Water quality and fish assemblages in the Trinity River, Texas, between Fort Worth and Lake Livingston

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Water quality and fish communities were sampled at 11 sites on the Trinity River between Fort Worth and Lake Livingston in 1987 and 1988. Two tributary sites, one impacted (East Fork Trinity River) and one minimally disturbed control site (Elm Fork Trinity River), were also sampled. Each site was sampled on six occasions using a variety of gear types, including seines, gill nets, and electrofishers. The primary goal of the study was to evaluate the possible influence of wastewater discharges on water quality and the fish community. A secondary objective was to obtain data for the Texas Water Commission (TWC) to utilize in a Use Attainability Study on TWC Segment 0805, which extends from Fort Worth to Trinidad.

The fish community demonstrated considerable improvement over previous studies. However, severe impacts to the fish community were apparent at the South Loop 12 site, which is downstream of the Dallas Central Wastewater Treatment Plant. Species richness, species diversity, and Index of Biotic Integrity (IBI) scores were significantly lower at South Loop 12 than at other sites sampled. Fish were completely absent from that reach during one sampling period. Impacts were at least partially attributed to ammonia and chlorine toxicity. Scheduled discharge limitations on ammonia and chlorine should alleviate those impacts.

Less severe impacts were observed at Belt Line Road and the East Fork. The former site may suffer from some of the ammonia and chlorine effects discussed above, whereas depressed dissolved oxygen concentrations appear to impact the East Fork.

IBI scores were used to assess the appropriate aquatic life use designation for TWC Segment 0805. Scores for the two-year period were on the border between "intermediate" and "high". However, scores were higher in 1988, despite the fact that it was a low flow year and conditions were harsh. With ammonia and chlorine limitations already scheduled for the major dischargers, it is probable that water quality and the fish community will continue to improve. Consequently, a "high" use appears appropriate for TWC Segment 0805.

Fillets from 36 individual fishes and five composite samples of three fish each were analyzed for a selected group of contaminants. Chlordane levels exceeding the Food and Drug Administration action level of 0.300 mg/kg were found in nine of the samples, all but one occurring in an urbanized area extending from downtown Fort Worth to South Loop 12 in Dallas. Results suggested that the elevated chlordane levels are related to urban or suburban runoff.

INTRODUCTION

The Trinity River from Fort Worth to Lake Livingston was sampled by Texas Parks and Wildlife Department (TPWD) Resource Protection Division staff to ascertain the status of the fish community. Longitudinal trends in fish distribution and their relation to major wastewater discharges were of primary interest along with evaluating the fish community following major fish kills in 1985. This study was also designed to provide the Texas Water Commission (TWC) with a fisheries evaluation to be employed in a use attainability analysis of TWC Segment 0805, which extends from Beach Street in Fort Worth to State Highway 31 near Trinidad.

STUDY AREA

The West Fork Trinity River (Figure 1) originates in southeastern Archer County and combines with the Clear, Elm, and East forks to form the main stem, which extends in a southeasterly direction with ultimate drainage into the Gulf of Mexico. The Trinity River drainage basin encompasses approximately 46,620 square km (18,000 square miles) and has a length of approximately 1130 km (702 miles). Mean annual rainfall for the period of 1951-1980 ranged from 66 to 122 cm (26 to 48 inches) in the basin (Larkin and Bomar 1983).

The Trinity River basin is located in the Coastal Plain Physiographic Province with geology dominated by Cretaceous, Tertiary, and Quaternary strata of sedimentary origin [United States Army Corps of Engineers (COE) undated]. The area from Beach Street to the Dallas County line drains the population centers of Fort Worth, Arlington, Grand Prairie, and Dallas. This area is heavily urbanized and ranks much higher than the state as a whole in population density [Texas Department of Water Resource (TDWR) 1984]. The human population in the Trinity River basin was 3.2 million in 1980, 75% of which resided in Dallas and Tarrant Counties (TDWR 1984).

Despite urbanization, much of the land immediately adjacent to the river in Dallas County has remained undeveloped because of flooding within the levees. Seven major floods have been recorded on the Trinity since the turn of the century (COE undated). In response, Fort Worth built a series of levees in the late 1920s along the West and Clear forks to provide protection from flooding (COE undated). Comparable levees were also constructed in Dallas. Following a severe flood in 1949, renovation and expansion work was undertaken on the levees and was completed during the 1950s. To the southeast of Dallas County, the Trinity watershed is primarily rural, with most land being used for grazing or cultivation.

Impoundments and wastewater discharges play a major role in regulating flow of the Trinity River. Upstream of the Dallas-Fort Worth area, the river is influenced by more than 2,500 minor flow retarding structures (COE undated) and a dozen major reservoirs. Consequently, the amount of water entering the Trinity downstream of these reservoirs depends upon their releases, wastewater discharges, and runoff. Within the Dallas-Fort Worth area, the Trinity becomes effluent dominated (TWC 1988a). In 1987, the Trinity received a mean of 380 million gallons per day (MGD) of wastewater, more than 15,000 lbs/day of biochemical oxygen demand (BOD), and 17,474 lbs/day of total suspended solids (TSS) from the four major treatment plants: Fort Worth Village Creek Wastewater Treatment Plant, Trinity River Authority Central Plant, Dallas Central Plant, and Dallas Southside Plant (TWC 1988b).

The area of primary interest in this study stretches from Beach Street to the upper end of Lake Livingston (TWC Segments 0805, 0804, and 0803). Eleven sites in that reach (Figure 1) were sampled during this study. Sites in the Dallas-Fort Worth area were selected based upon their proximity to major wastewater discharges. Where possible, wastewater discharges were bracketed by sampling locations. Downstream sites were selected to determine the longitudinal extent of wastewater influences, if any, on water quality and the fish community. An important factor in determining sampling locations was also the lack of physical access to the river. The Trinity River throughout its length has steep banks and launching sites are confined primarily to bridge crossings. Only one boat ramp, near U.S. 79, is located on the main river.

Also investigated were the East Fork (TWC Segment 0819), a segment that has historically ranked as the worst stream in Texas in relation to water quality standards violations (TWC 1988a), and the Elm Fork (TWC Segment 0822), a minimally impacted control site. It was not assumed that water quality and fish community patterns in the Elm Fork represented pristine or ideal conditions. Such places are rare and may not exist at all given present day conditions. Instead, it was viewed as a site with a fish community that was minimally impacted by wastewater discharges and could be used to define possible degradation at main stem sites. Descriptions of individual sites are provided below as well as information about any major wastewater dischargers upstream of them.

Beach Street (Site 1: River km 839.8)

Immediately upstream of Beach Street, the Trinity River consisted of a series of shallow (0.05 to 0.3 m), clean gravel riffles interrupted by pools with hard clay and bedrock substrates. Stream width varied from 6 to 23 m. Instream cover consisted of bank undercuts and a small amount of snag habitat.

Aquatic macrophytes were relatively abundant along point bars and stream margins. Considerable periphyton was observed on the stream bed. Banks were moderately sloping and stable in most instances and were well vegetated with grasses. Trees were not present. No major sewage treatment plants are located upstream of this site.

Belt Line Road (Site 2: River km 786.3)

A narrow, deep channel predominated upstream, with a series of moderately deep riffles (0.3 to 0.6 m) downstream. Stream width ranged from 15 to 25 m. Substrates varied considerably, with extensive cobble, gravel, and bedrock in riffle areas and hard clay and silt in long pools. Profuse bank undercuts and snags provided cover in addition to aquatic macrophytes along the stream margins. Banks were stable and vegetated with grasses and trees. Canopy cover averaged 10 to 15%. The Fort Worth Village Creek Wastewater Treatment Plant (Site A on Figure 1), which had a mean daily discharge of 114 MGD in 1987 (TWC 1988b), is located approximately 27.4 km (17 miles) upstream of this site.

Elm Fork Trinity River at Sandy Lake Road (Tributary Site 1)

Carollton Dam impounds water upstream of this crossing. Areas above and below the dam were sampled. Flow upstream of the dam was sluggish and soft silt substrates predominated. Bend development was strong in this deep section and stream widths averaged 25 to 28 m. Banks varied from gradually sloping to steep. Snags were abundant along with undercuts and aquatic vegetation. Canopies covered 8 to 15% of the stream. Downstream of the dam, the stream was narrower and defined by relatively steep banks. Stream width averaged 6 to 9 m. Substrate was bedrock interspersed by occasional gravel riffles. Instream cover was provided by snags and undercut banks. Canopy cover varied from 20 to 60%.

Sylvan Avenue (Site 3: River km 765.9)

This site is within the Trinity River levee in downtown Dallas and was characterized by a relatively straight, deep channel, occasionally broken by shallower sand and silt bars (0.6 to 1 m) which emanated from a series of stormwater drains and canals. Stream width varied from 21 to 29 m. A hard-packed, uniform clay or shale substrate predominated, with gravel and cobble creating areas of turbulence along the stream margins. Extensive snags provided instream cover for fishes. No aquatic vegetation was observed. Grasses extended to the water edge and the canopy was less than 5%, consisting mainly of willows (Salix). The Trinity River Authority Central Wastewater Treatment Plant (Site B on Figure 1), which had a mean daily discharge of 85.9 MGD in 1987 (TWC 1988b), is 10.9 km (6.8 miles) upstream of this site. The confluence with the Elm Fork is 8 km (5 miles) upstream.

South Loop 12 (Site 4: River km 750.1)

Steep banks began to confine the river at this site. Terraced outcroppings of sedimentary rock were common along the shoreline and the river became relatively deep with occasional shallow bars. Stream width varied from 20 to 24 m in the sampling area. Substrates ranged from hard clay or shale to soft silt, with an occasional gravel area causing turbulence. Instream cover consisted of extensive snags, bank undercuts, and midstream ridges shaped by river flow. No aquatic vegetation was observed. Canopies ranged from 5 to 10%. Paper and styrofoam debris were common in this area. The Dallas Central Wastewater Treatment Plant (Site C on Figure 1), which had a mean daily discharge of 150 MGD in 1987 (TWC 1988b), is located 6.9 km (4.3 miles) upstream of this site.

East Fork Trinity River (Tributary Site 2)

The East Fork Trinity River originates in Cooke County and flows southward through Collin County through Lake Lavon and Lake Ray Hubbard before joining the main stem in Kaufman County (TWC 1988a). The East Fork drains approximately 390 square km (243 square miles). The major portion of the drainage area was pasture, though increasing urbanization in the Garland and Mesquite areas has started to alter land usage. The East Fork was sampled at Malloy Bridge Road (April-May 1987, August 1987, January 1988 and April-May 1988) and FM 3039 (August 1988 and November-December 1988). In the areas sampled, the stream was bounded by steep banks, though gently rolling hills characterized the surrounding land. Stream widths varied from 17 to 19 m and little bend development was observed. Soft silt alternating with hard packed clay comprised the substrate. Snags provided the majority of cover along with occasional hard clay shoals. Blue-green algae (Cyanophyta) was observed on the stream bed on almost all sampling trips. Riparian vegetation was sparse. The Garland Duck Creek Wastewater Treatment Plant (Site E on Figure 1) and the North Texas Municipal Water District Plant (Site F on Figure 1) are both upstream and had a combined daily discharge of approximately 31.3 MGD in 1987 (TWC 1988b).

Red Oak Creek Confluence (Site 5: River km 695.9)

Steep, tall banks defined the channel in this area. Shale bars were observed, though the banks and shoreline consisted primarily of clay. Stream widths varied from 27 to 37 m. Most of the river was relatively deep with a swift current and silt substrate. However, several extensive clean gravel riffles were observed. Bank undercuts and snags were the primary instream cover in addition to the gravel bars. Canopies covered about 1% of the river bed. The Dallas Southside Wastewater Treatment Plant (Site D on Figure 1), which had a mean daily discharge of

30.8 MGD in 1987 (TWC 1988b), is located 37 km (23 miles) upstream of this site. The East Fork confluence with the Trinity River is approximately 4.8 km (3 miles) upstream.

FM 85 (Site 6: River km 657.4)

Strong bend development with deep undercuts and a few shallow point bars characterized the river at this location. Steep banks predominated from this site to the most downstream station, State Highway 21. Terraced outcroppings occurred occasionally as well as a few sparse riffles along stream banks. Stream width ranged from 27 to 48 m. Silt, both soft and hard packed, appeared to dominate other substrates. Bank undercuts and instream timber provided extensive cover. No aquatic vegetation was observed. Canopies covered an estimated 4% of the stream area.

State Highway 31 (Site 7: River km 597.3)

Steep, high banks defined the river channel at this site. Bend development was moderate. Substrates consisted mainly of soft and hard packed silt. A few shale outcroppings were observed. Stream widths varied from 15 to 25 m. No shallow riffles were observed and the reach appeared to be composed of deep water with relatively swift flows. Backwater areas were found on the downstream side of some point bars and instream cover consisted of snags and bank undercuts. Aquatic vegetation was sparse to nonexistent and canopies were less than 5%.

U.S. Highway 287 (Site 8: River km 568.6)

As with other adjacent sites, banks were extremely steep, tall, and composed of silt or clay soils. Shale outcroppings were observed in several areas. Stream width ranged from 12 to 30 m. Bend development was strong. The river was relatively deep at this location, though shallow riffles with broken shale and gravel substrates were found along the stream margins. Substrates were predominately clay, shales, and hard sand with occasional gravel. Instream cover was provided by profuse snag development, bank undercuts, and back eddies. Sparse aquatic vegetation was observed along the stream margins and canopies covered less than 5% of the stream bed.

U.S. Highway 79 (Site 9: River km 474.6)

Steep, sandy banks alternating with terraced rock outcroppings characterized this area. Bend development was strong and stream width ranged from 13 to 30 m. The channel was relatively deep and defined, with a mixture of silt, sand, and clay substrates. Occasional gravel shoals were present and instream cover was provided by bank undercuts and extensive snag development. Back eddies were common. Aquatic vegetation was not observed and canopies covered 2 to 5% of the stream bed.

State Highway 7 (Site 10: River km 399.7)

Upstream of this site is a lock and dam which provides considerable turbulence and a concentration area for fishes. This reach was characterized by steep clay banks and a well defined river channel with strong bend development. Stream widths ranged from 25 to 30 m. Gravel substrates and sandy bars were relatively common, with the bottom being firm in most areas. As with other sites, bank undercuts and woody debris provided the majority of cover. Sparse aquatic vegetation was observed along point bars and stream margins. Canopy cover averaged about 3%.

State Highway 21 (Site 11: River km 348.1)

Land surrounding the river flattened out in this reach. Broad, shallow areas and point bars were more extensive than at upstream sites. Steep banks were still present on the outer edge of bends. Bend development was strong and stream widths varied from 35 to 42 m. Sand was the dominant substrate. Cover was provided by bars, snags, and bank undercuts. Some aquatic vegetation was observed along stream margins. Canopy cover was approximately 1 to 2%.

In summary, some differences were observed among stations, but physical habitat appeared adequate to support a diverse assemblage of fishes and other aquatic resources in all areas surveyed. Snags, timber, bank undercuts and shoals provided the majority of instream cover, with some gravel riffles occurring at most sites. Macrophytes were scarce, which is to be expected given the turbid nature of the stream.

MATERIALS AND METHODS

Fish collections

Fish were collected on six sampling trips during 1987 and 1988 with a variety of gear types, including seines, gill nets, and boat or backpack type electrofishing gear (Table 1). Shallow water habitats were sampled by a straight seine measuring 4.5 m in length, 1.2 m in depth, and composed of 3.1 mm ace weave mesh. Gill nets were constructed of monofilament and were 60 m in length, 2.4 m in depth, and were composed of eight 7.5 m long panels varying in bar mesh size from 12.5 to 100 mm. Gill net sampling was discontinued after one year (three sampling trips) because of its high manpower requirements and because other methods were providing adequate data. Electrofishing was conducted from a boat equipped with a boom, a 5,000-watt Honda electrical generator, and a converter box designed to produce pulsed DC current. A backpack electrofisher (Smith-Root Type VII) was used at sites where boating was impractical. Electrofishing was not conducted on the initial sampling trip because of equipment malfunction. U.S. 287 was not sampled during January 1988 because the launching area was inaccessible due to recent rains. The sampling location on the East Fork was moved for the final two sampling periods because physical access became difficult at the original site. The Red Oak Creek confluence was not a regular sampling site because of a lack of suitable boat launching areas. However, an effort was made to sample it at least once, given the input of wastewater from the Dallas Southside Wastewater Treatment Plant and the 92 river km gap between South Loop 12 and FM 85.

Six to nine seine hauls were taken at each site. Seining techniques and efficiency varied among locations and dates because of steep banks, soft substrates, the infrequency of shallow bars at some sites, and flow fluctuations. Weight (g), total length (mm), and signs of disease or external abnormalities were recorded for larger individuals. A subsample of 75 small fish from each location were also examined for disease and other abnormalities. All fish were preserved in 10% formalin and transported to the laboratory for identification and enumeration. Taxonomic references included Douglas (1974), Eddy and Underhill (1978), Hubbs (University of Texas unpublished 1970 manuscript), Miller and Robinson (1973), and Pflieger (1975). Common and scientific names follow Robins et al. (1980).

One gill net was set for 13:30 to 21:25 hours at each station. Sets were made so that the period sampled included dawn, dusk, and evening periods, when fish are more active. Gill nets were set on the inside bends of meanders with the small mesh abutting the shoreline. Fish were identified, weighed, measured, and examined for disease and other abnormalities before their release.

Stations were electrofished for 15 minutes. Attempts were made to net all observed fish, regardless of size. Fish were identified, weighed, measured, and examined for disease and other abnormalities before their release.

Some larger individuals from routine sampling were retained for selected contaminant residue analysis. The fishes were analyzed by the Texas Department of Health to obtain data on potential human health hazards to those ingesting Trinity River fishes. Since documenting metal and pesticide concentrations in tissue was not a primary goal of the study, no additional sampling effort was employed to obtain like species at each site. However, following the initial results, collections were expanded to include several additional sites (Figure 1). Fishes were wrapped in aluminum foil, placed in a plastic bag, and kept on ice until they could be returned to the lab. Each fish was filleted and samples were sent to the Texas Department of Health where they were analyzed for selected organics and metals. The metals were mercury, cadmium, lead, copper, and zinc. The organic constituents included DDT, DDD, DDE, aldrin, chlordane, heptachlor expoxide, hexachlorobenzene, dieldrin, methoxychlor, toxaphene, PCBs, endrin, heptachlor, lindane, and pentachlorophenol (Jim Boyer Texas Department of Health personal communication). Values were compared to Food and Drug Administration action levels, where applicable, to evaluate their significance.

Methods for fish data analysis

Fish community data were evaluated using a variety of measures, including the Index of Biotic Integrity (IBI), species richness (the number of species), species diversity, the number of individuals, and condition (K) factors. Data from all collecting methods were combined to evaluate species richness and calculate IBI. Species diversity was calculated only for electrofishing samples. To test for longitudinal patterns, total species richness (from all collecting methods), IBI scores, electrofishing diversity, and condition factors were compared using one-way analysis of variance (ANOVA). Prior to applying ANOVA, data were tested for normality using the Shapiro-Wilk statistic (Zar 1984). IBI and diversity values were log transformed using the formula presented in Zar (1984):

$$\log_{10}(x+1),$$

where x = the IBI value. When ANOVA results were significant (α =0.05), means were compared using the Student-Newman-Keuls test (Zar 1984). Paired sample t-tests (Zar 1984) were employed to detect significant differences (α =0.05) in species richness, IBI scores, and diversity between like seasons in 1987 and 1988 (e.g.: spring 1987 vs spring 1988; See Table 1 for dates.).

Index of Biotic Integrity was calculated according to Karr et al. (1986), though the metrics and scoring criteria were modified to rate the Trinity River fish community (Table 2). Modifications were based upon suggestions by Karr (personal communication), Karr et al. (1986), and previous use of the IBI in Texas (Linam and Kleinsasser 1987). IBI scoring criteria are designed to vary according to stream size and geographical region (Karr et al. 1986). To address the issue of regional differences, metrics and expectation criteria were established based on preliminary sampling of minimally disturbed tributary sites in the Trinity basin plus collections from the control site on the Elm Fork. Though Karr et al. (1986) suggested that the total number of species should increase with stream size, stream order or drainage basin size was not considered in setting criteria or metrics. The homogeneity of habitat from site to site in the Trinity River and the large number of sites, each with a different drainage area, made it impractical to establish separate criteria for different river reaches. Species similarities and faunal overlap also argued against separate scoring criteria (Hughes and Gammon 1987). In addition, difficult seining conditions and the large volume of water and discharge may have caused sampling efficiency in the Trinity River to decline in a downstream direction, offsetting an assumed increase in species at higher order sites. One regional reference study that used IBI found no relationship between certain species richness metrics and drainage basin size at boat shocking sites [Ohio Environmental Protection Agency (OEPA) 1988].

Eight of the original IBI metrics were employed in this study. The number of sucker species and the number of darter species were eliminated because few species of darters or suckers were collected at the least disturbed sites. Only one catostomid, smallmouth buffalo (Ictiobus bubalus), was common in the river, whereas another, river carpsucker (Carpiodes carpio), was collected with less frequency. Neither is considered sensitive to environmental degradation. Black buffalo (Ictiobus niger) was also collected, but only once. Darters were collected infrequently, and their low abundance would have reduced the sensitivity necessary to detect site differences. The number of catfish species and the number of cyprinid species other than common carp were substituted for the sucker and darter metrics. Catfish were used based upon suggestions by Karr et al. (1986) and because they are widely distributed in the Trinity basin. Five species were collected at the least disturbed sites and Hubbs (1982) lists seven species that could occur in the Trinity basin. Cyprinid species were selected because they were common at least disturbed sites and appeared to suffer from few distributional limitations within the Trinity Basin. Hughes and Gammon (1987) used cyprinids as a target group in an IBI study of the Willamette River, citing the responsiveness of that family to deterioration of habitat structure (Minckley 1973; Moyle 1976). Ramsey (1968) proposed that many species in the minnow family could be good indicators of water quality, though he cautioned that specific habitat requirements for many species are unknown. Carp were omitted from the cyprinid metric because they are tolerant of environmental perturbations and are non-native.

In other modifications, the percentage of individuals as tolerants was substituted for percent green sunfish. Karr selected green sunfish as a species that tends to overpopulate disturbed areas, but offered percent tolerants as an alternate metric. Percent invertebrate feeders was substituted for percent insectivorous cyprinids, following the guidance of Karr et al. (1986). Trophic and tolerance classifications for Trinity fishes were established based upon a survey of ichthyologists familiar with Texas freshwater fishes and a comprehensive literature review (Appendix C; Linam and Kleinsasser unpublished).

IBI was the principal tool used to evaluate the sites for fisheries use attainability. This approach was used because IBI has gained acceptance by a number of states as a tool for evaluating fish communities for water quality standards purposes. In addition, the United States Environmental Protection Agency (EPA) has increasingly recommended its use for biological assessments of fish communities (Plafkin et al. 1988; EPA 1983). For use attainability purposes, IBI integrity classes were developed to evaluate the appropriate aquatic life use for sites within TWC Segment 0805.

The Texas Surface Water Quality Standards (TWC 1988c) provide a framework for protecting aquatic life in public waters. Depending on the nature of a particular water body and its biota, it may be classified as having limited, intermediate, high, or exceptional aquatic life and would be afforded varying levels of protection based upon a tiered set of water quality criteria. These levels of aquatic life are termed "aquatic life use subcategories" and their ecological characteristics are defined qualitatively in the Texas Surface Water Quality Standards (TWC 1988c).

Twidwell and Davis (1988) proposed numerical IBI criteria for determining aquatic life uses in small, unclassified streams (Table 3). Those criteria were translated directly from the original integrity classes proposed by Karr et al. 1986 (Appendix D). In their study of six streams, the IBI consistently underestimated the aquatic life use when compared to other rating criteria (Steve Twidwell TWC personal communication). Consequently, the investigators recognized the need to further refine IBI for use in Texas (Twidwell personal communication). The modifications by Twidwell and Davis (1988) were based on best professional judgement and have not been tested extensively in Texas. Karr (personal communication) recommended caution in establishing such guidelines without validation. His original integrity classes were developed after sampling streams in the midwest and may not be applicable in all geographical regions.

Just as individual IBI metrics in this study were established based on data from the Elm Fork control site and least-disturbed, reference streams in the basin, so were total IBI scores assigned to the various aquatic life uses. Consequently, use class criteria represent a knowledge of the biological community performance that can be attained at least disturbed sites in the Trinity River basin given present-day conditions. Other states, most notably Ohio, have used reference site studies to develop numerical criteria for aquatic life use categories (OEPA 1988).

To establish aquatic life use criteria, the 12 IBI metrics from each reference site were summed and the total IBI scores were ranked. Modifying an approach that has been used elsewhere (OEPA 1988), exceptional use was defined as any IBI score equalling or exceeding the 75th percentile value of the reference sites (Table 4). The 25th percentile value was selected as the lower limit for high use. Those percentiles were selected because it was assumed that the reference sites represented "best case" conditions and should receive either a high or exceptional rating. Values falling within the bottom quartile of the reference site scores were defined as intermediate. Limited use was defined as any score that was less than the minimum IBI score of the reference sites. Criteria for aquatic life use designations were derived a priori to evaluation of IBI scores to avoid bias in setting the criteria.

Species diversity was calculated only for electrofishing samples. Diversity is sensitive to the number of individuals and it was felt that seining conditions varied enough to confound the calculations. Gill net catches were not used because in most cases few numbers of fishes were captured. Diversity was calculated according to the equation presented in Wilhm (1970):

$$\bar{H} = -\sum_{i=1}^{s} (n_i/n)\log_2(n_i/n),$$

where $\bar{H}$ = species diversity, n_i = number of individuals in i^{th} species, n = number of individuals in the sample, and s = number of species.

Condition factors, a measure of the well-being or plumpness of a fish, were calculated according to the equation presented in Carlander (1969, 1977):

$$K = W*10^5/L^3,$$

where K = condition factor, W = weight in grams, L = total length in millimeters, and 10^5 is a factor to bring the value of K near unity. Generally, K-factors were calculated only for species for which Carlander (1969, 1977) lists comparative data and ranges of means for each individual species were used for comparison. K-factors vary with species and size, but generally, larger values are indicative of better fish condition.

Water quality sampling and analysis

Dissolved oxygen, pH, temperature, and conductivity were measured in situ at each station with a Hydrolab Surveyor II. Total NH_3-N was measured in the field using a Hach colorimetric test kit based on the Nesslerization method. Samples were filtered to prevent interference from turbidity. Water transparency was measured with a Secchi disk, and stream width was measured by optical rangefinder. Flow and dissolved oxygen data were also obtained from continuous reading monitors at

United States Geological Survey (USGS) gaging stations (Figure 2). Additional ammonia nitrogen data was gathered by the TWC stream monitoring network (Figure 2). In-stream total residual chlorine concentrations were calculated for areas below wastewater outfalls using USGS stream flow data and treatment plant self-reporting data for monthly mean flow and total chlorine residual. For the purposes of the dilution calculation, it was assumed that chlorine concentrations above the outfall were 0 mg/L and total mixing occurred downstream of the outfall. If either of those conditions were not met, localized concentrations within the stream would have been higher than the value calculated. Consequently, this method should provide a conservative estimate. The equation used for calculations was:

$$\text{mg/L chlorine}^{rs} = (\text{mg/L chlorine}^{e} * Q^{e}) / Q^{rs}$$

where rs = receiving waters downstream of the plant, e = effluent, and Q = flow. Though these data were used with caution given their theoretical nature, they provided valuable information on the potential for chlorine toxicity immediately below the major wastewater plants.

FISH COMMUNITY EVALUATION

River Basin Overview

When all sampling methods were considered, 50 species of fishes comprising 12 families were collected from sites on the Trinity main stem, Elm, and East forks (Table 5). Collections included three species of gar (Lepisosteidae), two species of shad (Clupeidae), 13 species in the family Cyprinidae (minnows), three species of Catostomidae (suckers), and five species of catfish (Ictaluridae). Perichthyidae (temperate basses) was represented by three species, whereas 12 species in the family Centrarchidae (sunfish) were collected. Five different species of darters (Percidae) were collected, although they were rare in occurrence. Other families represented in the collections were Cyprinodontidae (killifishes; one species), Poeciliidae (livebearers; one species), Atherinidae (silversides; one species), and Sciaenidae (drums; one species).

A 1972-1974 study in which boat electrofishing was the only sampling method collected 36 species (Table 6) from six reaches stretching from South Loop 12 to Lake Livingston (TPWD 1974). Four species collected during that effort were absent from the present samples. They were bowfin (Amia calva), black bullhead (Ictalurus melas), brook silverside (Labidesthes sicculus), and spotted sucker (Minytrema melanops). Nine species (Table 7) were observed during two kills totalling approximately 270,000 fish in July 1985 (Palma 1986a; 1986b). All of those species were collected during this survey. Hall (1973) reported some 130 species and hybrids known to occur in the Trinity River. However, that evaluation involved a larger area than sampled in this study and included many esturine species.

Three small fishes--red shiner (Notropis lutrensis), bullhead minnow (Pimephales vigilax), and mosquitofish (Gambusia affinis)--were found in more collections than any other species. Red shiner was the dominant species both in terms of percent occurrence and total numbers. Red shiners were found in 69 of 72 collections (95.8%) and at all sites. Bullhead minnows were second in percent occurrence, being found in 66 collections (91.7%) and at all sites. Mosquitofish were found in 61 collections (84.7%) and at all sites except for the area upstream of the Red Oak Creek confluence.

Other species found in a high percentage of collections included smallmouth buffalo, longear sunfish (Lepomis megalotis), gizzard shad (Dorosoma cepedianum), and longnose gar (Lepisosteus osseus). Smallmouth buffalo were present in 50 collections (69.4%), longear sunfish in 49 collections (68%), and gizzard shad and longnose gar in 37 collections (51.4%). Smallmouth buffalo were present in 30% of the collections in the 1972-1974 study (TPWD 1974). More than 120,000 smallmouth buffalo were estimated killed during the July 1985 fish kills, attesting to their abundance in the river (Palma 1986a; 1986b).

Most species were scattered throughout the watershed, though some were consistently collected at only a few stations. The Elm Fork site provided the majority of species that were rarely collected or absent at other sites. Golden shiners (Notemigonus crysoleucas) were present in two Elm Fork collections, but also at two main stem sites, Belt Line Road and Sylvan Avenue. Those two sites bracket the Elm Fork confluence with the main stem, with Belt Line Road being upstream and Sylvan Avenue downstream. Pugnose minnow (Notropis emiliae) and redfin shiner (Notropis umbratilis) were present in three Elm Fork collections, but were also collected once at Highway 21, the furthest downstream site sampled. Pugnose minnows were also found once at Sylvan Avenue. Spotted bass (Micropterus punctulatus) were present in one collection from the Elm Fork and one collection at Sylvan Avenue. Fishes collected only in the Elm Fork were logperch (Percina caprodes) and redear sunfish (Lepomis microlophus). Largemouth bass (Micropterus salmoides) were present in eight collections, at the three sites farthest upstream and in the Elm Fork.

A few species were found primarily at downstream sites. Silverband shiners (Notropis shumardi) were present in five collections at only two sites: Highway 7 and Highway 21. Weed shiners (Notropis texanus) were found in three collections at Highway 79, but nowhere else. Ghost shiner (Notropis buchanani) were abundant at times and found in 28 collections, all but one from stations downstream of and including FM 85. Blue catfish (Ictalurus furcatus) were also common, being found mainly downstream of and including Red Oak Creek. That species was rarer at upstream locations. White bass (Morone chrysops) also tended to be present at downstream sites. Though collected once at Sylvan Avenue, all other white bass were found at U.S. 79, Highway 7, and Highway 21. Dusky darters (Percina sciera) were present in two collections at Highway 7 and one at Highway 21, but were also found once in the Elm Fork, at the other end of the watershed. Darters were notable for their absence at the sites farthest upstream--Beach Street and Belt Line Road. Suitable physical habitat was available, but none were collected.

Fishes present in three or fewer collections included weed shiner, fathead minnow (Pimephales promelas), central stoneroller (Campostoma anomalum), black buffalo (Ictiobus niger), yellow bullhead (Ictalurus natalis), yellow bass (Morone mississippiensis), spotted bass, spotted sunfish (Lepomis punctatus), redear sunfish, redbreast sunfish (Lepomis auritus), black crappie (Pomoxis nigromaculatus), logperch, bluntnose darter (Etheostoma chlorosomum), slough darter (Etheostoma gracile), and cypress darter (Etheostoma proeliare).

Collected throughout the watershed, but not in high abundance were channel catfish (Ictalurus punctatus). Palma (1986a; 1986b) reported an estimated 119,000 killed during the two July 1985 fish kills. Blue catfish, mentioned above as relatively common in this survey, were rare in the fish kill counts (Palma 1986a; 1986b). In the 1972-1974 TPWD study, channel catfish were present in 27% of the collections, whereas blue catfish were not present in any sample (TPWD 1974). The ratio between blue and channel catfish observed in this study may represent a temporary shift in the catfish population caused by the fish kills, though it may also be a sampling artifact. Temporal variation in channel catfish collections also lends support to the notion that the catfish population was still in flux from the 1985 fish kills during this study. Channel catfish were collected at 10 sites during the final sampling period, compared to a maximum of three on any other sampling date.

Temporal variation was also observed in the occurrence of two other species, one of which was a catfish. Freckled madtoms (Noturus nocturnus) were collected only during the final sampling period and were present at five sites. Largemouth bass were also present in more collections during the second year of the study.

The majority of species were collected for the first time during the initial three sampling efforts (Figure 3). However, species additions continued through the end of the study, particularly at Sylvan Avenue and the Elm Fork. Cumulative species richness for all collections on all dates (Figure 3) demonstrated depressed species richness at the Belt Line Road and South Loop 12, sites immediately downstream of major wastewater inputs. Sylvan Avenue presented something of an anomaly. Despite a major wastewater discharge upstream of it, the Sylvan site had the third highest cumulative species richness of any site. The Elm Fork may have provided a source for recruitment. Some evidence for that comes from the aforementioned occurrence of certain species only in the Elm Fork and adjacent sites. Cumulative species richness at FM 85 was the fourth highest and values tended to maintain a similar level downstream to Highway 21 where richness increased to the second highest level. The Elm Fork, used as a control, had the highest cumulative species richness of any site.

Mean species richness (Figure 4) followed a similar pattern, with moderate declines being observed at the Belt Line Road and East Fork sites and a major one at South Loop 12. The latter site had significantly lower species richness than all sites but Belt Line Road and the East Fork. No fishes were collected from the South Loop 12 site on one occasion. Mean electrofishing diversity (Figure 5) showed a slightly different pattern. Some of the diversity differences may be of minimal biological significance. However, South Loop 12 was still by far the most depauperate site. As with other measures, mean IBI scores demonstrated a significant difference between South Loop 12 and other sites (Figure 6).

Some temporal variation was indicated statistically. Paired sample t-tests indicated that total species richness, electrofishing diversity, and IBI scores were significantly higher in winter 1988 than in winter 1987. No differences were noted for spring and summer sampling between 1987 and 1988. In comparing all collecting periods, August samples had the highest IBI scores.

During the 1972-1974 study, fishes were absent in four of six samples from a reach beginning at South Loop 12 and extending to the East Fork confluence (TPWD 1974). The fish community improved slightly in the next downstream reach, though gar, a tolerant species, were collected more often than any other fishes. Mean species richness in the 1972-1974 study generally increased downstream with increasing distance from Dallas (Figure 7). Species richness was appreciably higher in this study than it was in 1972-1974 when all collecting methods were considered. Species richness was also higher in the present study when only electrofishing samples were examined.

Hall (1973) reported that the river from near Fort Worth to Crockett (Highway 7) was devoid of game fish and contained few rough fish species. Seine collections in that study from the South Loop 12 area produced only one gizzard shad and 11 mosquitofish (Hall 1973). A site between Dallas and Fort Worth produced only four species: mosquitofish, red shiner, black bullhead catfish, and gizzard shad.

Overall, the fish community appears to have improved considerably in the years since Hall (1973) and TPWD (1974) conducted their studies, particularly in the area immediately downstream of the Fort Worth-Dallas metroplex.

<u>First sample: April 20-24 and May 4-7, 1987</u>

Total species richness (Figure 8) was highest at Beach Street, followed by the Elm Fork and U.S. 79 sites. The lowest species richness was observed at Belt Line Road and South Loop 12. Slightly higher were Sylvan Avenue and the East Fork sites. All of those stations are downstream of major wastewater inputs. The number of individuals varied considerably among sites (Tables 8 and 9). Particularly with seining, the catch abundance depended on the prevalence of firm areas in which to sample. The South Loop 12 seine collection, however, had substantially fewer individuals when compared to other sites. Seine catches at all stations were dominated by red shiner and bullhead minnow. Gill net collections demonstrated wide variation in number of individuals, though the extremely large catch at Highway 21 can be attributed to transient movements of shad into the area. Gar, particularly longnose, and smallmouth buffalo accounted for the bulk of the gill net catch at most stations.

IBI values (Table 10) indicated an intermediate use at the upper three sites, with South Loop 12 dropping to limited. Downstream, values improved to intermediate at FM 85 and Highway 31 and high use at U.S. 287. The control site at the Elm Fork ranked high, whereas the East Fork was limited.

When compared to potential scores for individual IBI metrics, total number of species was depressed at all sites except for Beach Street. Decreased numbers of cyprinid species were observed at all sites except for Highway 7 and the Elm Fork, whereas all stations except U.S. 79 showed lower numbers of catfish species. Only Beach Street received an excellent rating for the number of *Lepomis* species. Few intolerant species and a high percentage of tolerants lowered the rating at all sites. The East Fork was the only station with a balanced trophic structure. A high percentage of omnivores and low percentage of invertebrate feeders resulted in lowered scores at Beach, South Loop 12 and Highway 21. All sites except Highway 21 and the East Fork had depressed numbers of piscivores. The number of individuals collected was depressed at FM 85 and Highway 21 and very low at South Loop 12 and the East Fork. A high percentage of fishes with disease or other anomalies caused low ratings at Beach Street, Belt Line Road, Sylvan Avenue, South Loop 12, FM 85, Highway 31, and the East Fork. Overall, South Loop 12 rated as low or lower than other stations for 10 of the 12 individual metrics.

Second Sample: Aug. 24-28, 1987

The fish community appeared to be in better condition during this sampling period, both in terms of IBI ratings and species richness. IBI ratings increased at all sites except U.S. 79, which remained the same. Much of the improvement may be related to increased sampling effort, since sites were not electrofished during April and May. When one compares seine collections, species richness increased at 9 of 12 sites. However, gill net sampling demonstrated decreases.

Total species richness (Figure 9) was highest at U.S. 287 and U.S. 79, whereas the lowest species richness was observed at South Loop 12 as in the April-May 1987 sample. Beach Street had the second lowest richness. The number of individuals again varied considerably among sites (Tables 11-13). In terms of seine collections, numbers increased considerably over April-May in the South Loop 12 seine collection, though fewer individuals were collected there than at other sites. As in the earlier collections, seine catches at all stations were dominated by red shiner and to a lesser degree by bullhead minnows and mosquitofish. Most species were scattered throughout the watershed. Blacktail shiners (Notropis venustus) were found at Beach Street and at the lower six sites. Ghost shiners were found mainly at downstream sites. Darters were found at only two stations. Three different species--dusky darter, bluntnose darter, and cypress darter--were all collected at U.S. 287, whereas only slough darter was found in the Elm Fork. Gill net sampling was fairly ineffective, with a maximum of eight fish being taken at any one site (U.S. 287). No fish were collected in gill nets at Sylvan Avenue and South Loop 12. For electrofishing samples, the largest number of individuals was collected at Sylvan Avenue. The fewest were collected at Highway 31, followed by South Loop 12. Electrofishing collections were dominated by red shiner, gizzard shad, longear sunfish, and blue catfish. Most species were scattered throughout the watershed, though blue catfish were present mainly at the lower four sites.

IBI values (Table 14) ranked intermediate at Beach Street, Belt Line Road, and Sylvan, but limited at South Loop 12. Aquatic life use increased to exceptional at FM 85 and high at Highway 31, U.S. 287, U.S. 79, Highway 7, and Highway 21. The Elm Fork was in the high range and the East Fork rated intermediate.

In examining individual IBI metrics, total number of species met the expected criteria at all stations except for Beach Street, Belt Line Road, South Loop 12, and the East Fork. Beach Street, Belt Line Road, Sylvan Avenue, South Loop 12, and the East Fork had depressed numbers of cyprinid species. FM 85, U.S. 287, U.S.

79, and Highways 7 and 21 achieved an excellent rating for number of catfish species. At least one Lepomis species was collected at each station, though only Highway 31 and U.S. 79 received an excellent rating. Two intolerant species were collected at FM 85, Highway 31, U.S. 287, Highway 7, and Highway 21, whereas only one was found at the other sites. Scores were reduced at all stations due to a high percentage of tolerants. Highway 31 came closest of any station to achieving a balanced trophic structure, deficient only in the percentage of piscivores. Only the Elm Fork had a high enough percentage of piscivores to receive an excellent rating for that metric. A high percentage of omnivores caused Sylvan Avenue, U.S. 79, Highway 7, Highway 21, and the Elm Fork to receive less than excellent ratings for that metric. Those same stations and U.S. 287 were downrated for having a lower than expected percentage of invertebrate feeders. Number of individuals was depressed at South Loop 12, FM 85, Highway 31, U.S. 79, Highway 21, the Elm Fork, and the East Fork. Belt Line Road, Highway 31, U.S. 287, Highway 7, and Highway 21 had a higher than expected percentage of individuals with diseases or other anomalies and received a less than excellent rating.

Third Sample: Jan. 4-5 and 18-21, 1988

The condition of the fish community during this sampling period was mixed when compared to the August collections, though for the most part demonstrated a slight decline. IBI values were higher at Highway 21 and the East Fork, the same at Beach Street, and declined at all other sites. Total species richness increased at Beach Street and Highway 21, but declined at all other sites.

Total species richness (Figure 10) was highest at Highway 21 with 18. No fish were collected at the South Loop 12 site by any method. Seine collections (Table 15) yielded a widely varying number of individuals, which as before, was partially a function of suitable sampling substrate. Beach Street, FM 85, Highway 7, and Highway 21 yielded the largest catches and red shiner numerically dominated each of those collections. The fewest individuals other than at South Loop 12 were at Belt Line Road. Samples were collected during relatively cold weather and that may have affected the catch rate, due to the inactivity of the fish. Sunfish were noticeably absent from the downstream sites. Gill net sampling (Table 16) was largely ineffective except at Highway 7 and Highway 21. White bass bolstered the numbers at the latter site. No fish were collected in gill nets at Beach Street, Belt Line Road, South Loop 12, and U.S. 79. In electrofishing collections (Table 17), Beach Street yielded the largest number of individuals, followed by Highway 21. No fish were collected by electrofishing at South Loop 12 and only 12 individuals were taken at the Belt Line Road and U.S. 79 sites.

IBI scores (Table 18) were highest at Highway 21. An IBI of zero was assigned to South Loop 12 since no fish were collected. Moving from upstream to downstream, the IBI rating was intermediate at Beach Street, but dropped to limited at Belt Line Road and Sylvan Avenue. FM 85 received a high ranking. Except for Highway 21, which received a rating of high, the other downstream sites ranged between limited and intermediate. The Elm Fork ranked intermediate and the East Fork achieved a high rating. As far as individual IBI metric scores, total species richness was less than the expected criteria at all sites except FM 85 and Highway 21. Number of cyprinids were below expectations at all sites but U.S. 79, Highway 7, and Highway 21. Reduced numbers of catfish species caused all stations except FM 85 to receive a less than optimal rating. Two of the 11 sites sampled received ratings of excellent for the number of Lepomis species--the Elm and East forks. All sites had a depressed number of intolerant species and a higher than optimal number of tolerants. U.S. 79 and Highway 21 had the most balanced trophic structures of any stations. The only stations with a sufficiently high piscivore percentage were Belt Line Road, Highway 7, and the East Fork. However, those stations, Sylvan Avenue, and the Elm Fork had higher than optimal percentages of omnivores and low percentages of invertebrate feeders. Number of individuals was depressed at Belt Line Road, Sylvan Avenue, FM 85, Highway 31, U.S. 79, Highway 7, the Elm Fork, and the East Fork. Four sites--Belt Line Road, FM 85, Highway 31, and Highway 7--had a higher than expected percentage of fishes with disease or other anomalies.

Fourth Sample: April 26-28 and May 3-5, 1988

No overall trend was evident when comparing the condition of the fish community during this sampling period to that during the January sample. Species richness (Figure 11) increased at Beach Street, Belt Line Road, South Loop 12, and U.S. 79; remained the same at Sylvan Avenue and the Elm Fork; and declined at FM 85, Highway 31, Highway 7, Highway 21, and the East Fork. The decline at highways 7 and 21 may have resulted in part from discontinuing gill net sampling, since that method was most productive at those sites. Total IBI scores increased at Beach Street, Belt Line Road, Sylvan Avenue, South Loop 12, Highway 7, and the Elm Fork. They declined at FM 85, Highway 31, U.S. 79, Highway 21, and the East Fork.

Total species richness was highest at U.S. 79, followed by the Elm Fork. The lowest species richness was observed at South Loop 12 and the East Fork. In seine collections (Table 19), Beach Street, Highway 7, and U.S. 79 had the largest number of individuals. Red shiners dominated the catch. No fish were collected seining at South Loop 12, whereas only six were taken at the East Fork site. Adequate seining habitat existed at South Loop 12, though difficult seining could at least partially explain the results in the East Fork. Highway 21 boasted the greatest number of individuals collected electrofishing (Table 20). The fewest number were taken at Highway 31, South Loop 12, and the East Fork.

Total IBI scores (Table 21) were in the high range at Beach Street and Sylvan Avenue, but were intermediate at Belt Line Road and limited at South Loop 12. Downstream, the scores ranged between limited and intermediate. As far as each individual metric, total species richness was less than the optimum level at all sites except for U.S. 79. The number of cyprinid species were depressed at Belt Line Road, Sylvan Avenue, South Loop 12, FM 85, Highway 31, U.S. 287, Highway 7, and the Elm and East forks. The number of catfish species was low at all sites but Beach Street, U.S. 79, Highway 7, and the Elm Fork. Lepomis species richness was depressed at all sites except for the Elm Fork. All sites were downrated for having few intolerant species and a high percentage of tolerants. The percentage of omnivores was greater than desirable at South Loop 12, U.S. 287, Highway 21, and the Elm Fork. Beach Street, Belt Line Road, Sylvan Avenue, Highway 31, and Highway 7 received an excellent rating for the percentage of invertebrate feeders. The percentage of piscivores was depressed at all sites but FM 85, the East Fork, and the Elm Fork. The number of individuals was depressed at Belt Line Road, Sylvan Avenue, South Loop 12, FM 85, Highway 31, U.S. 287, U.S. 79, the Elm Fork, and the East Fork. High percentages of fish with disease and other anomalies caused South Loop 12, FM 85, Highway 31, U.S. 287, U.S. 79, Highway 7, and the Elm Fork to receive a less than excellent rating.

Fifth Sample: Aug. 8-12, 1988

Fish community condition demonstrated improvement during this sampling period when compared to the April-May values. Total species richness (Figure 12) increased at nine of the 12 sites, whereas total IBI scores were higher at 10 of the 12 sites. Only Beach Street experienced a slight drop in IBI score from 46 to 42, whereas Belt Line Road remained the same.

Species richness for all collecting methods was highest at Sylvan Avenue. The site immediately downstream, South Loop 12, had the lowest species richness, along with Beach Street. Seine collections (Table 22) generally contained a larger number of individuals than in earlier collections. Red shiners and to a lesser degree bullhead minnows and mosquitofish were responsible for swelling the numbers. Highway 7 had the largest number of individuals, 97% of which were red shiner and bullhead minnow. The Elm Fork collection had the fewest number of individuals, but they were more evenly distributed. Red shiners and bullhead minnows constituted only 43% of that collection. In electrofishing collections (Table 23), Highway 21 had the largest number of individuals, with South Loop 12, as in other samples, having the fewest.

Most stations sampled fell into the high range when rated by the IBI (Table 24). South Loop 12, though it ranked intermediate, showed improvement over earlier samples. In examining individual metrics, no station received the lowest ranking for the total number of species collected. However, Beach Street, Belt Line Road, South Loop 12, Highway 31, U.S. 287, U.S. 79, Highway 21, the East Fork, and the Elm Fork all had less than optimal species richness. Beach Street, Belt Line Road, South Loop 12, FM 85, Highway 31, and the East Fork had a depressed number of cyprinid species. FM 85, Highway 31, U.S. 287, U.S. 79, Highway 7, Highway 21, and the East Fork had an optimal number of catfish species. All sites but Beach Street and Sylvan Avenue received a less than excellent rating for the number of Lepomis species. All sites were downrated for having few numbers of intolerant species and only the Elm Fork had a low percentage of tolerants. Most stations had a slightly imbalanced trophic structure, mainly because of low numbers of piscivores. Belt Line Road, Highway 7, and the Elm Fork demonstrated the largest variation from optimal levels, whereas U.S. 79 had a balanced trophic structure. Number of individuals was low at South Loop 12, Highway 31, and the Elm Fork. Only Beach Street had a higher than expected incidence of disease of other anomalies.

Sixth Sample: Oct. 31-Nov. 4 and Dec. 5-6

Fish community indices calculated for this sample demonstrated no overall trend compared to August. Total species richness (Figure 13) increased at seven sites, remained the same at two sites, and declined at three sites. The highest species richness value in the study was observed during this sampling period at the Elm Fork site. IBI scores were also somewhat varied when compared to August, though five sites experienced an increase, three sites remained the same, and four others showed a decline.

As mentioned earlier, total species richness was highest at the Elm Fork, followed by Highway 7, and Sylvan Avenue. As in other samples, species richness was lowest at South Loop 12, but recovered to some degree at Red Oak Creek. Seine collections (Table 25) had a similar pattern, with the highest species richness occurring at the Elm Fork and the lowest at South Loop 12 where nothing was collected despite repeated seining. Number of individuals seining was highest at FM 85 and obviously lowest at South Loop 12. As in earlier collections, red shiners dominated all seine collections. Electrofishing collections (Table 26) followed a similar pattern. The highest species richness was at the Elm Fork, followed by Sylvan Avenue. The largest number of individuals was taken at Beach Street, whereas the lowest number was found at South Loop 12.

IBI scores (Table 27) were in the intermediate to high range at most sites, with notable exceptions being South Loop 12 and Highway 21, both of which received limited ratings. The Elm Fork received an exceptional ranking. Beach Street, Belt Line Road, South Loop 12, Red Oak Creek, U.S. 287, and the East Fork were all downrated for having less than optimal species richness. Only U.S. 79 and the Elm Fork received excellent ratings for numbers of cyprinid species. Nine sites received excellent ratings for the number of catfish species. Beach Street, Belt Line Road, South Loop 12, and the East Fork were rated less than excellent for that metric. Belt Line Road, South Loop 12, Red Oak Creek, Highway 31, U.S. 287, U.S. 79, and Highway 21 were rated less than excellent for having low numbers of *Lepomis* species. Highway 7 and the Elm Fork were the only sites having the optimal number of intolerant species and all sites received a less than excellent rating for having high percentages of tolerants. Skewed trophic structures were observed at all sites, though were most severe at Belt Line Road, South Loop 12, Highway 7, and Highway 21. The number of individuals were greatly depressed at South Loop 12. Beach Street, Sylvan Avenue, South Loop 12, Red Oak Creek, FM 85, U.S. 287, Highway 7, Highway 21, and the Elm Fork were all downrated for having a higher than expected percentage of fishes with diseases and other physical anomalies.

Condition Factors

ANOVA was applied to condition factor data for smallmouth buffalo, common carp, blue catfish, longear sunfish, and gizzard shad. Those were the only species for which an adequate sample size from a wide variety of sites was available for analysis. Significant differences were observed among sites for longear sunfish and gizzard shad (Table 28), though no particular trend was evident. Numerous condition factors were based on one specimen and are reported for informational purposes only. Caution should be used in drawing conclusions from those samples.

Condition factors did not reflect any trends at the Beach Street station throughout this study (Table 29). This may have been due to the sporadic capture of species for which condition factors were calculated. Longear sunfish was the only species collected in every sample. The condition factor for that species fell within the expected literature range from Carlander (1969,1977) on four occasions, but was considerably depressed on the fifth collection date. Also low during the fifth sampling period was the condition factor for green sunfish. The only other values that were considerably lower than the expected range were for redbreast sunfish and one flathead catfish (*Pylodictis olivaris*). Condition factors for river carpsucker and smallmouth buffalo exceeded their respective literature ranges.

Most condition factors were within expected ranges at Belt Line Road (Table 30). All the omnivorous fish species had condition factors within or exceeding the reported ranges, except for carp in the third collection and gizzard shad and channel catfish (based on one fish) in the last collection. Smallmouth buffalo consistently exceeded the literature values. However, in each case the condition factors were based on only one fish. Condition factors for two invertebrate feeders were calculated. Longear sunfish were always within the expected range, save for the last collection period when their value was low; whereas, the condition factor for bluegill was very low.

Condition factors for omnivorous species at Sylvan Avenue were all above or within their expected ranges (Table 31). Smallmouth buffalo exceeded the reported range of condition factors on all six collection dates. Condition factors for two invertebrate feeders were computed. Three of the four sampling periods reflected low values for longear sunfish; whereas, all three collections of bluegill were within their expected range.

South Loop 12 boasted condition factors within or exceeding the expected range for all omnivores (Table 32). No condition factors were calculated for invertebrate feeders or piscivores due to either the lack of large enough specimens to weigh or the absence of reference ranges.

Condition factors at Red Oak Creek fell within, slightly above (smallmouth buffalo), or slightly below (gizzard shad) their respective ranges on all four species for which they were calculated (Table 33).

Condition factors for the omnivorous community at FM 85 were once again all within or above their respective derived ranges, except for gizzard shad (based on one fish) in the third collection and channel catfish in the sixth collection (Table 34). All values for invertebrate feeding species also fell within expectations. The majority of the values for piscivores, however, were low. White crappie was the only species without a condition factor below the expected criteria. Low piscivore values may reflect inadequate forage.

All omnivores, except carp, met or exceeded their respective condition factor ranges at Highway 31 (Table 35). Both values for carp were low (based on one fish). Longear sunfish exhibited values within the expected range. Several of the values for piscivores were low. Only blue catfish were without a condition factor below the expected range, possibly suggesting a competitive advantage over other piscivore species.

Condition factors for all omnivorous species except smallmouth buffalo, whose condition factors exceeded the reference ranges, fell below expectations at least once during the study at U.S.

287 (Table 36). Once again, this may indicate a competitive advantage for smallmouth buffalo. Condition factors were computed for one invertebrate feeder, longear sunfish. Both values were low (each based on one fish). Most piscivore values were within the expected range or just below it.

Condition factors for omnivorous species were generally within or exceeded literature values at U.S. 79 (Table 37). Smallmouth buffalo exceeded reported ranges in all but the fourth sampling period. The single condition factor for longear sunfish (invertebrate feeder) was within the expected range. Condition factors for white crappie (one value) and blue catfish (except the sixth collection period, which was based on one fish) fell within their established ranges. All three of the flathead catfish values were low.

Condition factors were within or exceeded listed ranges for all omnivore species except gizzard shad (third and fourth collection periods) and channel catfish (based on one fish) at Highway 7 (Table 38). In all collecting periods except the second, when they were not found, condition factors for smallmouth buffalo exceeded expectations. River carpsucker boasted a high condition factor (based on one fish) in the second collection. The longear sunfish (invertebrate feeder) value fell within the listed range. Most condition factors for piscivorous species also were within their respective ranges. One of the four values for blue catfish, however, was low and flathead catfish had one low and one high value (each based on one fish) in addition to two values that fell within expectations.

Many condition factors were less than the expected values at Highway 21 (Table 39). Gizzard shad had low values during every collecting period but the second. The single channel catfish value was also low. Carp values were within the listed range. As at the upstream stations, condition factors for smallmouth buffalo exceeded the listed literature range. Bluegill fell slightly below expectation in its sole table value, whereas longear sunfish were twice within their expected range and once less than it. White crappie was the only piscivore species without a value less than its expected range.

Small sample sizes within most species precluded making many assumptions about condition factors in the Elm Fork (Table 40). Once again smallmouth buffalo exceeded the expected range. Gizzard shad yielded low values on three collection dates. Both channel catfish values were low (each based on one fish). Values for invertebrate feeders were sometimes below their respective ranges. Longear sunfish values were less than expected during the third, fourth, and fifth sampling periods, whereas a single redear sunfish had a low value in the April-May 1988 sample. Bluegill were always within their literature range. Piscivore values were variable, with green sunfish, largemouth bass, and warmouth sunfish falling below reported ranges on at least one occasion.

Several condition factors were below expectations in the East Fork (Table 41). Once again, however, smallmouth buffalo exceeded reference values in all sampling periods on which they were present. Carp values, on the other hand, were low (based on one fish) in two of three collections. Other omnivores were within their respective ranges or slightly above it. The single species of invertebrate feeder exhibited low condition factors in each collection, save the fifth when it met expectations. The three piscivore species for which reference values were available each had at least one value below the suggested range. Poor condition factors for both the piscivorous and invertebrate feeding communities, coupled with the overall high condition factors for the omnivore community, suggests a stressful environment. Poor condition factors for the former two groups may be due to water quality and a low abundance of suitable food (which in itself may reflect poor water quality). The opportunistic feeding behavior of omnivores would allow them to flourish in such situations.

WATER QUALITY EVALUATION

Dissolved Oxygen and Flow

Water quality data collected at the time of sampling are presented in Table 42. The lowest dissolved oxygen concentration during the study was 3.3 mg/L at U.S. 79, recorded at 9:45 a.m. Seventy-nine percent of the dissolved oxygen measurements were higher than the 6.0 mg/L, 24-hour mean criterion the TWC has established for exceptional quality aquatic habitat, whereas 16% fell between 5.0 and 6.0 mg/L, 2% between 4.0 and 5.0 mg/L, and 3% less than 4.0 mg/L. TWC has established a 5.0 mg/L, 24-hour mean criterion to define "high" use. No consistent relationship was observed between dissolved oxygen and site location or stream km.

Minimum and mean daily dissolved oxygen concentrations and flow data from USGS continuous automated monitoring system sites (CAMS) are presented in Figures 14-20. Only dissolved oxygen data were available from the East Fork site (Figure 21). River flow in 1987 was typical for the period from 1979 to 1988. However, 1988 had the lowest flow of any year in the past decade.

Except in the East Fork, the majority of daily dissolved oxygen means and minima exceeded 6 mg/L. Mean values were higher than 5.0 mg/L more than 97% of the time at Beach Street, Belt Line Road, and Sylvan Avenue. The percentage of observations higher than 6.0 mg/L at those three stations were 94.9%, 92.9%, and 86.4%, respectively. More than 90% of the daily minima at those stations exceeded 5 mg/L. Two values at Beach Street were less than 1.0 mg/L, whereas concentrations recorded at Belt Line Road and South Loop 12 were never less than 2.0 mg/L. South Loop 12 had a slightly lower frequency of values exceeding 5.0 mg/L (91.8%) and 6.0 mg/L (68.3%). More than 80% of the daily minima at South Loop 12 were higher than 5.0 mg/L, 59.8% were higher than 6.0 mg/L, and no minima were less than 3.0 mg/L.

Of the main stem stations, Highway 34 (Site 5a; Figure 2) had the lowest frequency of mean and minimum dissolved oxygen concentrations exceeding 5.0 mg/L (85.6% and 76.4%, respectively). Those conditions may relate to the influence of upstream wastewater discharges into the main stem and the East Fork. Two observations at Highway 34 were at or less than 1.0 mg/L. Conditions improved at Highway 31, with mean and minimum concentrations exceeding 5.0 mg/L 93.3% and 89.5% of the time, respectively. However, two minimum values dipped to 0.0 mg/L or near 0.0 mg/L. Concentrations at Highway 7 were similar, although no means or minima dropped to less than 3.0 mg/L.

The East Fork presented a much different picture than the main stem stations. Mean concentrations less than or equal to 5.0 mg/L occurred about as frequently as those above it. On two occasions, daily minima were less than 2.0 mg/L.

Studies by Davis (1983; 1984) documented a longitudinal pattern of dissolved oxygen depression downstream of Beach Street. Recovery was incomplete at Highway 31, though considerable improvement over values from a 1974 study was noted and attributed primarily to a five-fold decrease in BOD loading from the major point source dischargers (Davis 1984). Subsequent plant renovations have continued that trend, with total BOD loading decreasing substantially even while flows have continued to rise (Figure 22). Loadings peaked in 1976-1977 and have generally declined since (North Central Texas Council of Governments 1988).

Some evidence of lowered species richness and diversity was observed in the East Fork and that could be at least partially attributable to chronically low dissolved oxygen values. However, at main stem sites, dissolved oxygen concentrations did not appear to limit fish populations. Impacts at the most disturbed site, South Loop 12, could not be explained by dissolved oxygen data. Oxygen depressions tied to rise events were observed at a few sites and could have stressed fishes even though they did not prove lethal. However, in most instances when sharp dissolved oxygen depressions occurred during the study, the duration was relatively short. Swingle (1969) indicated that values greater than 5.0 mg/L were desirable in pond situations, whereas concentrations less than 1.0 mg/L could be lethal if exposure was prolonged. Davis (1987) also suggested that the duration of exposure may be as important as the minimum concentration in causing in-stream impacts, an observation at least partially corroborated by the absence of reported or massive fish kills during rise events in 1987 and 1988.

Ammonia

A 0.7 mg/L NH_3-N concentration from the East Fork on August 11, 1988, was the only in situ measurement that exceeded 4-day chronic guidelines for ammonia (EPA 1984) in this study. Acute and chronic ammonia toxicity depends on temperature and pH, so absolute values cannot be compared without considering those factors. Data from the TWC stream monitoring network is presented in Table 43 and presents a different picture than values measured in the field. Stream monitoring network samples consist of single grabs collected at varying intervals depending on the site. Mean ammonia nitrogen for the two-year study period was highest in the East Fork. South Loop 12 had the next highest values, followed by South Belt Line Road (Site 4a; Figure 2), 21 km (13 miles) downstream. Ammonia maxima for the period were highest at South Belt Line Road with 5.35 mg/L, followed by South Loop 12 with 3.49 mg/L. The East Fork had the highest percentage of ammonia values exceeding the 4-day chronic guidelines (EPA 1984), followed by South Loop 12 (Figure 23). The relationship between species richness was variable, though mean species richness was lowest at South Loop 12 and the East Fork. Only one exceedance was tied to a rise event (and theoretically, the influence of stormwater runoff) and that was in February 1987 at South Loop 12. When that value was deleted from calculations, the percentage of values exceeding the chronic guidelines at South Loop 12 dropped from 27.2 to 22.7% and was still the second highest in the study.

Effluent ammonia concentrations for the four major plants are presented in Figures 24-27. Temporal decreases in ammonia concentrations were observed at most plants. Yearly maximum values were highest at Dallas Southside in both 1987 and 1988. Yearly mean values were highest at the Trinity River Authority Central Plant in 1987 and Dallas Central and Southside in 1988. The Sylvan Avenue-Commerce Street area, though downstream of TRA Central, had only one grab sample from the TWC stream monitoring network exceed the chronic guidelines despite some elevated values in the plant effluent. That may have resulted from the hit or miss nature of grab sampling or may be attributable to the 13.1 km (8.2 miles) gap between the outfall and the sampling site at Commerce Street. The Elm Fork, 8.1 km (5.1 miles) upstream, provides considerable dilution. Those factors could also explain the fact that fish collections at Sylvan Avenue demonstrated little or no impact.

Chlorine

Total chlorine residual concentrations in effluents discharged from the four major treatment plants on the Trinity River main stem are presented in Figures 28-31. Mean values in 1987 and 1988 were highest for Dallas Central. The maximum value for the period was observed at Dallas Central. Total residual chlorine values calculated for the receiving water downstream of the four major wastewater outfalls in the Trinity River are presented in Table 44. Values decrease in a downstream direction, primarily because of higher dilution rates. With few exceptions--mainly at Dallas Southside--the calculated concentrations exceed the chronic and acute criteria recommended by EPA (1986). According to the 1986 Quality Criteria for Water (EPA 1986), "freshwater aquatic organisms and their uses should not be affected unacceptably" if the 4-day average concentration of total residual chlorine does not exceed 0.011 mg/L and the 1-hour average concentration does not exceed 0.019 mg/L more than once every 3 years on the average.

Although the study values are based on dilution calculations, the few in-stream measurements available corroborate the presence of toxic levels downstream of the major plant outfalls. While conducting acute toxicity tests in April 1987, Dean (1988) measured mean in-stream chlorine concentrations as high as 1.3 mg/L at a site 1.3 km (0.8 mile) downstream of the Village Creek plant. A mean concentration of 0.6 mg/L was measured 8.2 km (5.1 miles) downstream (Dean 1988). At sites approximately 30 m downstream of the TRA Central and Dallas Central plants, concentrations were measured at 0.4 mg/L and 1.0 mg/L, respectively.

RELATIONSHIP OF FISH ASSEMBLAGES TO WATER QUALITY

A TPWD report from 1957 cited pollution problems from Fort Worth to below Trinidad (Highway 31) as limiting fish production in the Trinity River (TPWD 1957). Those problems included heavy population concentrations in Dallas-Fort Worth and a resulting overload of municipal sewage disposal systems, inadequately treated industrial wastes, and salt water from oil production (TPWD 1957).

A 1972-1974 study found a positive correlation between fish community condition and increasing distance from the metropolitan area (TPWD 1974). Strong positive correlation was also found between dissolved oxygen levels and species richness, the number of individuals, and catch per unit effort. Organic loads from municipal wastewater treatment plants and the resulting low dissolved oxygen levels were isolated as limiting factors to the fish community, along with high ammonia and phosphorous concentrations (TPWD 1974).

Considerable improvement in the fish community was observed in this study when compared to past surveys. Declines in species richness, in some cases abundance, and IBI ratings were a problem in the South Loop 12 area, just as in 1972-1974 (TPWD

1974). However, fish community indices demonstrated greater biological integrity at other sites. In addition, chronically depressed dissolved oxygen levels no longer appear to be a major limitation to Trinity River fishes, at least in the main river. Relationships between ambient dissolved oxygen levels and fish distribution were not observed in the Dallas area as in the 1972-1974 study. The East Fork, which was not studied in 1972-1974, may be an exception. Generally, improvement in ambient water quality conditions has allowed a fishery to develop in the reaches downstream of Dallas.

Despite improvements, a zone with few or no fishes still exists at times in the South Loop 12 reach. Long-term depletion of fishes in that area by large, episodic fish kills resulting from rise events (Davis 1987) is unlikely. No such major kills have been reported since 1985, though minor kills could periodically reduce fish populations and go unnoticed given the isolated nature of the reach near South Loop 12. Even if the area was plagued by such events, fishes should have been collected during all sampling periods unless chronic water quality problems have prevented them from repopulating the area. From the abundance of fishes downstream and at times in the South Loop 12 area, it is apparent that at least some fishes are available to repopulate the area within a relatively short period of time. A likely scenario is that chronic water quality problems unrelated to low dissolved oxygen are causing fish to avoid the area.

Two potentially toxic constituents of secondary effluent that have received regulatory attention and show signs of limiting fish populations in the Trinity River are chlorine and ammonia. In a study of 12 Illinois streams, Lewis et al. (1981) observed that total residual chlorine was the most overriding toxicant in secondary sewage. Paller et al. (1988) concluded that strong improvements occurred in the fish communities of three Illinois streams following cessation of effluent chlorination. Dean (1988) ran in situ acute toxicity tests downstream of the Village Creek, TRA Central, and Dallas Central plants with golden shiners and concluded that chlorination caused significant toxicity to Trinity River fishes, sometimes five miles downstream. Without frequent in-stream measurements, it is impossible to know with certainty the long-term impact chlorine has on Trinity River fish communities downstream from major wastewater treatment plant outfalls. However, given that parts per billion concentrations of chlorine are toxic to fishes (Brungs 1973), it is probable that chlorine exerts an impact and creates an avoidance area for fishes. The depauperate fish community observed at South Loop 12 probably results at least partially from chlorine, based on work by Dean (1988) and on concentrations estimated downstream of the discharge.

This study found no major toxic effects at sites downstream from two other treatment plants--Village Creek and TRA Central--

despite an indication of potentially toxic levels. Lewis et al. (1981) observed that in 10 of the streams they studied, chlorine dissipated rapidly downstream of an outfall (maximum distance = 8.8 km). Dallas Central is 6.9 km (4.3 miles) upstream of South Loop 12. By contrast, Village Creek is 27.4 km (17 miles) upstream of W. Belt Line Road and TRA Central is 10.9 km (6.8 miles) upstream of Sylvan Avenue. Dilution from the Elm Fork probably influenced the water quality at Sylvan Avenue as well. Consequently, if a depauperate zone existed downstream of those two plants, it would not have been detected in this study. As noted before, Dean (1988) did find significant toxicity downstream of both plants. Problems with chlorine toxicity should be eliminated within the next two to three years as the major plants discharging into the Trinity River are required to dechlorinate their effluents (Jack Davis TWC personal communication).

Although not as toxic as chlorine, ammonia has been shown to exert an impact on stream fish communities (Lewis et al. 1981). However, researchers have disagreed as to the magnitude. Ellis (1937) reported that "good fish fauna" showed a preference to waters containing less than 2 ppm total ammonia nitrogen, whereas Tsai (1973) observed that fish communities were largely unaffected by total ammonia levels as high as 10 ppm. Some agreement between potentially harmful ammonia concentrations and fish communities with low species richness were observed during this study. Ammonia values exceeding the chronic criteria (EPA 1984) were apparent at South Loop 12 and the East Fork, both of which had low mean species richness. Another indication of ammonia toxicity as a problem comes from comparing fish community data from this study with simultaneous invertebrate sampling. Macroinvertebrates were found in adequate numbers at South Loop 12 during periods when fish collections were depauperate (Davis personal communication). Investigators have noted a higher tolerance for ammonia among invertebrates than fishes (EPA 1984), but have observed that the two groups respond similarly to elevated chlorine concentrations (EPA 1986).

As with chlorine, changes in wastewater permits should mitigate potential ammonia toxicity problems. By July 1990, the four major treatment plants on the Trinity main stem and Garland Duck Creek are scheduled to have ammonia limitations in place (Davis personal communication).

FISHERIES USE ATTAINABILITY CONSIDERATIONS

The concept of use attainability was developed by the U.S. Environmental Protection Agency to determine attainment of Clean Water Act mandated uses. Toward that end, this analysis will focus on what aquatic life uses are being achieved in TWC Segment 0805 based on an evaluation of the fish community. Also discussed will be causes of any use impairment and the potential aquatic life uses that can be supported with reasonable treatment technology. Evaluations were based on physical, chemical, and fish community data. The TWC use attainability analysis in which this report will be utilized will evaluate benthic invertebrate data as well as other use attainability considerations.

In the 1988 Texas Surface Water Quality Standards, TWC Segment 0805 was assigned an aquatic life use of limited and dissolved oxygen criteria of 3.0 mg/L (24-hour mean). However, when flow at USGS gage 08048000 in Fort Worth is less than 80 cfs the criterion drops to 1.0 mg/L (TWC 1988c). The 1.0 mg/L concentration is an absolute minimum. A limited aquatic life use implies that the segment has uniform habitat characteristics, few expected species, low diversity, low species richness, a severely imbalanced trophic structure, and few if any sensitive species (TWC 1988c).

Mean IBI scores for the two-year period were largely divided between intermediate and high use (Table 45). Beach Street and FM 85 rated a high use, Highway 31 ranked intermediate, and Sylvan Avenue ranked between intermediate and high. Belt Line Road, which showed some evidence of impact, ranked intermediate. South Loop 12 was obviously impacted and rated limited.

As previously noted in this report, some temporal improvement was observed. Mean IBI scores increased from 1987 to 1988 at four of the six sites sampled in TWC Segment 0805, despite the fact that 1988 was a low flow year and ambient conditions should have approached their harshest levels. FM 85 evidenced a minor decrease in 1988, the degree of which was small enough to be meaningless, since in both years it achieved a high rating. Highway 31 demonstrated no change between 1987 and 1988. During the final two sampling periods, four of the six sites received a high rating. The exceptions were Belt Line Road and South Loop 12.

The increase in IBI scores may be tied to the continuing improvement of wastewater facilities. If upgrades at the wastewater plants were responsible, then it is likely that continued improvement in the fish community will be observed as ammonia and chlorine limitations are implemented. Another possible explanation for the increase in IBI scores is that the river was still recovering from the major fish kills of 1985 when this study began.

When a large area of a watershed is affected, recolonization must be done by surviving organisms (Larimore et al. 1959) or by organisms that move from upstream, downstream, or out of tributaries. Fish are highly mobile and can rapidly repopulate an area following catastrophic events as long as lingering toxicity is not a problem. However, physical or chemical barriers may inhibit their movements (Larimore et al. 1959).

Chlorinated effluent could provide such a barrier, particularly at sites bracketed by wastewater discharges, such as Belt Line Road. The home range for some species may be relatively small and their movement into an area may take place at a slower rate, especially if chronic water quality problems still persist. Consequently, the major fish kills of 1985 may have decimated certain species that have returned slowly or were present in low densities at the beginning of the study and were not likely to be captured.

The continued species additions and shift in catfish populations observed in this study suggest the river may still have been recovering from the 1985 fish kills. Other evidence supporting the notion of a gradual recovery comes from an analysis of the temporal pattern of fish kills in the Trinity River. Davis (1987) noted a hiatus of several years between major fish kills in the Trinity River and postulated that further kills were precluded by the depauperate condition of the fishery. That pattern suggested that several years might be required for recovery once the population had been decimated by a step-wise series of major kills (Davis 1987). When recovery reached a certain level, the river was again susceptible to another major kill (Davis 1987). In one Illinois stream that was decimated by drought, fishes began to repopulate the area as soon as flow resumed, but certain species had not repopulated the stream three years later (Larimore et al. 1959). Gunning and Berra (1969) experimentally decimated two streams of sharpfin chubsuckers (Erimyzon tenuis) and found that one of the streams had still not attained its former level 13 months later.

Even if the temporal improvement resulted from gradual recovery following the fish kills, improving effluent quality probably helped facilitate that recovery. TWC Segment 0805 is currently attaining an intermediate to high use. It is likely that the fish community will continue to improve as scheduled ammonia and chlorine limitations are placed on the major dischargers. In addition, the potential for major fish kills appears to have diminished with recent improvements in effluent quality and a decrease in bypasses of raw sewage (Davis personal communication). Consequently, this report recommends a high use designation for TWC Segment 0805.

An additional factor arguing for a high use designation is the planned re-establishment of a state listed endangered species, the paddlefish (Polyodon spathula), in the Trinity River (Veronica Pitman TPWD personal communication). Historically, paddlefish were found in the Trinity River as far upstream as Trinidad. TPWD has developed a recovery plan to stock fingerling paddlefish in Lake Livingston with the goal of re-establishing a self-sustaining population in the middle and lower Trinity River system (Pitman personal communication). For this recovery plan to be successful, water quality must be maintained to allow this species to survive and reproduce.

CONTAMINANT RESIDUE IN FISH TISSUE

Fillets from 36 individual fish and five composite samples of three fish each were analyzed for selected organic constituents and metals (Table 46). Contaminant concentrations were compared to FDA action levels, where applicable. However, FDA lists action levels for only a few of the contaminants detected.

Chlordane concentrations exceeded the FDA action level of 0.300 mg/kg in nine samples. No other contaminants exceeded FDA action levels. All of the samples with elevated chlordane levels were collected within or adjacent to the urban centers of Fort Worth and Dallas. In addition, two other fishes approached the action level for chlordane: one white bass from Highway 21 with a concentration of 0.290 mg/kg and one smallmouth buffalo from FM 85 with a concentration of 0.250 mg/kg. Chlordane was less than the detectable limit in six of eight samples from sites free of major urban runoff: Bear Creek at FM 1187 and the Clear Fork of the Trinity immediately downstream of Benbrook Dam. Samples from the Trinity Park area on the Clear Fork also showed no signs of elevated chlordane levels. Two samples from the Purcy Street storm drain, adjacent to downtown Fort Worth and the next downstream site sampled, were submitted for analysis and both had elevated levels of chlordane.

Results suggest that elevated chlordane levels in the Trinity River were related to urban or suburban runoff. Irwin (1988) concluded in a study of toxic chemicals in the Trinity River that elevated concentrations of chlordane were strongly associated with residential runoff. In a study on the Kansas River, fish tissue from more than 80% of locations sampled had detectable levels of chlordane (Arruda et al. 1987). Mean chlordane concentrations in that study increased at or downstream of major urban areas.

Elevated levels have been found in several fish tissue studies, which is not surprising given that chlordane is highly persistent, bioaccumulates in aquatic organisms, and has been used extensively for pest control. In an EPA fish monitoring program comprising Iowa, Kansas, Missouri, and Nebraska, chlordane was detected in 71% of the samples (Tompkins et al. 1988). Concentrations exceeded the FDA action level in 32%, causing the authors to conclude that chlordane was the most "important" organic pollutant in fish tissue today. Tissues sampled in 10 of 50 reservoirs monitored in Oklahoma had chlordane concentrations that during at least one sampling period exceeded the FDA action level (McElvany and Janacek 1988).

A more extensive and systematic sampling approach would need to be employed to fully evaluate the extent of the contaminants problem in Trinity River fishes and the associated health risks for persons consuming those fishes. A study by Irwin (1988) provides useful information, but is not comparable given the fact that it evaluated contaminant levels in whole fish rather than fillets.

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APPENDIX A - TABLES

TABLE 1. List of fish sampling gear used in the Trinity River by site and trip (s = seine, g = gill net, bp = backpack electrofisher, be = boat electrofisher; NS = no sample.)

Site	Sampling dates					
	April-May 87	August 87	January 88	April-May 88	August 88	Nov-De 88
1. Beach Street	s,g	s,g,bp	s,g,bp	s,bp	s,bp	s,bp
2. Belt Line Road	s,g	s,g,be	s,g,be	s,be	s,be	s,be
3. Sylvan Avenue	s,g	s,g,be	s,g,be	s,be	s,be	s,be
4. S. Loop 12	s,g	s,g,be	s,g,be	s,be	s,be	s,be
5. Red Oak Creek	NS	NS	NS	NS	NS	s,be
6. FM 85	s,g	s,g,be	s,g,be	s,be	s,be	s,be
7. Highway 31	s,g	s,g,be	s,g,be	s,be	s,be	s,be
8. U.S. 287	s,g	s,g,be	NS	s,be	s,be	s,be
9. U.S. 79	s,g	s,g,be	s,g,be	s,be	s,be	s,be
10. Highway 7	s,g	s,g,be	s,g,be	s,be	s,be	s,be
11. Highway 21	s,g	s,g,be	s,g,be	s,be	s,be	s,be
T1. Elm Fork	s,g	s,g,be	s,g,be	s,be	s,be	s,be
T2. East Fork	s,g	s,g,bp	s,g,bp	s,bp	s,be	s,bp

TABLE 2. Index of Biotic Integrity scoring criteria used to rate the Trinity River fish community.

Metric	Scoring criteria 5	3	1
1. Total number of fish species	>13	7-13	<7
2. Number of cyprinid species excluding common carp	> 3	2-3	0-1
3. Number of catfish species	> 1	1	0
4. Number of *Lepomis* species	> 3	2-3	0-1
5. Number of intolerant species	2	1	0
6. Proportion of individuals as tolerants	<20%	20-50%	>50%
7. Proportion of individuals as omnivores	<20%	20-45%	>45%
8. Proportion of individuals as invertebrate feeders	>80%	>40-80%	≤40%
9. Proportion of individuals as piscivores	> 5%	5-1%	< 1%
10. Number of individuals*			
a. electrofishing	> 50	>20-50	≤20
b. seining	>200	>50-200	≤50
11. Proportion of individuals as hybrids	0	>0-1%	>1%
12. Proportion of individuals with disease or other anomalies	0-2%	>2-5%	>5%

*A mean of the metric scores for both sampling methods is used to obtain the ranking for number of individuals.

TABLE 3. Proposed Index of Biotic Integrity scores used by Twidwell and Davis (1988) for rating aquatic life use in unclassified streams.

Aquatic life use subcategory	IBI score
Exceptional	58-60
High	48-52
Intermediate	40-44
Limited	< 34

TABLE 4. Index of Biotic Integrity Scores for rating aquatic life use subcategories in the Trinity River basin.

Aquatic life use subcategory	IBI score
Exceptional	$\geq$ 49
High	41-48
Intermediate	36-40
Limited	$\leq$ 35

TABLE 5. Checklist of fishes collected from 13 sites on the Trinity River and two of its tributaries using all methods in 1987 and 1988. The numbers 1-6 refer to sampling dates outlined in the text.

SPECIES	Beach Street						Belt Line						Sylvan Avenue						South Loop 12					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Lepisosteus oculatus	X									X				X			X						X	
Lepisosteus osseus	X										X		X	X	X									
Lepisosteus spatula																							X	
Dorosoma cepedianum								X		X	X	X		X	X		X	X						
Dorosoma petenense			X											X			X			X				
Cyprinus carpio	X	X						X	X	X	X	X		X	X	X		X				X	X	X
Notemigonus crysoleucas								X							X									
Notropis buchanani																	X							
Notropis emiliae																	X							
Notropis lutrensis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	
Notropis shumardi																								
Notropis texanus																								
Notropis umbratilis																								
Notropis venustus		X	X	X	X	X											X	X						
Notropis volucellus																								
Pimephales promelas				X																				
Pimephales vigilax	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			X	
Campostoma anomalum				X																				
Ictiobus bubalus	X							X		X	X	X	X	X	X	X	X	X	X	X		X	X	X
Ictiobus niger																								
Carpiodes carpio	X																		X				X	
Ictalurus furcatus																X	X	X						
Ictalurus natalis																								
Ictalurus punctatus				X			X					X						X					X	X
Pylodictis olivaris		X		X				X			X													
Noturus nocturnus																		X						
Fundulus notatus	X													X			X	X						
Gambusia affinis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	
Menidia beryllina	X	X	X		X	X					X	X	X	X		X	X			X				
Morone chrysops															X									
Morone mississippiensis																								

SPECIES	Red Oak						FM 85						HWY 31						US 287					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	*	*	*	*	*																*			
Lepisosteus oculatus										X		X			X			X				X	X	X
Lepisosteus osseus						X	X		X	X	X	X	X	X	X		X	X	X	X		X	X	X
Lepisosteus spatula								X					X					X		X				
Dorosoma cepedianum						X		X	X		X	X		X	X		X	X	X	X			X	
Dorosoma petenense								X				X		X						X				
Cyprinus carpio							X		X	X					X	X			X			X		
Notemigonus crysoleucas																								
Notropis buchanani							X	X	X		X	X			X			X		X		X	X	X
Notropis emiliae																								
Notropis lutrensis						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Notropis shumardi																								
Notropis texanus																								
Notropis umbratilis																								
Notropis venustus								X						X						X			X	
Notropis volucellus								X						X										
Pimephales promelas																								
Pimephales vigilax						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Campostoma anomalum																								
Ictiobus bubalus						X	X	X		X	X	X	X		X	X	X	X	X	X		X	X	X
Ictiobus niger						X																		
Carpiodes carpio																								
Ictalurus furcatus						X	X	X	X	X	X		X			X	X		X	X			X	X
Ictalurus natalis																	X							
Ictalurus punctatus						X					X	X						X					X	X
Pylodictis olivaris								X	X		X	X		X				X		X		X	X	X
Noturus nocturnus																								X
Fundulus notatus								X											X					
Gambusia affinis							X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X
Menidia beryllina								X							X		X							
Morone chrysops																								
Morone mississippiensis																								

SPECIES	HWY 79						HWY 7						HWY 21						Elm Fork						East Fork					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Lepisosteus oculatus	X		X	X	X	X		X					X		X	X	X	X				X				X			X	
Lepisosteus osseus	X	X		X	X	X	X	X	X	X	X	X	X	X	X										X				X	
Lepisosteus spatula	X												X			X									X					
Dorosoma cepedianum		X						X	X	X	X		X	X	X	X	X	X		X	X	X	X	X					X	
Dorosoma petenense		X						X		X			X	X	X	X	X				X			X						
Cyprinus carpio	X			X					X			X				X		X						X	X	X	X			
Notemigonus crysoleucas																			X			X								
Notropis buchanani	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X												
Notropis emiliae														X						X			X	X						
Notropis lutrensis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Notropis shumardi								X			X			X		X	X													
Notropis texanus		X	X	X																										
Notropis umbratilis																	X			X			X	X						
Notropis venustus		X		X	X	X	X	X	X		X			X	X		X		X		X			X						
Notropis volucellus														X											X					
Pimephales promelas																										X				
Pimephales vigilax	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X
Campostoma anomalum																														
Ictiobus bubalus	X	X	X	X	X	X	X		X	X	X	X			X				X	X					X	X	X		X	
Ictiobus niger																														
Carpiodes carpio								X			X			X				X			X		X							
Ictalurus furcatus	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X											X	
Ictalurus natalis																														
Ictalurus punctatus	X			X		X		X				X		X				X				X		X	X	X			X	
Pylodictis olivaris		X		X	X	X	X	X		X	X			X			X	X				X								
Noturus nocturnus						X						X												X						
Fundulus notatus																				X				X						X
Gambusia affinis	X	X	X	X	X	X	X	X			X	X	X	X	X		X	X	X	X	X	X		X		X	X		X	X
Menidia beryllina		X						X			X	X		X			X	X	X		X		X	X		X			X	
Morone chrysops				X					X	X		X			X	X														
Morone mississippiensis															X															

Table 5. continued.

SPECIES	Beach Street						Belt Line						Sylvan Avenue						South Loop 12					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Morone saxatilis													X											
Micropterus punctulatus																		X						
Micropterus salmoides	X				X						X	X					X							
Lepomis auritus	X				X																			
Lepomis cyanellus				X	X	X		X	X	X	X	X		X		X	X	X					X	
Lepomis gulosus				X	X	X						X		X				X						
Lepomis humilis	X					X									X	X	X	X	X					
Lepomis macrochirus	X		X		X	X	X	X					X		X		X	X	X					
Lepomis megalotis	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X			X	
Lepomis microlophus																								
Lepomis punctatus																								
Pomoxis annularis																	X	X						
Pomoxis nigromaculatus																								
Percina sciera																								
Percina caprodes																								
Etheostoma chlorosomum																								
Etheostoma gracile																								
Etheostoma proeliare																								
Aplodinotus grunniens																								

SPECIES	Red Oak						FM 85						HWY 31						US 287					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Morone saxatilis							X																	
Micropterus punctulatus																								
Micropterus salmoides																								
Lepomis auritus													X											
Lepomis cyanellus									X		X	X		X						X				
Lepomis gulosus											X	X		X			X	X						
Lepomis humilis							X	X				X	X	X				X						
Lepomis macrochirus							X		X		X	X	X						X	X				
Lepomis megalotis						X		X				X		X			X	X	X	X		X	X	X
Lepomis microlophus																								
Lepomis punctatus																								
Pomoxis annularis								X	X		X	X	X	X						X				
Pomoxis nigromaculatus																								
Percina sciera																								
Percina caprodes																								
Etheostoma chlorosomum																				X				
Etheostoma gracile									X											X				
Etheostoma proeliare																				X				
Aplodinotus grunniens									X													X		X

SPECIES	HWY 70						HWY 7						HWY 21						Elm Fork						East Fork					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Morone saxatilis									X						X										X					
Micropterus punctulatus																							X							
Micropterus salmoides																					X		X	X						
Lepomis auritus																														
Lepomis cyanellus		X																	X	X	X			X			X	X		X
Lepomis gulosus		X										X			X									X			X			
Lepomis humilis		X				X						X							X		X	X		X						X
Lepomis macrochirus	X	X												X	X				X	X	X	X	X	X			X			X
Lepomis megalotis		X				X		X			X	X		X	X			X		X	X	X	X	X	X	X	X	X	X	X
Lepomis microlophus																						X								
Lepomis punctatus												X																		
Pomoxis annularis		X	X		X										X			X	X	X		X		X						
Pomoxis nigromaculatus																													X	
Percina sciera								X				X				X								X						
Percina caprodes																								X						
Etheostoma chlorosomum																														
Etheostoma gracile																				X										
Etheostoma proeliare																														
Aplodinotus grunniens				X		X	X	X			X	X	X					X		X									X	

TABLE 6. Checklist of fishes collected from the Trinity River, 1972-1974, by TPWD (1974). The letters A-F refer to sampling sites.

Species	July 1972						September 1972						December 1972					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
Amia calva																		
Aplodinotus grunniens																		
Carpiodes carpio									X		X	X						
Chaenobryttus (Lepomis) cyanellus																		
Chaenobryttus (Lepomis) gulosus						X					X						X	X
Cyprinus carpio			X		X	X			X	X	X	X			X	X	X	X
Dorosoma cepedianum					X	X					X	X					X	X
Dorosoma petenense						X						X						X
Gambusia affinis											X							
Ictalurus melas												X						X
Ictalurus natalis					X													
Ictalurus punctatus			X									X				X		X
Ictiobus bubalus									X						X			
Labidesthes sicculus											X						X	X
Lepisosteus oculatus			X	X					X	X				X		X		
Lepisosteus osseus		X	X	X	X			X	X	X				X	X	X		
Lepisosteus platostomus			X															
Lepisosteus spatula														X				
Lepomis humilis																		
Lepomis machrochirus					X	X					X	X					X	X
Lepomis megalotis					X	X					X	X			X		X	X
Lepomis microlophus					X												X	X
Menidia beryllina												X						
Micropterus punctulatus																		
Micropterus salmoides					X	X					X	X					X	X
Minytrema melanops																	X	
Morone chrysops					X	X					X						X	
Notemigonus crysoleucas						X												X
Notropis lutrensis					X						X						X	
Opsopoeodus (Notropis) emiliae																		
Pimephales vigilax																		X
Pomoxis annularis					X						X						X	X
Pomoxis nigromaculatus					X						X						X	
Pylodictis olivaris											X	X						
Roccus (Morone) mississippiensis																	X	X
Zygonectes (Fundulus) notatus																X		

A = South Loop 12 to East Fork confluence
B = FM 85 to Highway 31
C = Reach near U.S. 287
D = Reach near U.S. 79
E = Highway 7 to Highway 21
F = Reach near Highway 19

TABLE 6. continued.

Species	December 1973						February 1974						April 1974					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
				*							*	*						
Amia calva																	X	
Aplodinotus grunniens		X	X		X				X	X							X	X
Carpiodes carpio			X		X	X			X							X		
Chaenobryttus cyanellus																	X	X
Chaenobryttus gulosus			X			X				X								X
Cyprinus carpio	X	X	X			X		X	X	X					X	X	X	X
Dorosoma cepedianum	X	X	X		X	X				X						X	X	X
Dorosoma petenense					X	X											X	X
Gambusia affinis																		
Ictalurus melas																		
Ictalurus natalis						X												X
Ictalurus punctatus			X		X	X				X					X			
Ictiobus bubalus	X	X	X				X	X	X	X					X			
Labidesthes sicculus																		
Lepisosteus oculatus			X		X			X		X				X	X	X		
Lepisosteus osseus		X	X		X			X	X	X				X		X		
Lepisosteus platostomus																		
Lepisosteus spatula																		
Lepomis humilis		X																
Lepomis machrochirus						X				X								X
Lepomis megalotis		X	X		X	X				X						X	X	X
Lepomis microlophus						X											X	X
Menidia beryllina																		X
Micropterus punctulatus						X												
Micropterus salmoides						X											X	X
Minytrema melanops																		
Morone chrysops			X		X	X			X	X					X	X	X	
Notemigonus crysoleucas																		
Notropis lutrensis			X														X	
Opsopeodus emiliae																		X
Pimephales vigilax																		X
Pomoxis annularis			X		X				X									
Pomoxis nigromaculatus																	X	X
Pylodictis olivaris																		
Roccus mississippiensis	X																X	X
Zygonectes notatus																		X

*No collection data for this segment.

TABLE 7. List of species observed during July 5 and July 26, 1985, Trinity River fish kills (Palma 1986a; 1986b).

Species	Common name
Lepisosteus oculatus	Spotted gar
Cyprinus carpio	Common carp
Ictalurus furcatus	Blue catfish
Ictiobus bubalus	Smallmouth buffalo
Ictalurus punctatus	Channel catfish
Pylodictis olivaris	Flathead catfish
Morone chrysops	White bass
Lepomis macrochirus	Bluegill
Aplodinotus grunniens	Freshwater drum

TABLE 8. Fishes collected by seine in April 1987 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
<u>Dorosoma</u> <u>cepedianum</u>	Gizzard shad							3			1		
<u>Notemigonus</u> <u>crysoleucas</u>	Golden shiner											3	
<u>Notropis</u> <u>buchanani</u>	Ghost shiner					1			62	190			
<u>Notropis</u> <u>lutrensis</u>	Red shiner	305	922	273	1	168	261	517	575	3431	99	599	46
<u>Notropis</u> <u>venustus</u>	Blacktail shiner									7		3	
<u>Notropis</u> <u>volucellus</u>	Mimic shiner											1	
<u>Pimephales</u> <u>vigilax</u>	Bullhead minnow	74	101	62		9	10	5	25	113	24	42	
<u>Fundulus</u> <u>notatus</u>	Blackstripe topminnow	2						1					
<u>Gambusia</u> <u>affinis</u>	Mosquitofish	10	3	33	10	9	3	11	9	2	15	3	
<u>Menidia</u> <u>beryllina</u>	Inland silverside	1		5								15	
<u>Lepomis</u> <u>auritus</u>	Redbreast sunfish	1					1						
<u>Lepomis</u> <u>cyanellus</u>	Green sunfish											1	
<u>Lepomis</u> <u>humilis</u>	Orangespotted sunfish	1			1	1	5					1	
<u>Lepomis</u> <u>macrochirus</u>	Bluegill	4	11	3	1	1	1	1	1			2	
<u>Lepomis</u> <u>megalotis</u>	Longear sunfish	15	2					3					1
<u>Pomoxis</u> <u>annularis</u>	White crappie						1					1	
<u>Aplodinotus</u> <u>grunniens</u>	Freshwater drum									8			
Total # of individuals		413	1039	376	13	189	282	541	672	3751	139	671	47
Total # of species		9	5	5	4	6	7	7	5	6	4	11	2

TABLE 9. Fishes collected by gill net in April and May 1987 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Lepisosteus oculatus	Spotted gar	2							1		1		
Lepisosteus osseus	Longnose gar	2		3		2	9	4	1	6	15		2
Lepisosteus spatula	Alligator gar						1		1		2		1
Dorosoma cepedianum	Gizzard shad										8		
Dorosoma petenense	Threadfin shad										111		
Cyprinus carpio	Common carp	9				2		1	1				2
Ictiobus bubalus	Smallmouth buffalo	4		2	3	1	8	9	2	2		11	1
Carpiodes carpio	River carpsucker	2			1								
Ictalurus furcatus	Blue catfish					4	2	8	2		1		
Ictalurus punctatus	Channel catfish		1						2				1
Pylodictis olivaris	Flathead catfish									1			
Morone saxatilis	Striped bass			1		1							1
Micropterus salmoides	Largemouth bass	1											
Aplodinotus grunniens	Freshwater drum									2	1		
Total # of individuals		20	1	6	4	10	20	22	10	11	139	11	8
Total # of species		6	1	3	2	5	4	4	7	4	7	1	6

TABLE 10. Summary table for calculating the Index of Biotic Integrity for 12 sites on the Trinity River and its tributaries sampled in April and May 1987. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited.)

Metric	Main river										Tributaries	
	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	15 (5)	6 (1)	8 (3)	6 (1)	11 (3)	11 (3)	11 (3)	12 (3)	9 (3)	10 (3)	12 (3)	8 (3)
2. Number of cyprinid species	2 (3)	2 (3)	2 (3)	1 (1)	3 (3)	2 (3)	2 (3)	3 (3)	4 (5)	2 (3)	5 (5)	1 (1)
3. Number of catfish species	0 (1)	1 (3)	0 (1)	0 (1)	1 (3)	1 (3)	1 (3)	2 (5)	1 (3)	1 (3)	0 (1)	1 (3)
4. Number of <u>Lepomis</u> species	4 (5)	2 (3)	1 (1)	2 (3)	2 (3)	3 (3)	2 (3)	1 (1)	0 (1)	0 (1)	3 (3)	1 (1)
5. Number of intolerent species	1 (3)	1 (3)	0 (1)	0 (1)	0 (1)	0 (1)	1 (3)	0 (1)	0 (1)	0 (1)	1 (3)	1 (3)
6. Percentage of individuals as tolerants	75.8 (1)	88.9 (1)	80.9 (1)	64.7 (1)	91.0 (1)	90.7 (1)	94.7 (1)	86.2 (1)	91.4 (1)	47.5 (3)	88.9 (1)	92.7 (1)
7. Percentage of individuals as omnivores	20.6 (3)	9.8 (5)	16.8 (5)	23.5 (3)	6.0 (5)	6.0 (5)	3.2 (5)	4.4 (5)	3.1 (5)	51.4 (1)	8.4 (5)	7.3 (5)
8. Percentage of individuals as invertebrate feeders	78.3 (3)	90.2 (5)	82.2 (5)	76.5 (3)	90.5 (5)	89.7 (5)	94.7 (5)	94.9 (5)	96.5 (5)	41.0 (3)	91.3 (5)	85.5 (5)
9. Percentage of individuals as piscivores	1.2 (3)	0.0 (1)	1.0 (3)	0.0 (1)	3.5 (3)	4.3 (3)	2.1 (3)	0.7 (1)	0.5 (1)	7.2 (5)	0.3 (3)	7.3 (5)
10. Number of individuals seining	413 (5)	1039 (5)	376 (5)	13 (1)	189 (3)	282 (5)	541 (5)	672 (5)	3751 (5)	139 (3)	671 (5)	47 (1)
11. Percentage of individuals as hybrids	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
12. Percentage of individuals with disease or other anomaly	5.3 (1)	5.1 (1)	2.6 (3)	6.3 (1)	2.4 (3)	6.1 (1)	2.0 (5)	1.2 (5)	0.0 (5)	0.8 (5)	0.0 (5)	5.9 (1)
Total score	38	36	36	22	38	38	44	40	40	36	44	34
Aquatic life use	I	I	I	L	I	I	H	I	I	I	H	L

TABLE 11. Fishes collected by seine in August 1987 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river: Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Tributaries: Elm Fork	East Fork
Dorosoma cepedianum	Gizzard shad			2		5			1	2			
Dorosoma petenense	Threadfin shad				5	1	1		2	27	1		
Notemigonus crysoleucas	Golden shiner		1										
Notropis buchanani	Ghost shiner					15		1	8	4			
Notropis emiliae	Pugnose minnow										1	1	
Notropis lutrensis	Red shiner	6316	256	103	27	1014	145	449	232	401	179	3	219
Notropis shumardi	Silverband shiner										7		
Notropis texanus	Weed shiner								15				
Notropis umbratilis	Redfin shiner											3	
Notropis venustus	Blacktail shiner	17				3	1	1	6	11	14		
Notropis volucellus	Mimic shiner					1	1				2		
Notropis sp.	Juvenile shiner		1622						22	289		1	
Pimephales promelas	Fathead minnow												1
Pimephales vigilax	Bullhead minnow	156	368	223	1	252	2	147	225	268	149	38	19
Ictiobus bubalus	Smallmouth buffalo								2				
Carpiodes carpio	River carpsucker										3		
Ictalurus furcatus	Blue catfish					1							
Ictalurus punctatus	Channel catfish									1	1		
Pylodictis olivaris	Flathead catfish								1				
Fundulus notatus	Blackstripe topminnow			3		1						5	
Gambusia affinis	Mosquitofish	1325	454	753	89	308	79	287	165	237	186	71	50
Menidia beryllina	Inland silverside	10		17	15	8			1	5	134		1
Lepomis cyanellus	Green sunfish			1			1	1	3			3	
Lepomis gulosus	Warmouth						1		2				
Lepomis humilis	Orangespotted sunfish					17	3		23				
Lepomis macrochirus	Bluegill							1	1			3	
Lepomis megalotis	Longear sunfish					1	7	8	4	3	3	12	1
Lepomis sp.	Juvenile sunfish	3		5	1					2		3	
Pomoxis annularis	White crappie					1	1		1				
Percina sciera	Dusky darter									2			
Etheostoma chlorosomum	Bluntnose darter							1					
Etheostoma gracile	Slough darter							2				1	
Etheostoma proeliare	Cypress darter							1					
Total individuals		7827	2701	1107	138	1628	242	899	714	1252	680	144	291
Total # of species		5	4	7	5	14	11	11	17	11	12	10	6

TABLE 12. Fishes collected by gill net in August 1987 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Lepisosteus oculatus	Spotted gar									1			2
Lepisosteus osseus	Longnose gar						1	6		2	1		
Lepisosteus spatula	Alligator gar					1		1					
Dorosoma cepedianum	Gizzard shad											2	
Cyprinus carpio	Common carp	4	1										1
Ictiobus bubalus	Smallmouth buffalo					2		1				2	1
Ictalurus furcatus	Blue catfish										1		
Ictalurus punctatus	Channel catfish												1
Pylodictis olivaris	Flathead catfish										1		
Lepomis megalotis	Longear sunfish										1	1	
Aplodinotus grunniens	Freshwater drum									1			
Total individuals		4	1	0	0	3	1	8	0	4	4	5	5
Total # of species		1	1	0	0	2	1	3	0	3	4	3	4

TABLE 13. Fishes collected by electrofishing in August 1987 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Lepisosteus oculatus	Spotted gar			1									
Lepisosteus osseus	Longnose gar			7				8	4	5			
Dorosoma cepedianum	Gizzard shad		3	25		7	1	6		13	7	6	
Dorosoma petenense	Threadfin shad			1	8			1		1	3		
Cyprinus carpio	Common carp		2	5									
Notropis lutrensis	Red shiner	52	8	11		6	5	6	1	11	11		1
Notropis shumardi	Silverband shiner									2			
Notropis venustus	Blacktail shiner									1			
Pimephales promelas	Fathead minnow												1
Pimephales vigilax	Bullhead minnow	1	9	10		7	1	4		4			1
Ictiobus bubalus	Smallmouth buffalo		3	7	1	6		6	2				
Carpiodes carpio	River carpsucker									1			
Ictalurus furcatus	Blue catfish					1		10	9	13	18		
Pylodictis olivaris	Flathead catfish	2	1			6	3	8	3	9	2		
Gambusia affinis	Mosquitofish												27
Menidia beryllina	Inland silverside			1									
Lepomis cyanellus	Green sunfish		4									7	
Lepomis gulosus	Warmouth			1									
Lepomis macrochirus	Bluegill		1								1	11	
Lepomis megalotis	Longear sunfish	12	7	5	5	6		1				21	6
Pomoxis annularis	White crappie							1				2	
Aplodinotus grunniens	Freshwater drum									3		1	
Total individuals		67	38	74	14	39	10	51	19	63	42	48	36
Total # of species		4	9	11	3	7	4	10	5	11	6	6	5

TABLE 14. Summary table for calculating the Index of Biotic Integrity for 12 sites on the Trinity River and its tributaries sampled in August 1987. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited.)

Metric	Main river										Tributaries	
	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	8 (3)	11 (3)	14 (5)	7 (3)	17 (5)	14 (5)	19 (5)	19 (5)	18 (5)	17 (5)	14 (5)	10 (3)
2. Number of cyprinid species	3 (3)	3 (3)	2 (3)	2 (3)	5 (5)	4 (5)	4 (5)	5 (5)	5 (5)	6 (5)	4 (5)	3 (3)
3. Number of catfish species	1 (3)	1 (3)	0 (1)	0 (1)	2 (5)	1 (3)	2 (5)	2 (5)	3 (5)	3 (5)	0 (1)	1 (3)
4. Number of <u>Lepomis</u> species	1 (1)	3 (3)	2 (3)	1 (1)	2 (3)	4 (5)	3 (3)	5 (5)	1 (1)	2 (3)	3 (3)	1 (1)
5. Number of intolerant species	1 (3)	1 (3)	1 (3)	1 (3)	2 (5)	2 (5)	2 (5)	1 (3)	2 (5)	2 (5)	1 (3)	1 (3)
6. Percentage of individuals tolerants	97.5 (1)	85.7 (1)	74.7 (1)	76.3 (1)	79.6 (1)	91.7 (1)	79.1 (1)	55.5 (1)	49.7 (3)	51.9 (1)	42.6 (3)	91.0 (1)
7. Percentage of individuals as omnivores	2.0 (5)	14.1 (5)	23.1 (3)	9.9 (5)	16.8 (5)	2.4 (5)	17.2 (5)	31.7 (3)	24.0 (3)	22.9 (3)	24.4 (3)	7.5 (5)
8. Percentage of individuals as invertebrate feeders	97.9 (5)	85.7 (5)	76.1 (3)	90.1 (5)	82.6 (5)	94.9 (5)	79.1 (3)	65.2 (3)	73.2 (3)	73.6 (3)	69.0 (3)	91.9 (5)
9. Percentage of individuals as piscivores	0.0 (1)	0.2 (1)	0.8 (1)	0.0 (1)	0.6 (1)	2.8 (3)	3.7 (3)	3.1 (3)	2.6 (3)	3.2 (3)	6.6 (5)	0.6 (1)
10. Number of individuals electrofishing	67 (5)	38 (3)	74 (5)	14 (1)	39 (3)	10 (1)	51 (5)	19 (1)	63 (5)	42 (3)	48 (3)	36 (3)
seining	7827 (5)	2701 (5)	1107 (5)	138 (3)	1628 (5)	242 (5)	899 (5)	714 (5)	1252 (5)	680 (5)	144 (3)	291 (5)
mean	(5)	(4)	(5)	(2)	(4)	(3)	(5)	(3)	(5)	(4)	(3)	(4)
11. Percentage of individuals as hybrids	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
12. Percentage of individuals with disease or other anomaly	0.9 (5)	2.6 (3)	0.7 (5)	0.0 (5)	0.9 (5)	2.2 (3)	3.0 (3)	1.1 (5)	2.8 (3)	2.5 (3)	0.8 (5)	0.0 (5)
Total score	40	39	38	35	49	48	48	46	46	45	44	39
Aquatic life use	I	I	I	L	E	H	H	H	H	H	H	I

TABLE 15. Fishes collected by seine in January 1988 at 12 sites on the Trinity River and its tributaries (NS = not sampled).

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
<u>Notemigonus crysoleucas</u>	Golden shiner			1				NS					
<u>Notropis buchanani</u>	Ghost shiner					7	1		7	18	1		
<u>Notropis lutrensis</u>	Red shiner	2834	2	33		927	476		236	504	1725	7	2
<u>Notropis texanus</u>	Weed shiner								1				
<u>Notropis venustus</u>	Blacktail shiner	5								1	5	1	
<u>Pimephales vigilax</u>	Bullhead minnow	3	2	2		54	3		18	221	108	43	2
<u>Gambusia affinis</u>	Mosquitofish	16	1	62		22	16		6		1	19	8
<u>Menidia beryllina</u>	Inland silverside	17					1					2	
<u>Lepomis cyanellus</u>	Green sunfish											1	1
<u>Lepomis humilis</u>	Orangespotted sunfish			5								1	
<u>Lepomis macrochirus</u>	Bluegill			1		1						24	
<u>Lepomis megalotis</u>	Longear sunfish	2	1									5	2
<u>Etheostoma gracile</u>	Slough darter					1							
Total individuals		2877	6	104	0	1012	497		268	744	1840	103	15
Total # of species		6	4	6	0	6	5		5	4	5	9	5

TABLE 16. Fishes collected by gill net in January 1988 at 12 sites on the Trinity River and its tributaries (NS = not sampled).

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
<u>Lepisosteus</u> <u>osseus</u>	Longnose gar					3	2	NS		20	5		
<u>Dorosoma</u> <u>cepedianum</u>	Gizzard shad			1			1			1	1		
<u>Dorosoma</u> <u>petenense</u>	Threadfin shad										1		
<u>Cyprinus</u> <u>carpio</u>	Common carp												1
<u>Ictiobus</u> <u>bubalus</u>	Smallmouth buffalo										3		8
<u>Carpiodes</u> <u>carpio</u>	River carpsucker											2	
<u>Ictalurus</u> <u>furcatus</u>	Blue catfish										1		
<u>Morone</u> <u>chrysops</u>	White bass									8	39		
<u>Morone</u> <u>mississippiensis</u>	Yellow bass										10		
<u>Morone</u> <u>saxatilis</u>	Striped bass									1	1		
<u>Pomoxis</u> <u>annularis</u>	White crappie										1		
Total individuals		0	0	1	0	3	3		0	30	62	2	9
Total # of species		0	0	1	0	1	2		0	4	9	1	2

ABLE 17. Fishes collected by electrofishing in January 1988 at 12 sites on the Trinity River and its tributaries (NS = not sampled).

pecies	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
episosteus oculatus	Spotted gar						2	NS	3		2		
episosteus osseus	Longnose gar										1		
orosoma cepedianum	Gizzard shad			16		1	11			2	1	3	
orosoma petenense	Threadfin shad	2										19	
yprinus carpio	Common carp		2	16		1	1			1			
otropis lutrensis	Red shiner	71	2	3		27	3			1	36		7
otropis venustus	Blacktail shiner	1											
imephales vigilax	Bullhead minnow	26	1			3				1	9		6
ctiobus bubalus	Smallmouth buffalo			5			7		4	11			
ctalurus furcatus	Blue catfish					1			4	2			
ylodictis olivaris	Flathead catfish					1							
ambusia affinis	Mosquitofish	14									1		3
enidia beryllina	Inland silverside	4											
orone chrysops	White bass			1						12	1		
icropterus salmoides	Largemouth bass											1	
epomis cyanellus	Green sunfish		2			1							10
epomis gulosus	Warmouth	1									3		1
epomis macrochirus	Bluegill	1		2		3					1	1	3
epomis megalotis	Longear sunfish	30	5	6							2	1	13
epomis sp.	Juvenile sunfish										1		
omoxis annularis	White crappie					1			1		1		
plodinotus grunniens	Freshwater drum					3							
otal individuals		150	12	49	0	42	24		12	30	59	25	43
otal # of species		9	5	7	0	10	5		4	7	11	5	7

TABLE 18. Summary table for calculating the Index of Biotic Integrity for 12 sites on the Trinity River and its tributaries sampled in January 1988. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited. NF = no fish and NS = not sampled.)

Metric	Main river										Tributaries	
	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	9 (3)	6 (1)	11 (3)	NF	14 (5)	10 (3)	NS	9 (3)	11 (3)	18 (5)	13 (3)	9 (3)
2. Number of cyprinid species	3 (3)	2 (3)	3 (3)	NF	3 (3)	3 (3)	NS	4 (5)	4 (5)	4 (5)	3 (3)	2 (3)
3. Number of catfish species	0 (1)	0 (1)	0 (1)	NF	2 (5)	0 (1)	NS	1 (3)	1 (3)	1 (3)	0 (1)	0 (1)
4. Number of *Lepomis* species	3 (3)	2 (3)	3 (3)	NF	2 (3)	0 (1)	NS	0 (1)	0 (1)	3 (3)	4 (5)	4 (5)
5. Number of intolerant species	1 (3)	1 (3)	1 (3)	NF	0 (1)	0 (1)	NS	0 (1)	0 (1)	1 (3)	1 (3)	1 (3)
6. Percentage of individuals as tolerants	97.0 (1)	50.0 (3)	74.7 (1)	NF	92.8 (1)	95.4 (1)	NS	87.5 (1)	65.4 (1)	90.5 (1)	20.8 (3)	49.3 (3)
7. Percentage of individuals as omnivores	1.0 (5)	27.8 (3)	26.6 (3)	NF	5.6 (5)	4.4 (5)	NS	7.9 (5)	29.5 (3)	6.3 (5)	51.5 (1)	25.4 (3)
8. Percentage of individuals as invertebrate feeders	98.9 (5)	61.1 (3)	72.7 (3)	NF	93.5 (5)	94.8 (5)	NS	89.3 (5)	65.2 (3)	90.5 (5)	46.9 (3)	56.7 (3)
9. Percentage of individuals as piscivores	0.0 (1)	11.1 (5)	0.6 (1)	NF	0.9 (1)	0.8 (1)	NS	2.9 (3)	5.3 (5)	3.3 (3)	1.5 (3)	17.9 (5)
10. Number of individuals				NF			NS					
electrofishing	150 (5)	12 (1)	49 (3)	NF	42 (3)	24 (3)	NS	12 (1)	30 (3)	59 (5)	25 (3)	43 (3)
seining	2877 (5)	6 (1)	104 (3)	NF	1012 (5)	497 (5)	NS	268 (5)	744 (5)	1840 (5)	103 (3)	15 (1)
mean	(5)	(1)	(3)	NF	(4)	(4)	NS	(3)	(4)	(5)	(3)	(2)
11. Percentage of individuals hybrids	0 (5)	0 (5)	0 (5)	NF	0 (5)	0 (5)	NS	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
12. Percentage of individuals with disease or other anomaly	0.5 (5)	5.6 (1)	0.0 (5)	NF	2.6 (3)	2.9 (3)	NS	0.0 (5)	3.0 (3)	0.0 (5)	0.0 (5)	0.0 (5)
Total score	40	32	34		41	33		40	37	48	38	41
Aquatic life use	I	L	L		H	L		I	I	H	I	H

TABLE 19. Fishes collected by seine in April and May 1988 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
<u>Lepisosteus</u> <u>spatula</u>	Alligator gar										3		
<u>Dorosoma</u> <u>cepedianum</u>	Gizzard shad										21		
<u>Dorosoma</u> <u>petenense</u>	Threadfin shad									36	1		
<u>Notemigonus</u> <u>crysoleucas</u>	Golden shiner											1	
<u>Notropis</u> <u>buchanani</u>	Ghost shiner							2	147	20	35		
<u>Notropis</u> <u>lutrensis</u>	Red shiner	1608	26	206		33	141	301	566	878	93		2
<u>Notropis</u> <u>texanus</u>	Weed shiner								1				
<u>Notropis</u> <u>venustus</u>	Blacktail shiner	1							5				
<u>Pimephales</u> <u>vigilax</u>	Bullhead minnow	28	1	14		1	16	72	161	17	59	4	
<u>Campostoma</u> <u>anomalum</u>	Central stoneroller	1											
<u>Gambusia</u> <u>affinis</u>	Mosquitofish	39	10	38			1	1	29			3	
<u>Menidia</u> <u>beryllina</u>	Inland silverside			1									
<u>Lepomis</u> <u>cyanellus</u>	Green sunfish			1									
<u>Lepomis</u> <u>humilis</u>	Orangespotted sunfish			1									
<u>Lepomis</u> <u>megalotis</u>	Longear sunfish	2										10	4
<u>Lepomis</u> <u>microlophus</u>	Redear sunfish											1	
<u>Pomoxis</u> <u>annularis</u>	White crappie											1	
<u>Percina</u> <u>sciera</u>	Dusky darter										1		
Total # of individuals		1679	37	261	0	34	158	376	909	951	213	20	6
Total # of species		6	3	6	0	2	3	4	6	4	7	6	2

TABLE 20. Fishes collected by electrofishing in April and May 1988 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
<u>Lepisosteus</u> <u>oculatus</u>	Spotted gar		2			8		1	5		1	1	
<u>Lepisosteus</u> <u>osseus</u>	Longnose gar			4		2		4	3	7			
<u>Dorosoma</u> <u>cepedianum</u>	Gizzard shad		4							14	138	5	
<u>Dorosoma</u> <u>petenense</u>	Threadfin shad									102	154		
<u>Cyprinus</u> <u>carpio</u>	Common carp		1	6	7	1	1	5	2		1		
<u>Notemigonus</u> <u>crysoleucas</u>	Golden shiner											1	
<u>Notropis</u> <u>lutrensis</u>	Red shiner	121	92	71		15	1		1	3	146	1	
<u>Notropis</u> <u>shumardi</u>	Silverband shiner										3		
<u>Notropis</u> <u>venustus</u>	Blacktail shiner	1											
<u>Pimephales</u> <u>promelas</u>	Fathead minnow	1											
<u>Pimephales</u> <u>vigilax</u>	Bullhead minnow	10	1			4	1		1		1		
<u>Ictiobus</u> <u>bubalus</u>	Smallmouth buffalo		1	6	1	7	1	9	7	5			
<u>Ictalurus</u> <u>furcatus</u>	Blue catfish			1		1	1		2	5			
<u>Ictalurus</u> <u>punctatus</u>	Channel catfish	1							1			1	
<u>Pylodictis</u> <u>olivaris</u>	Flathead catfish	1						3	5	1		1	
<u>Morone</u> <u>chrysops</u>	White bass								1	6	9		
<u>Lepomis</u> <u>cyanellus</u>	Green sunfish	4	5										4
<u>Lepomis</u> <u>gulosus</u>	Warmouth	2											
<u>Lepomis</u> <u>humilis</u>	Orangespotted sunfish											1	
<u>Lepomis</u> <u>macrochirus</u>	Bluegill											1	
<u>Lepomis</u> <u>megalotis</u>	Longear sunfish	14	3	1				1				2	6
<u>Aplodinotus</u> <u>grunniens</u>	Freshwater drum							1	1				
Total # of individuals		155	109	89	8	38	5	24	29	143	453	14	10
Total # of species		9	8	6	2	7	5	7	11	8	8	9	2

TABLE 21. Summary table for calculating the Index of Biotic Integrity for 12 sites on the Trinity River and its tributaries sampled in April and May 1988. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited.)

Metric	Main river										Tributaries	
	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	11 (3)	9 (3)	11 (3)	2 (1)	7 (3)	6 (1)	11 (3)	15 (5)	10 (3)	11 (3)	13 (3)	3 (1)
2. Number of cyprinid species	5 (5)	2 (3)	2 (3)	0 (1)	2 (3)	2 (3)	3 (3)	5 (5)	3 (3)	4 (5)	3 (3)	1 (1)
3. Number of catfish species	2 (5)	0 (1)	1 (3)	0 (1)	1 (3)	1 (3)	1 (3)	3 (5)	2 (5)	0 (1)	2 (5)	0 (1)
4. Number of *Lepomis* species	3 (3)	2 (3)	3 (3)	0 (1)	0 (1)	0 (1)	1 (1)	0 (1)	0 (1)	0 (1)	4 (5)	2 (3)
5. Number of intolerant species	1 (3)	1 (3)	1 (3)	0 (1)	0 (1)	0 (1)	1 (3)	0 (1)	0 (1)	1 (3)	1 (3)	1 (3)
6. Percentage of individuals as tolerants	96.8 (1)	93.2 (1)	93.1 (1)	87.5 (1)	81.9 (1)	88.3 (1)	78.0 (1)	64.6 (1)	81.2 (1)	36.6 (3)	20.6 (3)	37.5 (3)
7. Percentage of individuals as omnivores	2.2 (5)	5.5 (5)	7.4 (5)	100 (1)	18.1 (5)	11.7 (5)	21.5 (3)	18.3 (5)	15.9 (5)	56.2 (1)	35.3 (3)	0.0 (5)
8. Percentage of individuals invertebrate feeders	97.4 (5)	89.7 (5)	90.9 (5)	0.0 (1)	66.7 (3)	87.7 (5)	76.3 (3)	79.9 (3)	82.4 (5)	41.7 (3)	55.9 (3)	75.0 (3)
9. Percentage of individuals as piscivores	0.4 (1)	4.8 (3)	1.7 (3)	0.0 (1)	15.3 (5)	0.6 (1)	2.3 (3)	1.8 (3)	1.7 (3)	2.0 (3)	8.8 (5)	25.0 (5)
10. Number of individuals												
electrofishing	155 (5)	109 (5)	89 (5)	8 (1)	38 (3)	5 (1)	24 (3)	29 (3)	143 (5)	453 (5)	14 (1)	10 (1)
seining	1679 (5)	37 (1)	261 (3)	0 (1)	34 (1)	158 (3)	376 (5)	909 (5)	951 (5)	213 (5)	20 (1)	6 (1)
mean	(5)	(3)	(4)	(1)	(2)	(2)	(4)	(4)	(5)	(5)	(1)	(1)
11. Percentage of individuals as hybrids	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
12. Percentage of individuals with disease or other anomaly	0.4 (5)	1.4 (5)	0.6 (5)	12.5 (1)	2.1 (3)	2.5 (3)	8.3 (1)	6.9 (1)	2.3 (3)	0.4 (5)	5.9 (1)	0.0 (5)
Total score	46	40	43	16	35	31	33	39	40	38	40	36
Aquatic life use	H	I	H	L	L	L	L	I	I	I	I	I

TABLE 22. Fishes collected by seine in August 1988 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Dorosoma cepedianum	Gizzard shad			2		1					1		
Dorosoma petenense	Threadfin shad			1									
Notropis buchanani	Ghost shiner			1		7		2	1	28	37		
Notropis emiliae	Pugnose minnow											3	
Notropis lutrensis	Red shiner	1908	173	1339	8	2847	1574	2789	319	3063	3488	32	882
Notropis shumardi	Silverband shiner									2	24		
Notropis umbratilis	Redfin shiner										1	49	
Notropis venustus	Blacktail shiner	4		1				1	4	21	4		
Notropis sp.	Juvenile shiner									18			
Pimephales vigilax	Bullhead minnow	17	28	102	5	3	50	67	22	2380	126	18	91
Ictalurus furcatus	Blue catfish							16					
Gambusia affinis	Mosquitofish	149	16	157	212	75	109	40	92	79	16		186
Menidia beryllina	Inland silverside	10	6	1			1			5	143	7	
Micropterus punctulatus	Spotted bass											3	
Micropterus salmoides	Largemouth bass											1	
Lepomis cyanellus	Green sunfish		1										
Lepomis humilis	Orangespotted sunfish			2									
Lepomis macrochirus	Bluegill	7											
Lepomis megalotis	Longear sunfish	1	1		1					4		3	1
Pomoxis annularis	White crappie								1				
Pomoxis nigromaculatus	Black crappie												1
Total individuals		2096	225	1606	226	2933	1734	2915	439	5600	3840	116	1161
Total # of species		7	6	9	4	5	4	6	6	8	9	8	5

TABLE 23. Fishes collected by electrofishing in August 1988 at 12 sites on the Trinity River and its tributaries.

Species	Common name	Main river										Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Lepisosteus oculatus	Spotted gar			3	1			1	1		1		5
Lepisosteus osseus	Longnose gar		1			1	5	4	2	2			1
Lepisosteus spatula	Alligator gar				1								
Dorosoma cepedianum	Gizzard shad		16	29		14	1	1		1	10	38	4
Dorosoma petenense	Threadfin shad										219		
Cyprinus carpio	Common carp		2		2								
Notropis emiliae	Pugnose minnow			1								1	
Notropis lutrensis	Red shiner	14	76	41		49	6	7	2	10	39	2	8
Notropis shumardi	Silverband shiner										3		
Notropis umbratilis	Redfin shiner											1	
Pimephales vigilax	Bullhead minnow		56	15		8		1	6			5	38
Ictiobus bubalus	Smallmouth buffalo		1	2	3	2	5	2	1	2			10
Carpiodes carpio	River carpsucker				1					1		1	
Ictalurus furcatus	Blue catfish			3		11	1	42	41	42	26		1
Ictalurus natalis	Yellow bullhead						1						
Ictalurus punctatus	Channel catfish					1		1					3
Pylodictis olivaris	Flathead catfish		1			11		15	20	8	4		
Fundulus notatus	Blackstripe topminnow			2									
Gambusia affinis	Mosquitofish	4		1									
Menidia beryllina	Inland silverside			5									1
Micropterus punctulatus	Spotted bass											1	
Micropterus salmoides	Largemouth bass	2	5	1								2	
Lepomis cyanellus	Green sunfish	24	4	6	1	1							
Lepomis gulosus	Warmouth	1				2	1						
Lepomis macrochirus	Bluegill	16		2		3						14	
Lepomis megalotis	Longear sunfish	41	10	6	2		1	1				16	2
Pomoxis annularis	White crappie			3		1							
Aplodinotus grunniens	Freshwater drum									4			1
Total # of individuals		102	172	120	11	104	21	75	73	70	302	81	74
Total # of species		7	10	15	7	12	8	10	7	8	7	10	11

TABLE 24. Summary table for calculating the Index of Biotic Integrity for 12 sites on the Trinity River and its tributaries sampled in August 1988. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited.)

Metric	Main river										Tributaries	
	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	10 (3)	12 (3)	19 (5)	10 (3)	14 (5)	11 (3)	13 (3)	11 (3)	15 (5)	13 (3)	11 (3)	13 (3)
2. Number of cyprinid species	3 (3)	2 (3)	5 (5)	2 (3)	3 (3)	2 (3)	4 (5)	4 (5)	5 (5)	6 (5)	4 (5)	3 (3)
3. Number of catfish species	0 (1)	1 (3)	1 (3)	0 (1)	3 (5)	2 (5)	3 (5)	2 (5)	2 (5)	2 (5)	0 (1)	2 (5)
4. Number of *Lepomis* species	4 (5)	2 (3)	4 (5)	2 (3)	3 (3)	2 (3)	1 (1)	0 (1)	1 (1)	0 (1)	2 (3)	1 (1)
5. Number of intolerant species	1 (3)	1 (3)	1 (3)	1 (3)	0 (1)	1 (3)	1 (3)	0 (1)	1 (3)	0 (1)	1 (3)	1 (3)
6. Percentage of individuals as tolerants	95.5 (1)	68.8 (1)	89.6 (1)	94.9 (1)	98.0 (1)	96.6 (1)	95.0 (1)	81.3 (1)	55.6 (1)	85.6 (1)	16.8 (5)	87.6 (1)
7. Percentage of individuals as omnivores	0.8 (5)	26.1 (3)	8.7 (5)	4.6 (5)	1.0 (5)	3.2 (5)	2.4 (5)	5.7 (5)	42.0 (3)	8.6 (5)	31.5 (3)	11.8 (5)
8. Percentage of individuals as invertebrate feeders	98.0 (5)	70.9 (3)	90.3 (5)	94.1 (5)	98.2 (5)	96.4 (5)	95.0 (5)	81.6 (5)	57.0 (3)	90.7 (5)	64.5 (3)	87.4 (5)
9. Percentage of individuals as piscivores	1.2 (3)	3.0 (3)	0.9 (1)	1.3 (3)	0.9 (1)	0.4 (1)	2.6 (3)	12.7 (5)	1.0 (3)	0.7 (1)	3.6 (3)	0.7 (1)
10. Number of individuals												
electrofishing	102 (5)	172 (5)	120 (5)	11 (1)	104 (5)	21 (3)	75 (5)	73 (5)	70 (5)	302 (5)	81 (5)	74 (5)
seining	2096 (5)	225 (5)	1606 (5)	226 (5)	2933 (5)	1734 (5)	2915 (5)	439 (5)	5600 (5)	3840 (5)	116 (3)	1161 (5)
mean	(5)	(5)	(5)	(3)	(5)	(4)	(5)	(5)	(5)	(5)	(4)	(5)
11. Percentage of individuals as hybrids	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
12. Percentage of individuals with disease or other anomaly	4.5 (3)	0.4 (5)	0.0 (5)	0.0 (5)	0.0 (5)	0.0 (5)	0.0 (5)	0.0 (5)	0.7 (5)	0.3 (5)	0.0 (5)	0.7 (5)
Total score	42	40	48	40	44	43	46	46	44	42	43	42
Aquatic life use	H	I	H	I	H	H	H	H	H	H	H	H

TABLE 25. Fishes collected by seine in November and December 1988 at 13 sites on the Trinity River and its tributaries.

Species	Common name	Main river											Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	Red Oak Creek	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Dorosoma cepedianum	Gizzard shad						1					2	1	
Dorosoma petenense	Threadfin shad						3							
Notropis buchanani	Ghost shiner						17	26	2	4	21	343		
Notropis lutrensis	Red shiner	1228	206	1122		860	3673	2547	1196	2344	1475	960	291	431
Notropis venustus	Blacktail shiner	3								1			34	
Pimephales vigilax	Bullhead minnow	2	17	135		60	25	470	89	346	462	2379	49	89
Carpiodes carpio	River carpsucker											1		
Ictalurus punctatus	Channel catfish			1		1					7	3		
Noturus nocturnus	Freckled madtom												1	
Fundulus notatus	Blackstripe topminnow			2									11	1
Gambusia affinis	Mosquitofish	148	20	70			118	210	62	459	64	32	2	130
Menidia beryllina	Inland silverside	2									6	6	17	
Morone chrysops	White bass										1			
Lepomis cyanellus	Green sunfish	1											1	
Lepomis gulosus	Warmouth			1										
Lepomis humilis	Orangespotted sunfish	1		2				1		1	2		1	1
Lepomis macrochirus	Bluegill	4		2									1	
Lepomis megalotis	Longear sunfish	4	1	3							11	11		1
Percina caprodes	Log perch												2	
Percina sciera	Dusky darter												4	
Aplodinotus grunniens	Freshwater drum										1			
Total individuals		1393	244	1338	0	921	3837	3254	1349	3155	2050	3737	415	653
Total # of species		9	4	9	0	3	6	5	4	6	10	9	13	6

TABLE 26. Fishes collected by electrofishing in November 1988 at 13 sites on the Trinity River and its tributaries.

Species	Common name	Main river											Tributaries	
		Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	Red Oak Creek	FM 85	Hwy 31	U.S. 287	U.S. 79	Hwy 7	Hwy 21	Elm Fork	East Fork
Lepisosteus oculatus	Spotted gar						4	5	1	4		4		
Lepisosteus osseus	Longnose gar					3	2	1	1	1	1			
Lepisosteus spatula	Alligator gar							1						
Dorosoma cepedianum	Gizzard shad		13	3		1		1				3	16	
Dorosoma petenense	Threadfin shad												2	
Cyprinus carpio	Common carp		3	12	1						1	9	1	
Notropis emiliae	Pugnose minnow												2	
Notropis lutrensis	Red shiner	98	103	30		25	19	10	16	2	31	2		8
Notropis umbratilis	Redfin shiner												27	
Notropis venustus	Blacktail shiner			1										
Pimephales vigilax	Bullhead minnow	3	87	5		15	2	15	3	2	20		3	13
Ictiobus bubalus	Smallmouth buffalo		1	5	1	24	7	5	11	4	3			
Ictiobus niger	Black buffalo					1								
Ictalurus furcatus	Blue catfish			1		6			1	1	18	13		
Ictalurus punctatus	Channel catfish		1				5	2	1	1	2		1	
Pylodictis olivaris	Flathead catfish						1	1	2	2		1		
Noturus nocturnus	Freckled madtom			1					2	1	1			
Fundulus notatus	Blackstripe topminnow			2									1	
Gambusia affinis	Mosquitofish	12												31
Menidia beryllina	Inland silverside		1										8	
Morone chrysops	White bass										3			
Micropterus punctulatus	Spotted bass			1										
Micropterus salmoides	Largemouth bass		2										5	
Lepomis auritus	Redbreast sunfish	7												
Lepomis cyanellus	Green sunfish	31	11	4			3						4	1
Lepomis gulosus	Warmouth	7	1	1			2	1			1		1	
Lepomis humilis	Orangespotted sunfish	13					1							
Lepomis macrochirus	Bluegill	46		1			3						14	1
Lepomis megalotis	Longear sunfish	48	18	15		1	19	5	1	1	8	2	40	18
Lepomis punctatus	Spotted sunfish										1			
Lepomis sp.	Juvenile sunfish												1	
Pomoxis annularis	White crappie			2			1					3	3	
Percina sciera	Dusky darter										1		1	
Aplodinotus grunniens	Freshwater drum								2	2	11	6		
Total individuals		265	241	84	2	76	69	47	41	21	102	43	130	72
Total # of species		9	11	15	2	8	13	11	11	11	14	9	16	6

TABLE 27. Summary table for calculating the Index of Biotic Integrity for 13 sites on the Trinity River and its tributaries sampled in November 1988. The metric ratings for each station are in parentheses and summed for the final IBI score. (For aquatic life use, E = exceptional, H = high, I = intermediate, and L = limited.)

	Main river											Tributaries	
Metric	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	Red Oak Creek	FM 85	Hwy31	US 287	US 79	Hwy 7	Hwy 21	Elm Fork	East Fork
1. Total number of species	11 (3)	12 (3)	18 (5)	2 (1)	9 (3)	17 (5)	14 (5)	13 (3)	15 (5)	18 (5)	15 (5)	22 (5)	8 (3)
2. Number of cyprinid species	3 (3)	2 (3)	3 (3)	0 (1)	2 (3)	3 (3)	3 (3)	3 (3)	4 (5)	3 (3)	3 (3)	5 (5)	2 (3)
3. Number of catfish species	0 (1)	1 (3)	3 (5)	0 (1)	2 (5)	2 (5)	2 (5)	4 (5)	4 (5)	3 (5)	3 (5)	2 (5)	0 (1)
4. Number of <u>Lepomis</u> species	6 (5)	3 (3)	5 (5)	0 (1)	0 (1)	5 (5)	3 (3)	1 (1)	2 (3)	4 (5)	1 (1)	5 (5)	4 (5)
5. Number of intolerant species	1 (3)	1 (3)	1 (3)	0 (1)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	2 (5)	1 (3)	3 (5)	1 (3)
6. Percentage of individuals as tolerants	92.0 (1)	70.9 (1)	87.2 (1)	50.0 (3)	89.2 (1)	98.0 (1)	84.1 (1)	91.8 (1)	88.5 (1)	73.1 (1)	26.6 (3)	55.0 (1)	82.9 (1)
7. Percentage of individuals as omnivores	0.3 (5)	25.2 (3)	11.3 (5)	100 (1)	10.1 (5)	1.1 (5)	14.9 (5)	7.5 (5)	11.1 (5)	23.0 (3)	63.4 (1)	13.4 (5)	14.1 (5)
8. Percentage of individuals as invertebrate feeders	97.3 (5)	72.0 (3)	88.0 (5)	0.0 (1)	89.0 (5)	98.7 (5)	84.8 (5)	92.0 (5)	88.6 (5)	75.3 (3)	35.9 (1)	84.0 (5)	85.8 (5)
9. Percentage of individuals as piscivores	2.4 (3)	2.9 (3)	0.7 (1)	0.0 (1)	0.9 (1)	0.3 (1)	0.3 (1)	0.5 (1)	0.3 (1)	1.7 (3)	0.7 (1)	2.6 (3)	0.1 (1)
10. Number of individuals													
electrofishing	265 (5)	241 (5)	84 (5)	2 (1)	75 (5)	69 (5)	47 (3)	41 (3)	21 (3)	102 (5)	43 (3)	130 (5)	72 (5)
seining	1393 (5)	244 (5)	1338 (5)	0 (1)	921 (5)	3837 (5)	3254 (5)	1349 (5)	3155 (5)	2050 (5)	3737 (5)	415 (5)	653 (5)
mean	(5)	(5)	(5)	(1)	(5)	(5)	(4)	(4)	(4)	(5)	(4)	(5)	(5)
11. Percentage of individuals as hybrids	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0.2 (3)	0 (5)
12. Percentage of individuals with disease or other anomaly	2.1 (3)	1.3 (5)	7.1 (1)	50.0 (1)	2.7 (3)	2.1 (3)	1.6 (5)	3.4 (3)	0.0 (5)	3.9 (3)	9.3 (1)	2.9 (3)	0.0 (5)
Total score	42	40	44	18	40	46	45	39	47	46	33	50	42
Aquatic life use	H	I	H	L	I	H	H	I	H	H	L	E	H

TABLE 28. Results of ANOVA and multiple range testing of condition factors for longear sunfish and gizzard shad. Sites with different letters had condition factors that are significantly different (= 0.05).

Site	Mean + standard error		Number of individuals
Longear sunfish			
Highway 31	2.57+0.14	a	6
FM 85	2.12+0.13	a b	20
Highway 7	2.07+0.14	a b	6
Highway 21	2.02+0.28	a b	4
Elm Fork	2.01+0.08	a b	50
Belt Line	1.99+0.06	a b	40
Beach Street	1.90+0.04	a b	90
East Fork	1.70+0.05	a b	30
Sylvan Avenue	1.62+0.10	b	18
Gizzard shad			
FM 85	1.12+0.05	a	18
Belt Line	1.06+0.04	a b	34
Sylvan Avenue	0.94+0.02	a b c	67
Elm Fork	0.94+0.03	a b c	55
Highway 31	0.94+0.05	a b c	4
U.S. 287	0.90+0.04	a b c	8
Highway 7	0.85+0.03	b c	29
Highway 21	0.82+0.02	c	71

TABLE 29. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at Beach Street. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Cyprinus carpio	1.32+0.053 (8)	1.22+0.057 (4)					1.23-1.83
Ictiobus bubalus	1.82+0.184 (4)						1.29-1.53
Carpiodes carpio	1.88 (2)						1.11-1.45
Ictalurus punctatus				0.76 (1)			0.75-1.12
Pylodictis olivaris				0.92 (1)			0.97-1.12
Micropterus salmoides	1.20 (1)				1.12 (1)		1.08-1.85
Lepomis auritus						1.83+0.030 (5)	1.90-4.21
Lepomis cyanellus				1.61+0.069 (4)	1.44+0.058 (5)	1.83+0.041 (24)	1.64-2.32
Lepomis gulosus			1.97 (1)			2.19 (2)	2.00-2.30
Lepomis macrochirus	1.74 (2)		1.56 (1)			1.79+0.067 (11)	1.11-3.27
Lepomis megalotis	1.91+0.114 (15)	2.37+0.083 (8)	1.99+0.064 (8)	1.93+0.120 (9)	1.61+0.088 (25)	1.99+0.049 (25)	1.93-4.25

TABLE 30. K-factors (+ standard error with number of individuals in parentheses) calculated for fishes collected from the Trinity River at Belt Line Road. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		1.14+0.008 (3)		1.01+0.051 (4)	1.23+0.035 (14)	0.86+0.040 (13)	0.91-1.11
Cyprinus carpio		1.62 (2)	0.79 (2)	1.36 (1)	1.26 (2)	1.37+0.057 (3)	1.23-1.83
Ictiobus bubalus		1.53+0.419 (3)		1.84 (1)	1.65 (1)	1.65 (1)	1.29-1.53
Ictalurus punctatus	1.23 (1)					0.68 (1)	0.75-1.12
Pylodictis olivaris					1.10 (1)		0.97-1.12
Micropterus salmoides					1.44+0.063 (5)	1.05 (2)	1.08-1.85
Lepomis cyanellus			2.08 (2)	1.68+0.069 (4)	1.76 (1)	1.49+0.031 (6)	1.64-2.32
Lepomis gulosus						1.79 (1)	2.00-2.30
Lepomis macrochirus	0.54+0.066 (6)						1.11-3.27
Lepomis megalotis	2.25 (1)	2.23+0.05 (4)	2.02+0.070 (4)	2.40+0.070 (3)	2.26+0.038 (11)	1.66+0.061 (17)	1.93-4.25

TABLE 31. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at Sylvan Avenue. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		0.96+0.022 (22)	0.94+0.045 (17)		0.93+0.027 (25)	0.95+0.036 (3)	0.91-1.11
Cyprinus carpio		1.19+0.319 (3)	1.35+0.031 (16)	1.74+0.222 (6)		1.43+0.083 (12)	1.23-1.83
Ictiobus bubalus	1.87 (1)	1.72+0.038 (7)	1.98+0.430 (5)	1.65+0.058 (6)	1.61 (2)	1.61+0.045 (5)	1.29-1.53
Ictalurus furcatus				0.86 (1)	0.83+0.008 (3)	1.00 (1)	0.77-2.57
Morone chrysops			1.25 (1)				---
Morone saxatilis	1.65 (1)						---
Micropterus punctulatus						1.30 (1)	1.01-3.10
Micropterus salmoides					1.45 (1)		1.08-1.85
Lepomis cyanellus					1.42 (2)	1.56+0.147 (4)	1.64-2.32
Lepomis gulosus		1.83 (1)				0.76 (1)	2.00-2.30
Lepomis macrochirus			1.93 (2)		1.95 (1)	1.54 (1)	1.11-3.27
Lepomis megalotis			1.61+0.085 (3)	2.19 (1)	1.22+0.099 (3)	1.68+0.137 (11)	1.93-4.25
Pomoxis annularis					1.23+0.180 (3)	1.45 (2)	0.82-1.99
Aplodinotus grunniens		1.32 (1)					---

TABLE 32. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at South Loop 12. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Cyprinus carpio				1.47+0.090 (7)	1.23 (2)	1.62 (1)	1.23-1.83
Ictiobus bubalus	1.77+0.116 (3)	1.74 (1)		1.79 (1)	1.61+0.042 (3)	1.71 (1)	1.29-1.53
Carpiodes carpio	1.54 (1)				1.34 (1)		1.11-1.45

TABLE 33. K-factors (± standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at South Loop 12 (NS = not sampled). Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum	NS	NS	NS	NS	NS	0.88 (1)	0.91-1.11
Ictiobus bubalus	NS	NS	NS	NS	NS	1.58±0.027 (24)	1.29-1.53
Ictalurus furcatus	NS	NS	NS	NS	NS	0.87±0.023 (6)	0.77-2.57
Lepomis megalotis	NS	NS	NS	NS	NS	2.31 (1)	1.93-4.25

TABLE 34. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at FM 85. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		1.05+0.017 (4)	0.83 (1)		1.17+0.066 (13)		0.91-1.11
Cyprinus carpio	1.34 (1)		1.37 (1)	1.50 (1)			1.23-1.83
Ictiobus bubalus	1.32 (4)	1.62+0.084 (8)		1.82+0.212 (7)	1.80 (2)	1.57+0.040 (7)	1.29-1.53
Ictalurus furcatus	0.96+0.041 (3)	0.65 (1)	0.64 (1)	0.58 (1)	0.81 (2)		0.77-2.57
Ictalurus punctatus					0.75 (1)	0.72+0.032 (3)	0.75-1.12
Pylodictis olivaris		0.90+0.065 (4)	0.81 (1)		0.94+0.062 (4)	0.87 (1)	0.97-1.12
Lepomis cyanellus			1.97 (1)		1.96 (1)	1.27+0.272 (3)	1.64-2.32
Lepomis gulosus					1.56 (2)	0.98 (2)	2.00-2.3
Lepomis macrochirus			1.76+0.108 (3)		1.81 (2)	2.13 (1)	1.11-3.27
Lepomis megalotis		2.60+0.208 (3)				2.03+0.137 (17)	1.93-4.25
Pomoxis annularis			1.27 (1)			1.04 (1)	0.82-1.99
Aplodinotus grunniens			1.25+0.061 (3)				---

TABLE 35. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at Highway 31. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		1.08 (1)	0.89+0.045 (12)		1.30 (1)	0.95 (1)	0.91-1.11
Cyprinus carpio			1.18 (1)	0.48 (1)			1.23-1.83
Ictiobus bubalus	1.76+0.069 (8)		2.00+0.230 (6)	1.64 (1)	1.59+0.040 (5)	1.64+0.076 (5)	1.29-1.53
Ictalurus furcatus	0.84 (2)			0.89 (1)			0.77-2.57
Ictalurus punctatus						0.74 (2)	0.75-1.12
Pylodictis olivaris		0.96 (2)				0.89 (1)	0.97-1.12
Lepomis gulosus					2.02 (1)	1.78 (1)	2.00-2.30
Lepomis humilis	0.96 (2)						1.24-2.02
Lepomis megalotis					2.93 (1)	2.49+0.140 (5)	1.93-4.25
Pomoxis annularis	0.50 (1)						0.82-1.99

TABLE 36. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at U.S. 287. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum	0.91 (1)	0.87+0.034 (6)			1.09 (1)		0.91-1.11
Cyprinus carpio	1.14 (1)			1.52+0.216 (5)			1.23-1.83
Ictiobus bubalus	1.89+0.037 (9)	1.89+0.043 (7)		1.75+0.089 (9)	1.71 (2)	1.55+0.062 (11)	1.29-1.53
Ictalurus furcatus	0.79+0.029 (8)	0.91 (2)			0.70+0.086 (6)	0.77 (1)	0.77-2.57
Ictalurus punctatus					0.73 (1)	0.65 (1)	0.75-1.29
Pylodictis olivaris		0.95+0.081 (5)		0.91+0.042 (3)	0.92+0.027 (9)	0.96 (2)	0.97-1.12
Lepomis megalotis				1.91 (1)		1.70 (1)	1.93-4.25
Pomoxis annularis		4.38 (1)					0.82-1.99
Aplodinotus grunniens				1.69 (1)		1.19 (2)	---

TABLE 37. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at U.S. 79. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Cyprinus carpio	1.20 (1)			1.41 (2)			1.23-1.83
Ictiobus bubalus	2.03 (2)	1.64 (2)	1.88+0.082 (4)	1.50+0.099 (7)	1.76 (1)	1.67+0.040 (4)	1.29-1.53
Ictalurus furcatus	0.90 (2)		0.79+0.039 (4)	0.95 (2)	0.77+0.034 (8)	0.61 (1)	0.77-2.57
Ictalurus punctatus	0.95 (2)			0.69 (1)		0.83 (1)	0.75-1.12
Pylodictis olivaris				0.85+0.052 (5)	0.93+0.027 (19)	0.93 (2)	0.97-1.12
Morone chrysops				1.21 (1)			---
Lepomis megalotis						1.98 (1)	1.93-4.25
Pomoxis annularis			0.91 (1)				0.82-1.99
Aplodinotus grunniens				1.42 (1)		1.34 (2)	---

TABLE 38. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at Highway 7. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		1.03+0.041 (11)	0.78+0.006 (3)	0.73+0.027 (14)	0.98 (1)		0.91-1.11
Dorosoma petenense				0.57+0.017 (25)			---
Cyprinus carpio			1.50 (1)			1.44 (1)	1.23-1.83
Ictiobus bubalus	2.08 (2)		1.92+0.114 (11)	1.74+0.140 (4)	1.84 (2)	1.97+0.113 (3)	1.29-1.53
Carpiodes carpio		1.75 (1)			1.23 (1)		1.11-1.45
Ictalurus furcatus			1.04 (2)	0.92+0.073 (5)	0.74 (2)	0.93+0.038 (18)	0.77-2.57
Ictalurus punctatus						0.69 (1)	0.75-1.12
Pylodictis olivaris	0.95 (1)	1.02+0.064 (6)		1.37 (1)	0.86+0.014 (8)		0.97-1.12
Morone chrysops			1.35+0.027 (20)	1.17+0.071 (5)		1.19+0.020 (3)	---
Morone saxatilis			1.14 (1)				---
Lepomis gulosus						2.19 (1)	2.00-2.30
Lepomis megalotis						2.07+0.135 (6)	1.93-4.25
Lepomis punctatus						1.59 (1)	---
Aplodinotus grunniens	0.81+0.05 (10)	1.13 (2)			1.26+0.224 (4)	1.12+0.038 (11)	---

TABLE 39. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Trinity River at Highway 21. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum	0.86+0.013 (33)	1.04+0.072 (6)	0.75 (2)	0.76+0.011 (26)	0.32 (2)	0.73 (2)	0.91-1.11
Dorosoma petenense	0.75+0.016 (51)		0.69 (1)	0.80+0.016 (25)			---
Cyprinus carpio				1.45 (1)		1.42+0.039 (9)	1.23-1.83
Ictiobus bubalus			1.90+0.130 (3)				1.29-1.53
Ictalurus furcatus	0.78 (1)	0.78+0.109 (3)	0.93 (1)		0.64+0.050 (5)	0.73+0.016 (12)	0.77-2.57
Ictalurus punctatus						0.62 (2)	0.75-1.12
Pylodictis olivaris	0.91+0.024 (4)	0.98+0.062 (3)			0.89+0.026 (4)	0.83 (1)	0.97-1.12
Morone chrysops			1.53+0.073 (40)	1.25+0.026 (9)			---
Morone mississippiensis			1.44+0.032 (10)				---
Morone saxatilis			1.11 (1)				---
Lepomis gulosus			1.56 (2)				2.00-2.30
Lepomis macrochirus			1.10 (1)				1.11-3.27
Lepomis megalotis		2.76 (1)	1.57 (2)			2.17 (1)	1.93-4.25
Pomoxis annularis			1.59 (1)			1.23+0.092 (3)	0.82-1.99
Aplodinotus grunniens	1.38 (2)					1.02+0.043 (6)	---

TABLE 40. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the Elm Fork of the Trinity River at Sandy Lake Road. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum		0.95+0.028 (7)	0.81+0.039 (3)	0.77+0.024 (5)	1.00+0.025 (25)	0.90+0.089 (15)	0.91-1.11
Cyprinus carpio						1.20 (1)	1.23-1.83
Ictiobus bubalus	2.09+0.150 (11)	1.71+0.105 (2)					1.29-1.53
Carpiodes carpio			1.27 (2)		1.34 (1)		1.11-1.45
Ictalurus punctatus				0.67 (1)		0.69 (1)	0.75-1.12
Pylodictis olivaris				0.98 (1)			0.97-1.12
Micropterus punctulatus					1.07 (1)		1.01-3.10
Micropterus salmoides			0.78 (1)		1.20 (2)	1.18+0.090 (5)	1.08-1.85
Lepomis cyanellus	1.46 (1)	1.49 (1)				1.59 (2)	1.64-2.32
Lepomis gulosus						1.94 (1)	2.00-2.30
Lepomis humilis				1.26 (1)			1.24-2.02
Lepomis macrochirus		1.93+0.104 (5)	1.26 (1)		1.42+0.106 (10)	1.43+0.131 (6)	1.11-3.27
Lepomis megalotis		2.18+0.047 (10)	1.84+0.174 (4)	1.85+0.137 (4)	1.89+0.053 (12)	2.07+0.197 (20)	1.93-4.25
Lepomis microlophus				1.24 (1)			1.72-1.83
Pomoxis annularis	0.88 (1)	1.25 (2)		1.23 (1)		1.13+0.018 (3)	0.82-1.99

TABLE 41. K-factors (+ standard error with numbers of individuals in parentheses) calculated for fishes collected from the East Fork of the Trinity River. Values from Carlander (1969; 1977) indicate the expected range.

SPECIES	SAMPLING DATE						CARLANDER
	April-May 87	August 87	January 88	April-May 88	August 88	Nov.-Dec. 88	
Dorosoma cepedianum					1.12 (2)		0.91-1.11
Cyprinus carpio	1.44 (2)	1.04 (1)	1.06 (1)				1.23-1.83
Ictiobus bubalus	2.08 (1)	1.80 (1)	1.55+0.046 (8)		1.98+0.323 (10)		1.29-1.53
Ictalurus furcatus					0.75 (1)		0.77-2.57
Ictalurus punctatus	0.86 (1)	0.84 (1)			0.76+0.075 (3)		0.75-1.12
Lepomis cyanellus			1.75+0.096 (4)	1.71 (2)		1.32 (1)	1.64-2.32
Lepomis gulosus			1.20 (1)				2.00-2.30
Lepomis megalotis	1.85 (1)	1.57+0.12 (5)	1.64+0.157 (5)	1.67+0.123 (8)	1.95 (2)	1.75+0.074 (9)	1.93-4.25
Aplodinotus grunniens					1.17 (1)		---

TABLE 42. Water quality parameters measured in the Trinity River, 1987-1988. (ND = no data collected.)

SITE	DATE	TIME	TEMP (C)	D.O. (mg/L)	COND (mmhos)	pH	SECCHI (m)	NH3-N (mg/L)
BEACH STREET (1)								
	04-20-87	15:27	25.50	9.60	700	7.80	0.61	ND
	08-24-87	14:20	33.29	10.2	610	8.07	0.60	ND
	08-25-87	13:28	34.00	9.90	390	7.00	ND	ND
	01-04-88	13:45	6.82	12.50	485	7.79	0.58	ND
	01-05-88	08:05	5.11	12.93	503	6.94	0.71	ND
	04-26-88	12:30	24.44	8.11	518	7.90	0.33	ND
	08-12-88	09:30	29.92	6.71	563	7.72	0.35	0.2
	10-31-88	15:09	16.27	8.48	352	7.44	0.40	0.6
BELT LINE ROAD (2)								
	04-21-87	11:00	22.50	6.81	850	ND	0.61	ND
	08-24-87	16:15	31.74	6.82	858	7.62	0.55	ND
	08-25-87	09:25	29.40	7.20	430	7.40	ND	ND
	01-04-88	14:55	9.75	11.67	593	7.46	0.30	ND
	01-05-88	11:15	8.93	11.23	629	7.39	0.48	ND
	04-27-88	15:45	23.49	8.49	732	7.60	0.30	ND
	08-11-88	14:28	30.76	5.75	994	7.71	ND	0.4
	11-01-88	12:15	19.49	7.66	609	7.44	0.18	0.2
SYLVAN AVENUE (3)								
	04-22-87	08:40	19.00	7.80	700	6.85	0.33	ND
	08-24-87	14:05	35.50	6.30	460	7.70	ND	ND
	08-25-87	10:08	29.29	6.07	806	7.54	0.20	ND
	01-18-88	17:30	14.70	6.58	881	7.26	0.30	ND
	04-28-88	12:50	22.52	9.75	789	7.50	0.35	ND
	08-11-88	10:05	29.88	5.47	925	7.57	0.45	0.4
	12-05-88	12:10	17.88	8.51	869	7.36	0.45	0.8
SOUTH LOOP 12 (4)								
	04-23-87	ND	21.50	6.60	800	6.85	0.33	ND
	08-24-87	18:30	31.10	6.50	575	7.60	ND	ND
	08-25-87	15:00	30.76	5.97	756	7.10	0.25	ND
	01-18-88	15:44	16.05	8.48	797	7.08	0.45	ND
	05-03-88	09:50	21.54	7.66	821	7.29	0.28	0.4
	08-16-88	09:00	30.44	5.76	836	7.37	0.30	0.7
	12-06-88	08:58	17.08	7.82	763	7.09	0.15	1.0
RED OAK CREEK CONFLUENCE (5)								
	12-06-88	15:30	15.01	8.31	722	7.62	0.30	1.0
FM 85 (6)								
	04-23-87	08:06	23.00	6.60	750	6.84	0.35	ND
	08-25-87	19:39	31.72	7.15	767	7.65	0.33	ND
	08-26-87	16:49	31.00	7.00	442	7.31	ND	ND
	01-18-88	17:37	12.50	8.40	440	7.46	0.43	ND
	01-19-88	10:10	12.87	7.65	752	7.28	0.43	ND
	05-03-88	17:55	22.86	5.90	761	7.35	0.25	0.9
	08-10-88	13:33	32.24	6.23	801	7.90	0.20	1.1
	11-02-88	11:07	18.07	7.81	535	7.70	0.15	0.7
HIGHWAY 31 (7)								
	05-05-85	08:50	24.00	5.50	800	ND	0.05	ND
	04-24-87	12:45	23.00	7.00	750	6.84	0.28	ND
	08-26-87	11:26	30.78	6.70	782	7.77	0.30	ND
	08-27-87	10:00	29.00	5.95	490	7.49	ND	ND
	01-19-88	14:45	12.50	8.31	730	7.22	0.35	ND
	01-20-88	10:30	11.26	8.70	764	7.20	0.30	ND
	05-04-88	09:50	21.25	5.77	790	7.40	0.28	0.5
	08-09-88	08:32	31.42	6.34	743	7.98	0.33	0.5
	11-02-88	15:40	18.69	7.09	499	7.73	0.15	0.7

TABLE 42. continued.

SITE	DATE	TIME	TEMP C (C)	D.O. (mg/L)	COND (mmhos)	pH	SECCHI (m)	NH3-N (mg/L)
U.S. 287 (8)								
	05-05-87	12:30	24.00	5.90	800	ND	0.13	ND
	08-26-87	17:05	31.72	10.81	765	8.37	0.35	ND
	08-27-87	13:50	30.50	6.50	650	7.50	ND	ND
	05-04-88	12:58	22.39	6.72	854	7.51	0.18	0.4
	08-09-88	15:03	32.70	8.70	800	8.36	0.18	0.3
	11-03-88	09:20	18.34	7.61	514	7.63	0.13	0.8
U.S. 79 (9)								
	05-05-87	16:00	25.00	6.80	850	ND	0.08	ND
	05-08-87	09:45	22.00	3.30	340	ND	0.08	ND
	08-27-87	10:18	30.96	5.81	772	7.73	0.15	ND
	08-28-87	11:30	30.00	6.00	429	7.70	ND	ND
	01-19-88	18:00	11.38	6.17	621	7.21	0.33	ND
	01-20-88	11:25	10.40	8.10	379	7.10	0.33	ND
	05-04-88	17:50	23.30	8.39	818	7.78	0.15	0.5
	08-09-88	10:00	31.80	5.82	867	7.86	0.15	0.3
	11-03-88	15:05	19.80	7.60	694	7.76	0.13	0.6
HIGHWAY 7 (10)								
	05-07-87	16:10	24.00	5.00	580	ND	0.05	ND
	08-28-87	14:43	31.00	7.45	794	7.92	0.20	ND
	01-20-88	17:15	10.50	8.90	410	7.53	0.45	ND
	01-21-88	10:10	9.30	9.60	608	7.38	0.38	ND
	05-05-88	10:47	22.74	8.89	806	7.89	0.20	0.4
	08-08-88	18:35	33.87	8.18	829	7.36	0.18	0.8
	11-04-88	08:36	19.77	8.09	716	7.43	0.18	0.6
HIGHWAY 21 (11)								
	05-06-87	14:55	24.50	8.90	800	ND	0.33	ND
	08-28-87	09:30	30.51	6.94	718	7.85	0.28	ND
	01-20-88	17:20	10.21	9.97	613	7.30	0.30	ND
	05-05-88	14:04	23.68	9.94	736	8.14	0.18	0.5
	08-08-88	14:16	33.10	10.68	791	8.72	0.25	0.2
	11-04-88	12:08	20.77	7.78	725	7.38	0.20	0.8
ELM FORK TRINITY RIVER AT SANDY LAKE ROAD (T1)								
	04-21-87	13:00	17.00	8.30	500	7.90	0.30	ND
	08-24-87	20:13	27.66	5.89	390	7.44	0.45	ND
	08-25-87	16:50	28.00	6.40	229	7.43	ND	ND
	01-04-88	15:25	7.28	12.51	417	7.74	0.28	ND
	01-05-88	16:30	6.36	12.25	422	7.35	0.38	ND
	04-28-88	09:40	19.02	7.02	447	7.51	0.30	ND
	08-11-88	17:41	33.64	6.66	441	7.96	0.35	0.3
	11-01-88	08:29	16.80	3.64	462	7.42	0.56	0.9
EAST FORK TRINITY RIVER (T2)								
	04-22-87	11:30	21.00	4.10	730	6.84	0.20	ND
	08-25-87	ND	30.00	4.10	400	7.26	ND	ND
	08-26-87	ND	28.50	3.50	400	7.30	ND	ND
	01-18-88	14:30	13.50	7.50	330	7.51	0.35	ND
	04-28-88	16:30	22.33	5.85	664	7.36	0.23	ND
	08-10-88	18:16	33.09	9.49	733	8.07	0.35	0.7
	11-01-88	16:41	19.10	7.68	467	7.69	0.20	1.5

TABLE 43. Total ammonia nitrogen (NH3-N) values from the Trinity River. Values represent single grab samples from the Texas Water Commission stream monitoring network. Asteriks mark values exceeding 4-day chronic guidelines.

Date	Main river										Tributaries	
	Beach Street	W. Belt Line	Sylvan Avenue	S. Loop 12	S. Belt Line	Hwy. 34	FM 85	Hwy. 31	U.S. 79	Hwy. 21	Elm Fork	East Fork
January 1987	0.310	0.620	0.120	0.730	0.390	0.980	0.370		0.397	0.300	0.050	3.420*
February				0.440*	0.530				0.461	0.200	0.040	0.060
March				0.250	0.280	0.250	0.220		0.122	0.200	0.040	0.100
April	0.050	0.150	2.110*	1.350	0.670		0.254	0.231	0.128	0.300	<0.020	1.260
May				0.730	0.800	0.090	0.442	0.088	0.073	0.022	0.070	0.310
							0.060			0.200		
							0.079					
June	<0.020	<0.020	<0.020	<0.020	0.020		0.032	0.016	0.046		<0.020	<0.020
July	0.320	0.400		0.560	0.550	0.310	0.310	0.060	0.023		0.030	1.210*
							0.110					
August				2.020*	0.730	0.180	0.780	0.120	0.020	<0.020	<0.020	2.190*
								0.060				
September	<0.020	0.280	1.110	1.180	1.030	0.180	0.340	0.070	<0.010		<0.020	1.690*
							0.240					
October				0.640	0.770		0.250	0.650	0.040		<0.020	0.980
November				0.720	1.810*	0.090	0.120	0.150	0.020	3.460*	0.030	0.280
December	<0.020	1.610	0.960	0.730	1.310			0.150	0.020		<0.020	0.650
January 1988				2.950*	1.490	0.440	0.540	1.610	1.360		0.830	0.910*
February				3.490*	5.350*			2.450*	0.440	0.130	<0.020	1.880
March	0.100	0.240	0.280	1.600	1.810*	1.280	1.150	0.270	0.220		<0.020	2.390*
April				1.350	1.100			0.120	<0.020		<0.020	1.490
May				0.690	0.520	0.030	<0.020	<0.020	0.190	<0.020	<0.020	0.770
June	<0.020	0.050	<0.020	0.800*	0.080			<0.020	<0.020		<0.020	0.880
July				0.150	0.210	0.020	0.050	0.070	0.130			0.310
August				1.510*	0.530		0.090					
September	0.040	0.140	0.860	0.260		<0.020	0.020	0.060				
November			0.100	0.520			0.360					
Mean	0.100	0.390	0.620	1.031	0.999	0.322	0.278	0.345	0.197	0.485	0.073	1.095
Maximum	0.320	1.610	2.110	3.490	5.350	1.280	1.150	2.450	1.360	3.460	0.830	3.420
N	9	9	9	22	20	12	21	16	19	10	18	19
N exceed	0	0	1	6	3	0	0	1	0	1	0	6
% exceed	0	0	11	27	15	0	0	6	0	10	0	32

TABLE 44. Theoretical chlorine concentrations derived for wastewater treatment plant effluents discharging into the Trinity River. Values were calculated using mean monthly flow and effluent concentrations. Letters below each plant refer to locations on Figure 1.

Month	Village Creek (A)	TRA Central (B)	Dallas Central (C)	Dallas Southside (D)
January 1987	0.672	0.358	0.208	0.027
February	0.326	0.179	0.106	0.013
March	0.111	0.073	0.099	0.015
April	0.880	0.445	0.087	0.019
May	0.314	0.189	0.044	0.100
June	0.121	0.068	0.048	0.100
July	0.470	0.305	0.090	0.014
August	1.332	0.590	0.281	0.039
September	1.419	0.463	0.224	0.030
October	---	0.637	0.524	0.082
November	0.743	0.395	0.388	0.055
December	0.612	0.323	0.346	0.088
Jaunary 1988	0.833	0.516	0.554	0.150
February	0.895	0.595	0.401	0.118
March	0.876	0.468	0.369	0.094
April	0.899	0.529	0.404	0.100
May	1.197	0.544	0.433	0.106
June	0.619		0.283	0.068
July	1.189	0.530	0.408	0.092
August	1.295	0.588	0.622	0.158
September	0.733	0.374	0.485	0.095
Mean	0.777	0.408	0.305	0.066

TABLE 45. IBI scores and use classes for Trinity River segment 805. (For use classes: E = exceptional, H = high, I = intermediate, and L = limited.)

Date	Beach Street	Belt Line	Sylvan Avenue	S. Loop 12	FM 85	Hwy. 31
April-May 87	38(I)	36(I)	36(I)	22(L)	38(I)	38(I)
August 87	40(I)	39(I)	38(I)	35(L)	49(E)	48(H)
January 88	40(I)	32(L)	34(L)	0(L)	41(H)	33(L)
April-May 88	46(H)	40(I)	43(H)	16(L)	35(L)	31(L)
August 88	42(H)	40(I)	48(H)	40(I)	44(H)	43(H)
Nov.-Dec. 88	42(H)	40(I)	44(H)	18(L)	46(H)	45(H)
Mean (Year 1)	39.3(I)	35.7(L-I)	36.0(I)	19.0(L)	42.7(H)	39.7(I)
Mean (Year 2)	43.3(H)	40.0(I)	45.0(H)	24.7(L)	41.7(H)	39.7(I)
Mean (87-88)	41.3(H)	37.8(I)	40.5(I-H)	21.8(L)	42.2(H)	39.7(I)

TABLE 46. Results of residue analysis on fillets of fishes collected from the Trinity River and its tributaries. Laboratory analyses were conducted by the Texas Department of Health. Results are reported on a wet weight basis. Values with asteriks exceed FDA criteria. (ND = not detected, C = three-fish composite, NA = not analyzed for.)

Station	Species	Chlordane (mg/kg)	DDE (mg/kg)	DDT (mg/kg)	Arochlor 1260 (mg/kg)	Dieldrin (mg/kg)	Hg (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Bear Creek	Yellow bullhead (C)	ND	ND	ND	ND	ND	0.065	<0.400	<1.800	<0.700	4.600
Bear Creek	Green sunfish (C)	ND	ND	ND	ND	ND	0.119	<0.400	<1.600	1.600	10.000
Below Benbrook Dam	Yellow bullhead (C)	<0.010	<0.005	ND	<0.040	<0.006	0.055	<0.400	<1.700	<0.700	4.100
Below Benbrook Dam	Longear sunfish (C)	ND	ND	ND	ND	ND	0.253	<0.400	<1.700	<0.700	5.700
Below Benbrook Dam	Largemouth bass	ND	ND	ND	ND	ND	0.324	<0.400	<1.700	<0.700	4.400
Trinity Park	White crappie	0.050	0.006	ND	ND	ND	0.293	<0.400	<1.700	<0.700	4.800
Trinity Park	Green sunfish	ND	ND	ND	ND	ND	0.151	<0.400	<1.700	<0.700	5.700
Trinity Park	Largemouth bass	ND	ND	ND	ND	ND	0.530	<0.400	<1.600	<0.700	4.600
Purcy Drain	Bluegill sunfish (C)	0.340*	0.040	ND	0.360	0.020	0.073	<0.400	<1.700	1.200	24.000
Purcy Drain	Gizzard shad	0.780*	0.050	ND	0.590	0.020	0.051	<0.400	<1.900	<0.800	6.000
Belt Line Road	Smallmouth buffalo	0.032	ND	ND	ND	ND	0.290	<0.600	<2.800	<1.1	3.400
Belt Line Road	Smallmouth buffalo	0.340*	0.030	0.120	0.390	0.032	0.360	<0.700	<3.100	<1.2	4.300
Commerce Street	Smallmouth buffalo	0.700*	0.170	0.080	0.270	0.035	0.209	<0.400	<1.600	1.100	5.100
Commerce Street	Smallmouth buffalo	0.500*	0.100	0.050	0.220	0.020	0.172	<0.400	<1.600	0.780	3.100
Commerce Street	Gizzard shad	0.840*	0.060	0.050	0.660	0.100	0.096	<0.400	<1.600	1.100	4.700
Commerce Street	Gizzard shad	0.800*	0.090	0.100	0.840	0.070	0.073	<0.400	<1.600	1.200	3.700
S. Loop 12	Smallmouth buffalo	0.500*	0.025	0.053	0.155	0.040	0.200	<0.600	<2.700	<1.100	3.300
FM 85	Smallmouth buffalo	0.250	0.060	0.015	0.066	0.034	0.096	<0.700	<3.100	<1.300	2.400
FM 85	Freshwater drum	0.120	0.015	0.020	0.050	0.010	0.240	<0.400	<1.600	<0.700	2.800
FM 85	Blue catfish	0.080	0.009	ND	0.170	ND	0.356	<0.400	<1.600	<0.700	3.900
FM 85	Gizzard shad	0.090	0.009	ND	ND	0.010	0.078	<0.400	<1.700	<0.700	4.300
State Highway 31	Smallmouth buffalo	0.050	0.020	ND	0.045	0.008	0.185	<0.400	<1.600	0.970	4.100
State Highway 31	Gizzard shad	0.190	0.025	ND	0.135	0.009	0.049	<0.400	<1.700	0.720	3.900
U.S. 287	Blue catfish	0.014	0.010	ND	ND	ND	0.170	<0.500	<2.200	<0.900	3.500
U.S. 79	Smallmouth buffalo	0.170	0.054	0.016	0.064	0.020	0.140	<0.600	<2.600	<1.100	2.700
U.S. 79	Smallmouth buffalo	0.024	0.006	ND	ND	ND	0.046	<0.300	<1.400	0.610	4.0
U.S. 79	Blue catfish	0.040	0.017	ND	0.090	ND	0.175	<0.300	<1.400	0.630	3.900
U.S. 79	Blue catfish	0.020	0.010	ND	0.050	ND	0.223	<0.400	<1.600	0.620	3.800
State Highway 7	Freshwater drum	ND	ND	ND	ND	ND	0.064	<0.600	<3.000	<1.200	6.600
State Highway 7	River carpsucker	0.047	0.012	ND	ND	ND	0.078	<0.700	<3.100	<1.300	3.200
State Highway 7	Flathead catfish	0.086	0.026	0.059	0.090	ND	NA	NA	NA	NA	NA
State Highway 21	Flathead catfish	0.077	0.038	0.040	0.120	ND	0.340	<0.600	<2.900	<1.200	4.300
State Highway 21	White bass	0.140	0.050	ND	0.090	0.015	0.145	<0.400	<1.600	0.550	3.100
State Highway 21	White bass	0.290	0.170	0.060	0.230	0.030	0.132	<0.300	<1.300	0.500	2.800
Elm Fork: Sandy Lake Road	White crappie	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
Elm Fork: Sandy Lake Road	Longear sunfish	ND	0.006	ND	ND	ND	NA	NA	NA	NA	NA
East Fork: Malloy Bridge	Longear sunfish	0.430*	0.065	0.085	0.110	0.030	NA	NA	NA	NA	NA
East Fork: Malloy Bridge	Longear sunfish	0.190	0.110	0.070	0.150	0.010	NA	NA	NA	NA	NA
East Fork: Malloy Bridge	Channel catfish	0.054	0.014	ND	ND	ND	0.120	<0.500	<2.300	<0.900	7.800
East Fork: Malloy Bridge	Smallmouth buffalo	0.030	0.020	ND	ND	ND	0.181	<0.400	<1.600	0.540	3.200
East Fork: Malloy Bridge	Smallmouth buffalo	0.140	0.030	ND	0.050	0.020	0.209	<0.400	<1.600	0.700	3.300

Applicable FDA action levels:
Chlordane = 0.300 mg/kg
Total DDT, DDE, TDE = 5.0 mg/kg
PCBs (Arochlor) = 2.0 mg/kg
Dieldrin = 0.300 mg/kg
Hg = 1.0 mg/kg

APPENDIX B - FIGURES

FIGURE 1. Map of the study area illustrating the sampling locations and major wastewater dischargers.

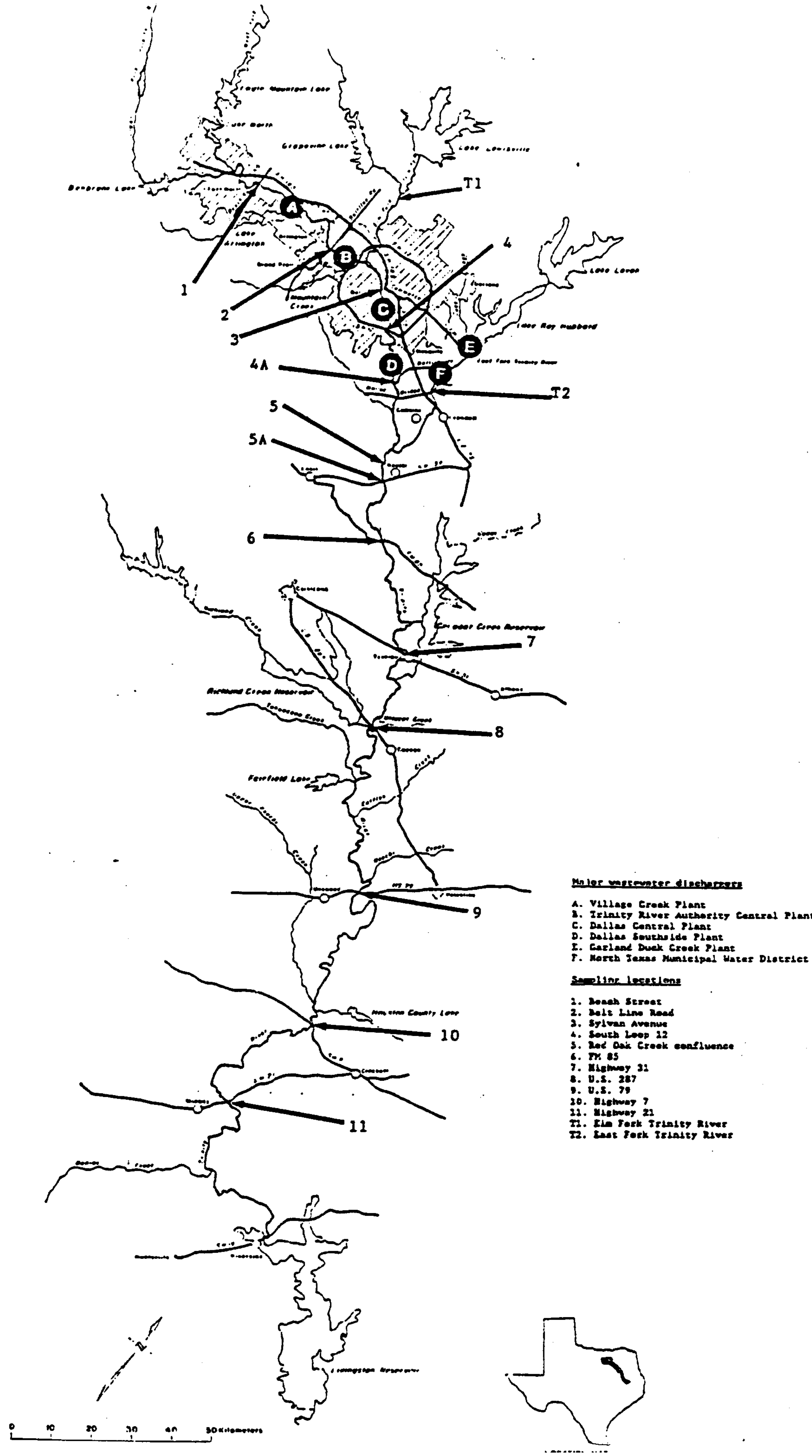
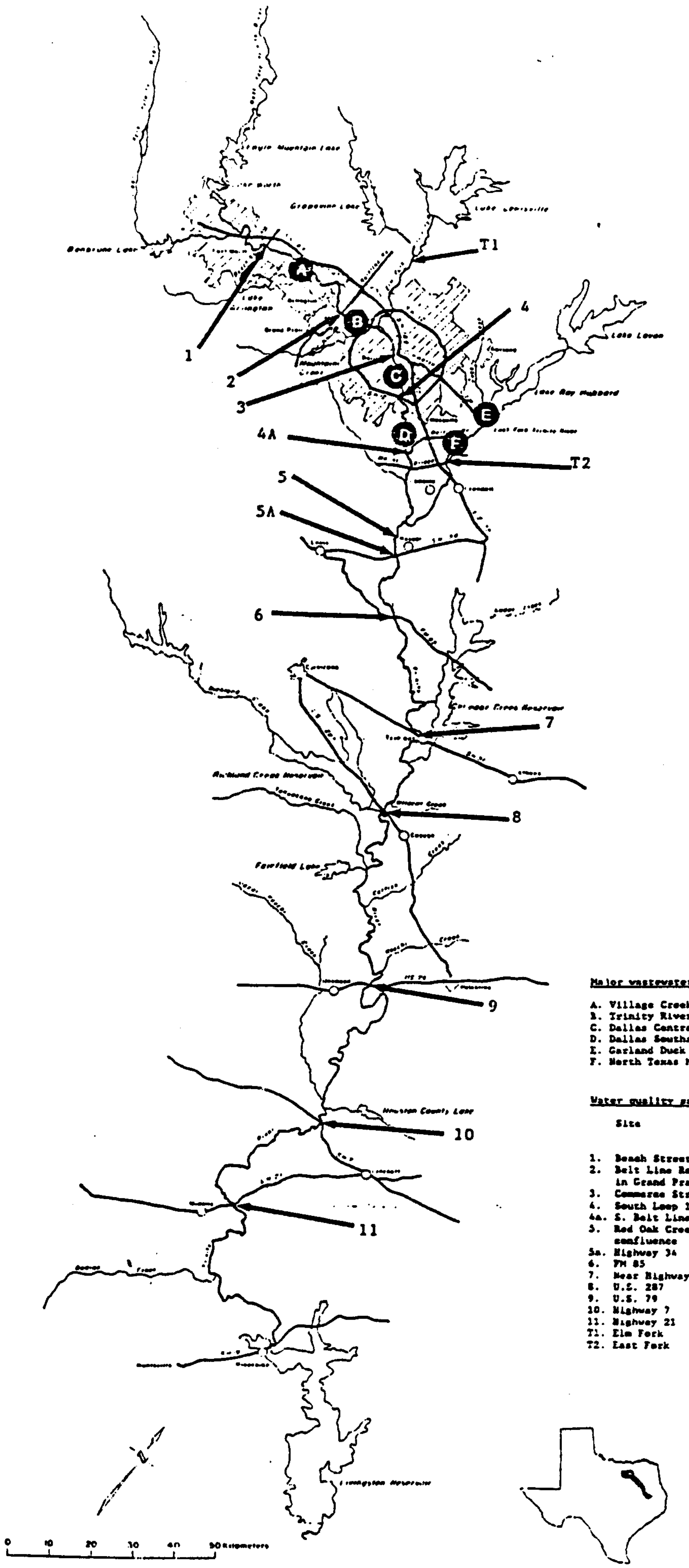

Major wastewater dischargers
A. Village Creek Plant
B. Trinity River Authority Central Plant
C. Dallas Central Plant
D. Dallas Southside Plant
E. Garland Duck Creek Plant
F. North Texas Municipal Water District
Sampling locations
1. Beach Street
2. Belt Line Road
3. Sylvan Avenue
4. South Loop 12
5. Red Oak Creek confluence
6. FM 85
7. Highway 31
8. U.S. 287
9. U.S. 79
10. Highway 7
11. Highway 21
T1. Elm Fork Trinity River
T2. East Fork Trinity River
0 10 20 30 40 50 Kilometers

FIGURE 2. Map of the study area illustrating the location of USGS flow and continuous automated monitoring stations and TWC stream monitoring network stations.



Major wastewater dischargers

A. Village Creek Plant
B. Trinity River Authority Central Plant
C. Dallas Central Plant
D. Dallas Southside Plant
E. Garland Duck Creek Plant
F. North Texas Municipal Water District

Water quality sampling sites

Site	CAMS station	SMOI station
1. Beach Street	X	X
2. Belt Line Road in Grand Prarie	X	X
3. Commerce Street	X	X
4. South Loop 12	X	X
4a. S. Belt Line Road		X
5. Red Oak Creek confluence		
5a. Highway 34	X	X
6. FM 85		X
7. Near Highway 31	X	X
8. U.S. 287		
9. U.S. 79		X
10. Highway 7	X	X
11. Highway 21		X
T1. Elm Fork		X
T2. East Fork	X	X

FIGURE 3. Cumulative species richness for all collections from all sites in the Trinity River. Bar patterns represent species additions during each collecting period.

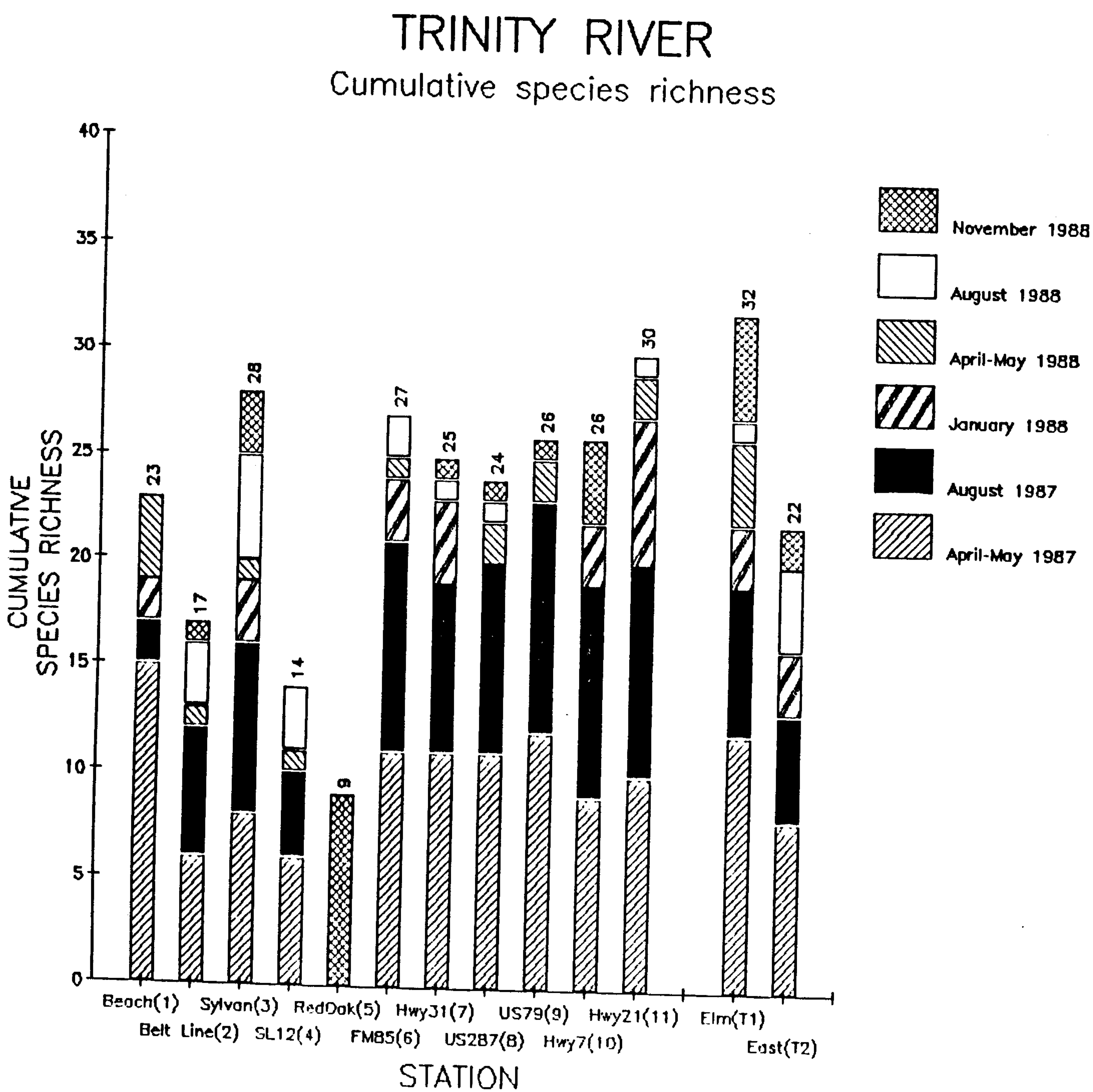

TRINITY RIVER
Cumulative species richness
CUMULATIVE SPECIES RICHNESS
0
5
10
15
20
25
30
35
40
23
17
28
14
9
27
25
24
26
26
30
32
22
Beach(1)
Belt Line(2)
Sylvan(3)
SL12(4)
RedOak(5)
FM85(6)
Hwy31(7)
US287(8)
US79(9)
Hwy7(10)
Hwy21(11)
Elm(T1)
East(T2)
STATION
November 1988
August 1988
April-May 1988
January 1988
August 1987
April-May 1987

FIGURE 4. Mean species richness and 95% confidence intervals for the Trinity River and its tributaries. Sites with different letters are significantly different.

TRINITY RIVER

Mean species richness
and 95% confidence levels

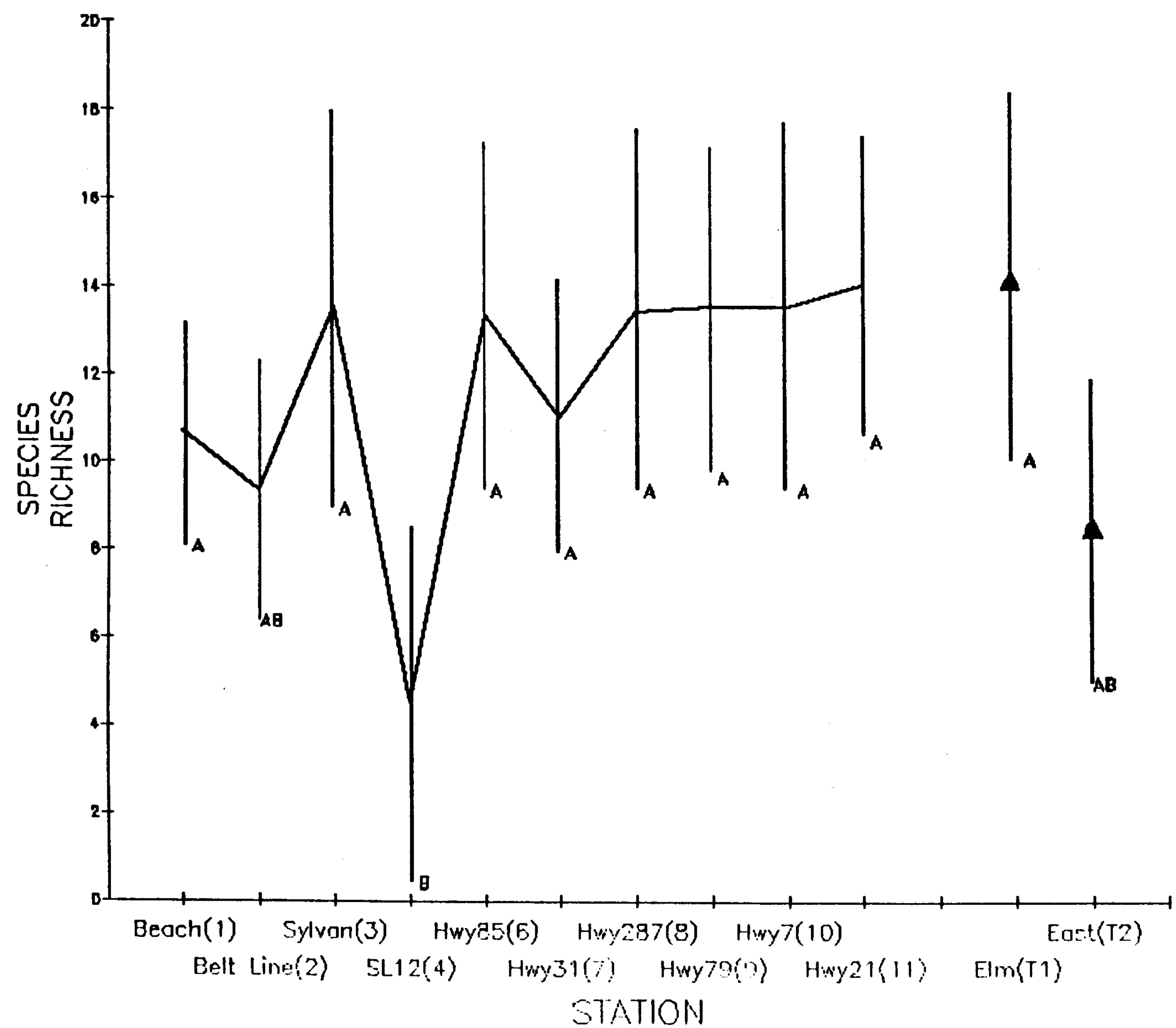


FIGURE 5. Mean Shannon-Wiener diversity and ranges from electrofishing samples collected from the Trinity River and its tributaries. Sites with different letters are significantly different.

TRINITY RIVER

Electrofishing samples
Mean Shannon diversity
and range

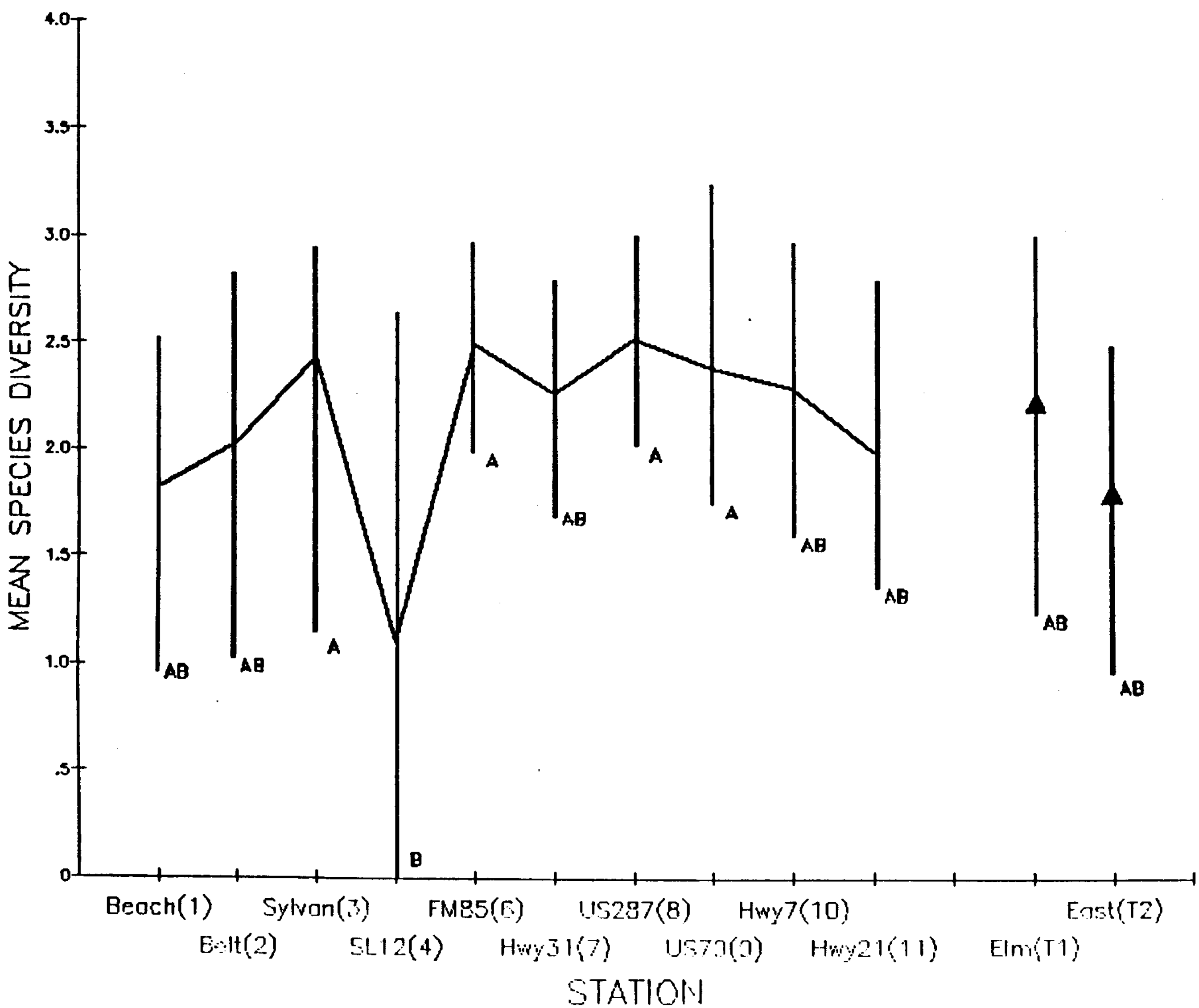


FIGURE 6. Mean IBI scores for the Trinity River and its tributaries. Sites with different letters are significantly different.

TRINITY RIVER

Mean IBI scores

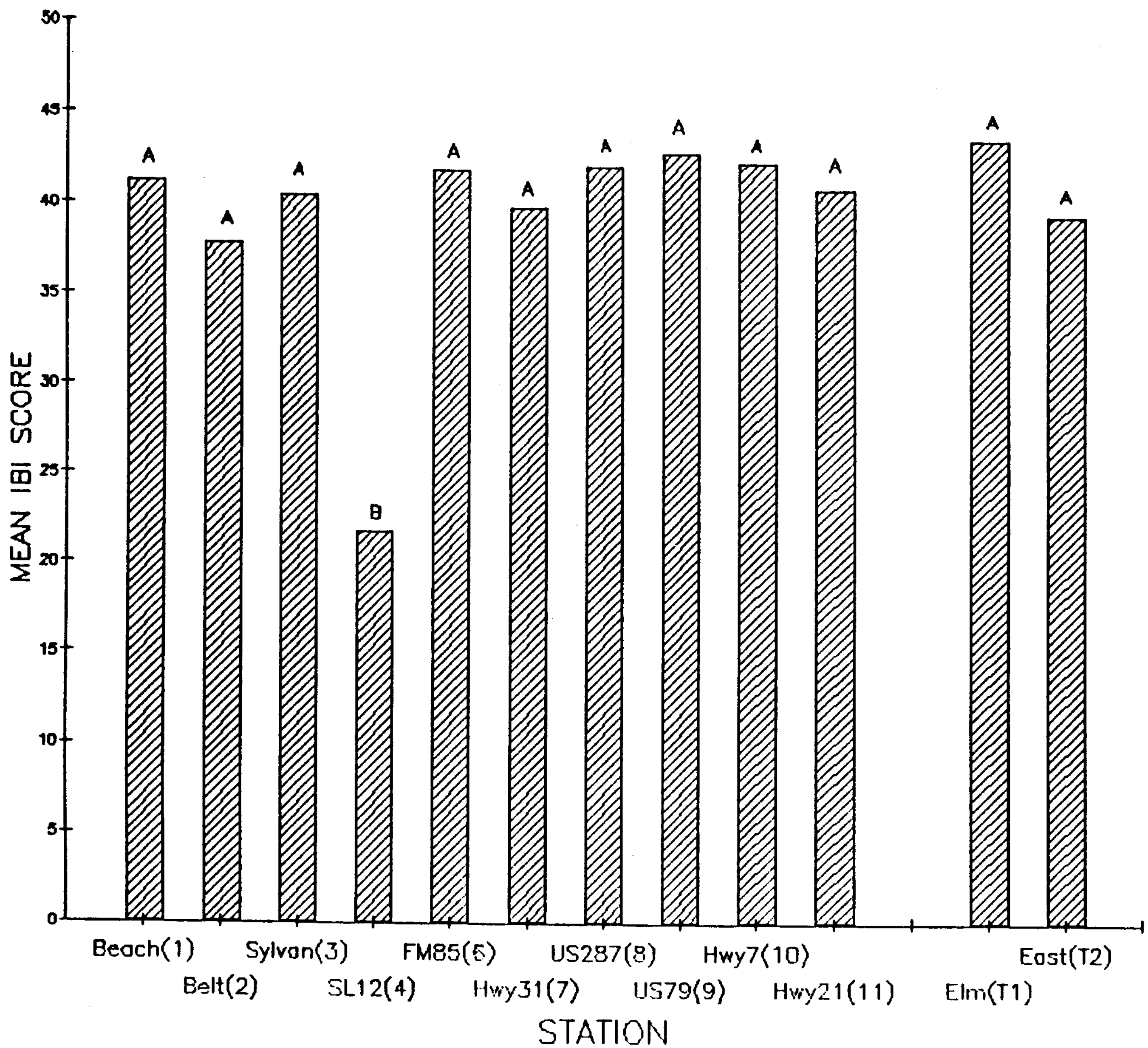


FIGURE 7. Mean species richness for 1972-1974 collections from the Trinity River and its tributaries (TPWD 1974). Site locations corresponding to those sampled in the present study are listed.

TRINITY RIVER

Mean species richness
1972-1974 TPWD Study

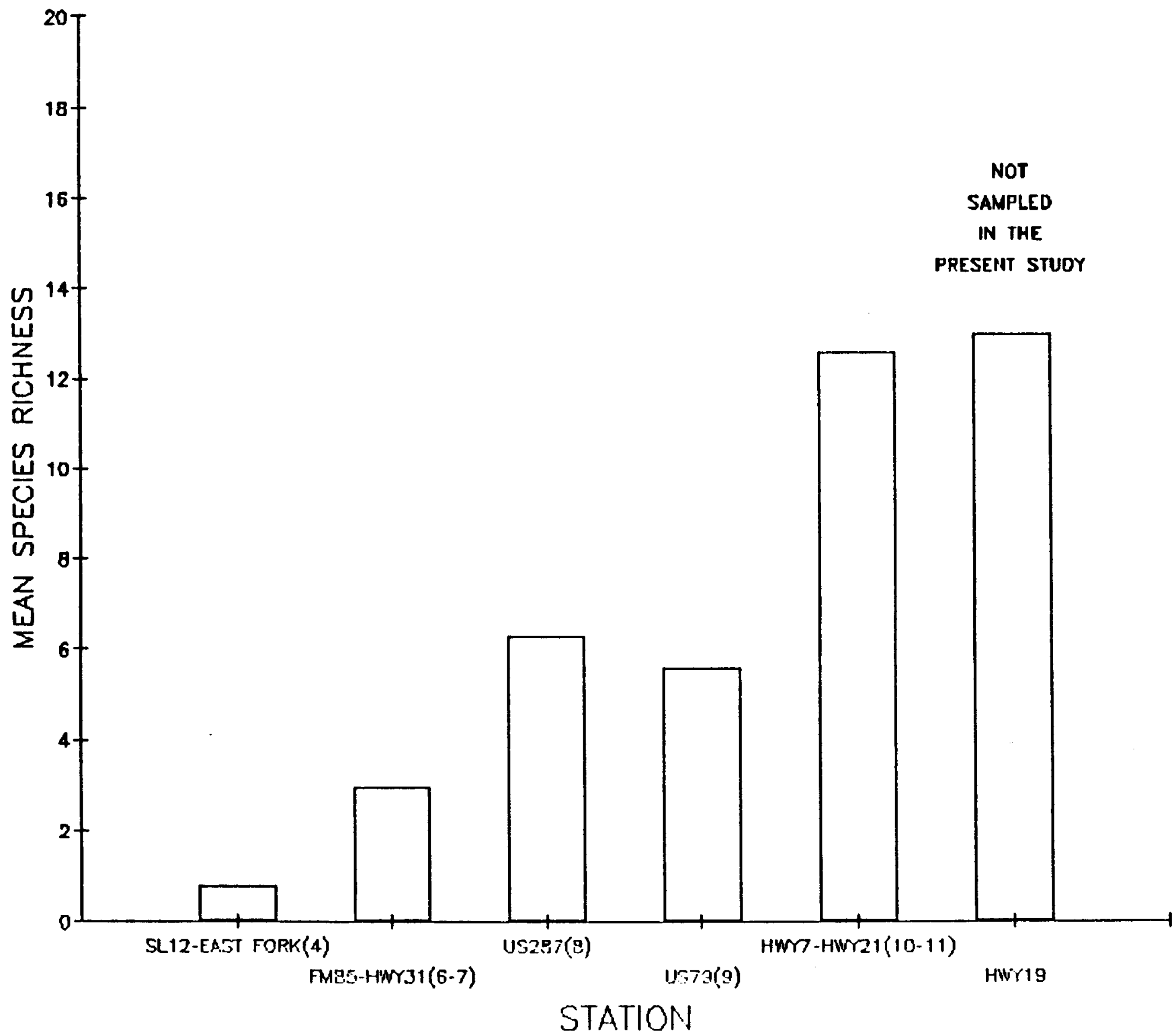


FIGURE 8. Species richness for samples collected in April and May 1987 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

TRINITY RIVER

April-May 1987

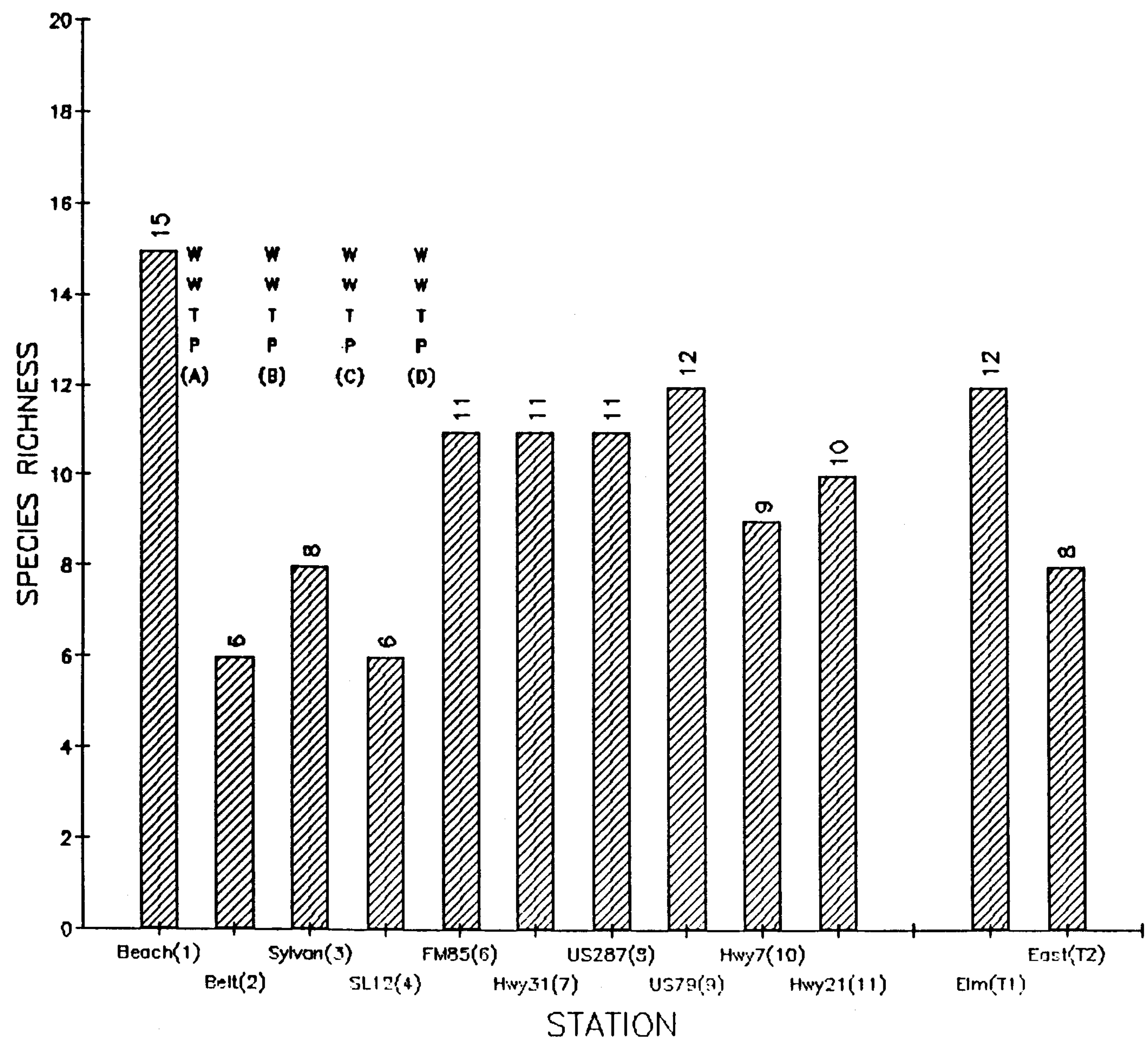


FIGURE 9. Species richness for samples collected in August 1987 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

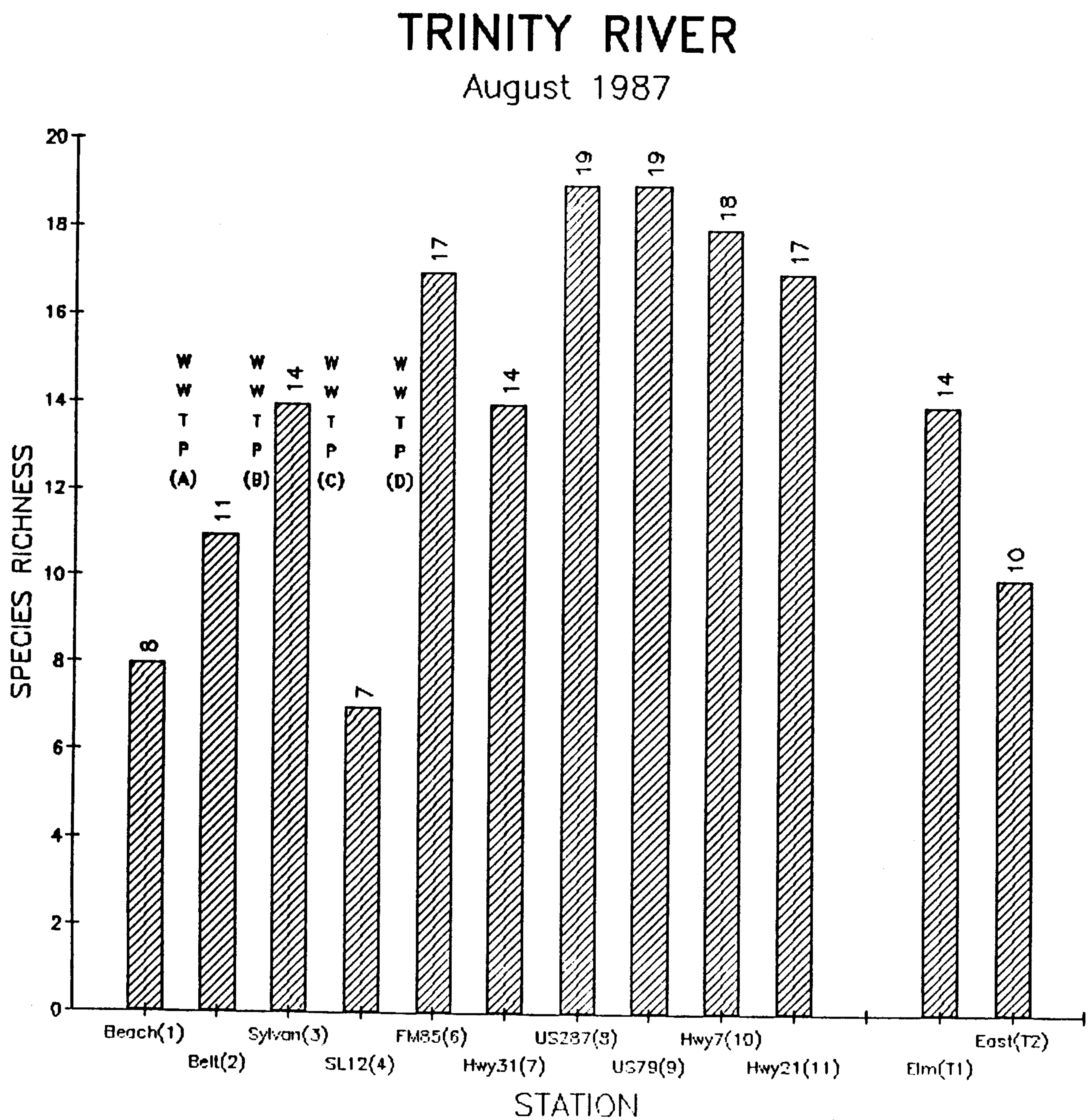
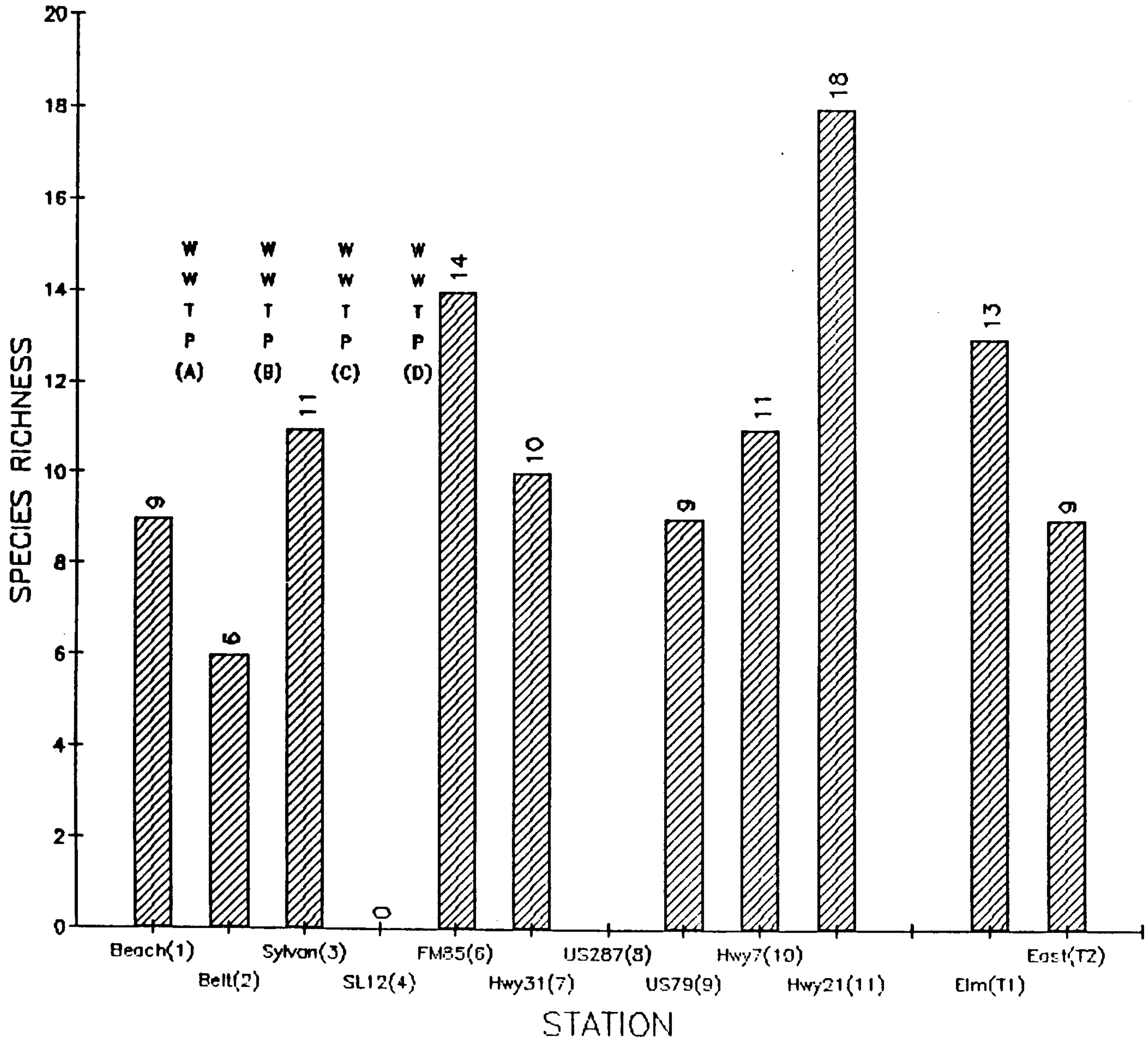

TRINITY RIVER
August 1987
SPECIES RICHNESS
STATION
Beach(1)
Belt(2)
Sylvan(3)
SL12(4)
FM85(6)
Hwy31(7)
US287(8)
US79(9)
Hwy7(10)
Hwy21(11)
Elm(T1)
East(T2)
WWTP (A)
WWTP (B)
WWTP (C)
WWTP (D)
8
11
14
7
17
14
19
19
18
17
14
10

FIGURE 10. Species richness for samples collected in January 1988 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

TRINITY RIVER

January 1988



TRINITY RIVER
January 1988

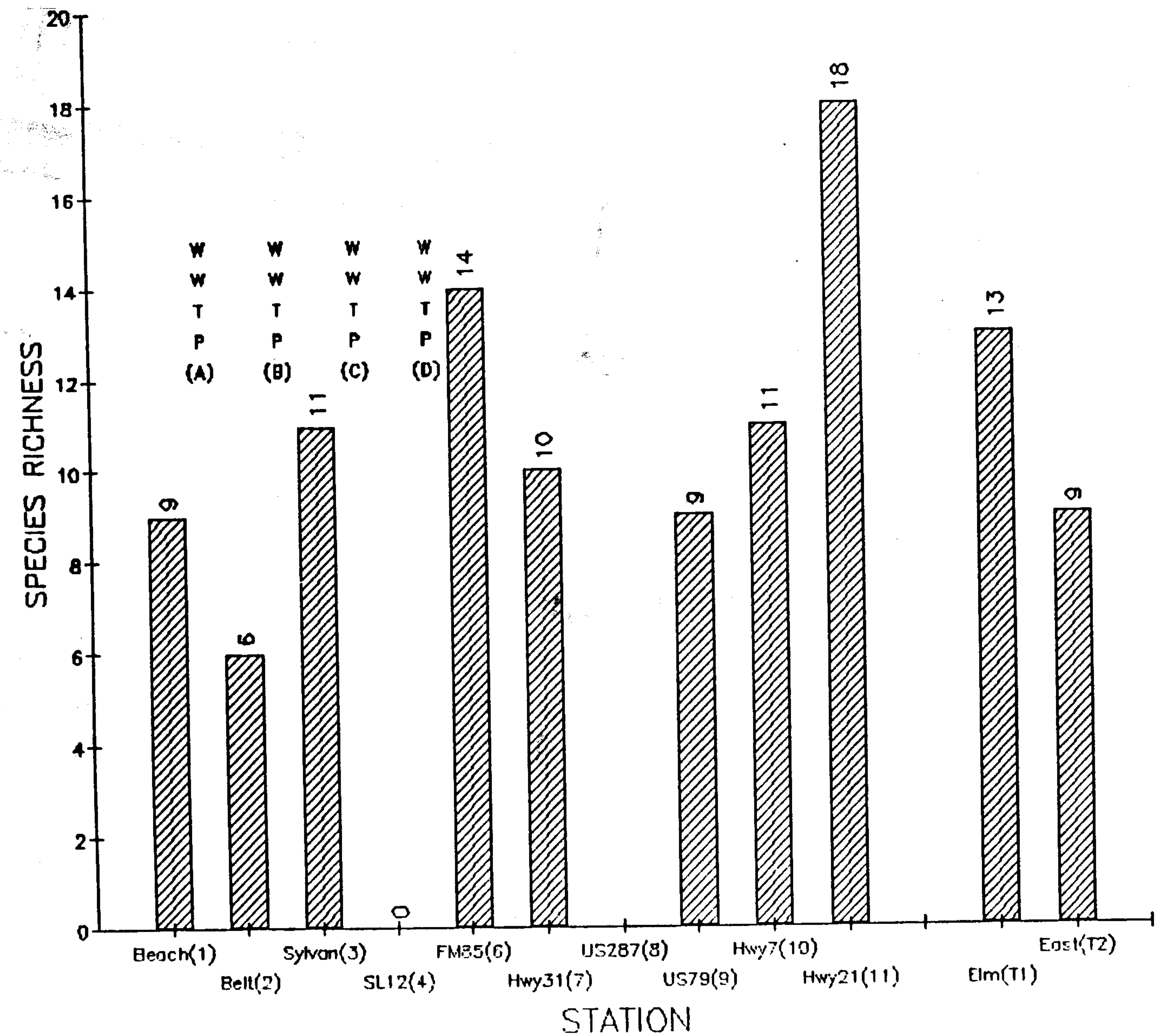


FIGURE 11. Species richness for samples collected in April and May 1988 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

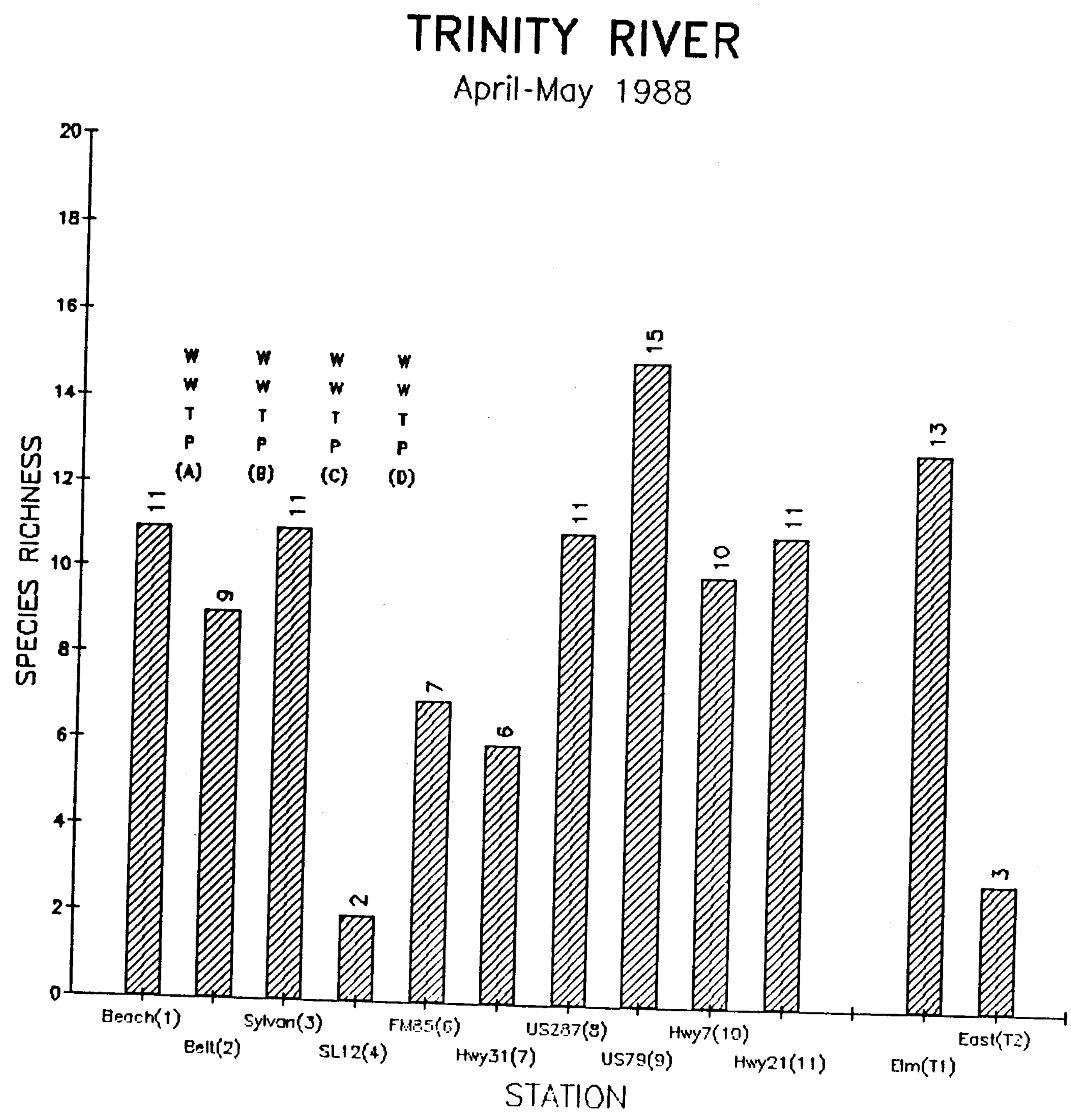

TRINITY RIVER
April-May 1988
SPECIES RICHNESS
20
18
16
14
12
10
8
6
4
2
0
WWTP (A)
WWTP (B)
WWTP (C)
WWTP (D)
11
9
11
2
7
6
11
15
10
11
13
3
Beach(1)
Bell(2)
Sylvan(3)
SL12(4)
FM85(6)
Hwy31(7)
US287(8)
US79(9)
Hwy7(10)
Hwy21(11)
Elm(T1)
East(T2)
STATION

FIGURE 12. Species richness for samples collected in August 1988 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

TRINITY RIVER

August 1988

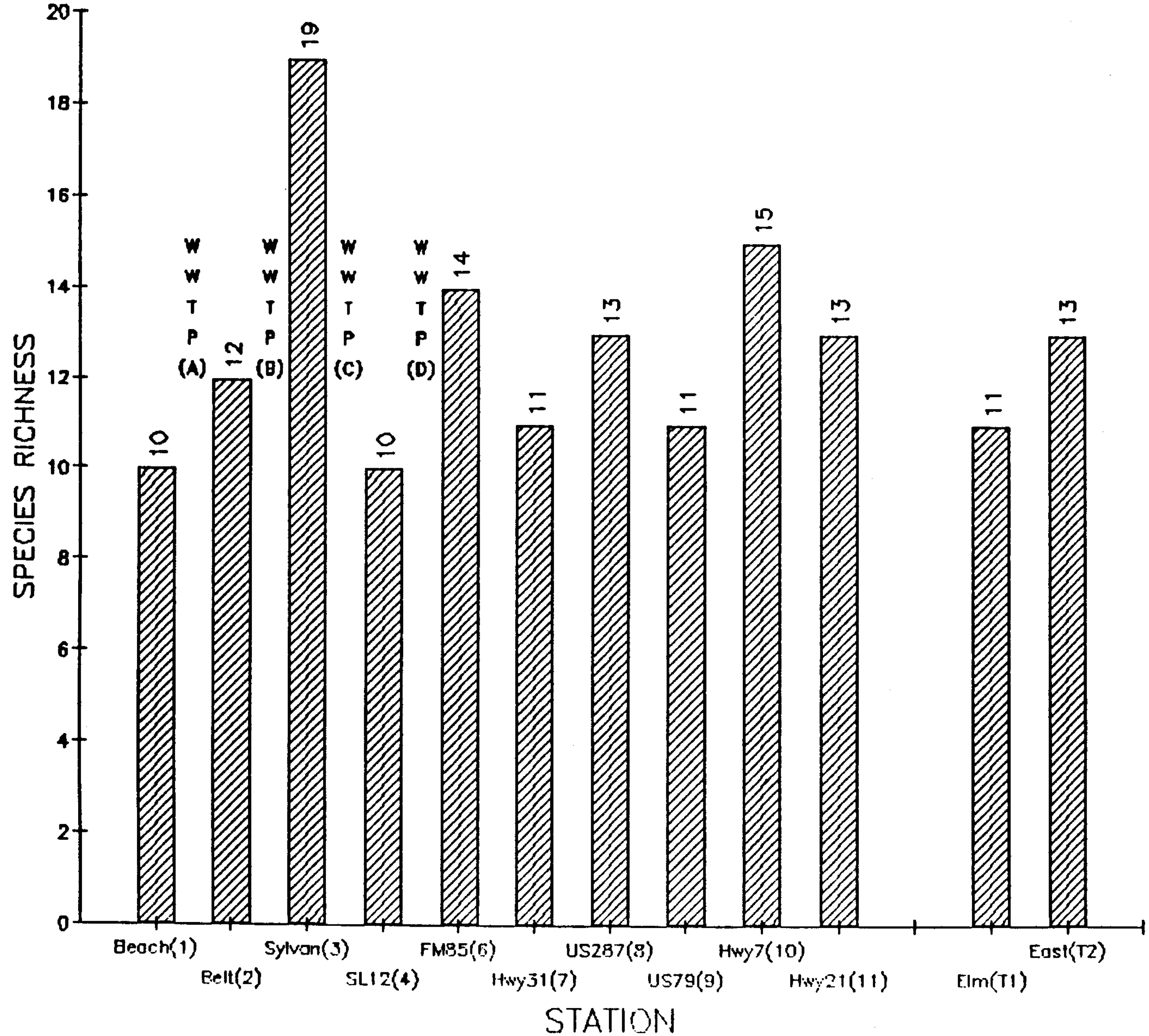


FIGURE 13. Species richness for samples collected in November and December 1988 from the Trinity River and its tributaries. All collecting methods were considered. Relative locations of wastewater discharges are noted.

TRINITY RIVER

November-December 1988

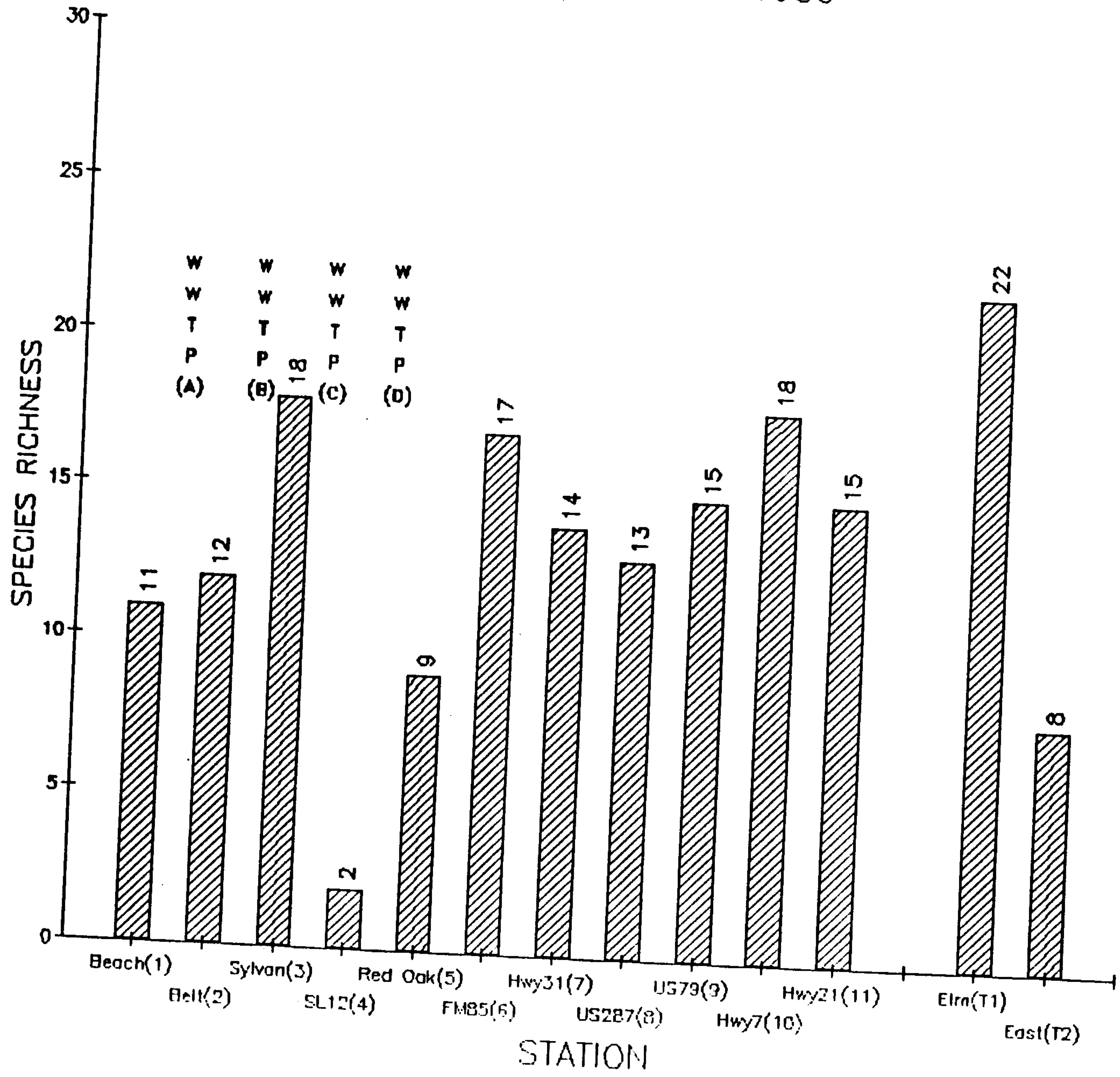
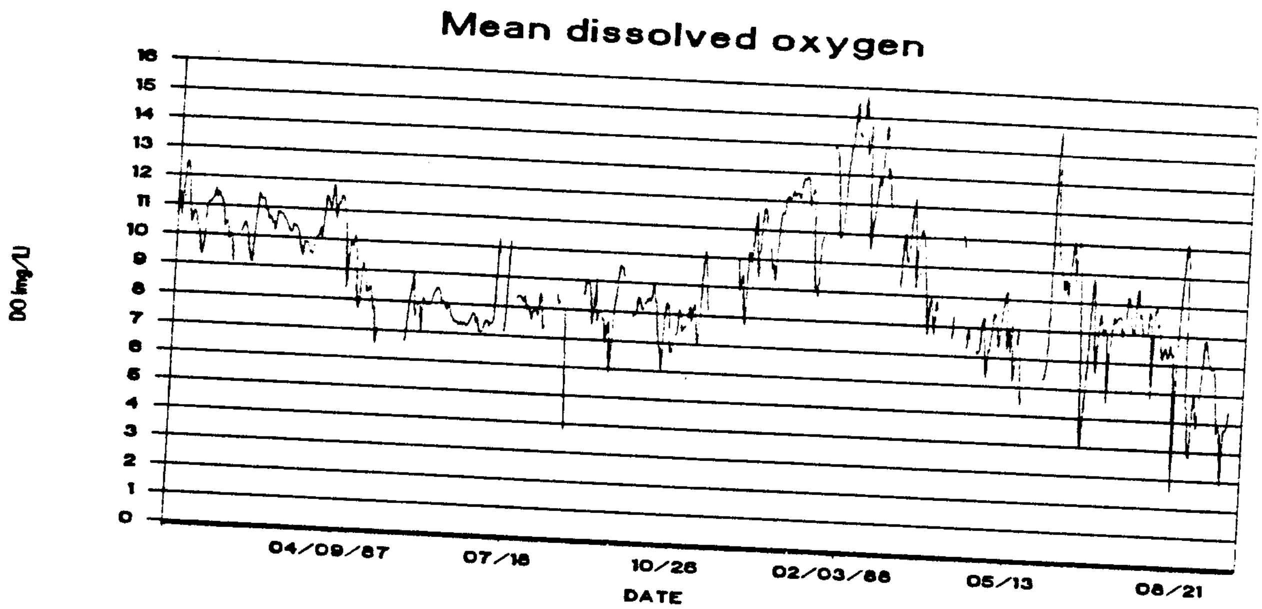
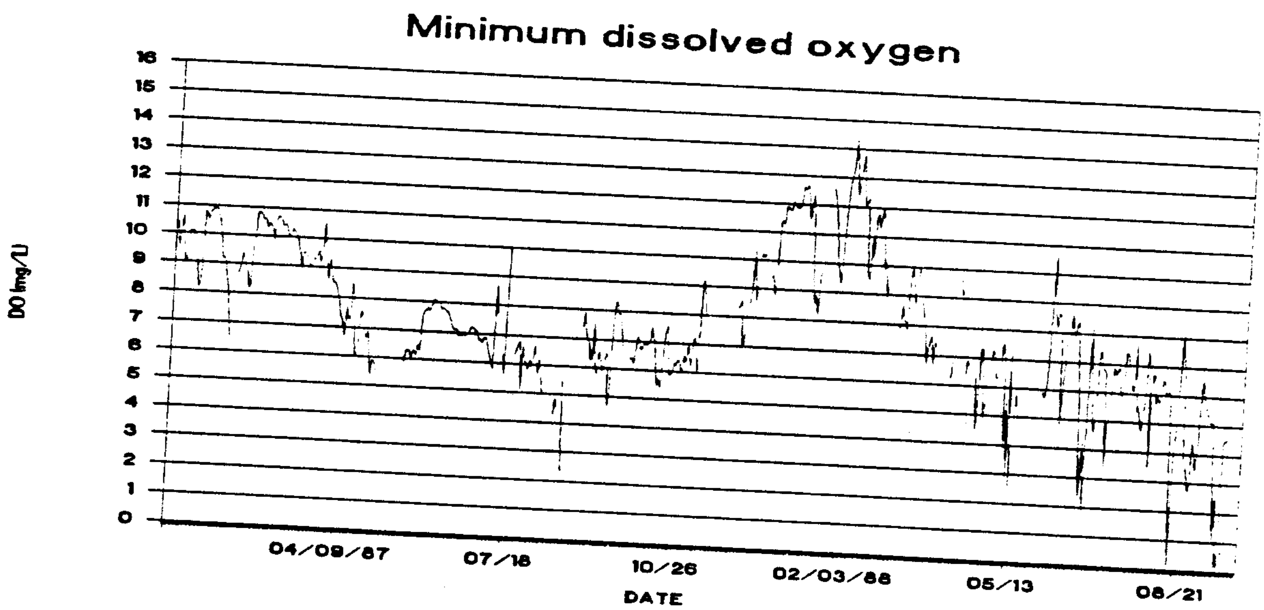


FIGURE 14. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Beach Street (Site 1).


Mean dissolved oxygen
DO (mg/L)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE


Minimum dissolved oxygen
DO (mg/L)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

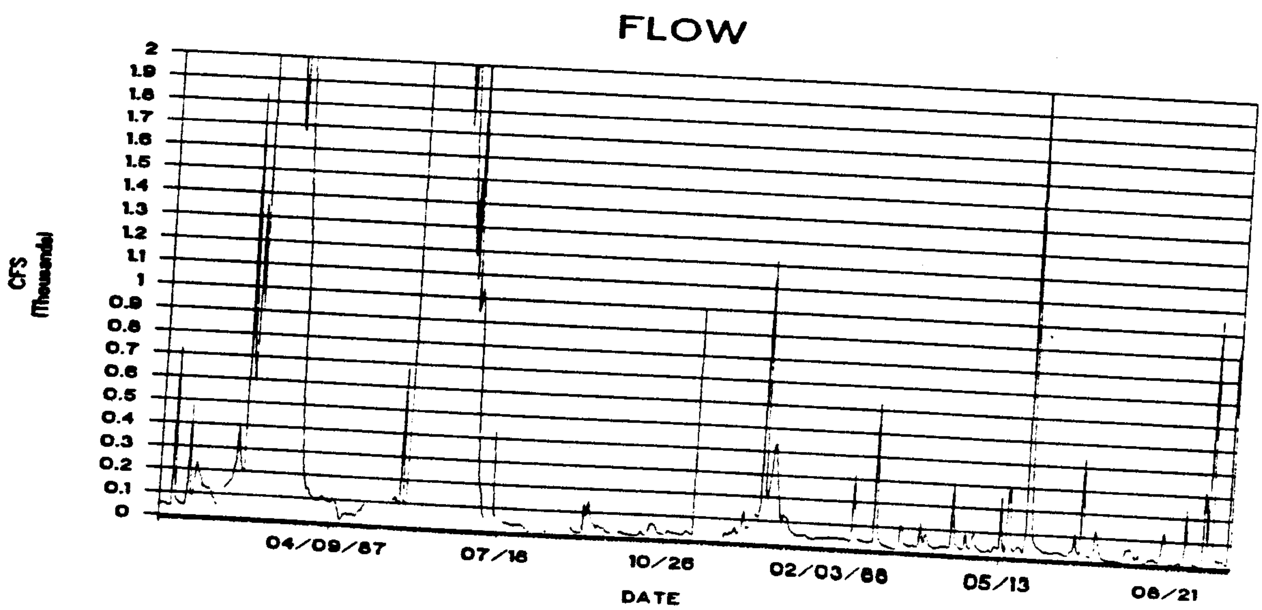
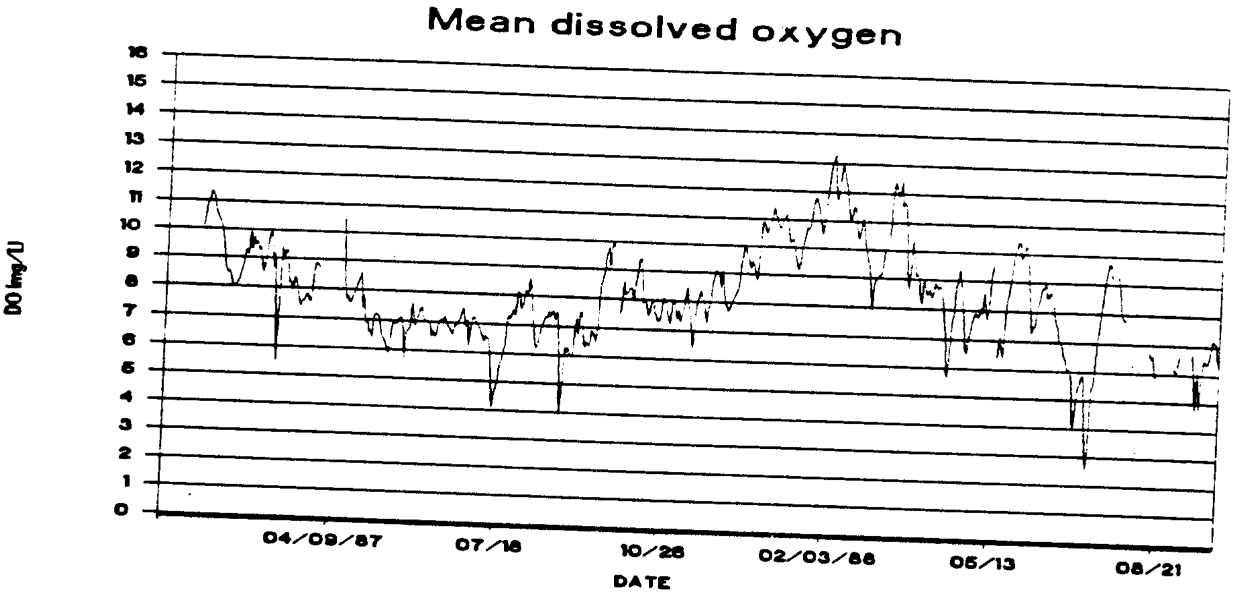
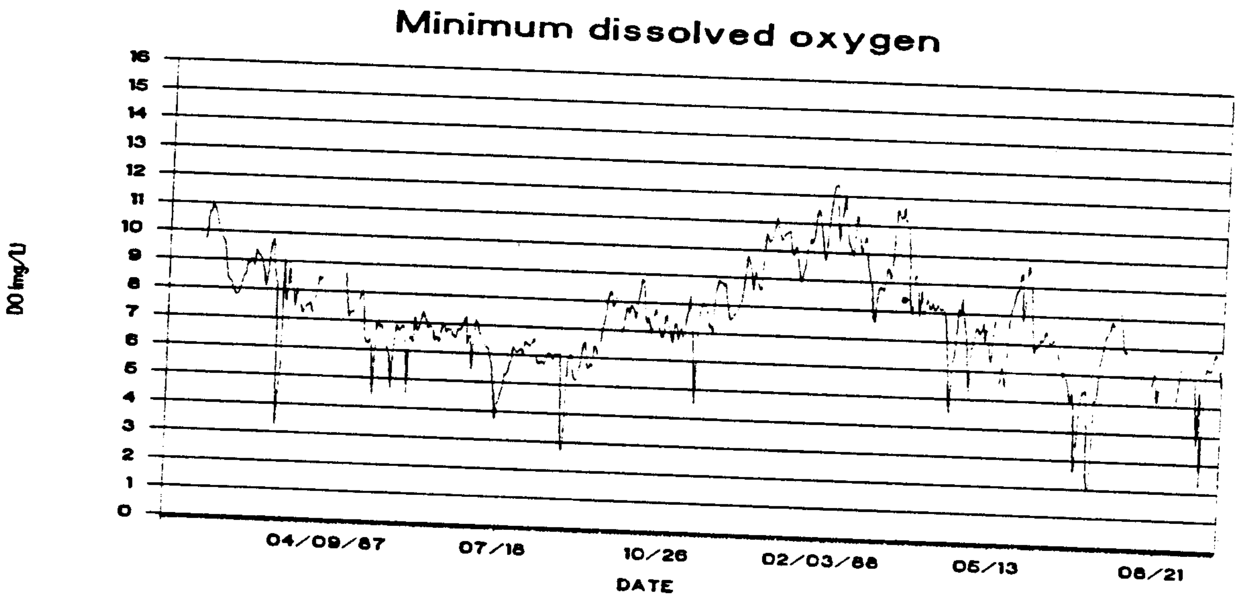

FLOW
CFS (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

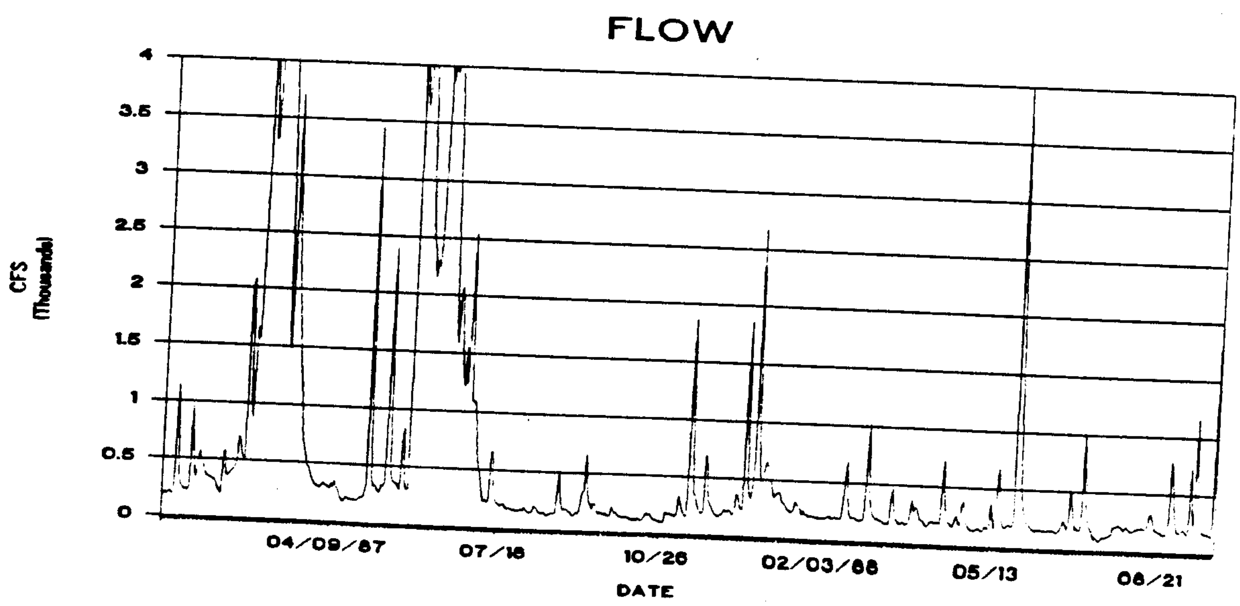
FIGURE 15. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Belt Line Road (Site 2).



Mean dissolved oxygen
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

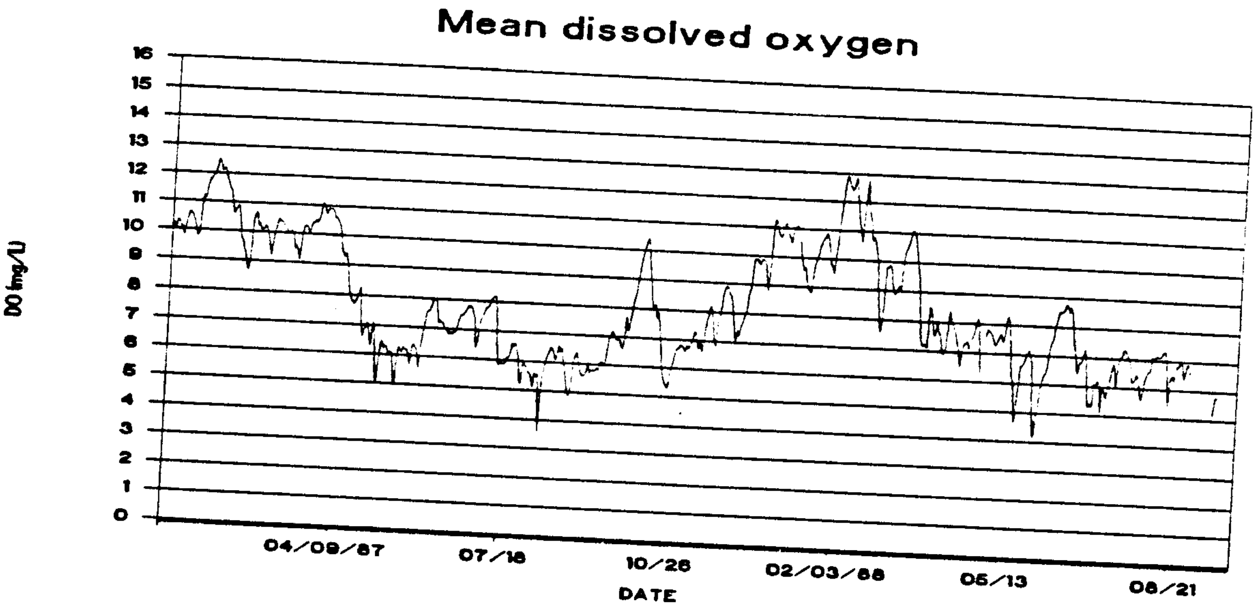


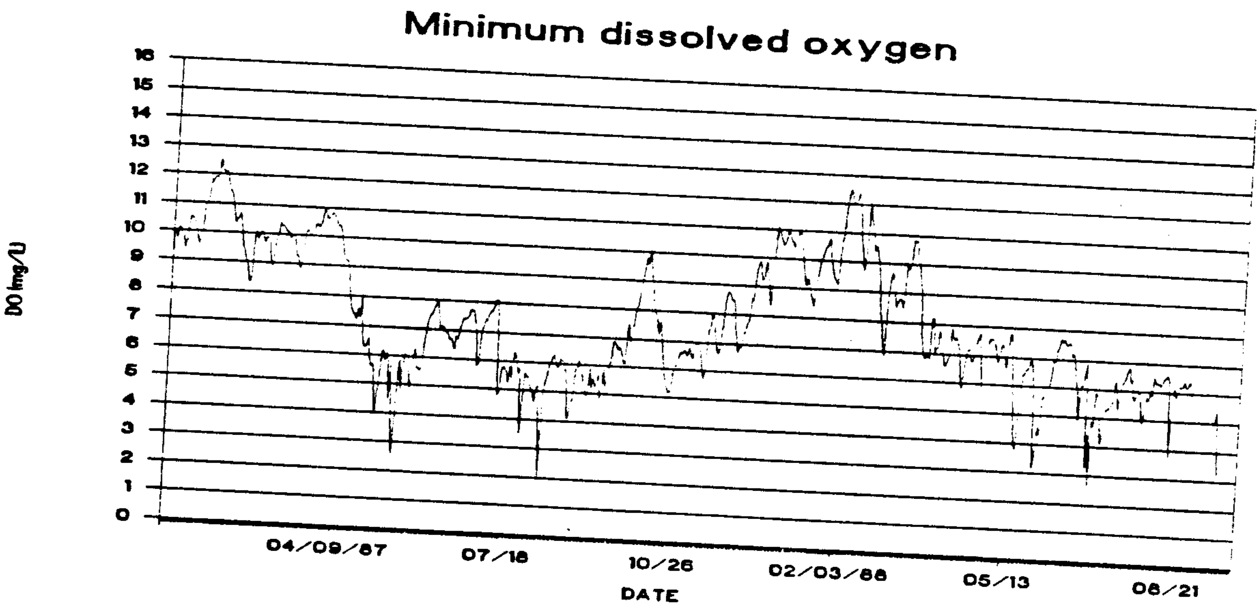
Minimum dissolved oxygen
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE



FLOW
4
3.5
3
2.5
2
1.5
1
0.5
0
CFS (Thousands)
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

FIGURE 16. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Commerce Street and Cedar Crest Blvd. (near Site 3: Sylvan Avenue).


Mean dissolved oxygen
DO (mg/L)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE


Minimum dissolved oxygen
DO (mg/L)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

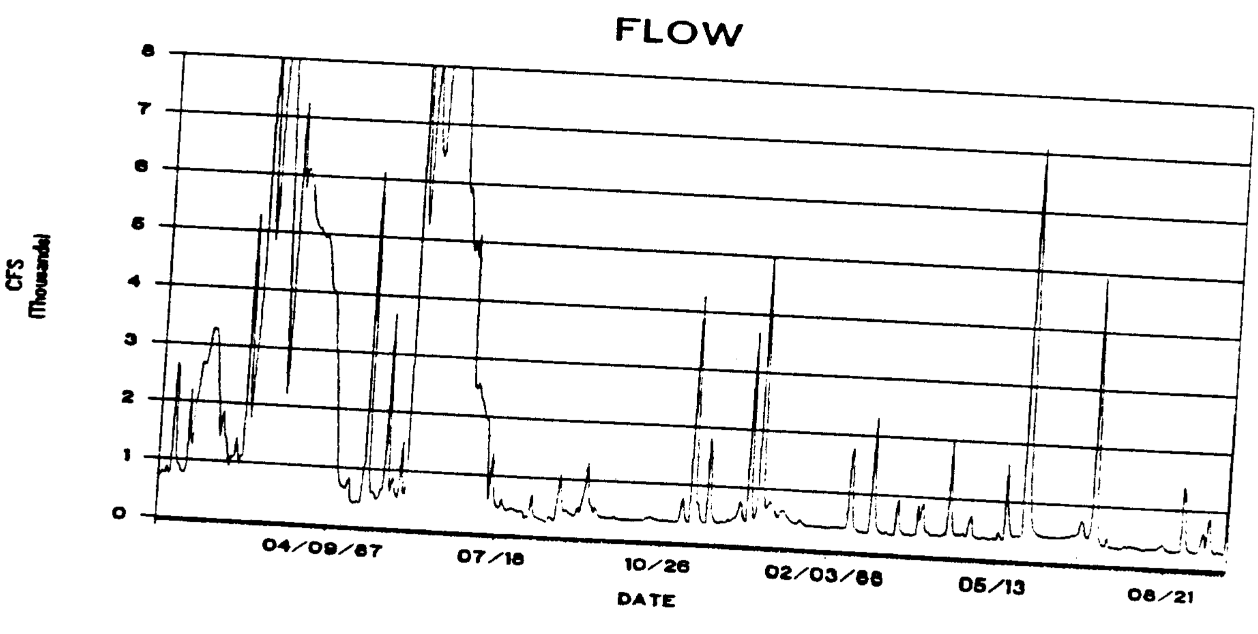
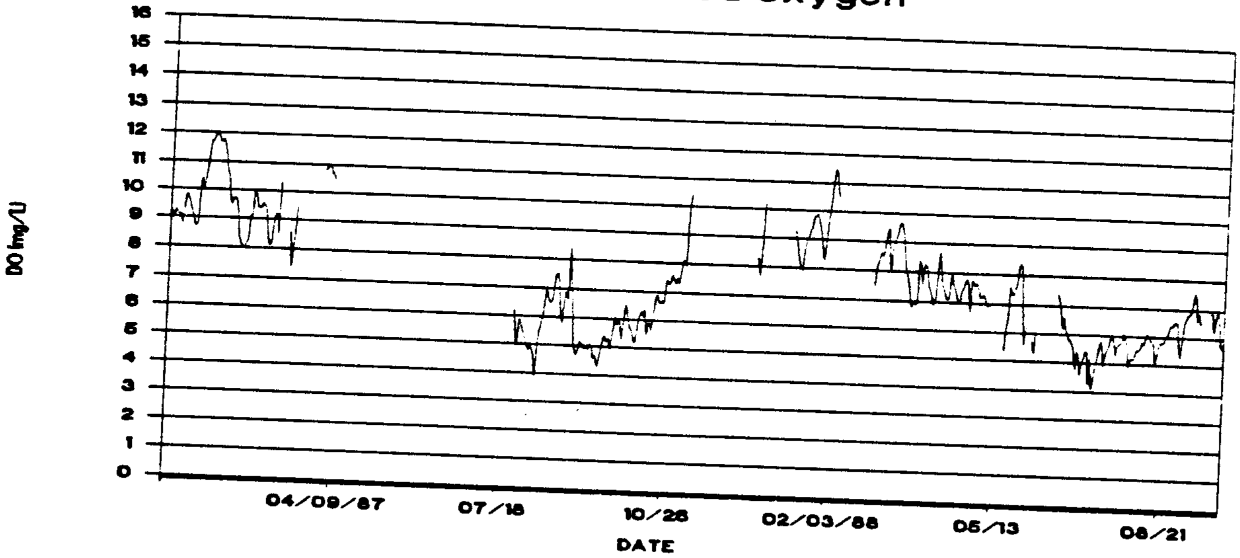
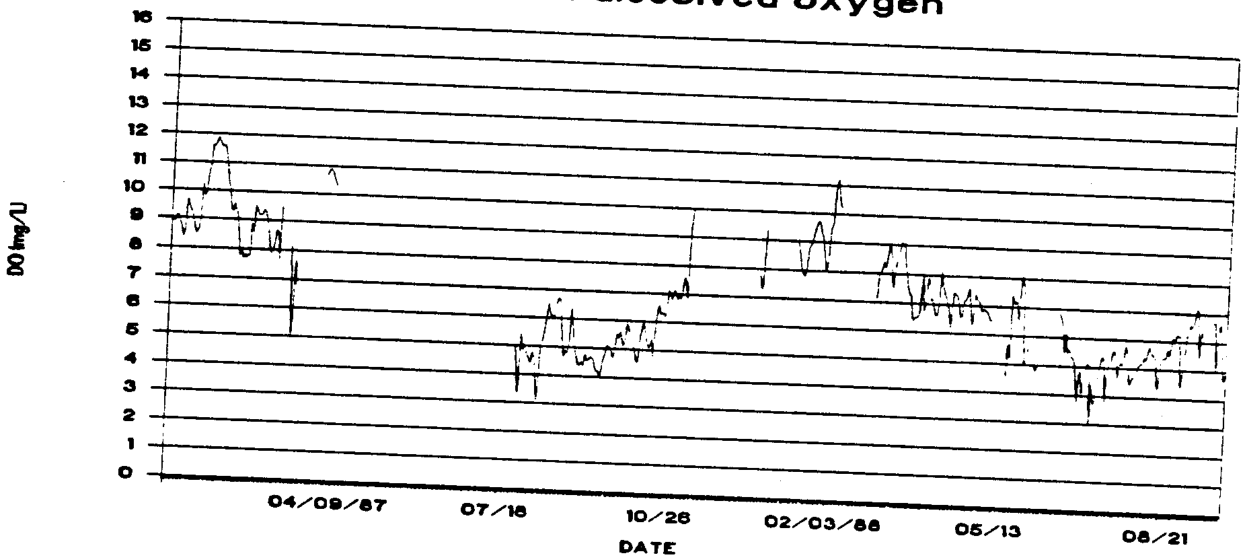

FLOW
CFS
(Thousands)
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

FIGURE 17. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at South Loop 12 (Site 4).

Mean dissolved oxygen



Minimum dissolved oxygen



FLOW

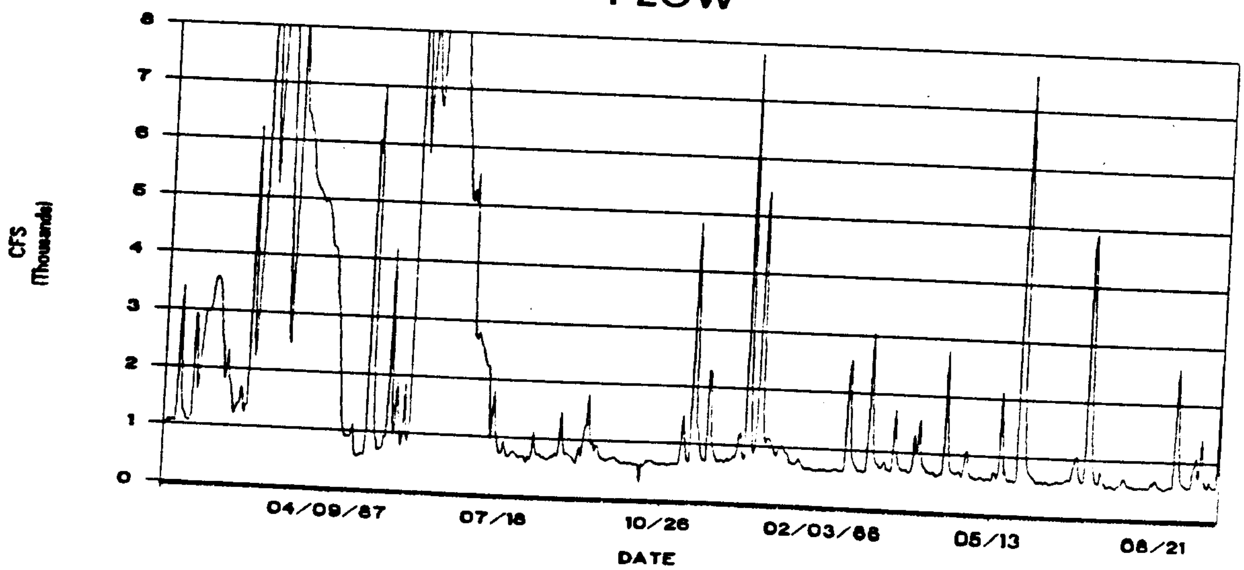
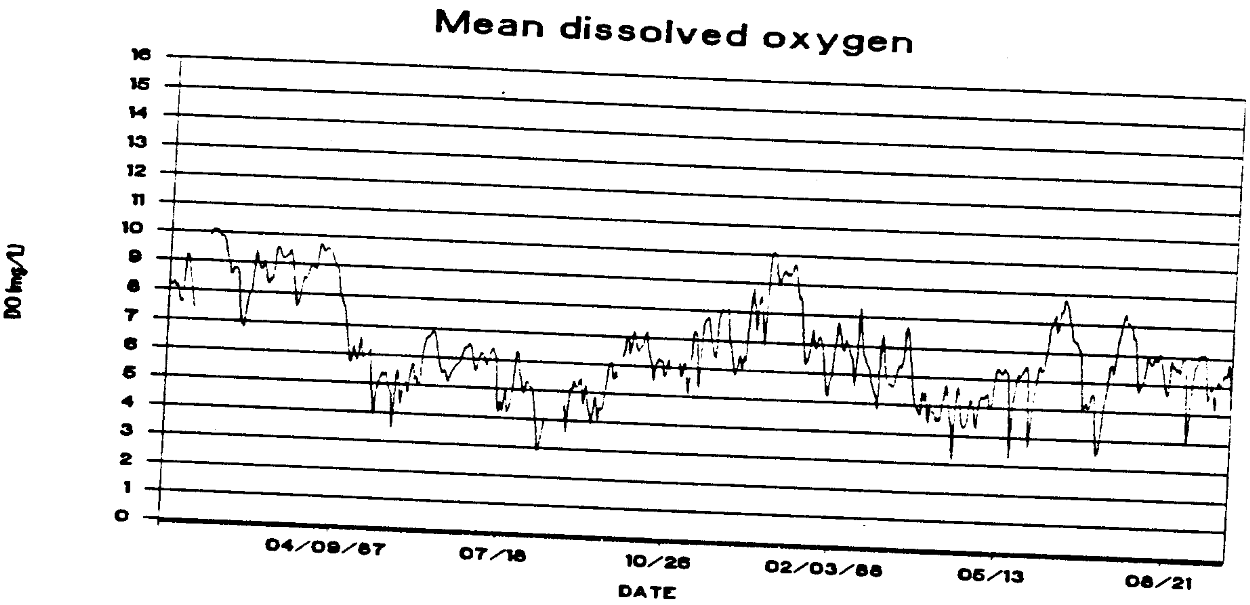
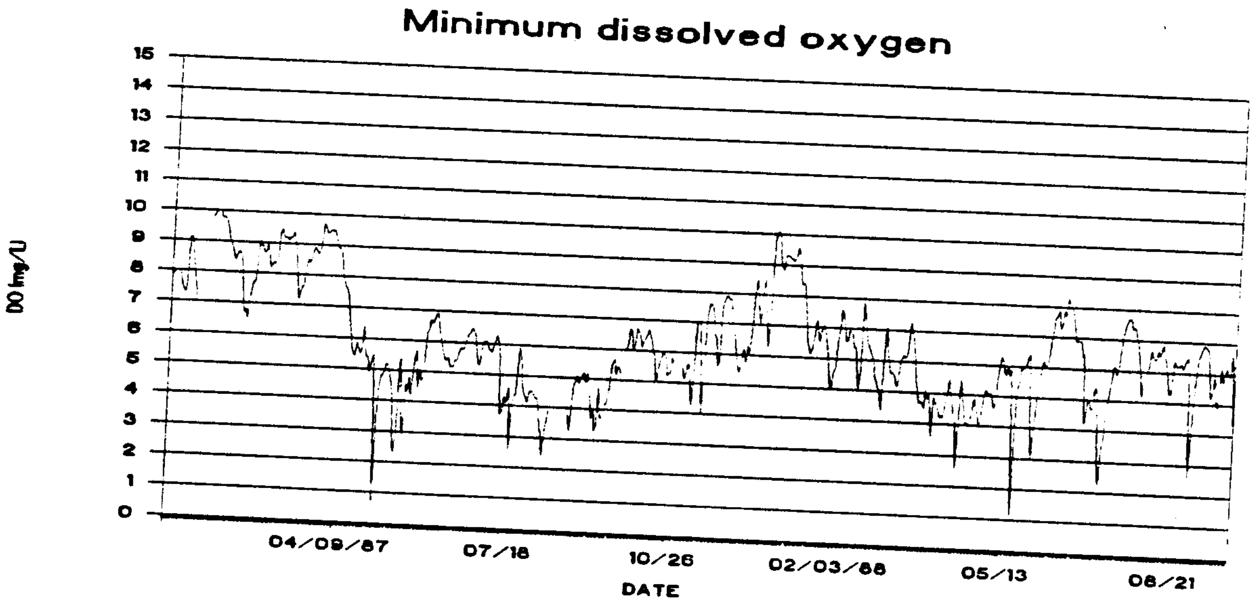


FIGURE 18. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Highway 34 (near Site 5: Red Oak Creek).


Mean dissolved oxygen
DO (mg/L)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE


Minimum dissolved oxygen
DO (mg/L)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

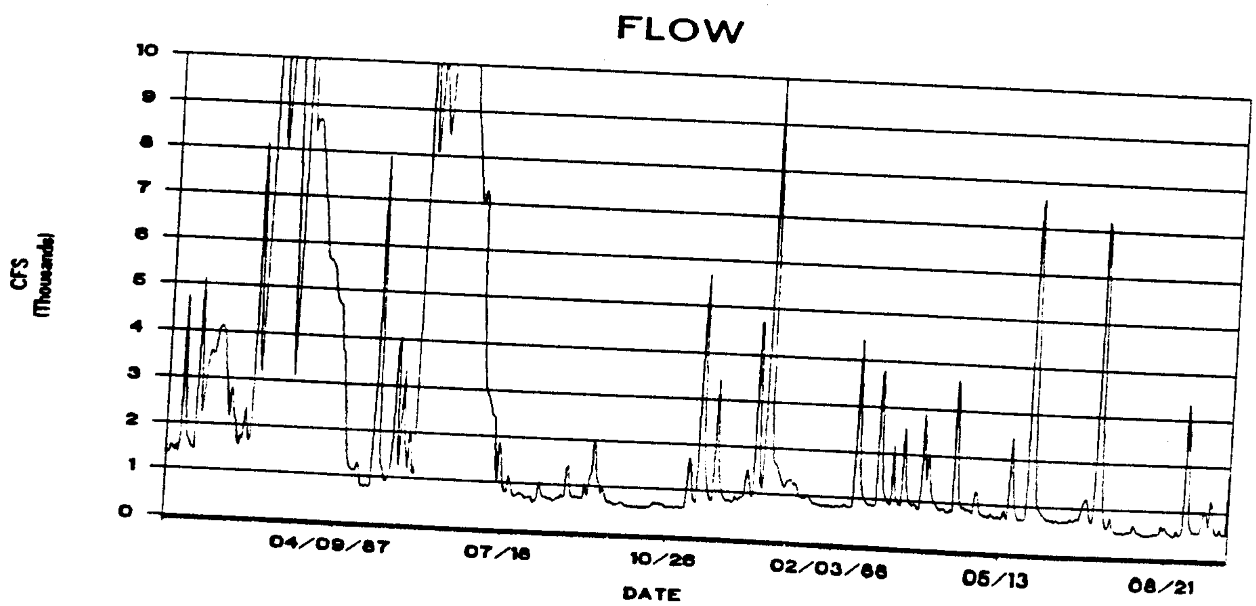
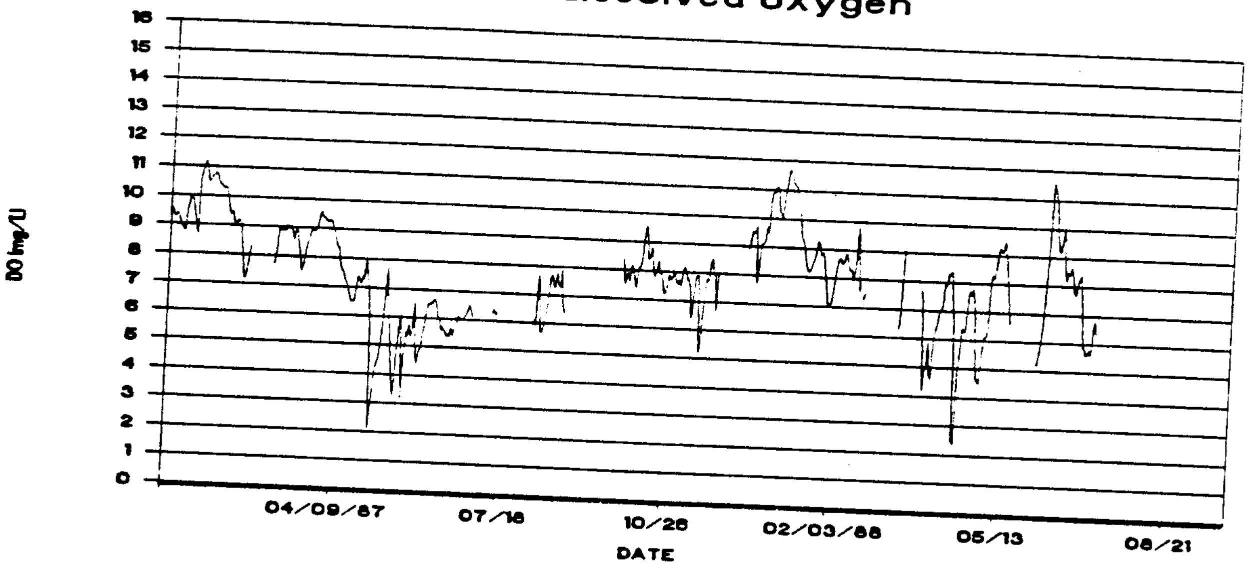
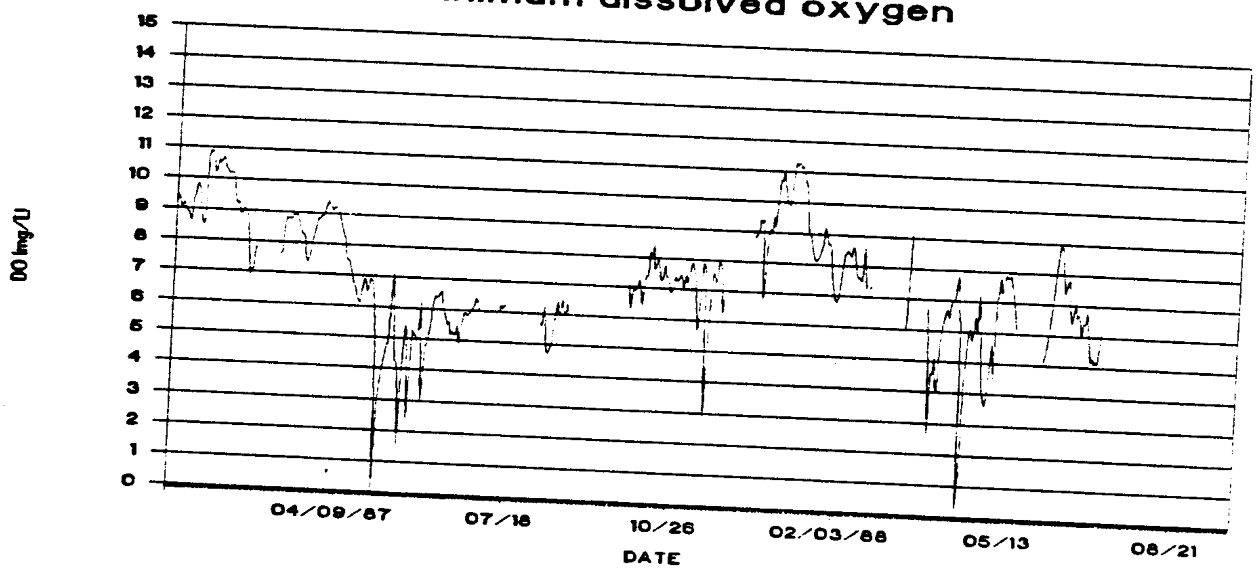

FLOW
CFS
(Thousands)
10
9
8
7
6
5
4
3
2
1
0
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

FIGURE 19. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Highway 31 (Site 7).

Mean dissolved oxygen



Minimum dissolved oxygen



FLOW

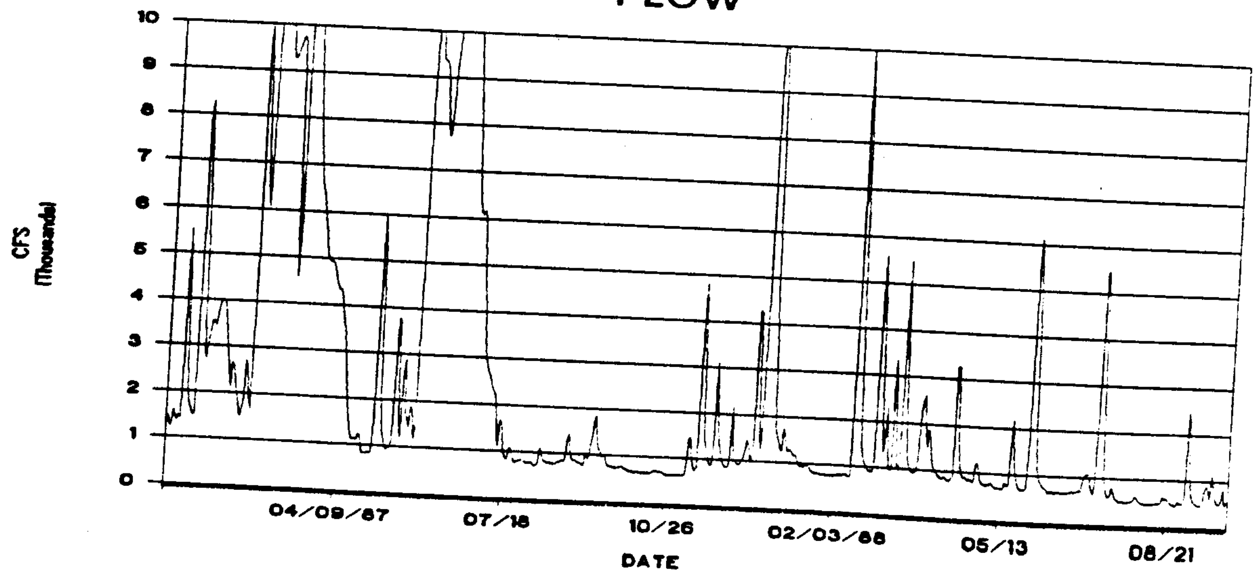
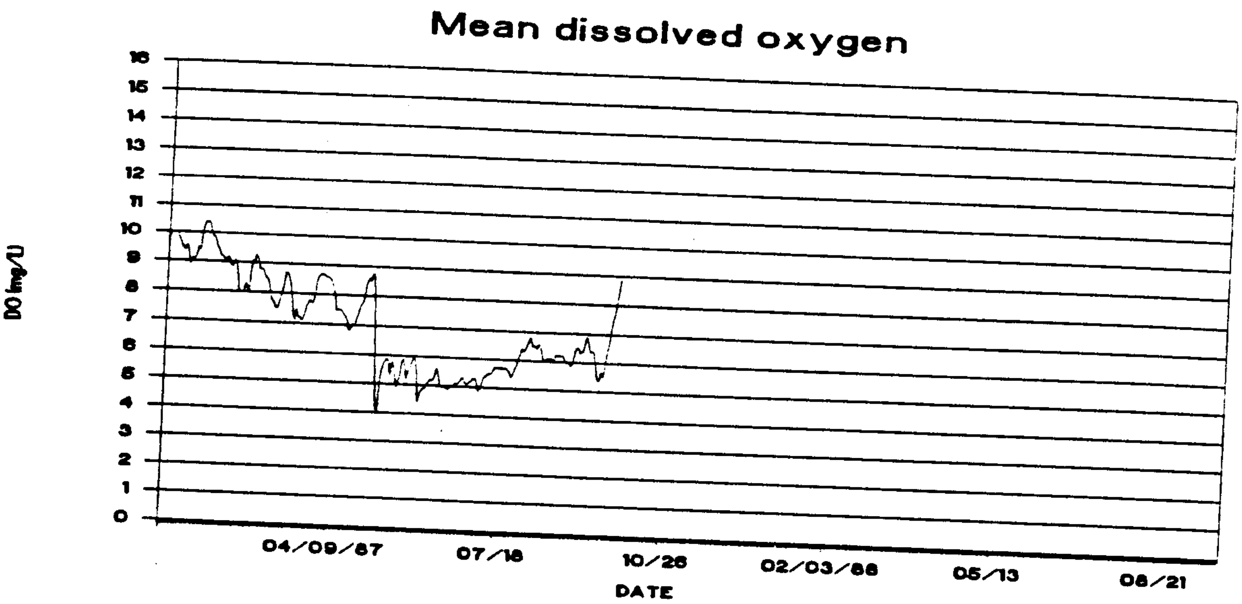
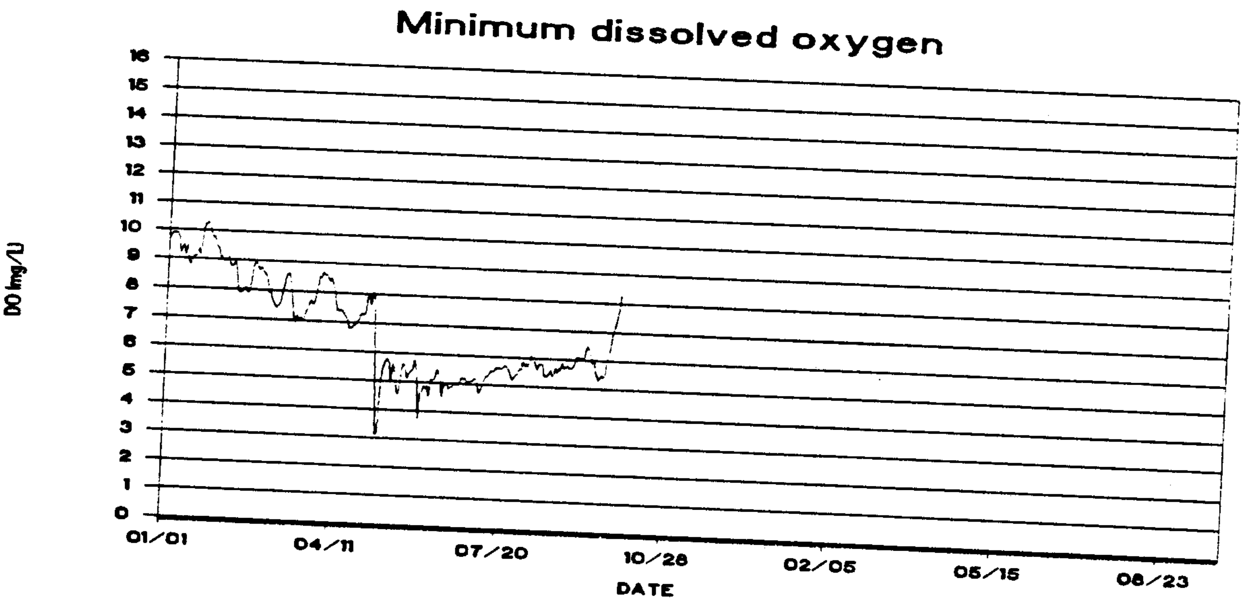


FIGURE 20. Daily mean and minimum dissolved oxygen and daily mean flow from a USGS continuous automated monitoring site on the Trinity River at Highway 7 (Site 10).


Mean dissolved oxygen
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE


Minimum dissolved oxygen
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
01/01
04/11
07/20
10/28
02/05
05/15
08/23
DATE

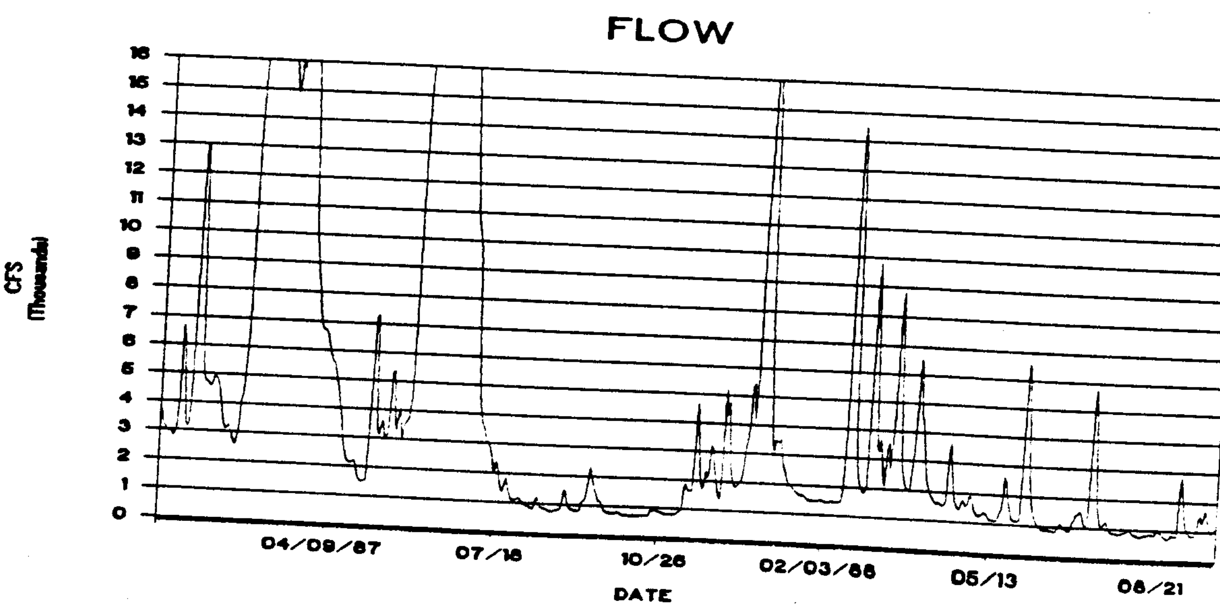
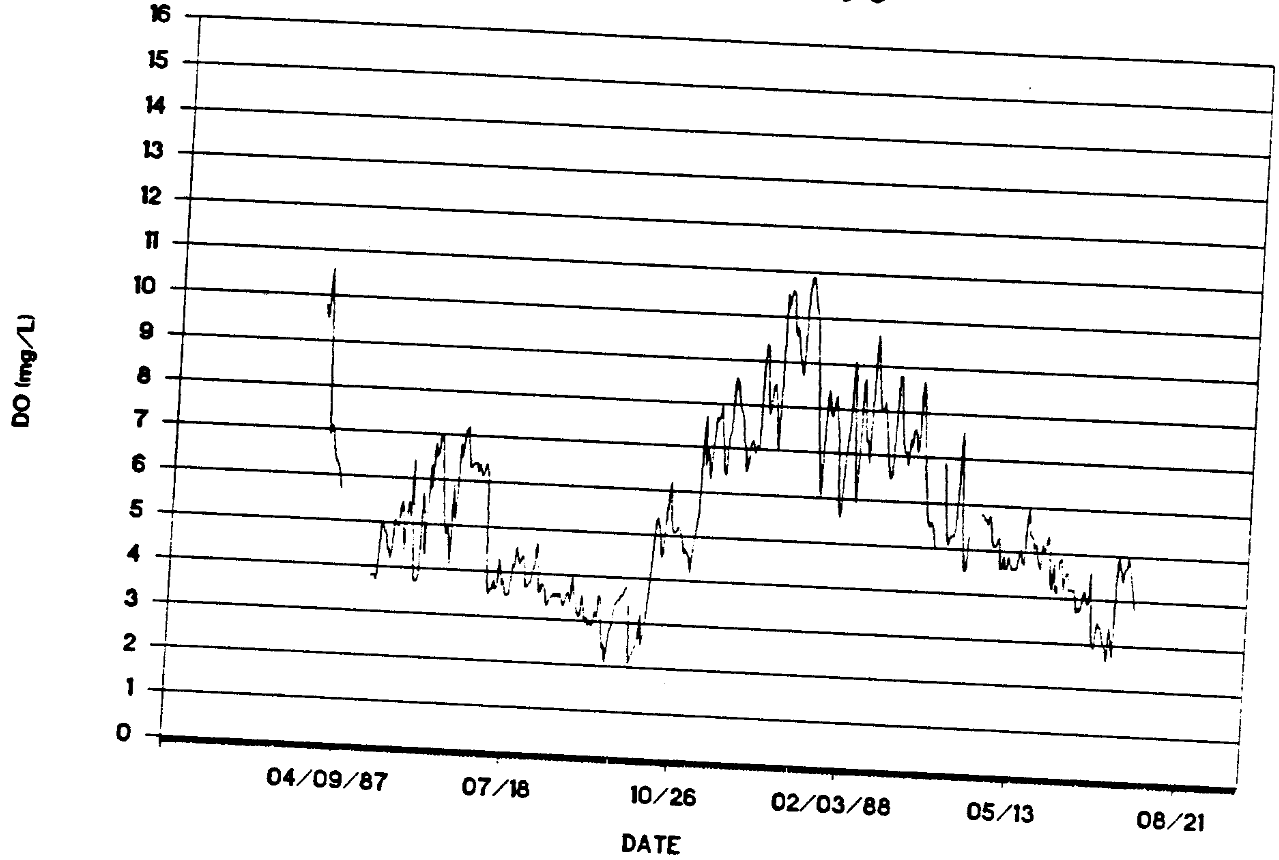

FLOW
CFS (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
04/09/87
07/18
10/26
02/03/88
05/13
08/21
DATE

FIGURE 21. Daily mean and minimum dissolved oxygen and from a USGS continuous automated monitoring site on the East Fork Trinity River at Malloy Bridge Road (Site T2).

Mean dissolved oxygen



Minimum dissolved oxygen

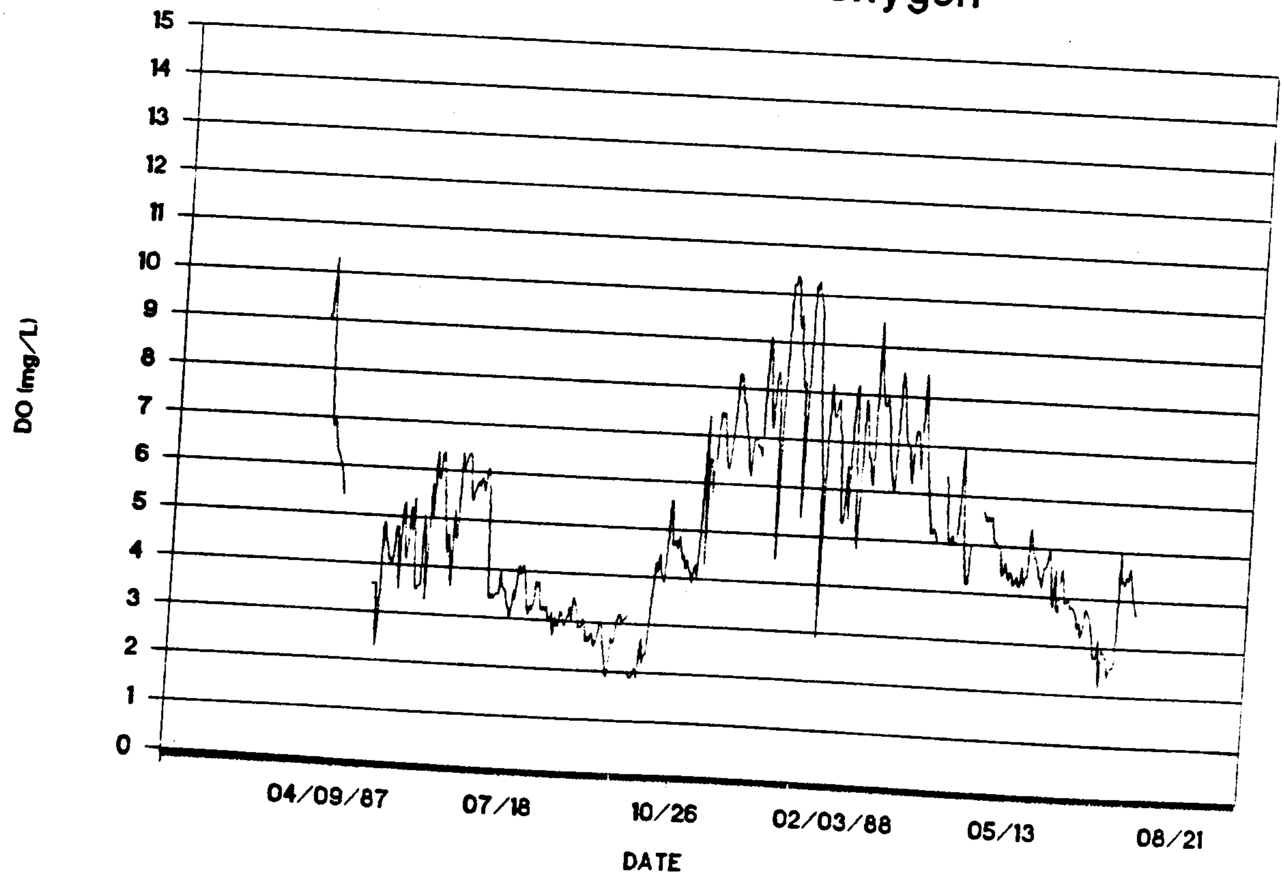
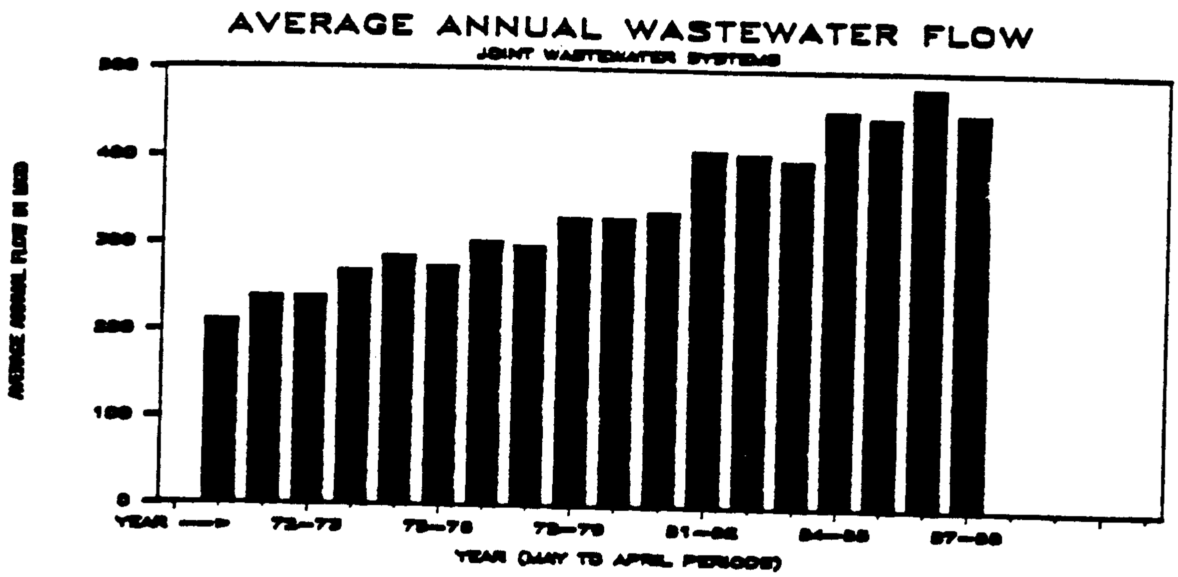
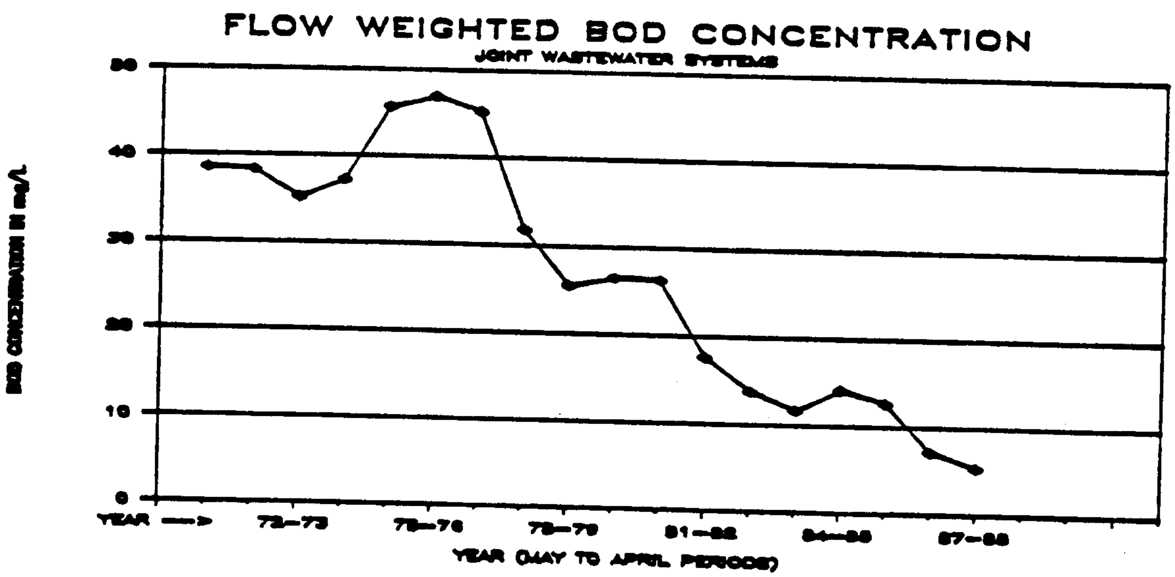


FIGURE 22. BOD and flow loading from major dischargers into the Trinity River and its tributaries (North Central Texas Council of Governments 1988).


AVERAGE ANNUAL WASTEWATER FLOW
JOINT WASTEWATER SYSTEMS
YEAR (MAY TO APRIL PERIODS)


FLOW WEIGHTED BOD CONCENTRATION
JOINT WASTEWATER SYSTEMS
YEAR (MAY TO APRIL PERIODS)

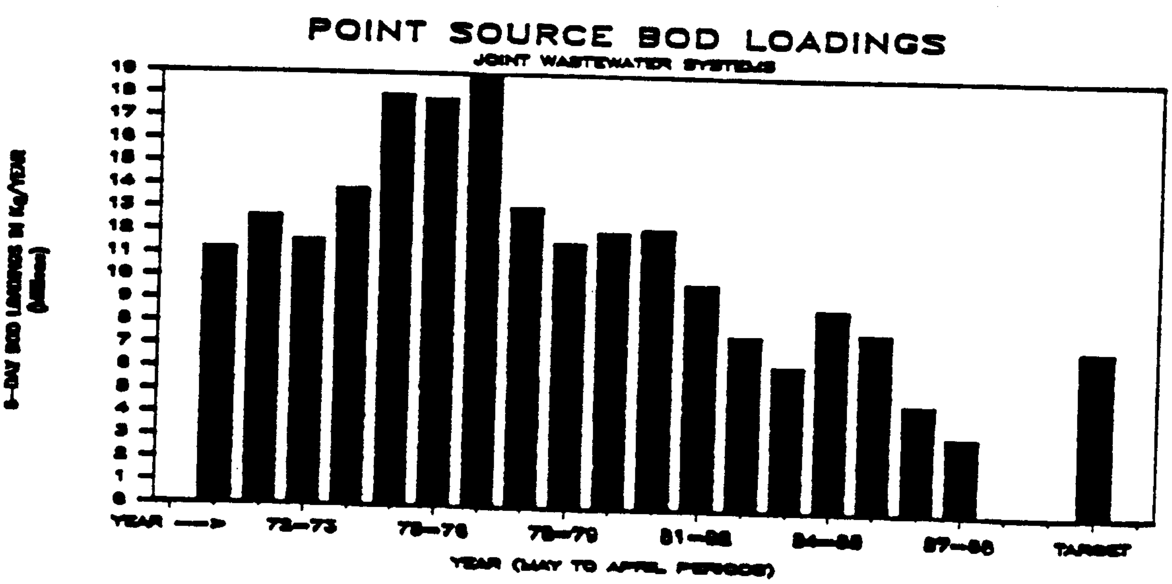

POINT SOURCE BOD LOADINGS
JOINT WASTEWATER SYSTEMS
TARGET
YEAR (MAY TO APRIL PERIODS)

FIGURE 23. In-stream mean ammonia nitrogen concentrations and the percentage of values exceeding chronic guidelines for 1987 and 1988. Data is from the TWC stream monitoring network. Mean species richness values are from this study and include all collecting methods.

TRINITY RIVER

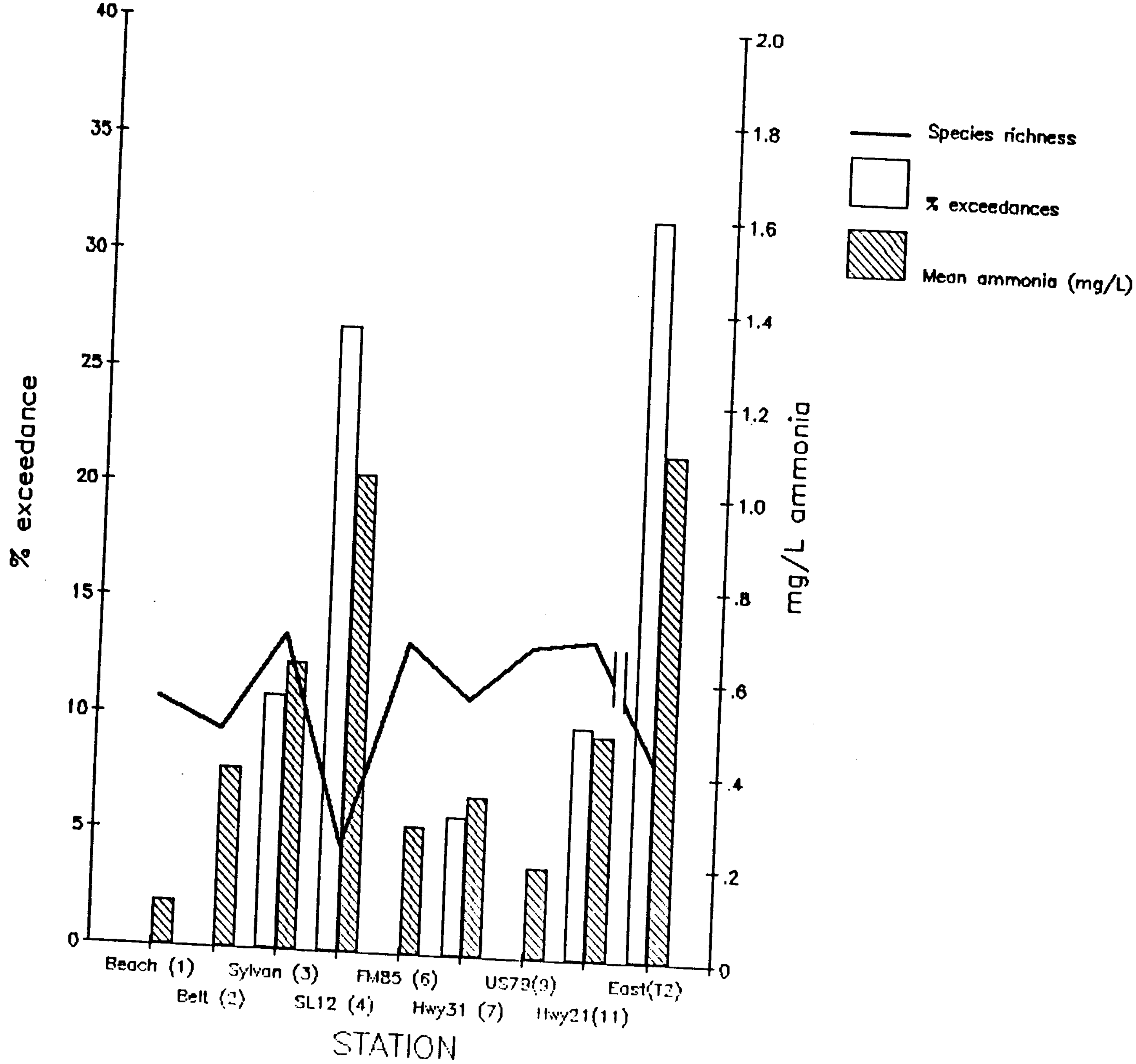


FIGURE 24. Monthly mean and maximum effluent ammonia nitrogen from the Village Creek Wastewater Treatment Plant (Site A).

FORT WORTH VILLAGE CREEK PLANT

Effluent ammonia concentration

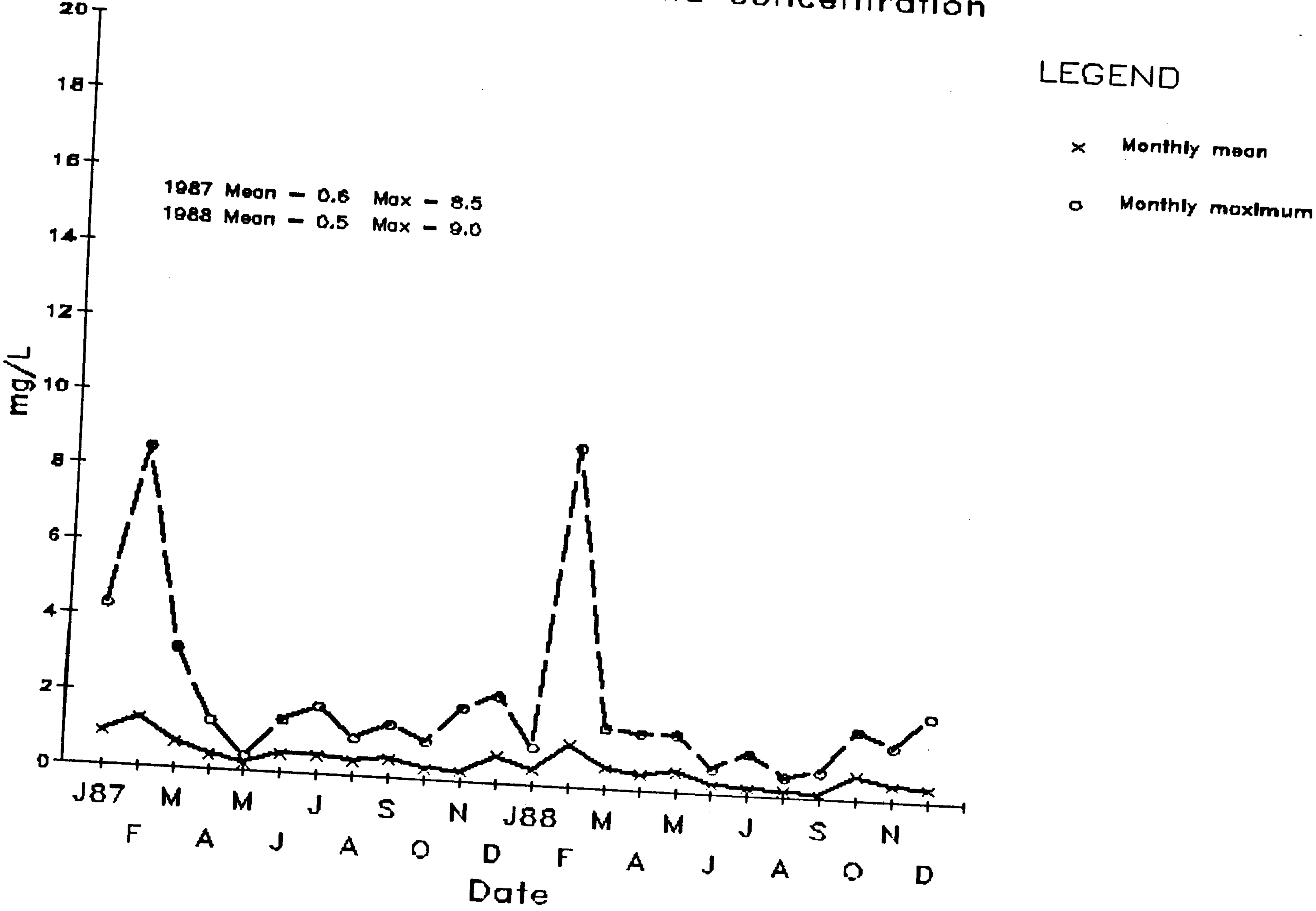


FIGURE 25. Monthly mean and maximum effluent ammonia nitrogen from the Trinity River Authority Central Wastewater Treatment Plant (Site B).

TRA CENTRAL PLANT

Effluent ammonia concentration

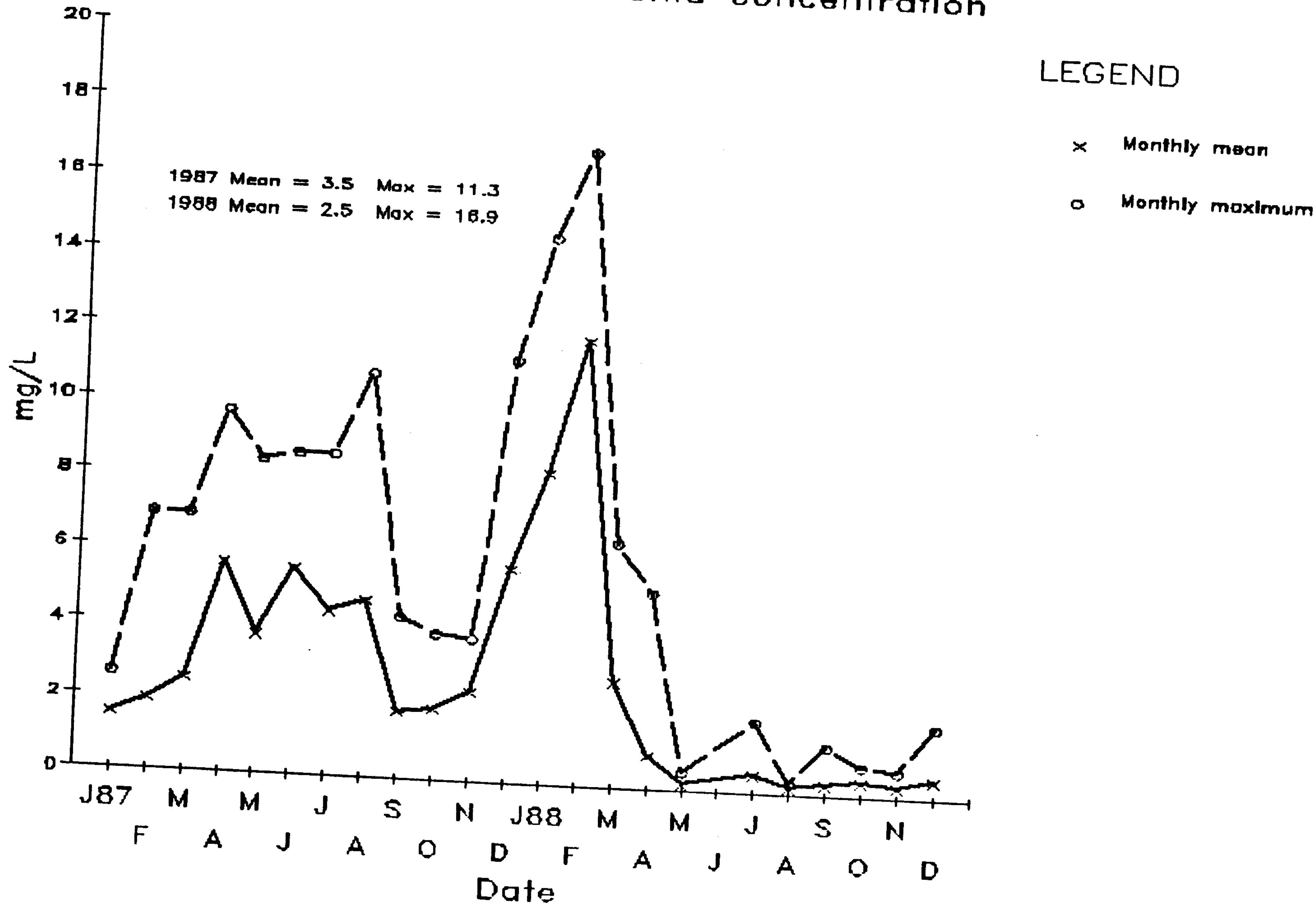


FIGURE 26. Monthly mean and maximum effluent ammonia nitrogen from the Dallas Central Wastewater Treatment Plant (Site C).

DALLAS CENTRAL PLANT

Effluent ammonia concentration

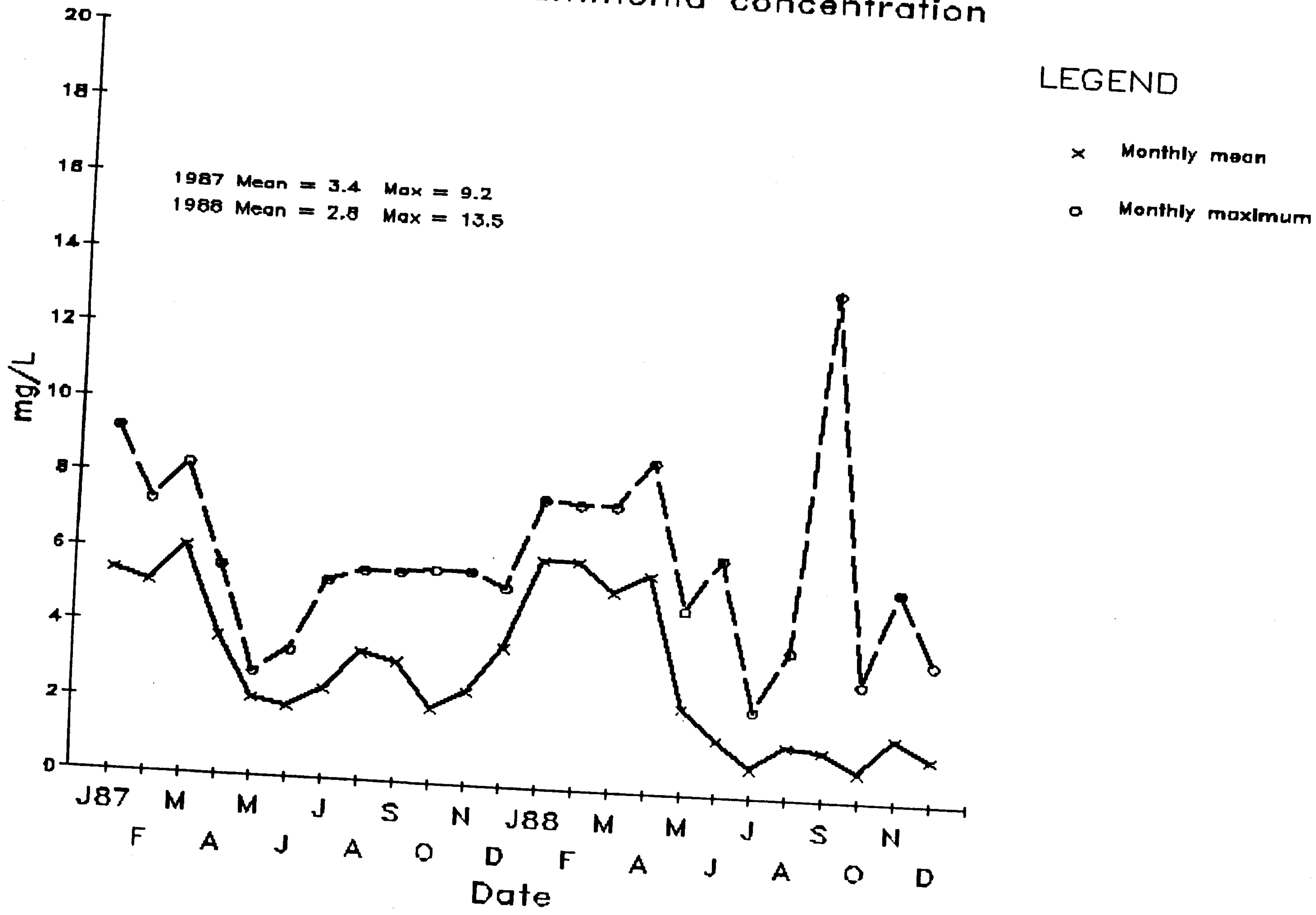


FIGURE 27. Monthly mean and maximum effluent ammonia nitrogen from the Dallas Southside Wastewater Treatment Plant (Site D).

DALLAS SOUTHSIDE PLANT

Effluent ammonia concentration

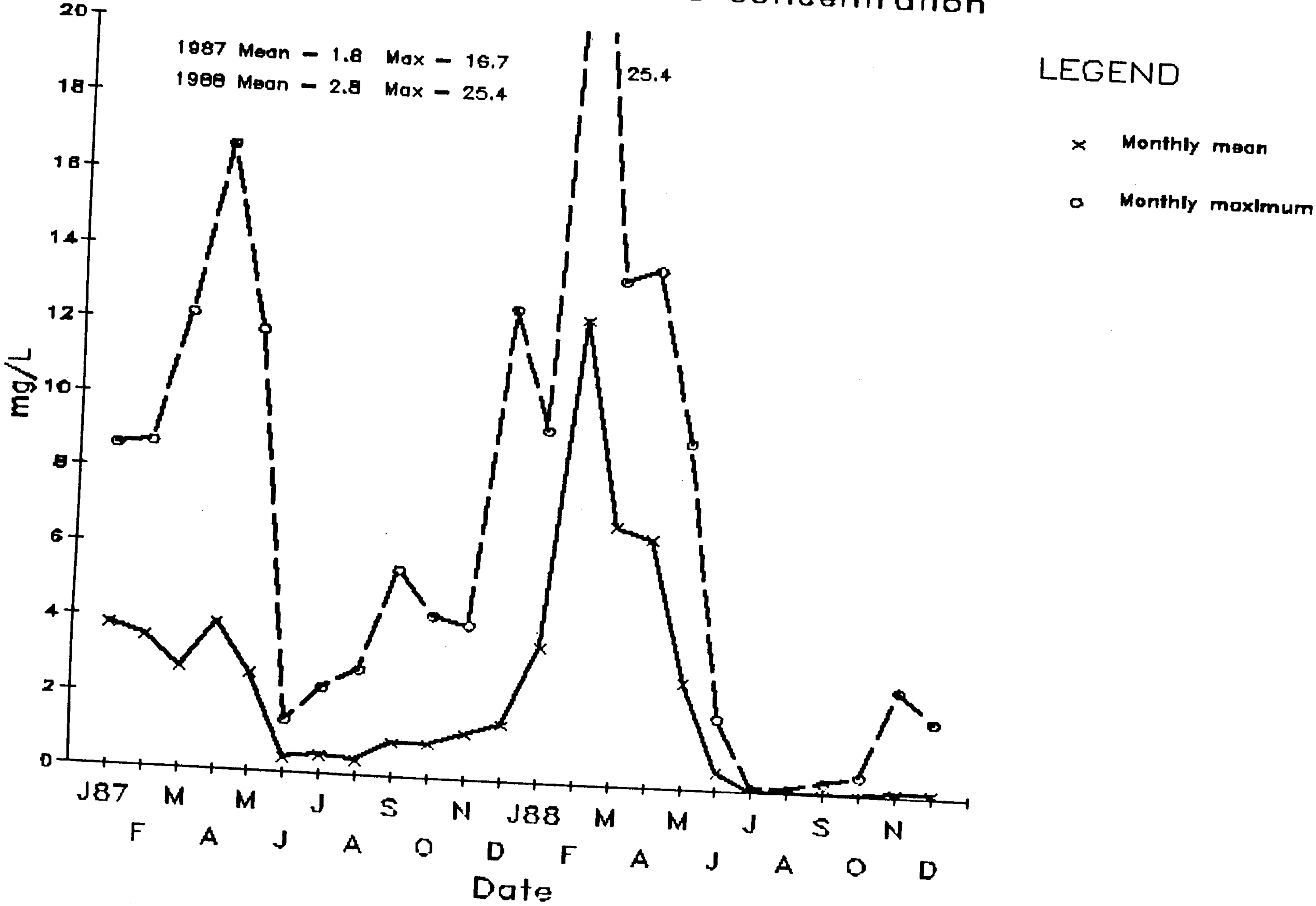


FIGURE 28. Monthly mean and maximum effluent total residual chlorine concentrations in the Village Creek Wastewater Treatment Plant (Site A) effluent.

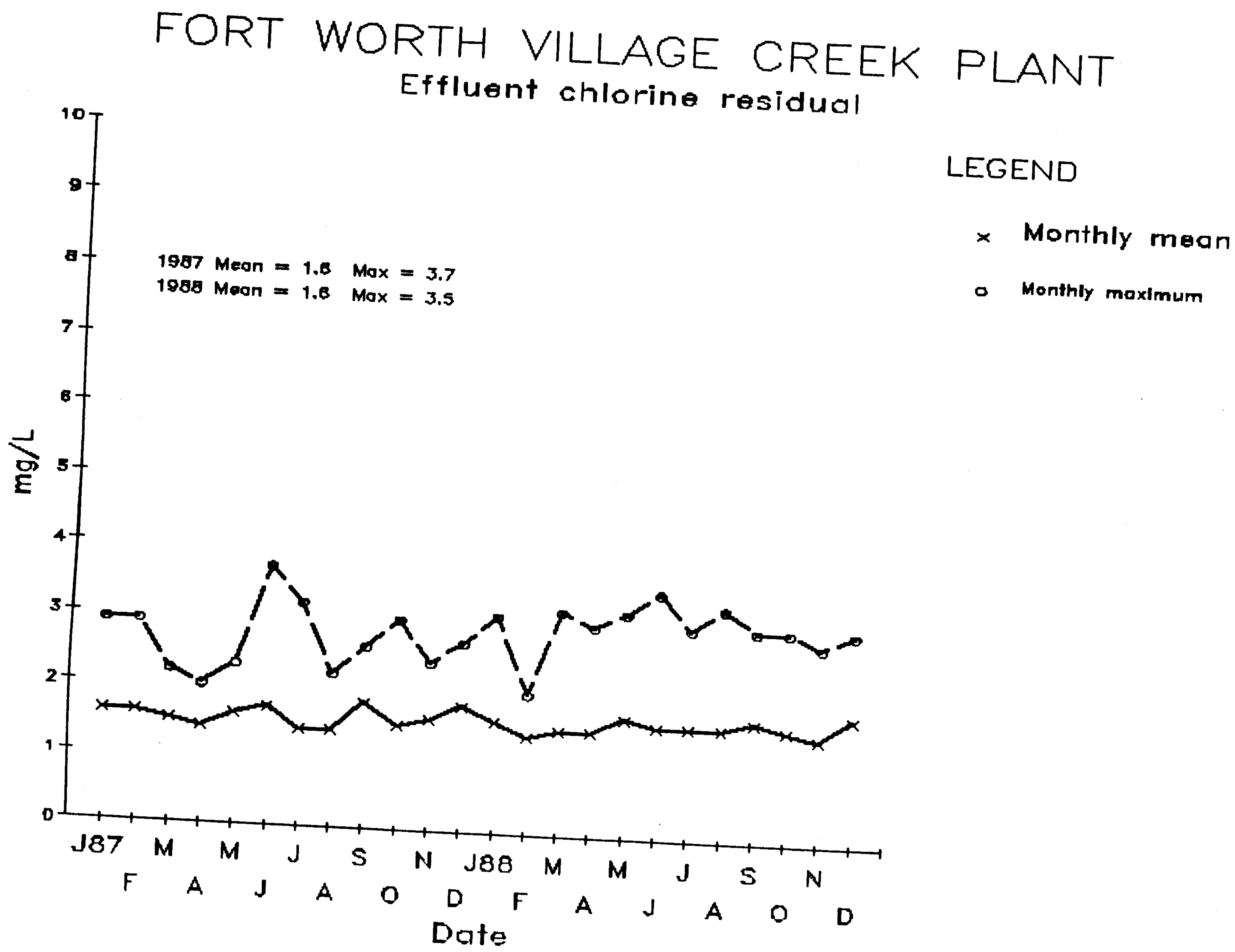

FORT WORTH VILLAGE CREEK PLANT
Effluent chlorine residual
LEGEND
× Monthly mean
o Monthly maximum
1987 Mean = 1.6 Max = 3.7
1988 Mean = 1.6 Max = 3.5
mg/L
0
1
2
3
4
5
6
7
8
9
10
J87
F
M
A
M
J
J
A
S
O
N
D
J88
F
M
A
M
J
J
A
S
O
N
D
Date

FIGURE 29. Monthly mean and maximum effluent total residual chlorine concentrations in the Trinity River Central Wastewater Treatment Plant (Site B) effluent.

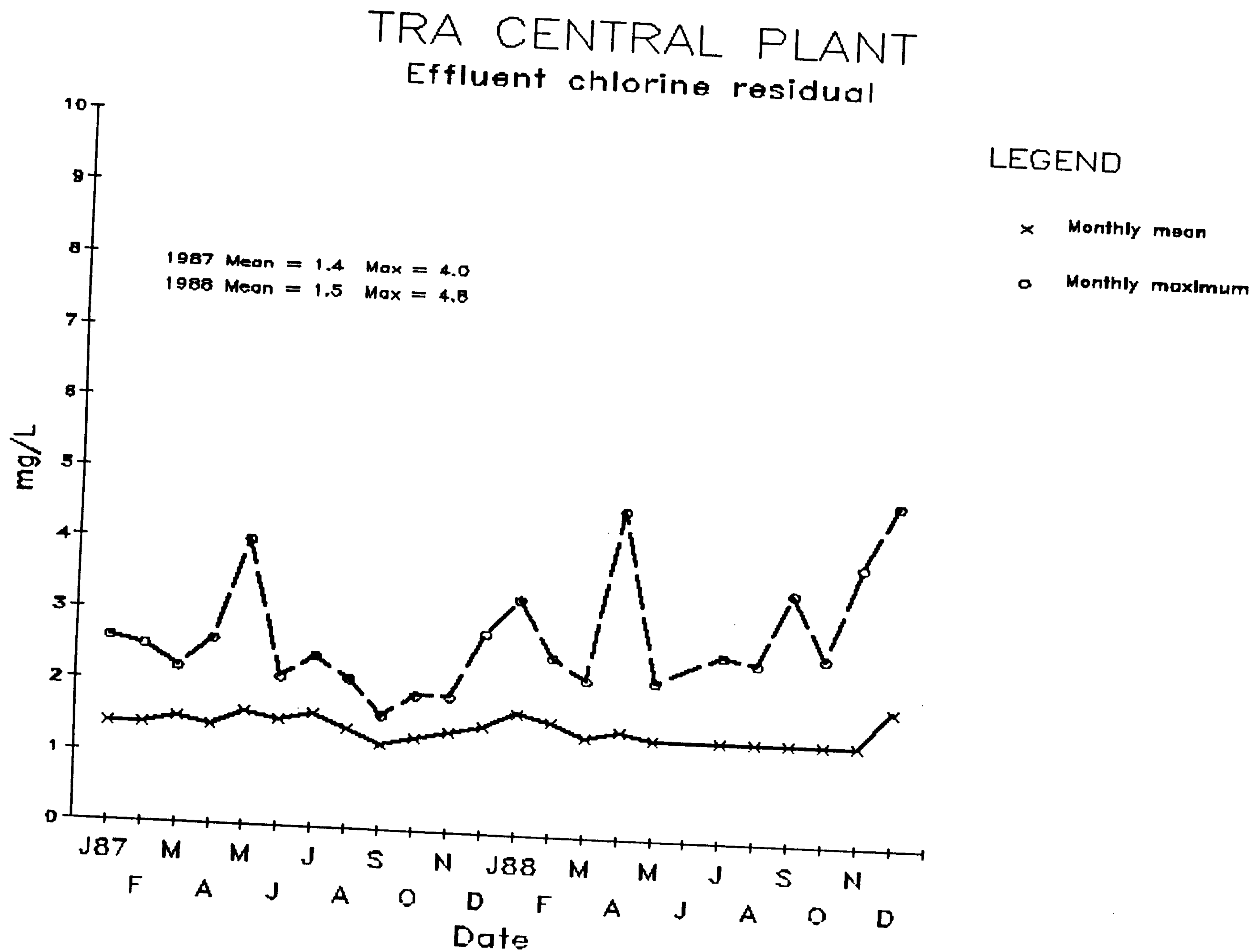

TRA CENTRAL PLANT
Effluent chlorine residual
1987 Mean = 1.4 Max = 4.0
1988 Mean = 1.5 Max = 4.8
LEGEND
× Monthly mean
o Monthly maximum
mg/L
0
1
2
3
4
5
6
7
8
9
10
J87
F
M
A
M
J
J
A
S
O
N
D
J88
F
M
A
M
J
J
A
S
O
N
D
Date

FIGURE 30. Monthly mean and maximum effluent total residual chlorine concentrations in the Dallas Central Wastewater Treatment Plant (Site C) effluent.

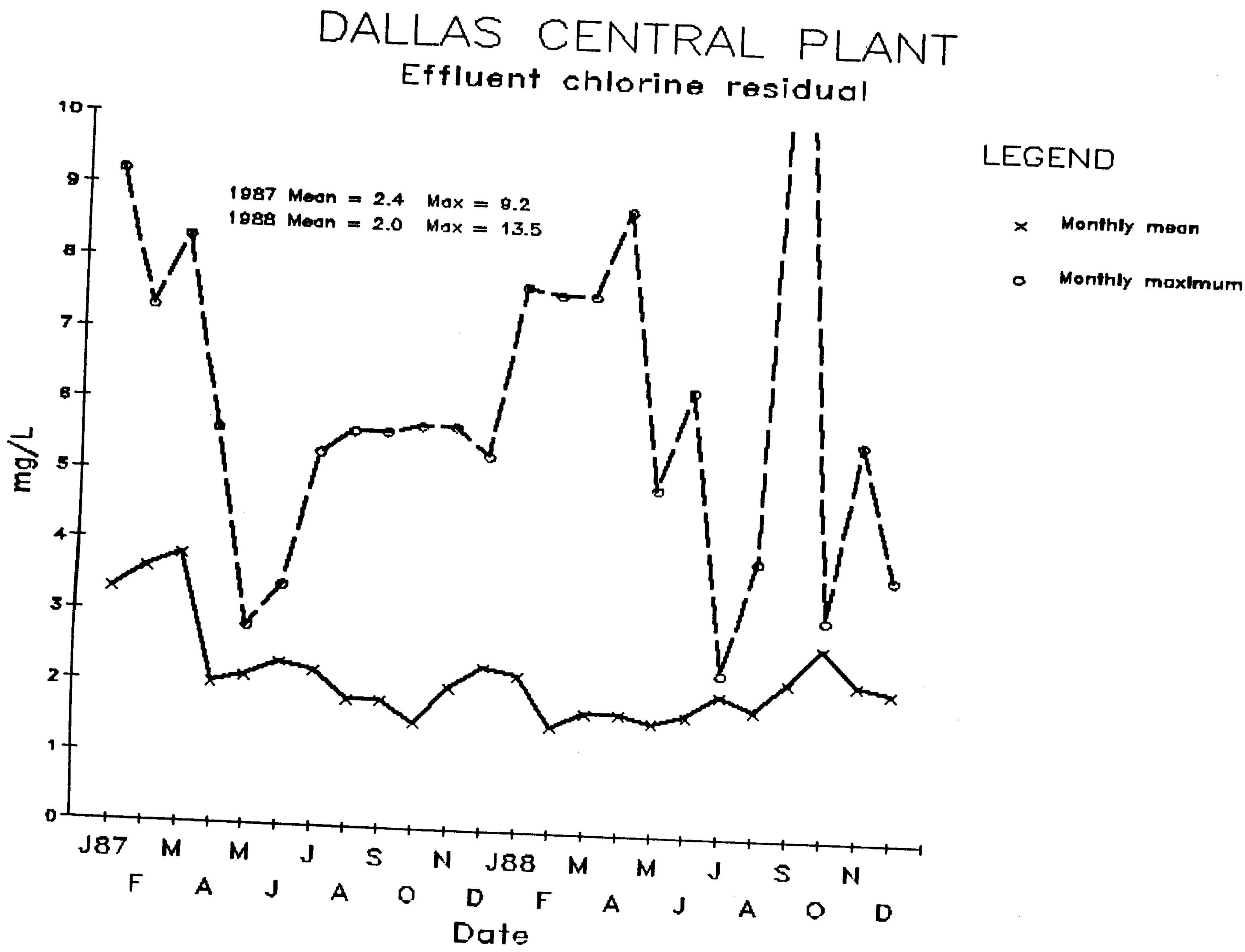
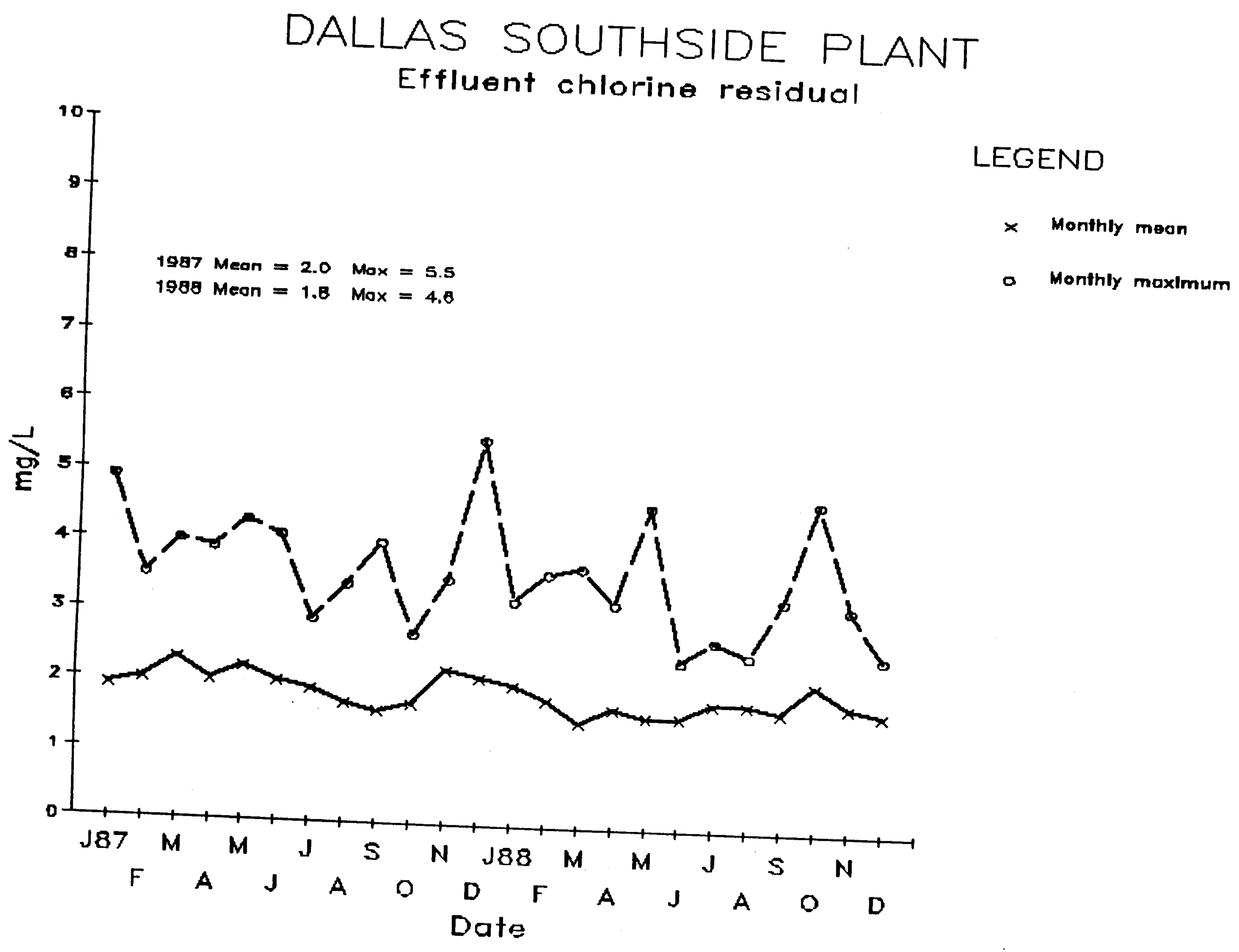

DALLAS CENTRAL PLANT
Effluent chlorine residual
1987 Mean = 2.4 Max = 9.2
1988 Mean = 2.0 Max = 13.5
LEGEND
× Monthly mean
o Monthly maximum
mg/L
0
1
2
3
4
5
6
7
8
9
10
J87 F M A M J J A S O N D J88 F M A M J J A S O N D
Date

FIGURE 31. Monthly mean and maximum effluent total residual chlorine concentrations in the Dallas Southside Wastewater Treatment Plant (Site D) effluent.


DALLAS SOUTHSIDE PLANT
Effluent chlorine residual
LEGEND
× Monthly mean
o Monthly maximum
1987 Mean = 2.0 Max = 5.5
1988 Mean = 1.8 Max = 4.8
mg/L
0
1
2
3
4
5
6
7
8
9
10
J87 F M A M J J A S O N D J88 F M A M J J A S O N D
Date

APPENDIX C

APPENDIX C. Trophic and tolerance classifications for fishes from the Trinity River and its tributaries. (For trophic status, IF = invertebrate feeder, P = piscivore, O = omnivore, and H = herbivore. For tolerance, T = tolerant and I = intolerant.)

Species	Common name	Trophic group	Tolerance
Lepisosteus oculatus	Spotted gar	P	T
Lepisosteus osseus	Longnose gar	P	T
Lepisosteus spatula	Alligator gar	P	T
Dorosoma cepedianum	Gizzard shad	O	
Dorosoma petenense	Threadfin shad	O	
Cyprinus carpio	Common carp	O	T
Notemigonus crysoleucas	Golden shiner	O	T
Notropis buchanani	Ghost shiner	IF	
Notropis emiliae	Pugnose minnow	IF	
Notropis lutrensis	Red shiner	IF	T
Notropis shumardi	Silverband shiner	IF	
Notropis texanus	Weed shiner	IF	
Notropis umbratilis	Redfin shiner	IF	
Notropis venustus	Blacktail shiner	IF	
Notropis volucellus	Mimic shiner	IF	I
Pimephales promelas	Fathead minnow	O	T
Pimephales vigilax	Bullhead minnow	O	
Campostoma anomalum	Central stoneroller	H	
Ictiobus bubalus	Smallmouth buffalo	O	
Ictiobus niger	Black buffalo	O	
Carpiodes carpio	River carpsucker	O	
Ictalurus furcatus	Blue catfish	P	
Ictalurus natalis	Yellow bullhead	O	
Ictalurus punctatus	Channel catfish	O	
Pylodictis olivaris	Flathead catfish	P	
Noturus nocturnus	Freckled madtom	IF	
Fundulus notatus	Blackstripe topminnow	IF	
Gambusia affinis	Mosquitofish	IF	T
Menidia beryllina	Inland silverside	IF	
Morone chrysops	White bass	P	
Morone mississippiensis	Yellow bass	P	
Morone saxatilis	Striped bass	P	
Micropterus punctulatus	Spotted bass	P	
Micropterus salmoides	Largemouth bass	P	
Lepomis auritus	Redbreast sunfish	IF	
Lepomis cyanellus	Green sunfish	P	T
Lepomis gulosus	Warmouth	P	T
Lepomis humilus	Orangespotted sunfish	IF	
Lepomis macrochirus	Bluegill	IF	
Lepomis megalotis	Longear sunfish	IF	I
Lepomis microlophus	Redear sunfish	IF	
Lepomis punctatus	Spotted sunfish	IF	
Pomoxis annularis	White crappie	P	
Pomoxis nigromaculatus	Black crappie	P	
Percina caprodes	Log perch	IF	I
Percina sciera	Dusky darter	IF	I
Etheostoma chlorosomum	Bluntnose darter	IF	
Etheostoma gracile	Slough darter	IF	
Etheostoma proeliare	Cypress darter	IF	I
Aplodinotus grunniens	Freshwater drum	P	

APPENDIX D

APPENDIX D. Total Index of Biotic Integrity scores, classes, and the attributes of those classes (modified from Karr et al. 1986).

Total IBI score (sum of the 12 metric ratings)	Integrity class	Attributes
58-60	Excellent	Comparable to the best situations without human disturbance; all regional expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
	No fish	Repeated sampling finds no fish.

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