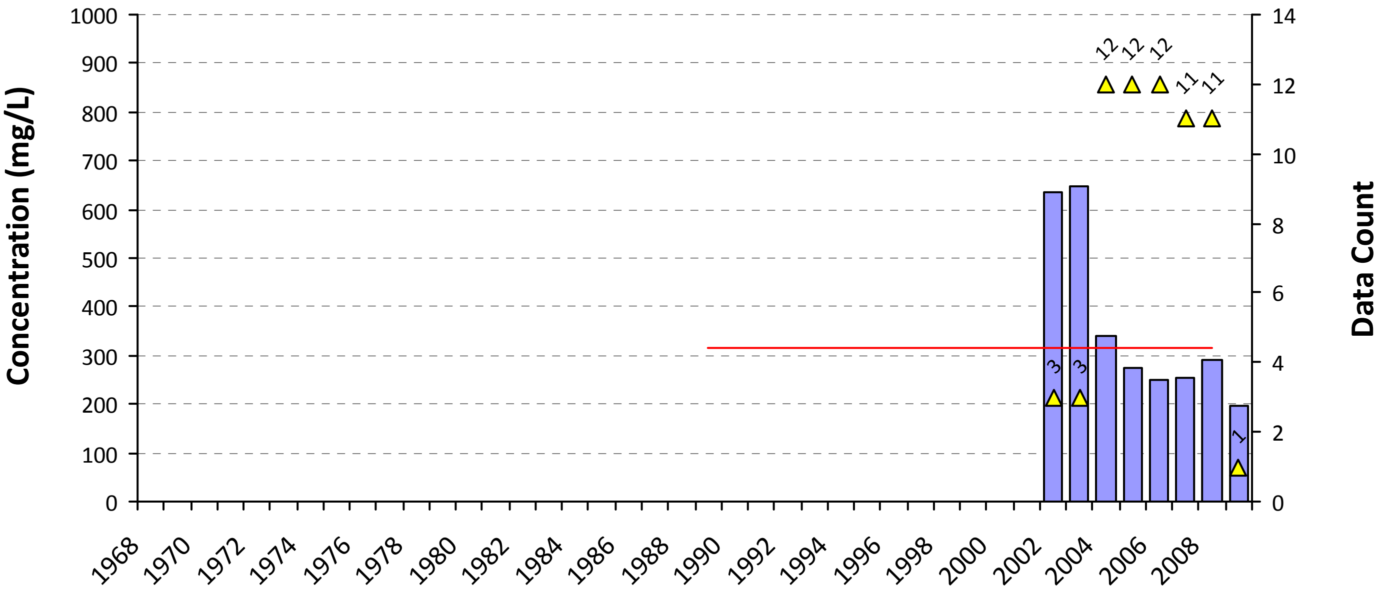
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841D Big Bear Creek



0841E Copart Branch Mountain Creek



■ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

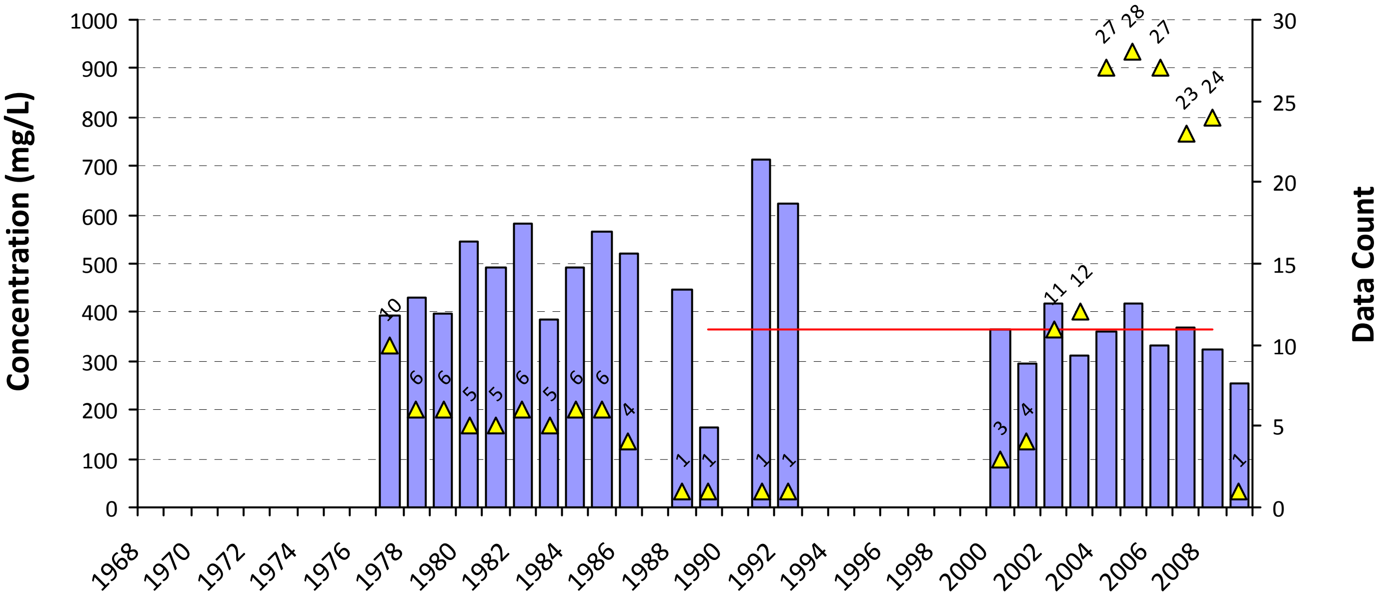
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

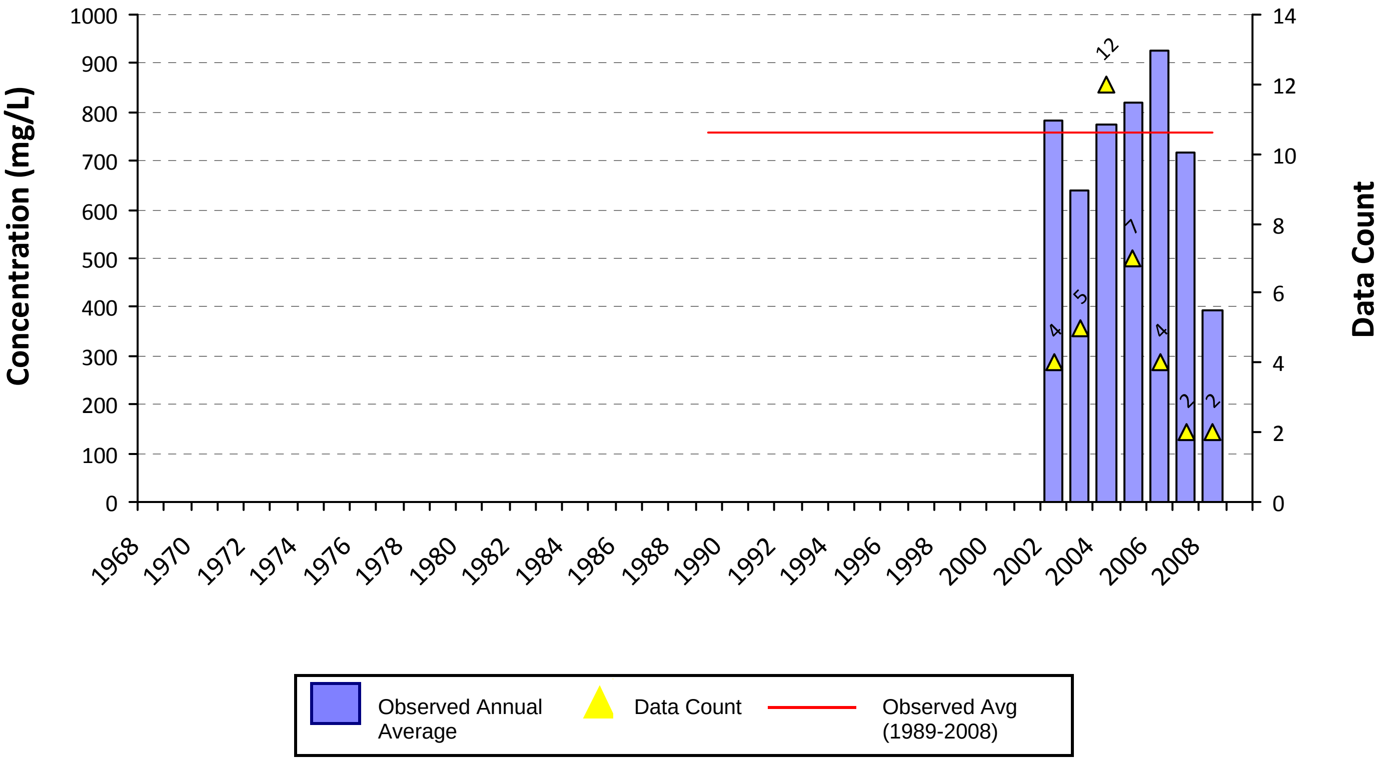
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841F Cottonwood Creek



0841G Dalworth Creek

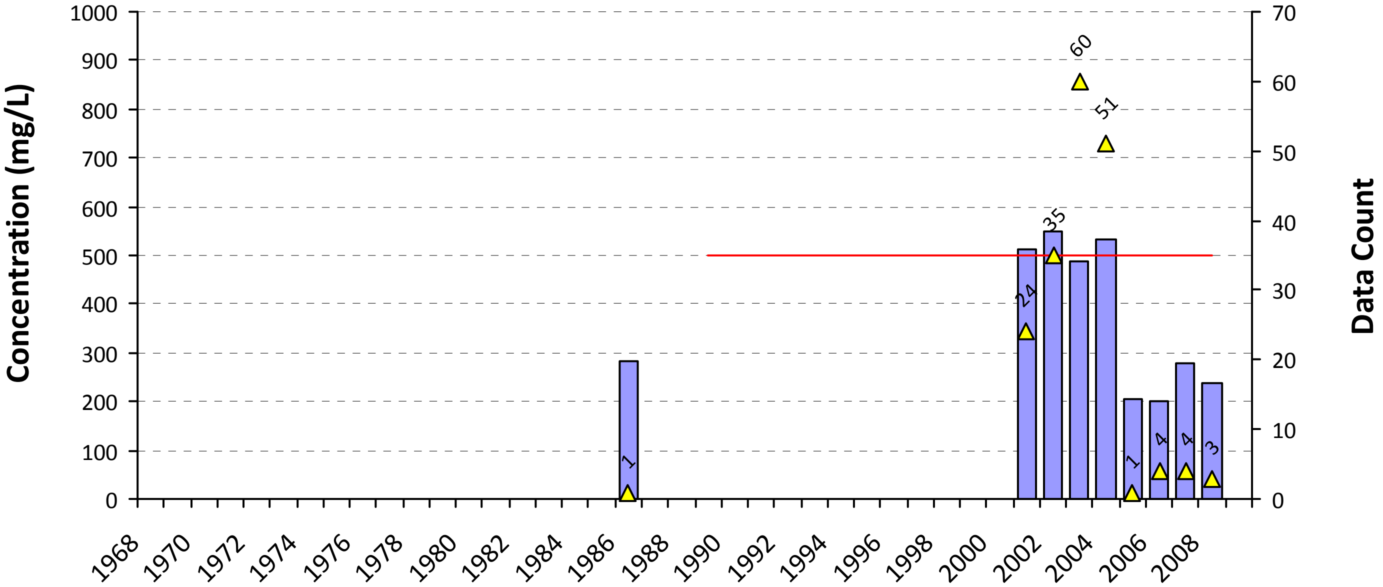


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

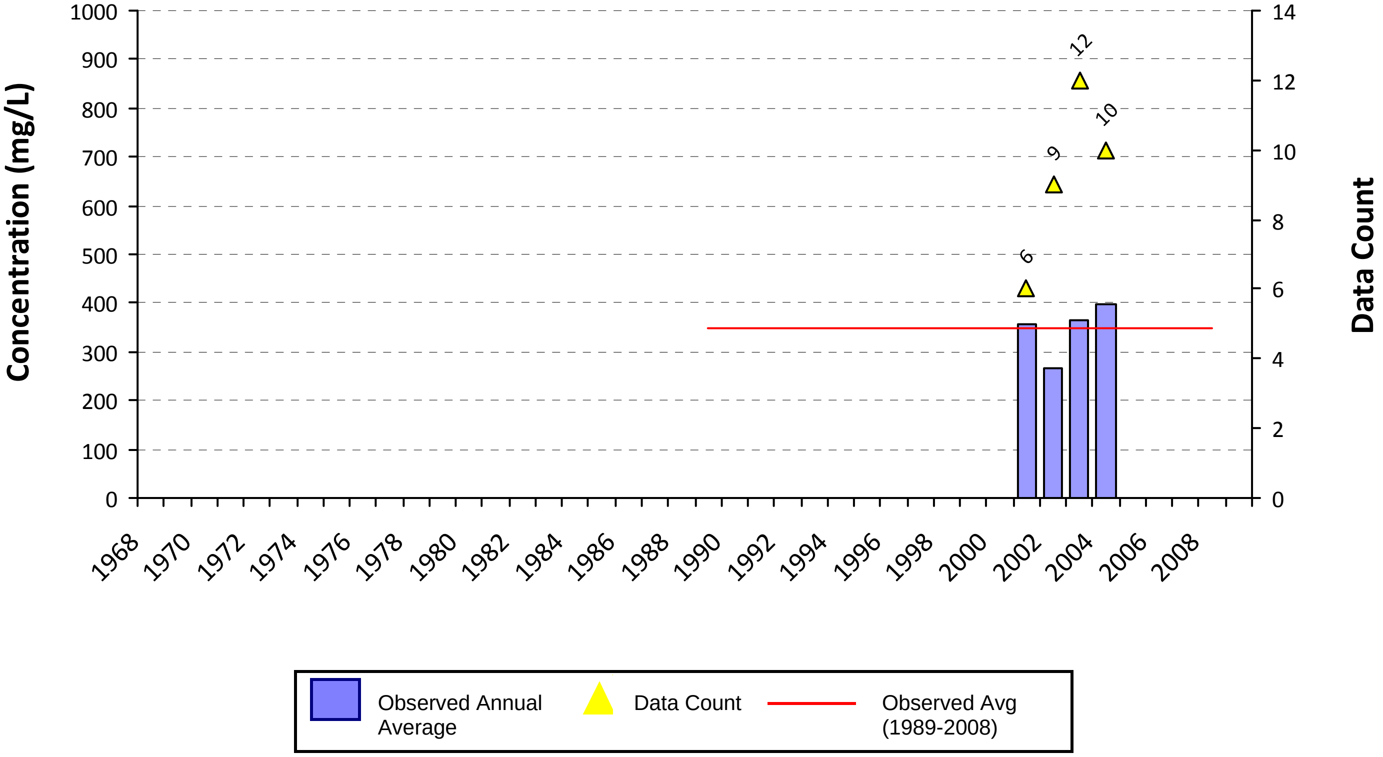
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841H Delaware Creek



0841I Dry Branch Creek

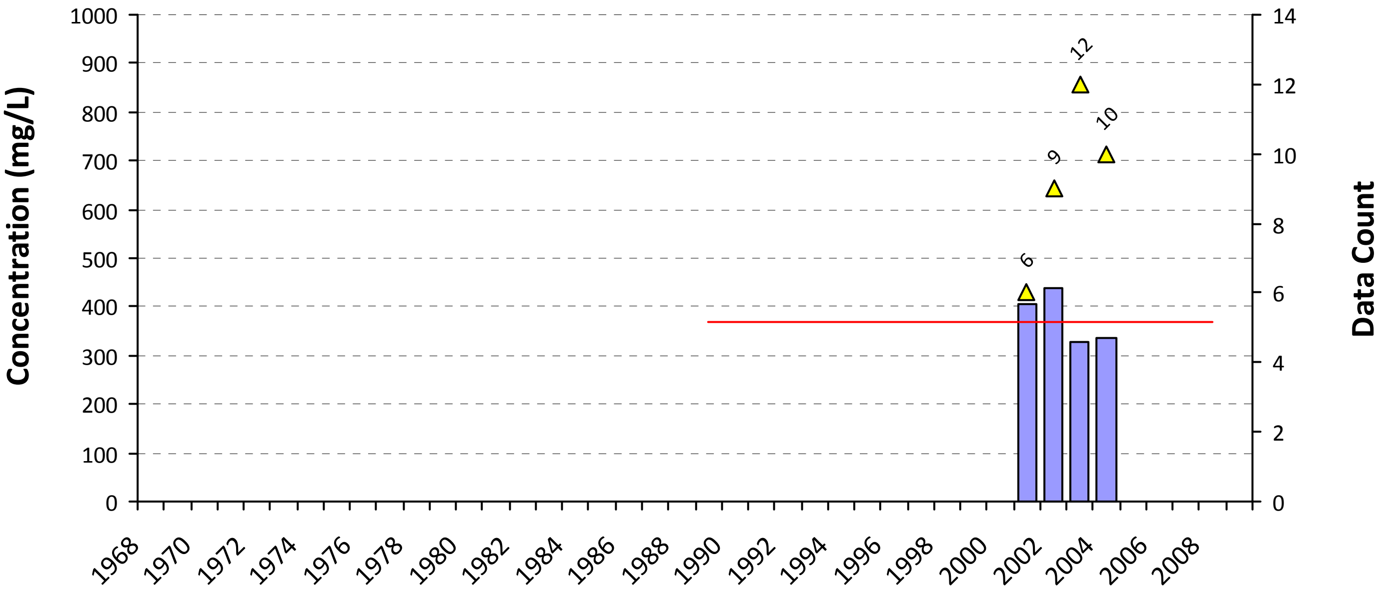


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

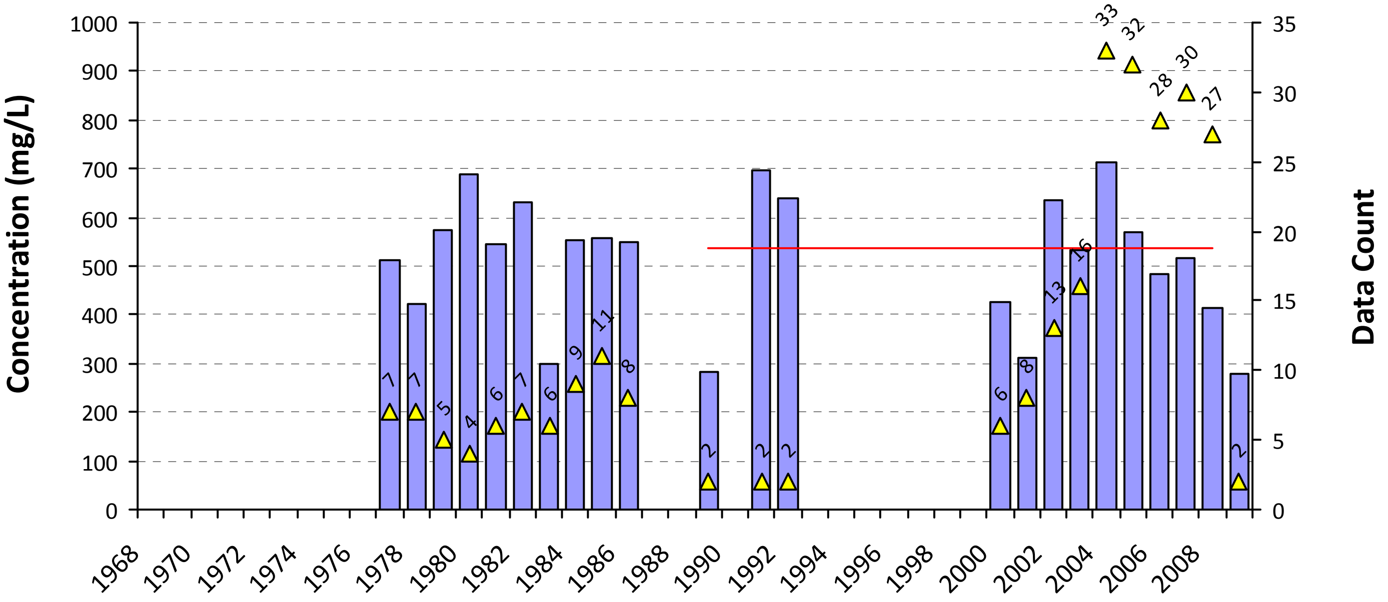
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841J Estelle Creek



0841K Fish Creek



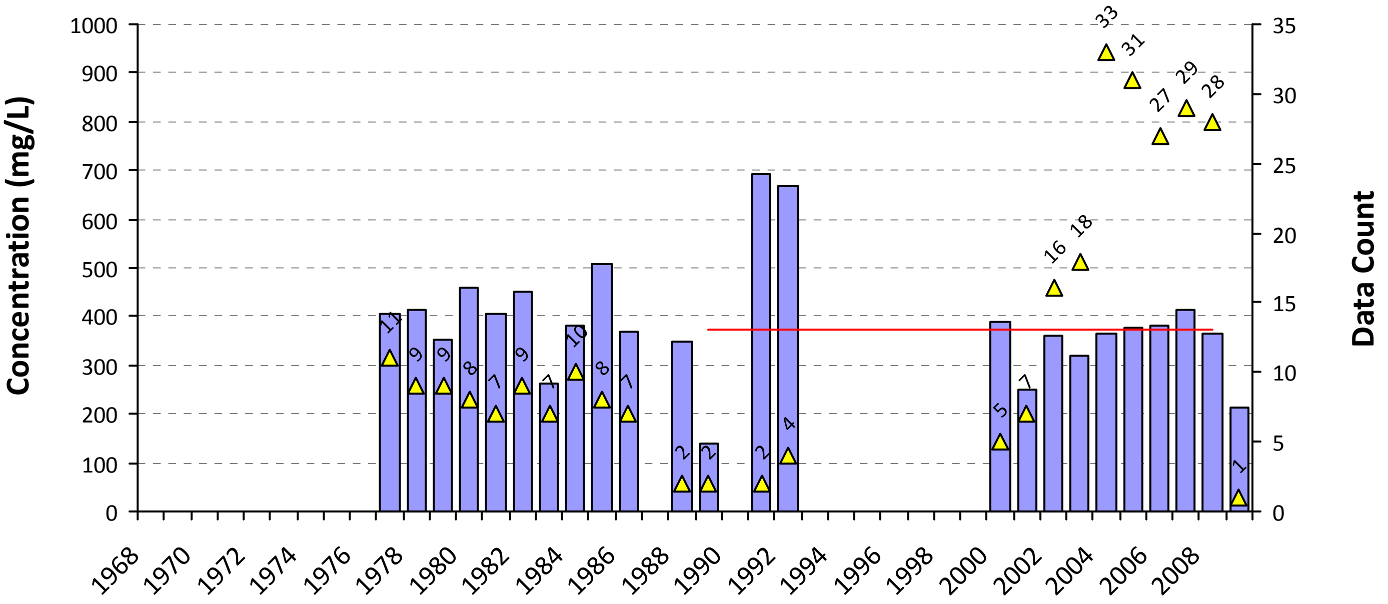
🟦 Observed Annual Average
▲ Data Count
— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

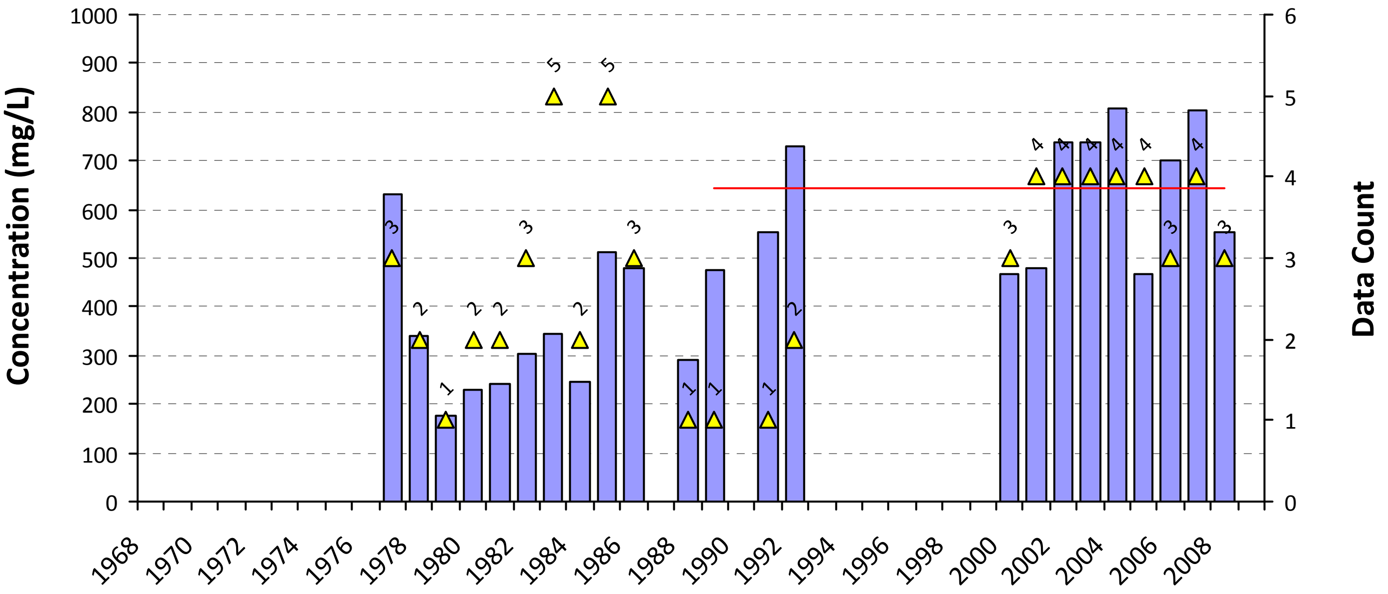
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841L Johnson Creek



0841M Kee Branch



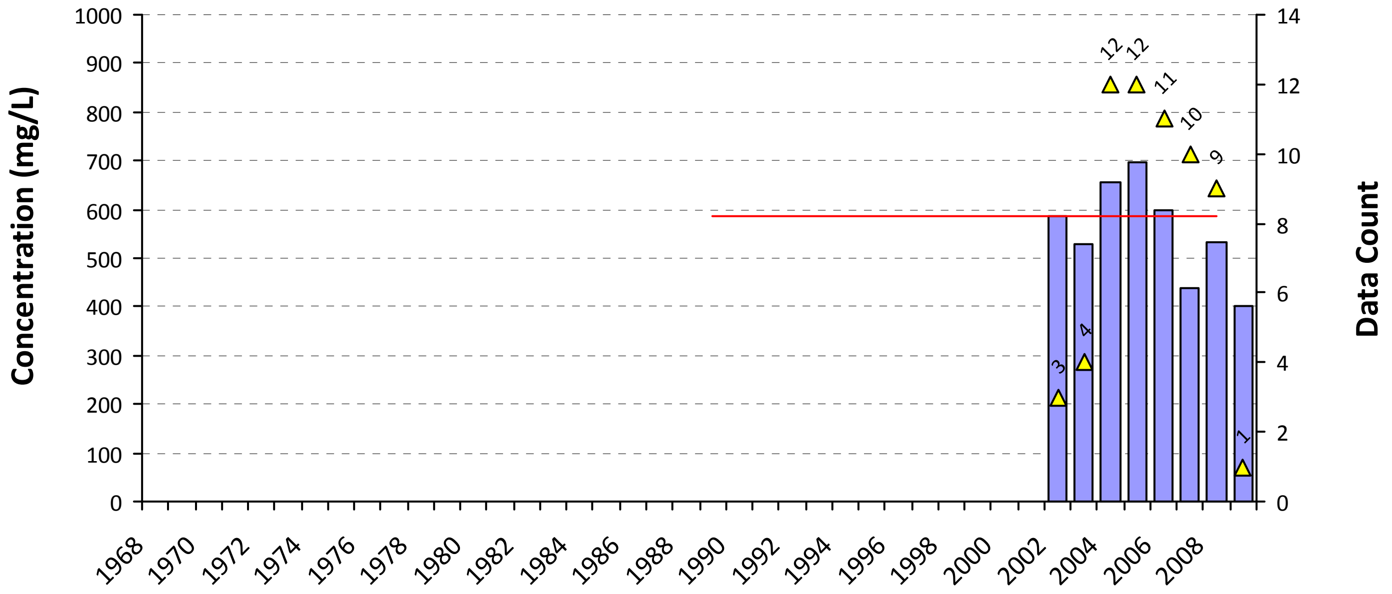
🟦 Observed Annual Average ▲ Data Count — Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

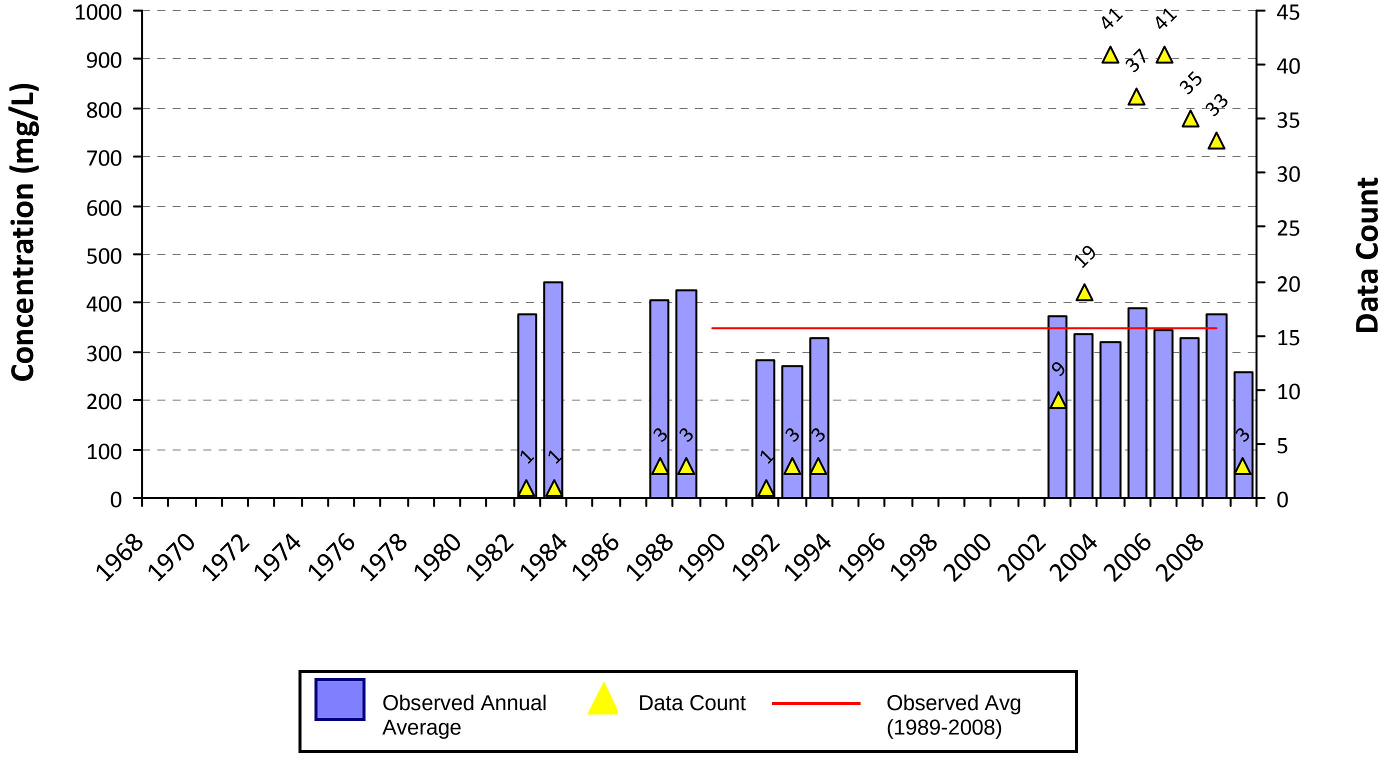
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841N Kirby Creek



0841O Mountain Creek

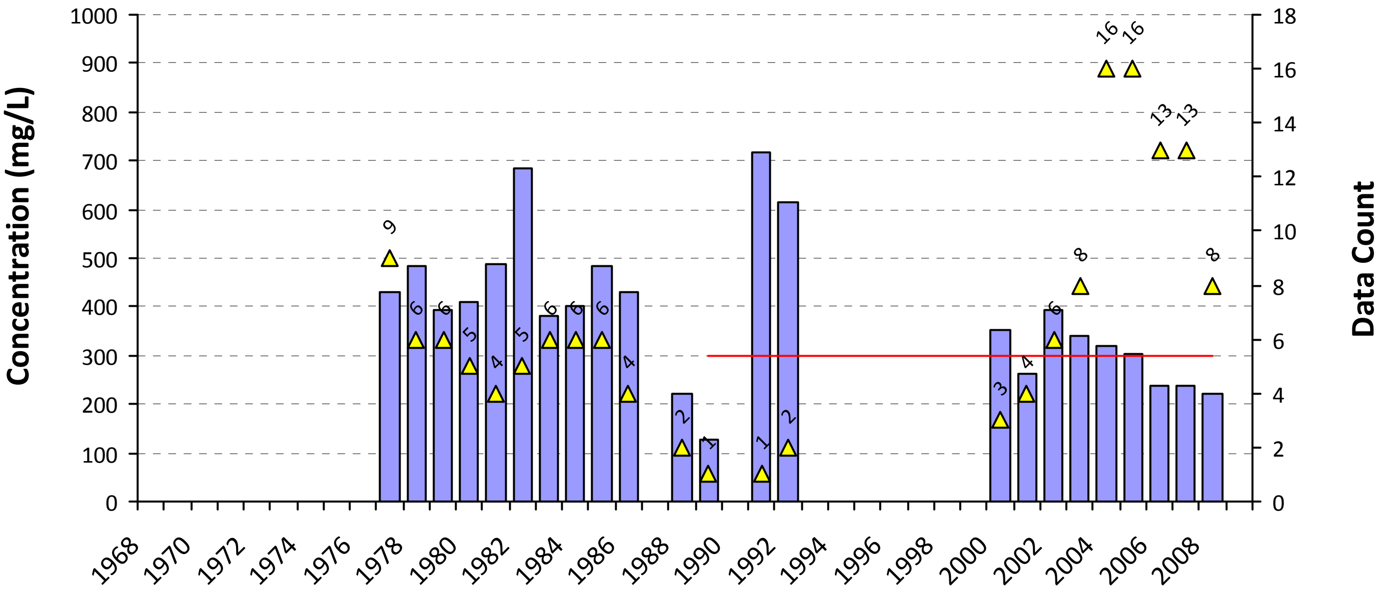


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

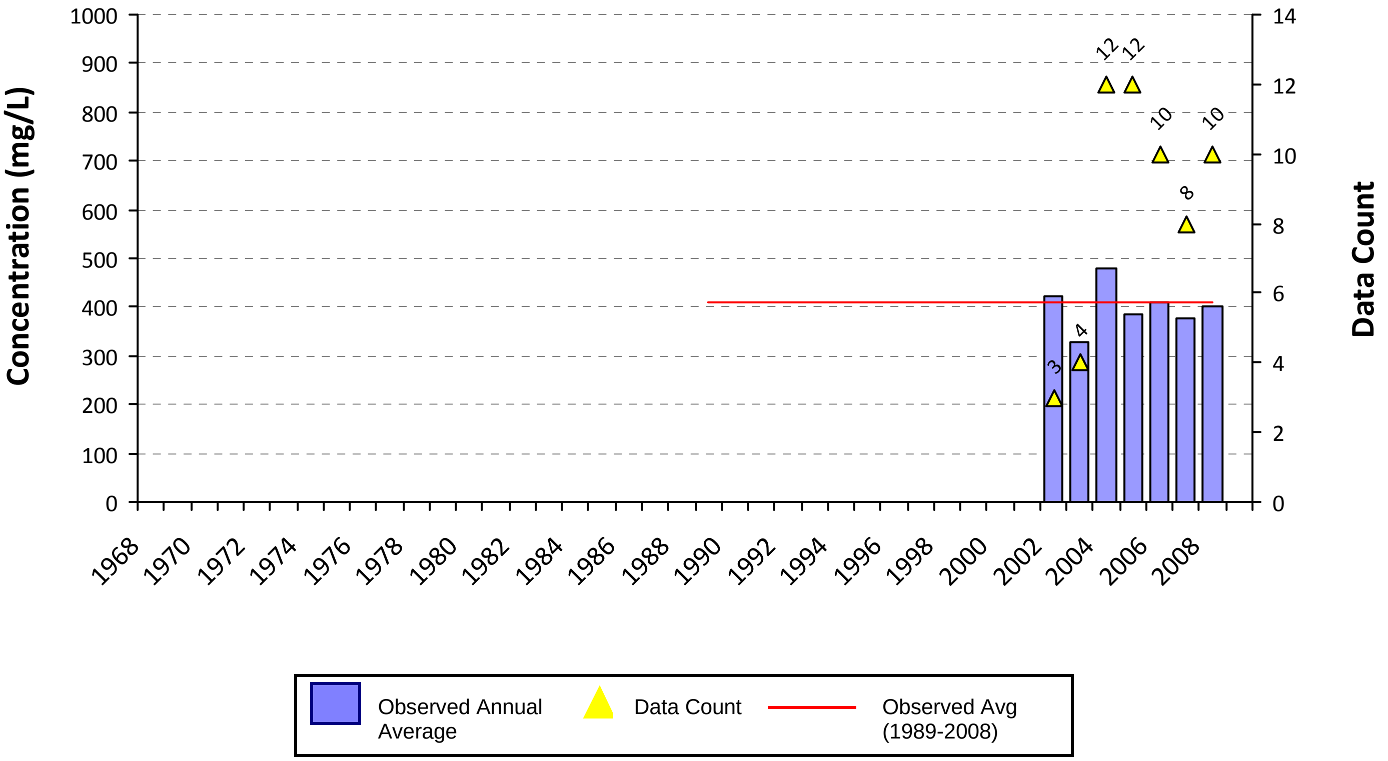
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841P North Fork Cottonwood Creek



0841Q North Fork Fish Creek

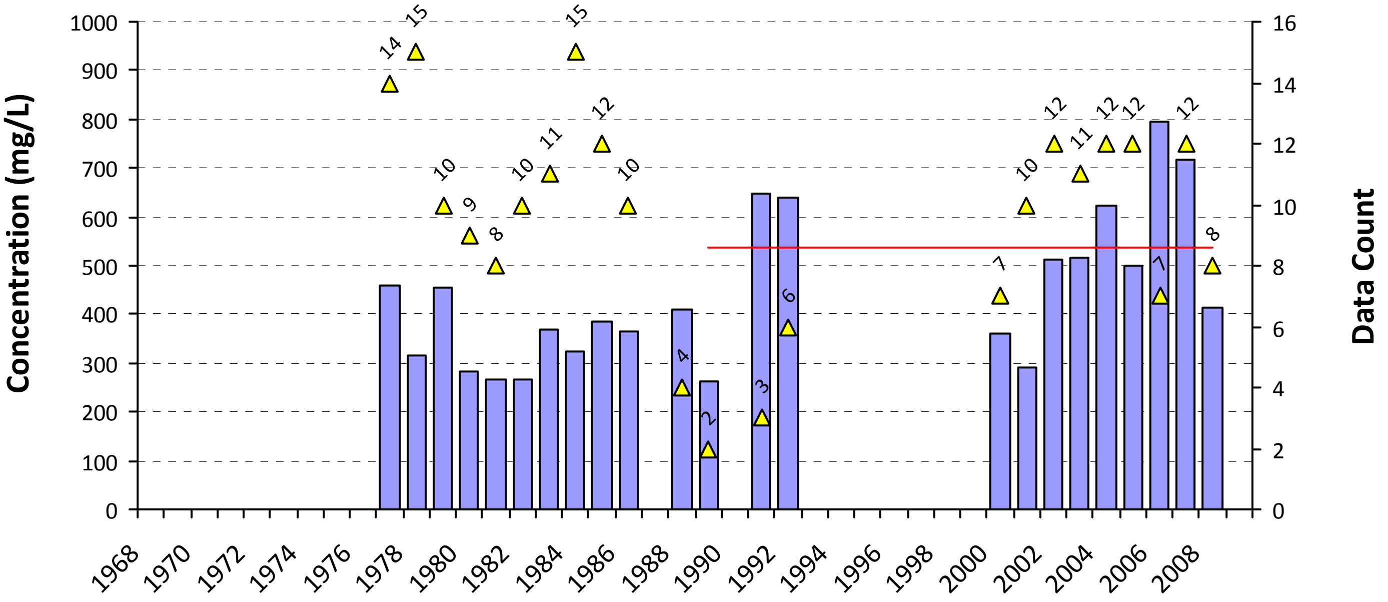


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

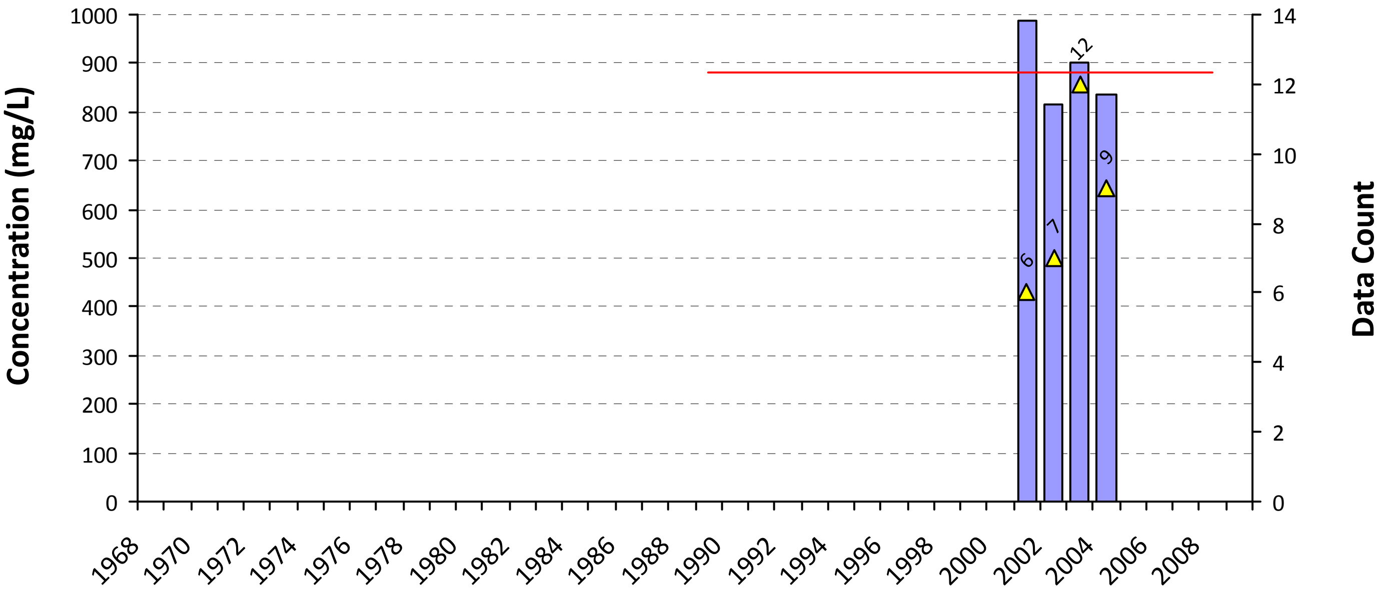
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841R Rush Creek



0841S Vilbig Lakes



■ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

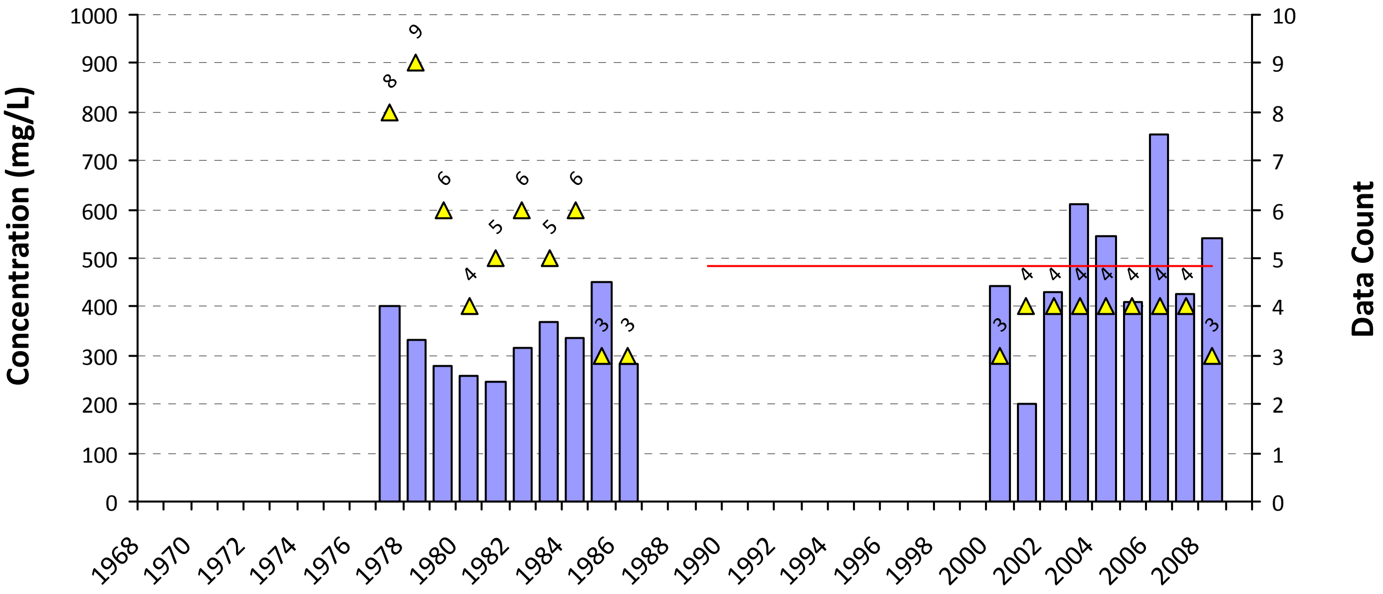
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

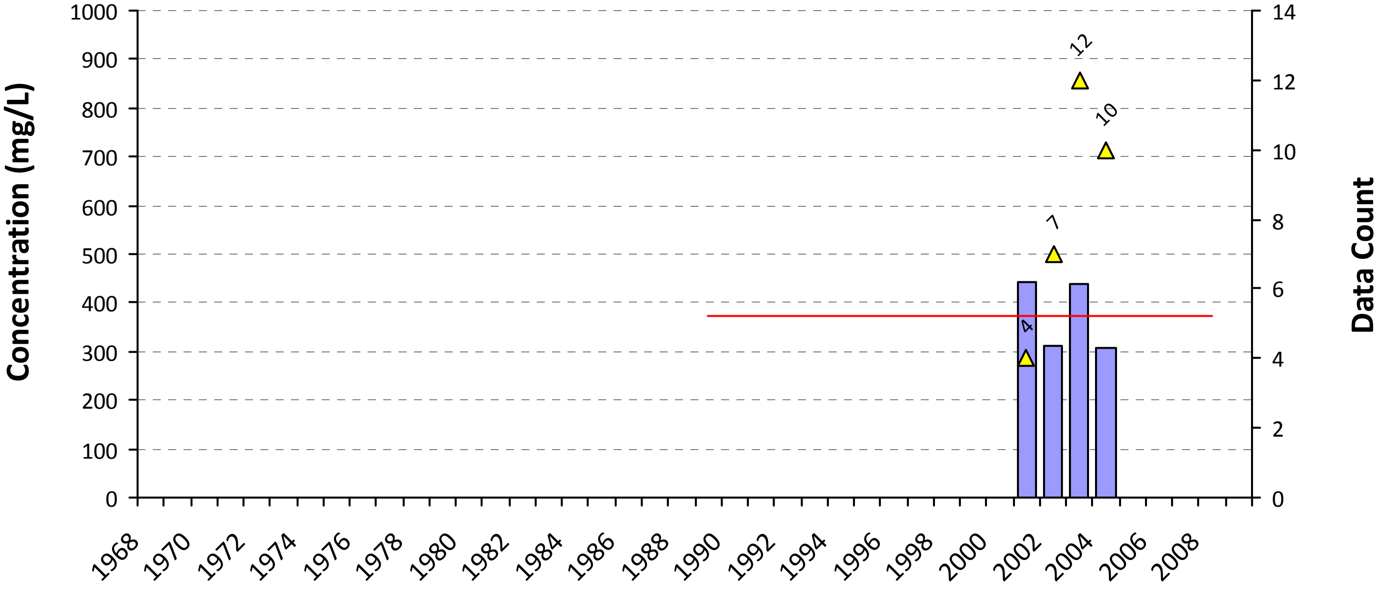
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841T Village Creek



0841U West Irving Creek



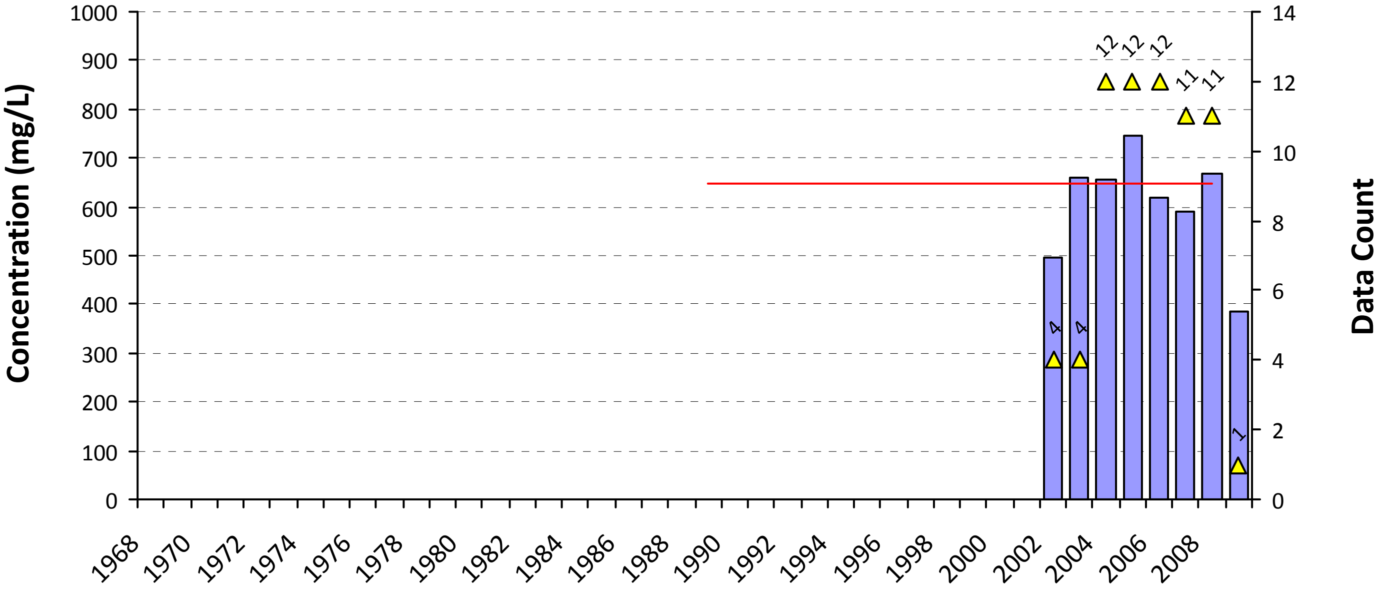
▨ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Upper Main Stem

0841V

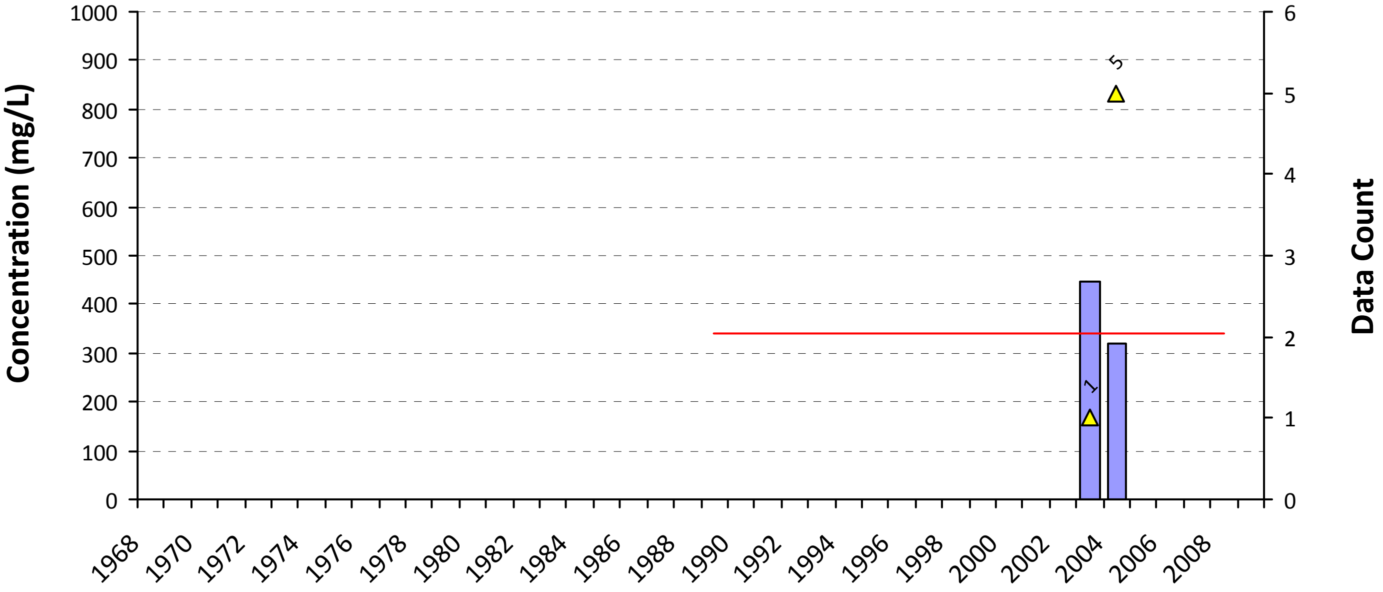


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

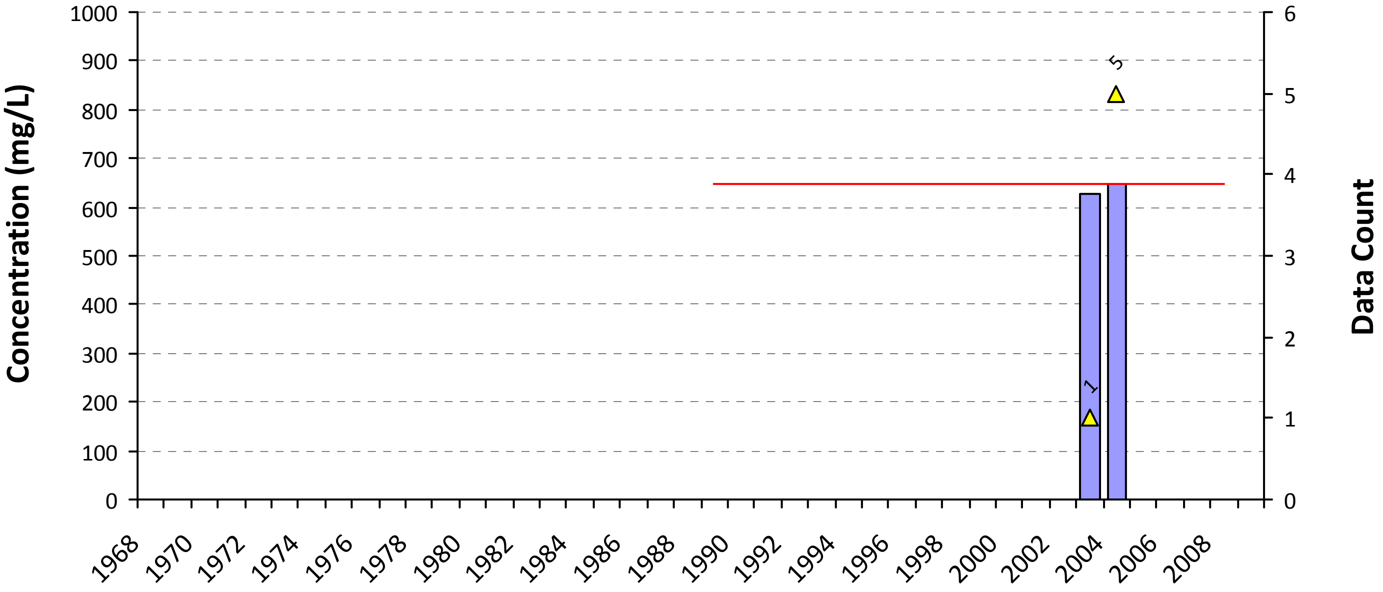
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Richland-Chambers & Cedar Creek

0814A Assessment Area



0814B



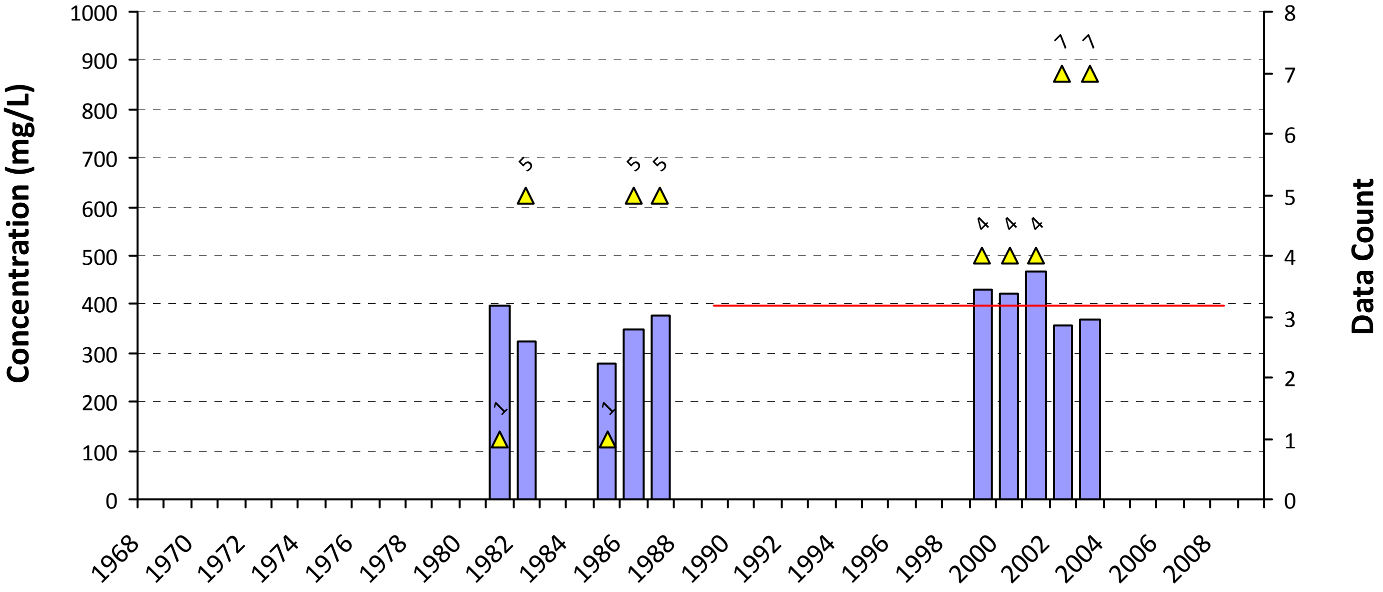
🟦	Observed Annual Average
▲	Data Count
—	Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

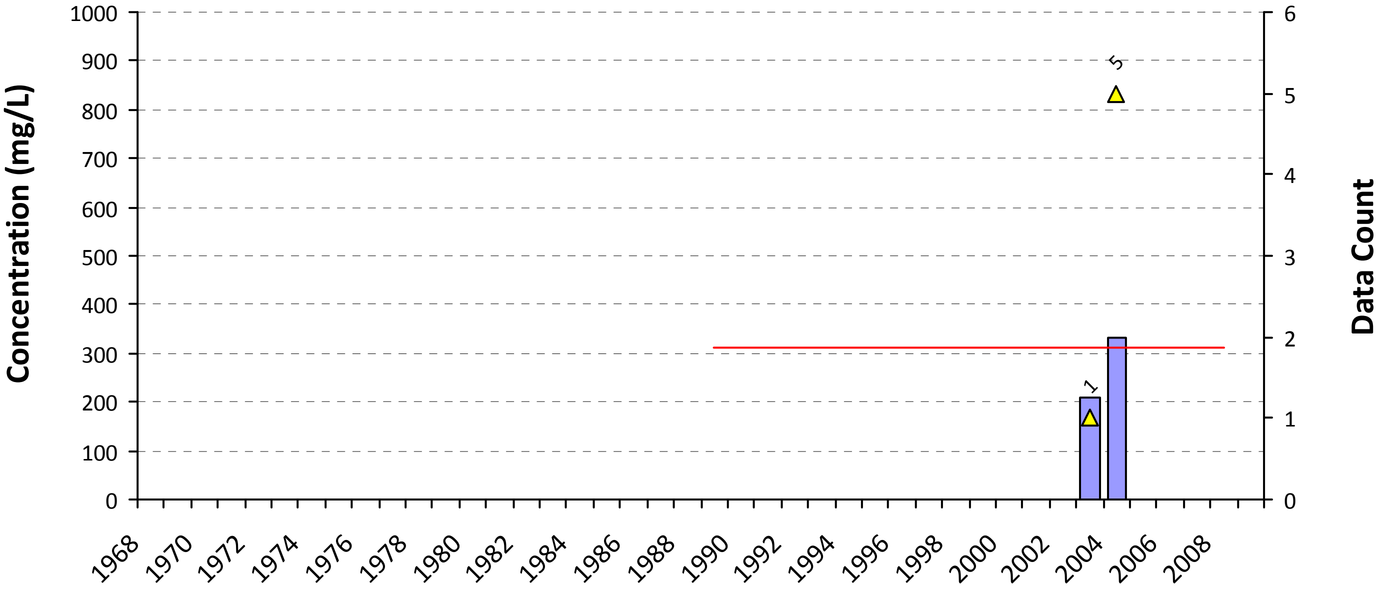
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Richland-Chambers & Cedar Creek

0815A Waxahachie Creek



0816A



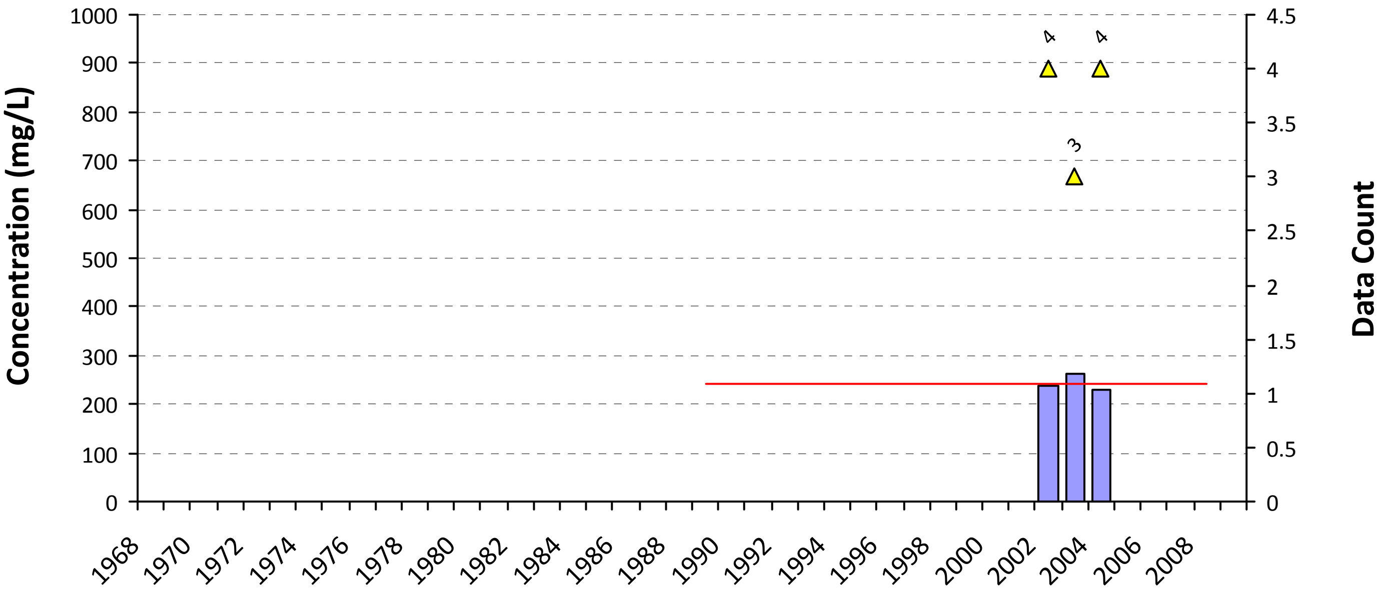
▨ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

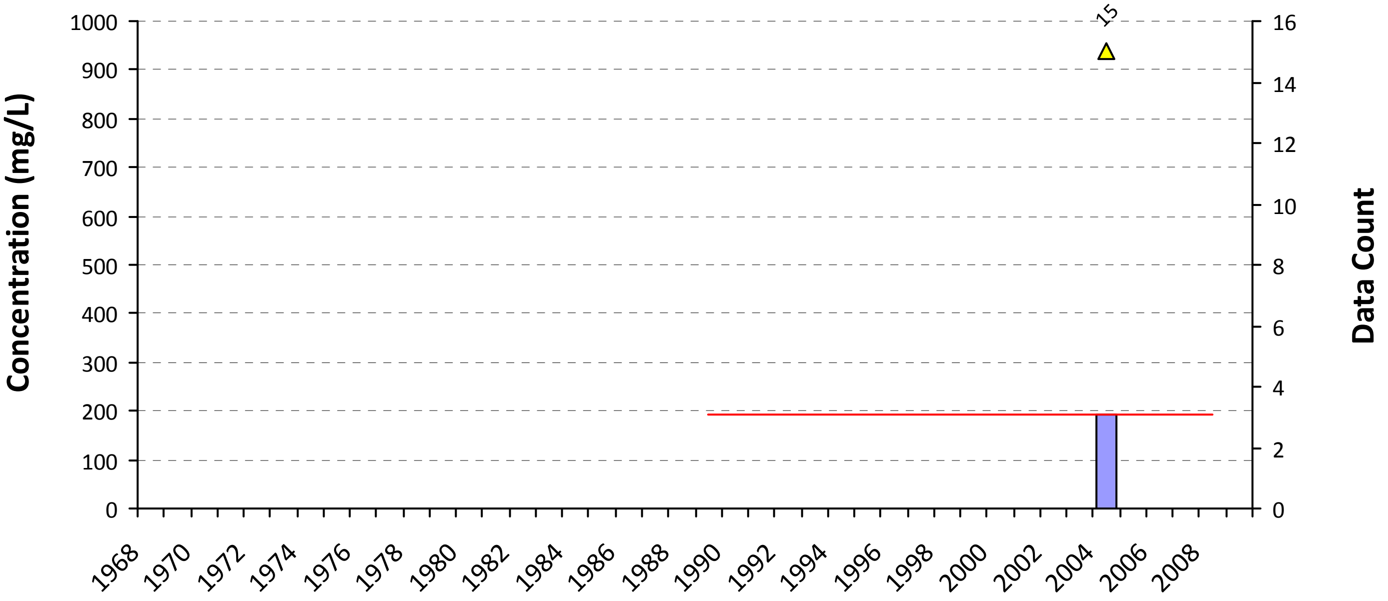
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Richland-Chambers & Cedar Creek

0817A Richland Creek



0836B



🟦 Observed Annual Average   ▲ Data Count   — Observed Avg (1989-2008)

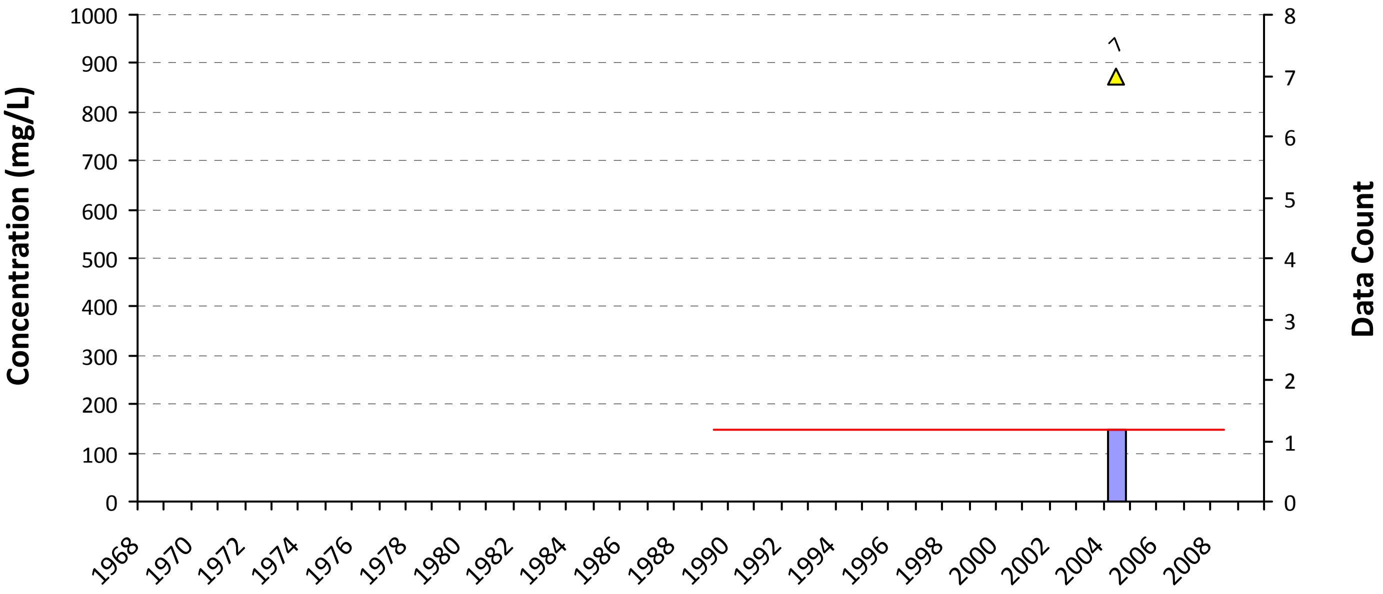
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

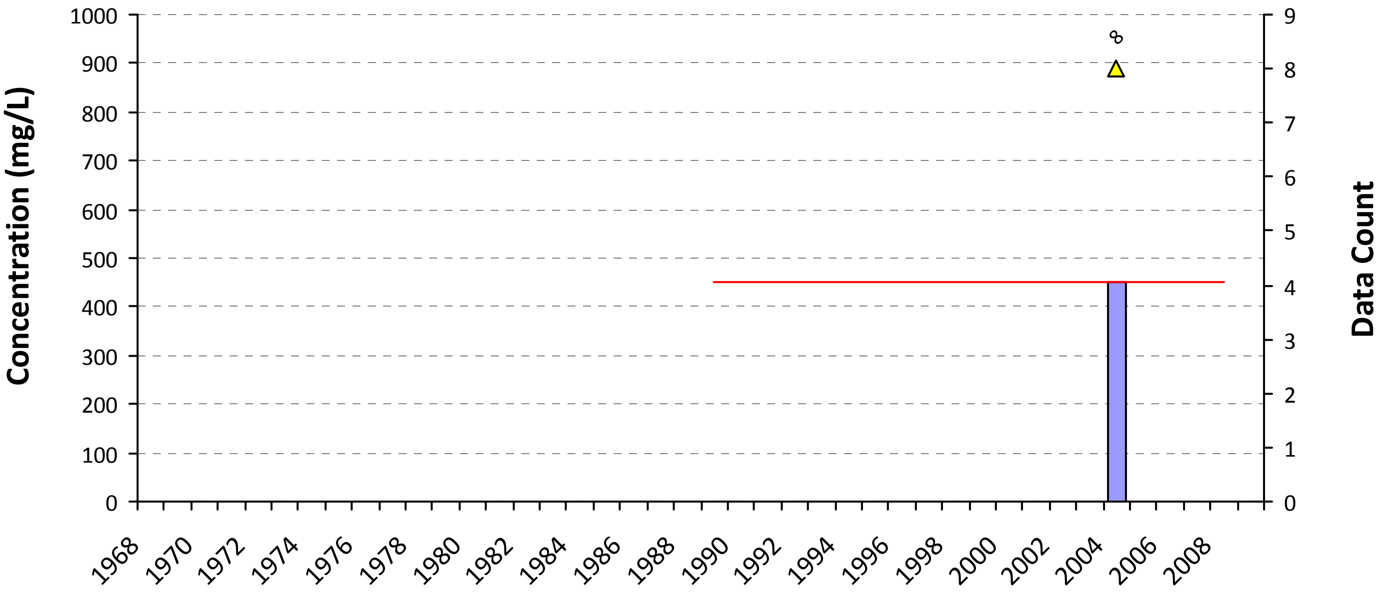
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Richland-Chambers & Cedar Creek

0836C



0836D



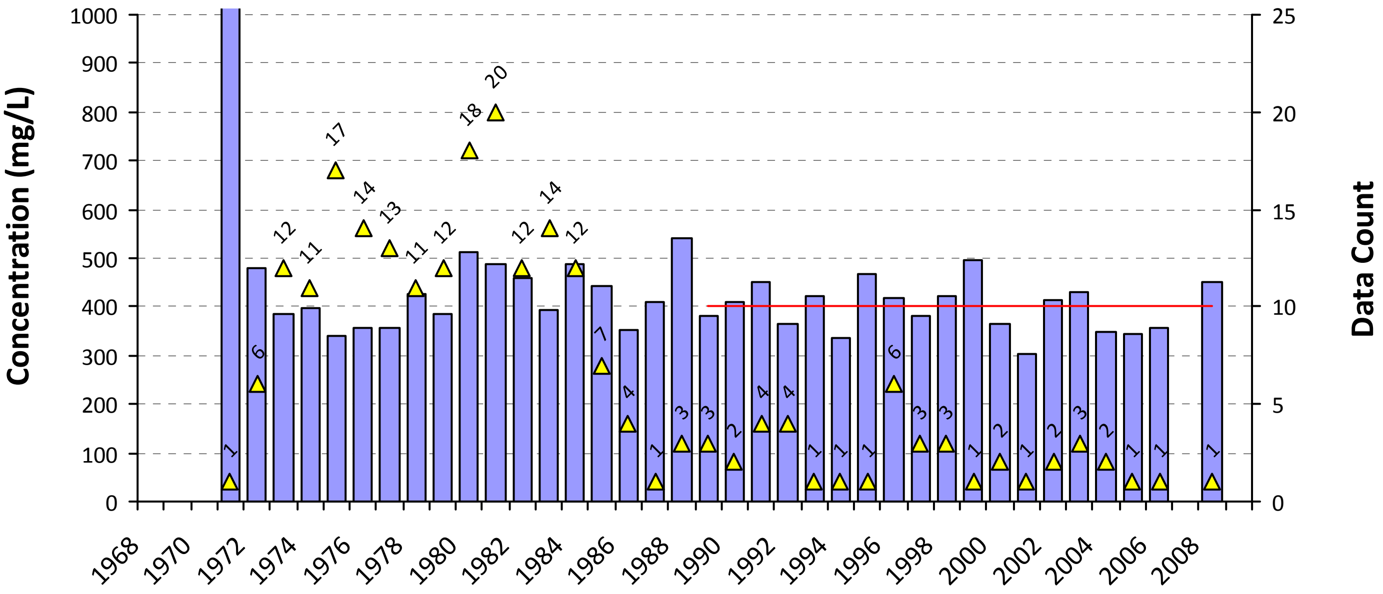
🟦 Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

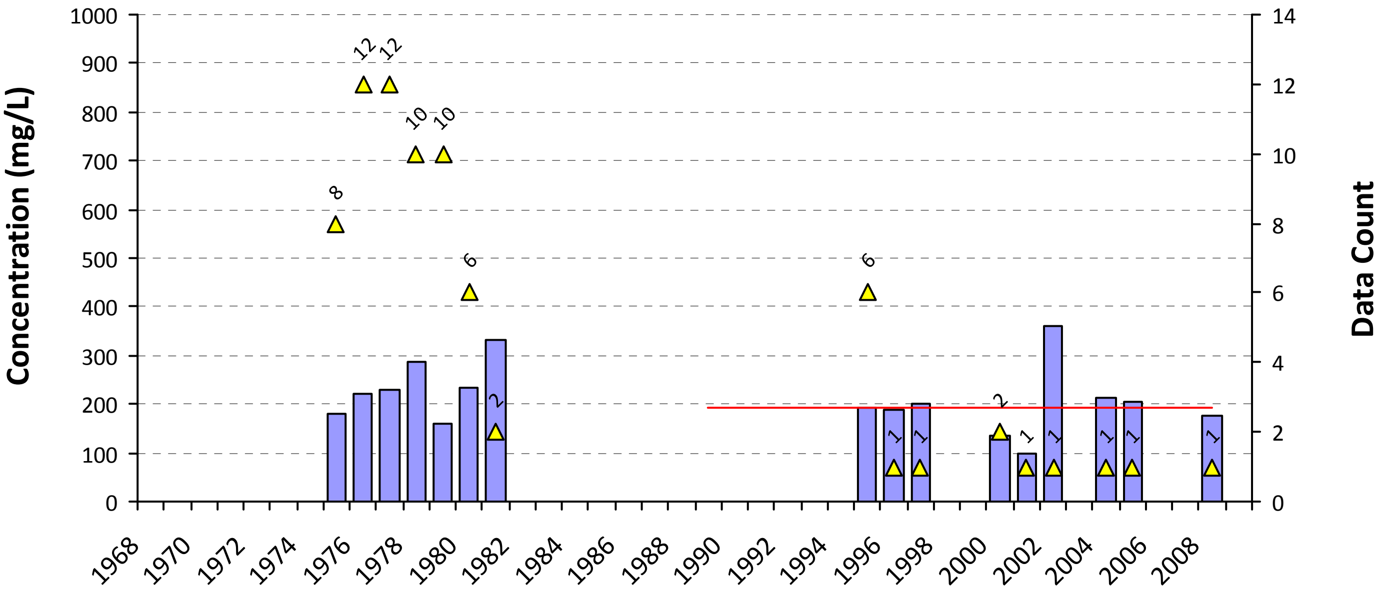
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0803A Harmon Creek



0803B White Rock Creek



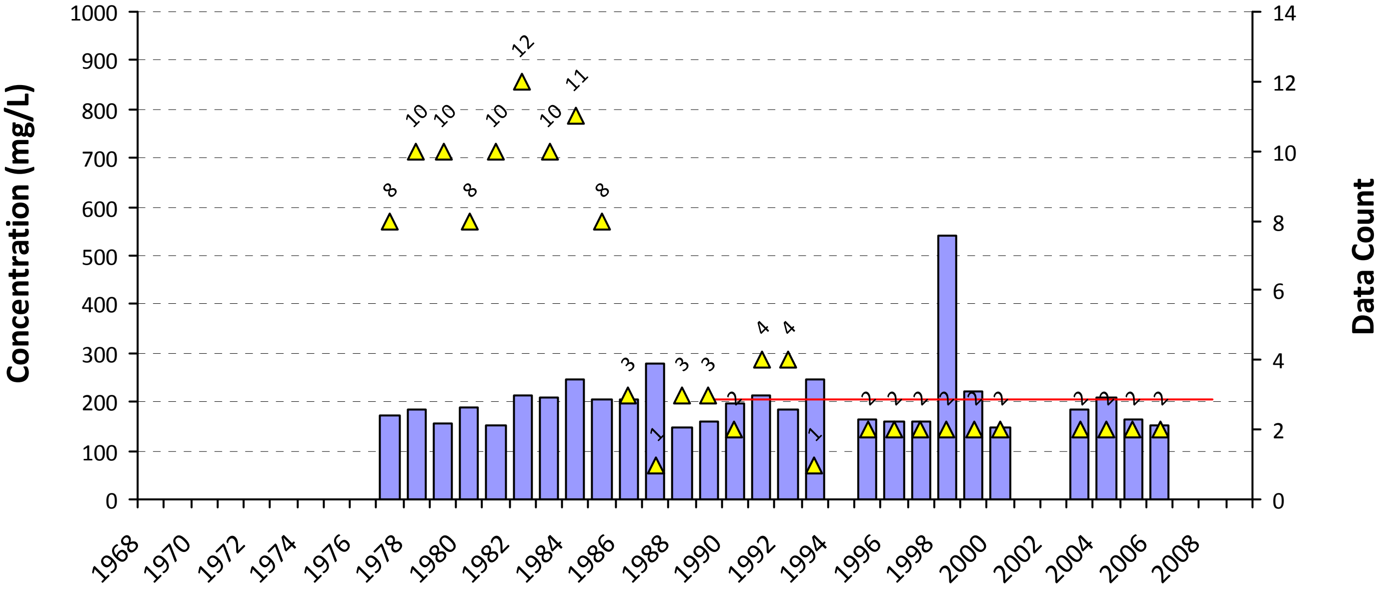
▨ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

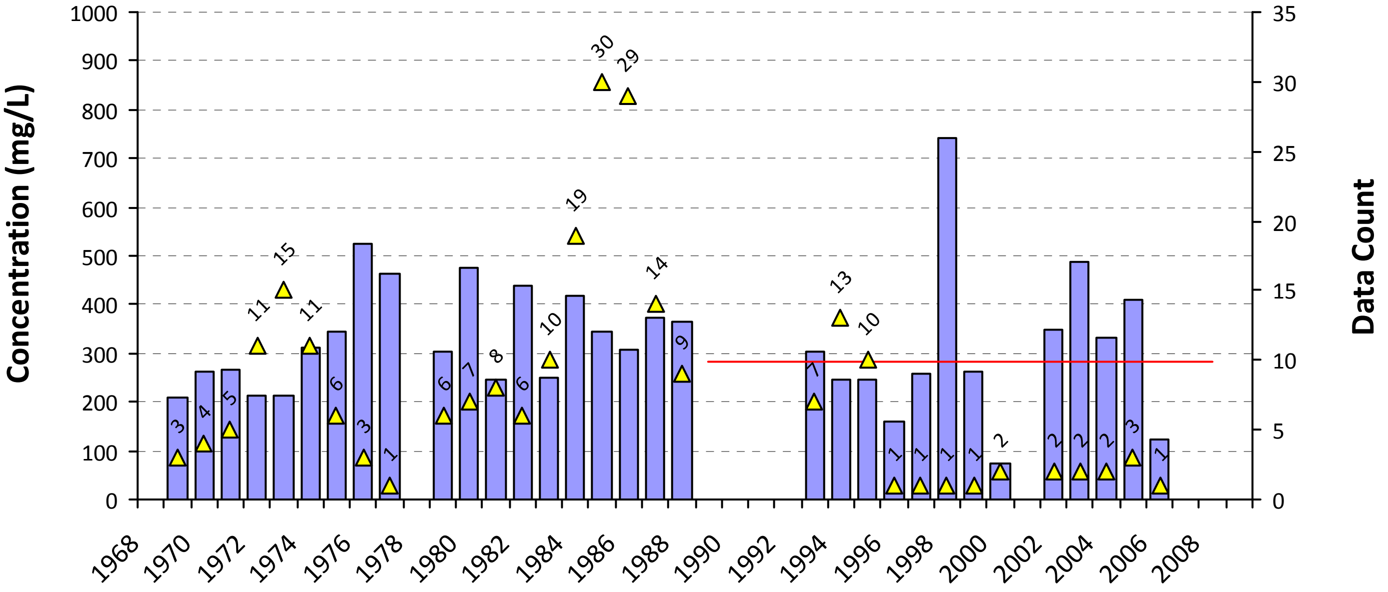
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0803E



0803F



🟦 Observed Annual Average ▲ Data Count — Observed Avg (1989-2008)

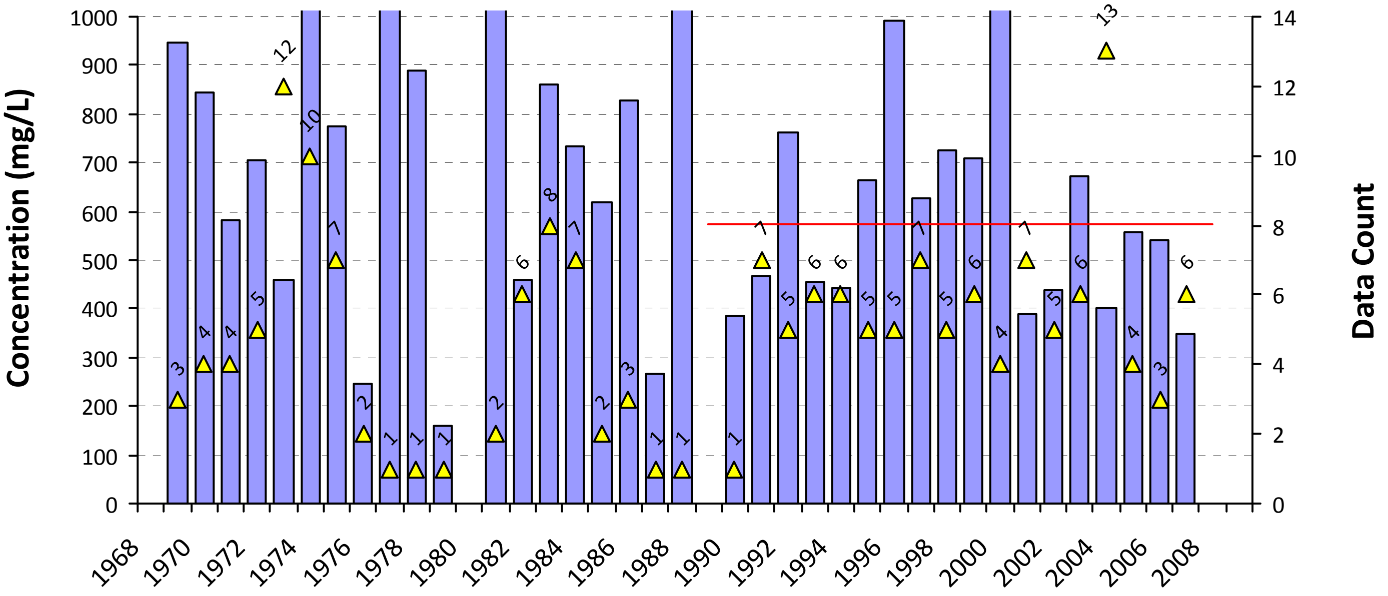
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

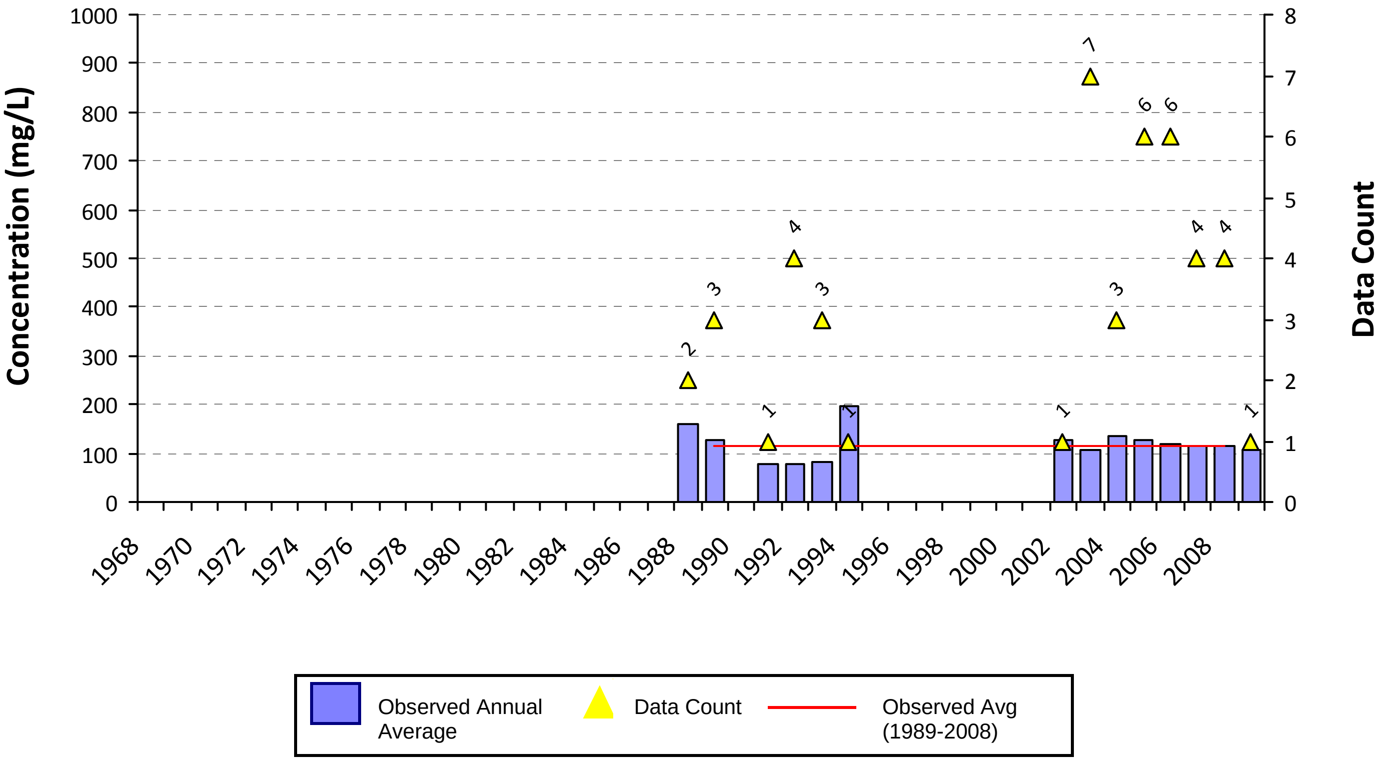
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0804F Tehuacana Creek



0804G Catfish Creek

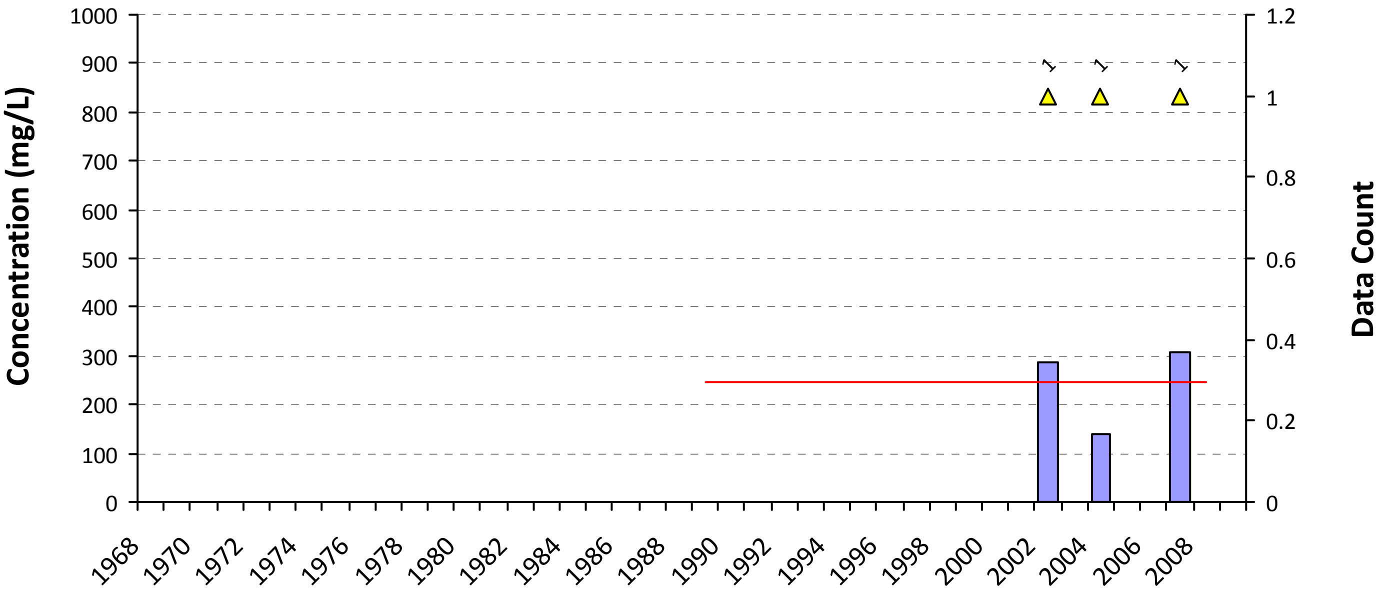


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

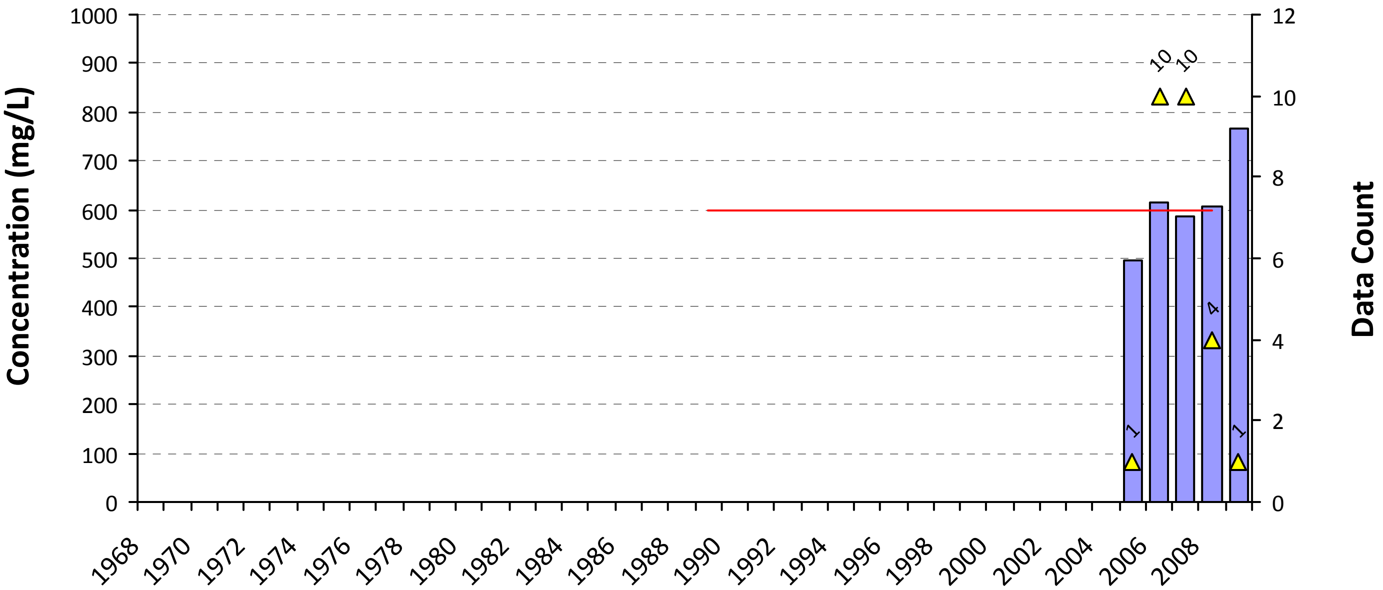
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0804H



0804J

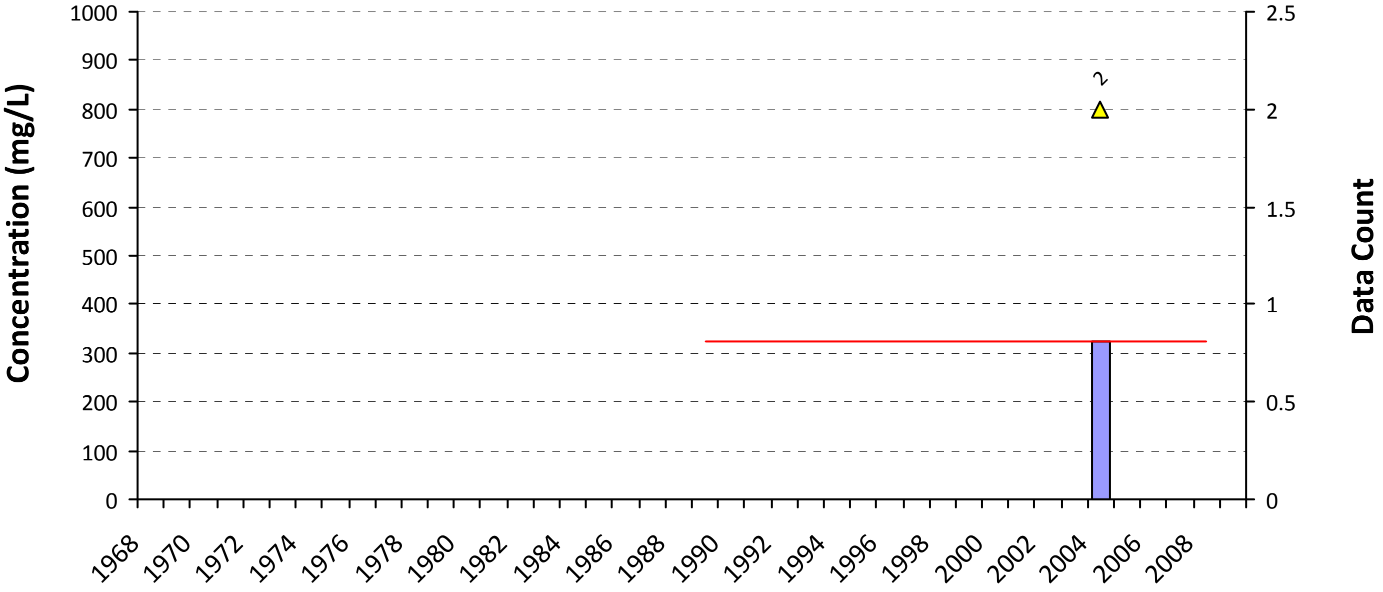


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

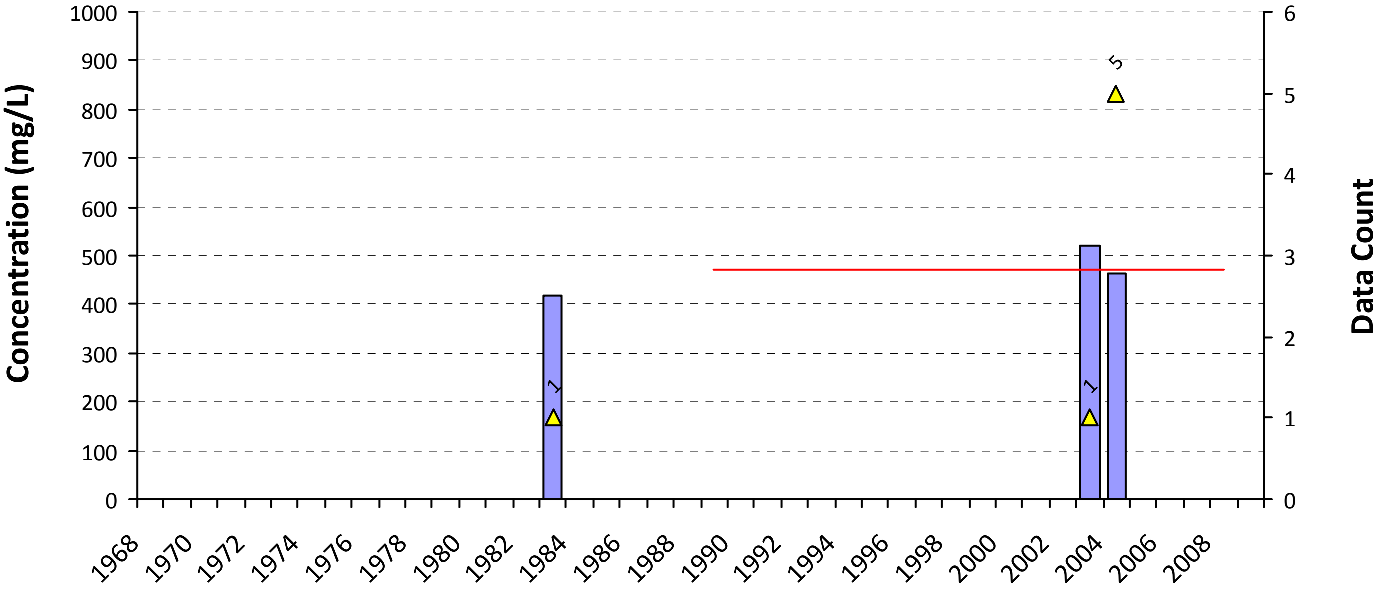
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0805A Red Oak Creek



0805B Parsons Slough



▨ Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

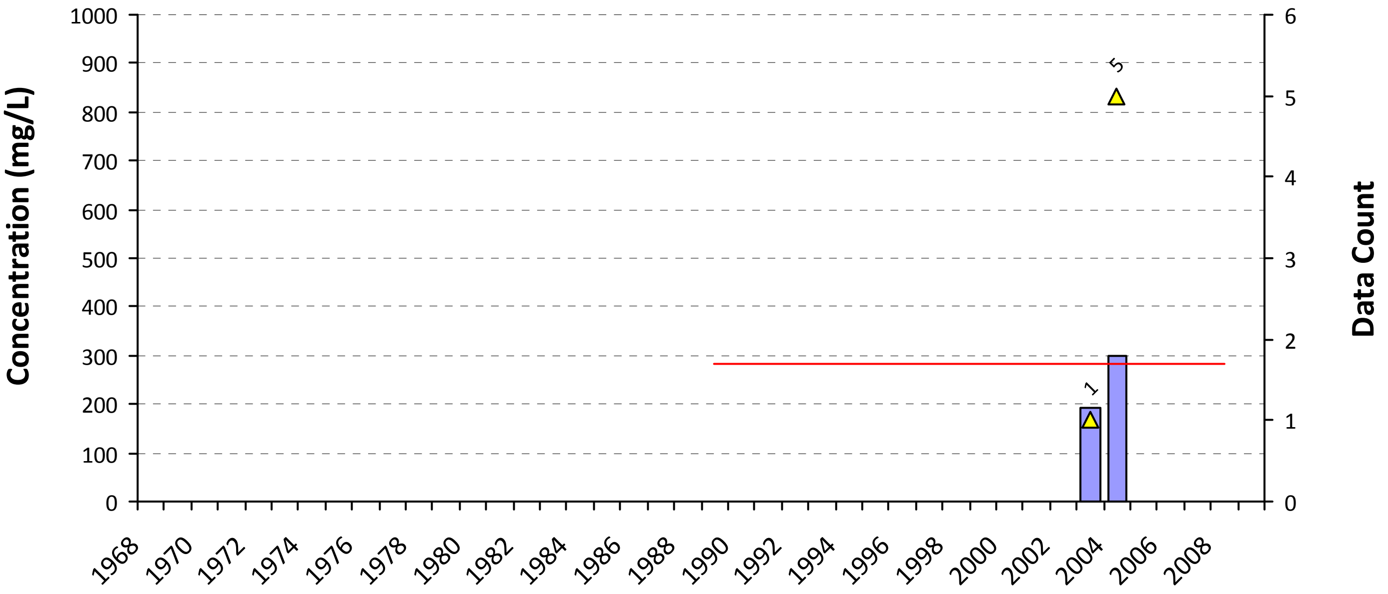
(1) Data set includes TDS derived from conductivity data (0.65 conversion)

Appendix B (cont.)

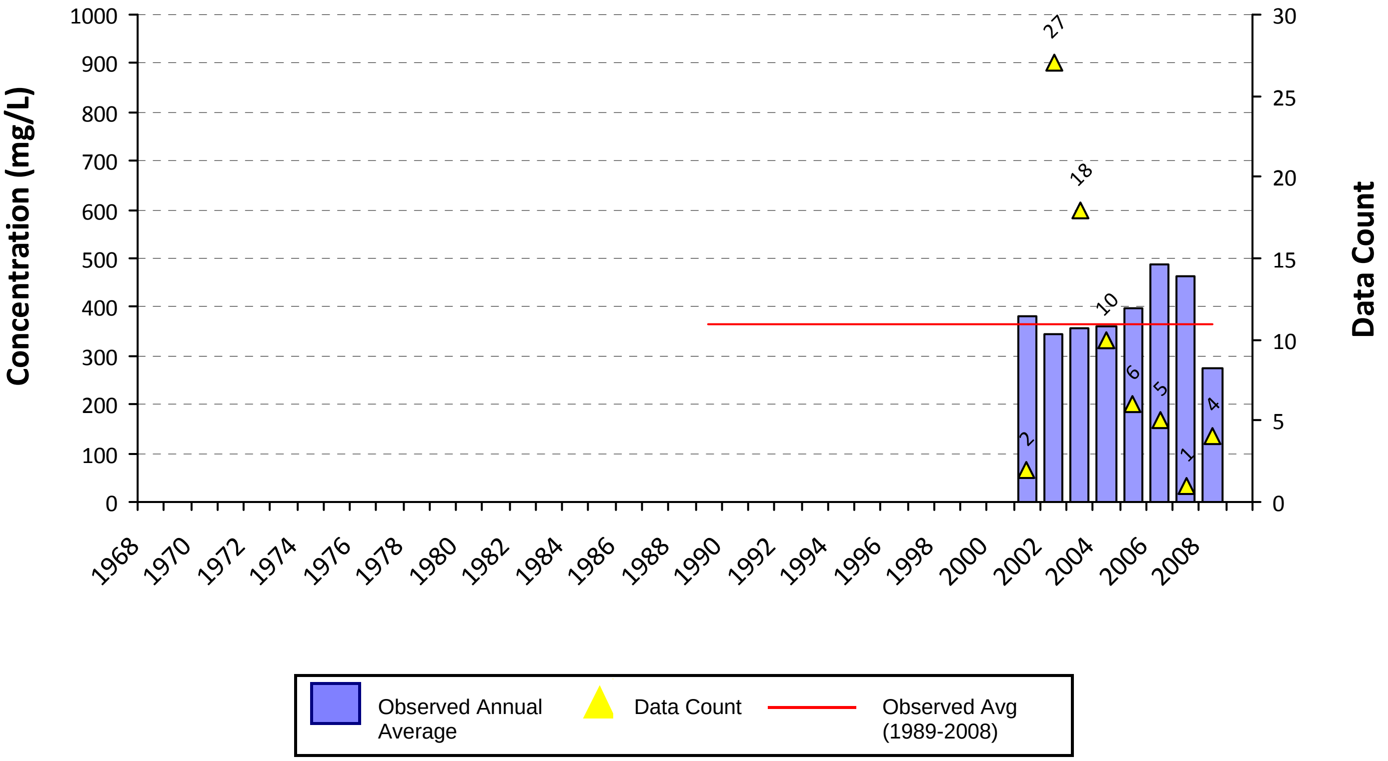
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Lower Main Stem

0805D



0827A White Rock Creek

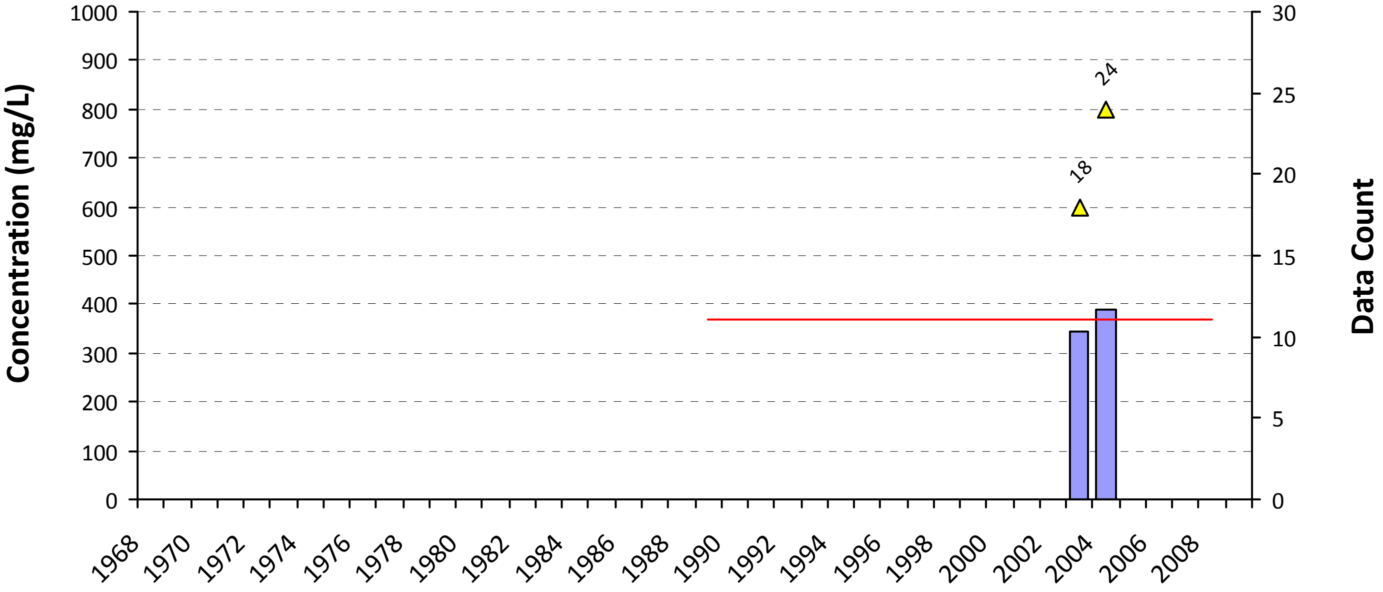


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

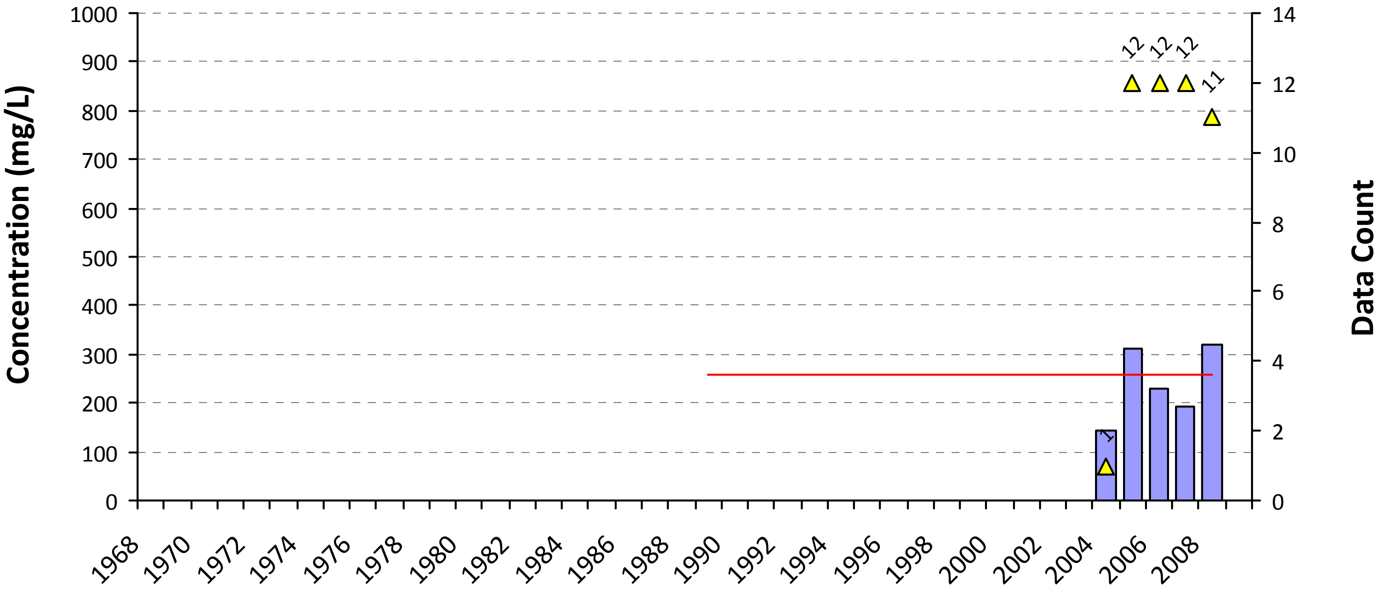
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Trinity Below Livingston

0801A Lost River



0801B Old River



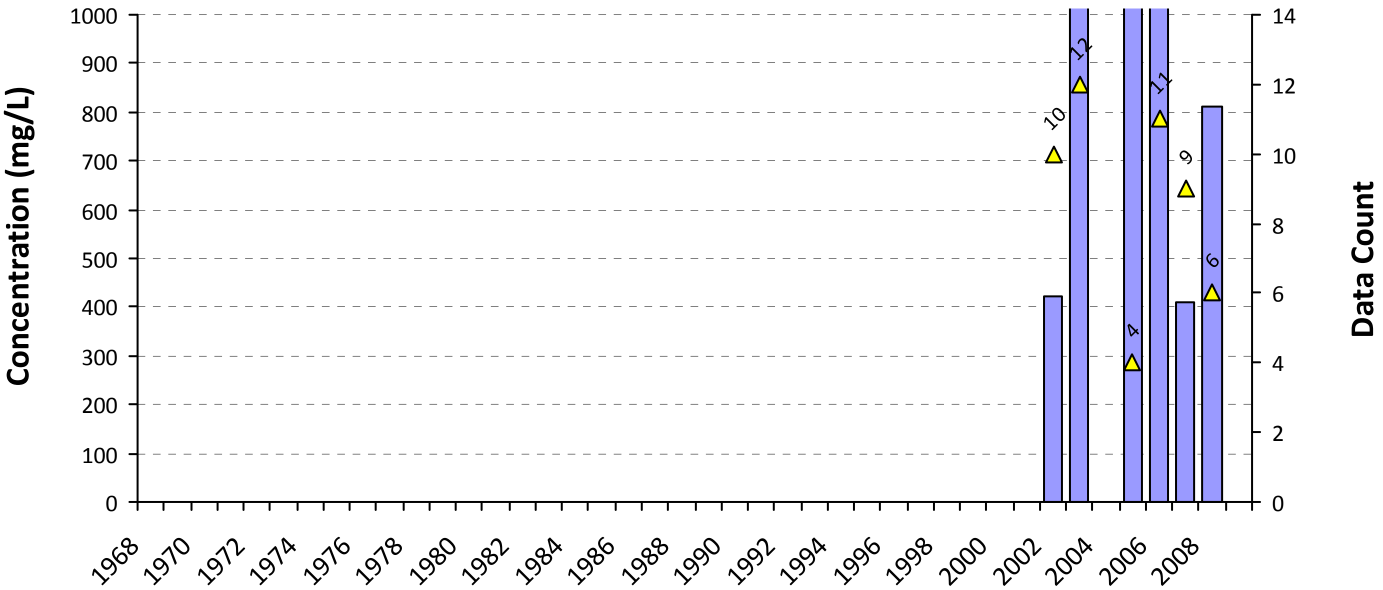
🟦 Observed Annual Average	▲ Data Count	— Observed Avg (1989-2008)

(1) Data set includes TDS derived from conductivity data (0.65 conversion)

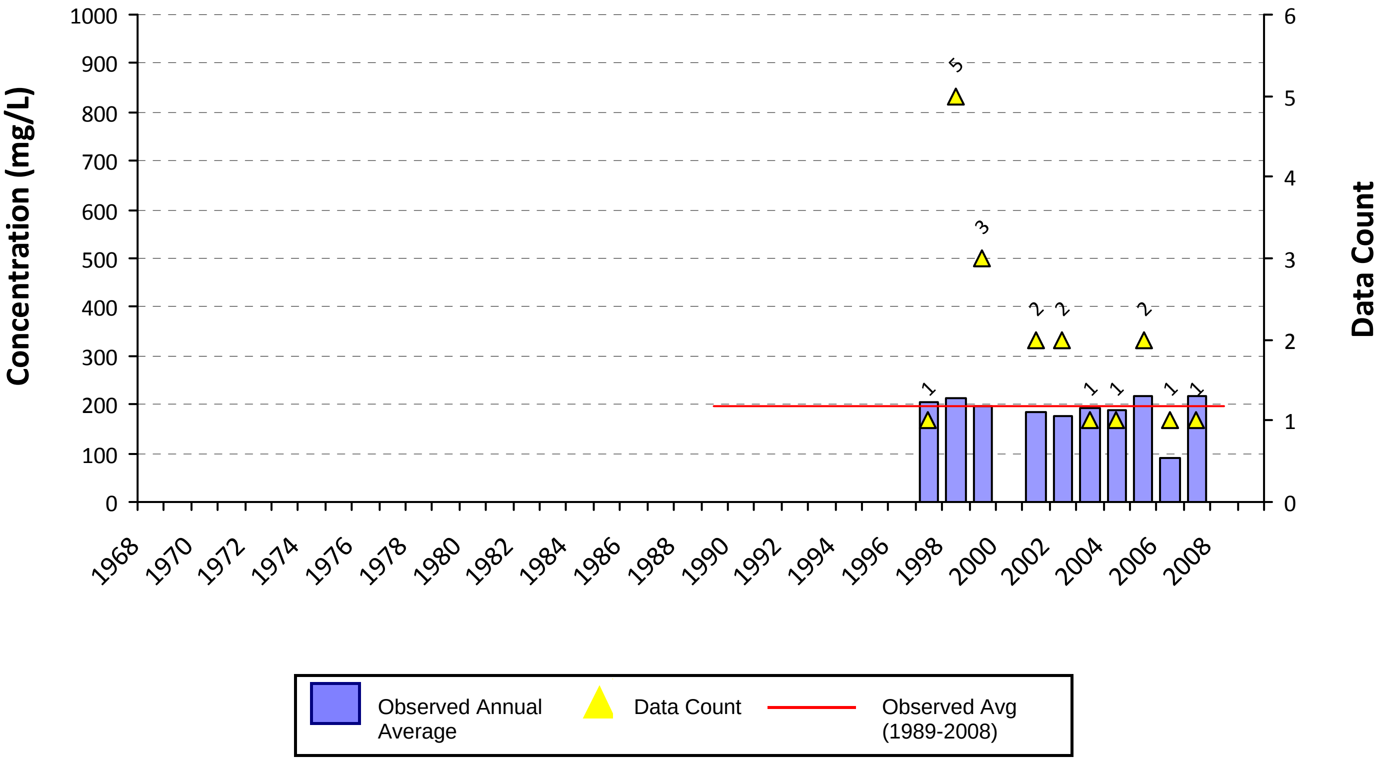
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Trinity Below Livingston

0801C Cotton Bayou (unclassified water body)



0801D

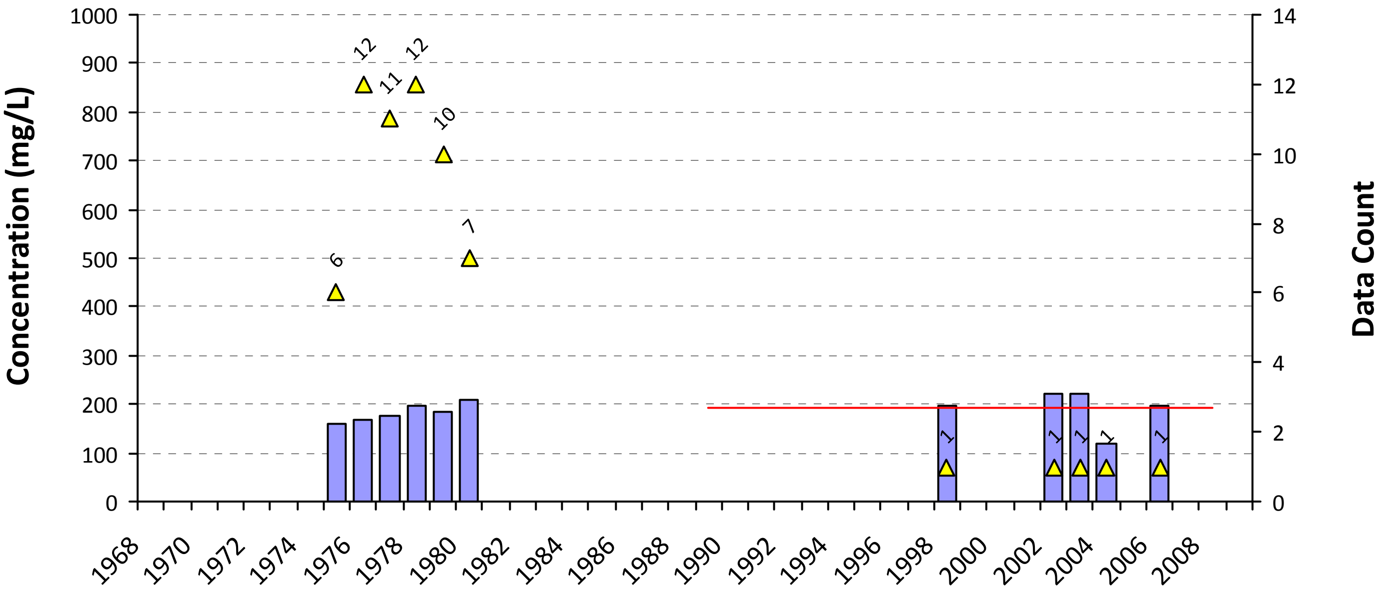


(1) Data set includes TDS derived from conductivity data (0.65 conversion)

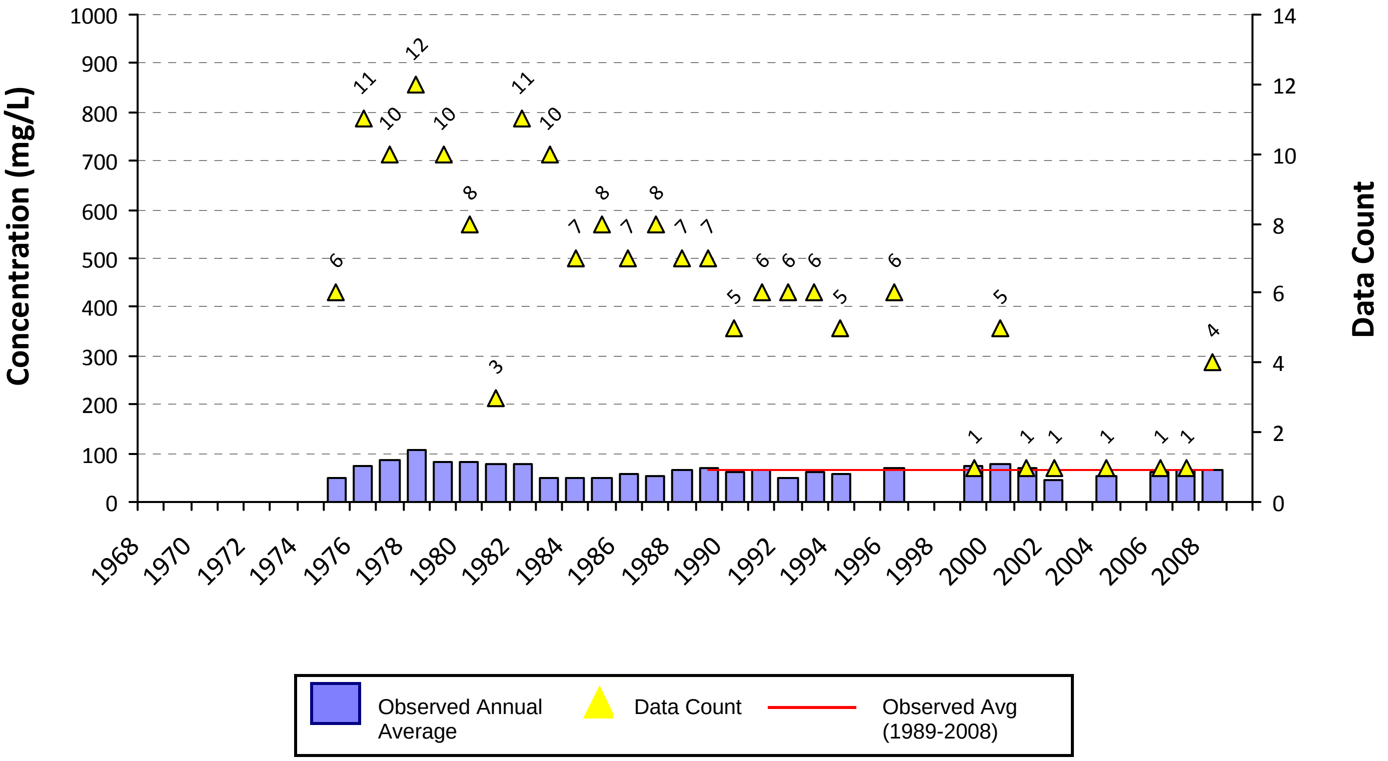
Appendix B (cont.)
Historical Annual Average Total Dissolved Solids* Concentrations for Trinity River Basin Unclassified Waterbodies

Trinity Below Livingston

0802B



0802D



(1) Data set includes TDS derived from conductivity data (0.65 conversion)