IS 86-08

Intensive Survey of Medio Creek Segment 1912 March 31—April 3, 1986

Texas Water Commission

November 1986

INTENSIVE SURVEY OF

MEDIO CREEK

SEGMENT 1912

MARCH 31 - APRIL 3, 1986

Hydrology, Field Measurements,
Water Chemistry

By

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ABSTRACT

An intensive survey was conducted on Medio Creek March 31 - April 3, 1986 by the Texas Water Commission. Medio Creek is a small, south central, Texas stream which drains northeast Medina and southwest Bexar Counties and enters the Medina River southwest of San Antonio. Low flow conditions existed during the survey and the maximum flow measured was only 0.17 m^3/s (5.8 ft^3/s); stream velocity ranged between 0.0162 and 0.1229 m/s (0.05 and 0.40 ft/s); and average stream width ranged from 4.4 to 10.9 m (14.4 to 35.8 ft). Diel field measurements indicate that two dissolved oxygen sag zones developed in Medio Creek; one in the upper portion near the Lackland Training Annex, and the other in the lower portion downstream of O. R. Mitchell Reservoir. The depressed dissolved oxygen levels (< 3 mg/L) were attributed to assimilation of wastewater effluents and metabolism of periphyton in the upper portion and succession of phytoplankton in the lower portion. Nutrient compounds (orthophosphorus and nitrate nitrogen) were elevated (> 6.5 mg/L and > 5.5 mg/L, respectively) in the upper portion of Medio Creek and the downstream decline in levels indicate substantial uptake by aquatic plants. O. R. Mitchell Reservoir, located on Medio Creek in the lower portion, substantially reduced nutrient levels.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

TABLES

TABLE OF CONTENTS CONTINUED

Page

TABLES CONTINUED

FIGURES

INTENSIVE SURVEY OF

MEDIO CREEK

SEGMENT 1912

INTRODUCTION

DIRECTIVE

This intensive survey was accomplished in accordance with the Texas Water Code, Section 26.127, as amended in 1985. The report is to be used for the purposes listed below.

PURPOSE

The purpose of this intensive survey was to provide the Texas Water Commission with a valid information source to:

1. determine quantitative cause and effect relationships of water quality;
2. obtain data for updating water quality management plans, setting effluent limits, and where appropriate, verifying the classifications of segments;
3. set priorities for establishing or improving pollution controls; and
4. determine any additional water quality management actions required.

METHODS

Field and laboratory procedures used during this survey are described in Appendix A. The field measurements, water chemistry, and hydraulic data were collected March 31 - April 3, 1986 by personnel of the Texas Water Commission's Water Quality Assessment and Modeling Units. Laboratory analyses of water samples were conducted by the Texas Department of Health Chemistry Laboratory in Austin, Texas. Bacteriological analyses were conducted by the Department's Water Quality Assessment Unit. Parametric coverage, sampling frequencies and spatial relationships of sampling stations were consistent with the objectives of the survey and with known or suspected forms and variabilities of pollutants entering the stream.

RESULTS AND DISCUSSION

SITE DESCRIPTION

An intensive survey of Medio Creek (Segment 1912) was conducted by the Texas Water Commission (TWC) March 31 - April 3, 1986. Medio Creek is a small south central, Texas stream that extends upstream from its confluence with the Medina River on the western edge of San Antonio in Southwest Bexar County to its headwaters in northeast Medina County, a distance of approximately 40.8 kilometers (25.3 miles)(Figure 1). The lower 3.7 kilometers (2.3 miles) of the creek, downstream of O. R. Mitchell Reservoir, has been established as a classified stream segment by the Texas Water Commission. Flow in Medio Creek is intermittent in the portion upstream of FM 1604. Headwater flow normally originates upstream of the Community Treatment Medio Creek Wastewater Treatment Plant (WWTP), approximately 2 kilometers (1.2 miles) upstream of US 90. This base flow is augmented by treated domestic wastewater flows from four plants. Flow in Medio Creek generally alternates between pool and riffle areas. Several small flow-through dams, two located on the U. S. Air Force Lackland Training Annex, and others downstream of Covel Road impede flow. In the lower portion of Medio Creek, upstream of IH-35 and on the Medio Creek Ranch (formerly known as the O. R. Mitchell Ranch), the creek is dammed to form O. R. Mitchell Reservoir. Several artesian wells flow into the impoundment near the headwaters. As much as 624,146 m^3/yr (506 ac ft/yr) of water from the reservoir is utilized annually to irrigate corn and coastal bermuda on the ranch (TWC, 1986a). Medio Creek is again impounded in Hidden Valley Park immediately upstream from its confluence with the Medina River. This small impoundment is utilized for recreation by people that frequent the park. The Medio Creek drainage basin is mostly rural and large portions are controlled by owners of the Medio Creek Ranch and U. S. Government (U. S. Department of Air Force Lackland Training Annex). Upstream of US 90 residential development has accelerated due to expansion of the San Antonio Metroplex from the southeast. Impoundment of the Medina River to form Applewhite Reservoir would inundate the lower 1.3 kilometers (0.8 miles) of Medio Creek.

Nineteen mainstream stations were established on Medio Creek for the survey. Sampling stations were also established on three tributary streams that were flowing at the time of study and at four domestic wastewater treatment plants (Figure 1, Table 1).

POPULATION

There are no population estimates for the watershed area of Segment 1912. Population figures were developed for a larger area, however, in a study done by the City of San Antonio for the Texas Department of Water Resources as an update to the State of Texas Water Quality Management Plan (Glass, 1981). The area studied was the Medio Creek watershed from its confluence with the Medina River upstream to the five-mile extraterritorial jurisdiction of the City of San Antonio near Culebra Road. This area encompassed approximately 104.6 km^2 (40.4 mi^2) and was estimated to have a population of 20,500 in 1980. By the year 2,000, the population is forecast to grow to some 49,500 people, a 144 percent increase.

CLIMATOLOGY

The location of San Antonio on the edge of the Gulf Coastal Plains results in a modified subtropical climate. Normal mean temperatures range from 10.2°C (50.4°F) in January to a high of 29.1°C (84.4°F) in July and August. While the summer is hot, with daily maximum temperatures above 32.1°C (90°F) over 80 percent of the time, extremely high temperatures are rare. Mild weather prevails during the winter months, with below freezing temperatures occurring on an average of about 20 days.

The normal annual rainfall of 69.9 cm (27.5 in) is sufficient for production of most crops. Precipitation is fairly well distributed throughout the year with the heaviest amounts falling during May in the spring and September in the fall. Northerly winds prevail during most of the winter, while southeasterly winds from the Gulf of Mexico prevail during the summertime (NOAA, 1986).

WATER QUALITY STANDARDS

Water quality standards specifying water uses deemed desirable and numerical criteria have recently been developed for Medio Creek. The current edition of the Texas Surface Water Quality Standards was adopted by the Texas Water Development Board in December 1984 (TWC, 1985). This document was written pursuant to Section 26.023 of the Texas Water Code to meet 1983 goals in Section 303 of the Federal Clean Water Act, as amended. These goals require that, where attainable, water quality will support aquatic life and recreational uses. The water uses deemed desirable for Medio Creek are contact recreation and intermediate quality aquatic life habitat. The following are the numerical criteria established for Medio Creek (Segment 1912) downstream of O. R. Mitchell Reservoir and are intended to insure that water quality will be sufficient to maintain the desired uses:

Parameter	Criteria
Dissolved Oxygen	Not less than 4.0 mg/L
pH	Not less than 6.5 nor more than 9.0
Temperature	Not to exceed 34.9°C (95°F)
Chloride	Annual average not to exceed 100 mg/L
Sulfate	Annual average not to exceed 125 mg/L
Total Dissolved Solids	Annual average not to exceed 550 mg/L
Fecal Coliform	Thirty-day geometric mean not to exceed 200/100 mL

These numerical criteria are not applicable in mixing zones nor whenever the stream flow is intermittent or less than the low-flow criterion. At least four measurements are required to determine compliance for chloride, sulfate, and total dissolved solids criteria and at least five measurements are required to determine the attainment of the fecal coliform criterion.

For streams, or portions of streams, that are not designated by the Texas Water Commission as classified segments, the general criteria of the Texas Surface Water Quality Standards are applicable. The goals of the Commission are to maintain a minimum of 3 mg/L of dissolved oxygen and a 2,000/100 mL fecal coliform density (thirty-day geometric mean) to protect minimum aquatic life and recreational uses for these streams. These general criteria, and others specified in Texas Surface Water Quality Standards, apply to Medio Creek upstream of the O. R. Mitchell Reservoir dam site.

WATER QUALITY MONITORING STATIONS

The Texas Water Commission has established two monitoring stations on Medio Creek where routine water quality data are collected for the Stream Monitoring Program (Table 2). These stations are located at IH-35 and US 90. The San Antonio River Authority (SARA) also monitors water quality at these two stations. The City of San Antonio (CSA) and SARA also monitor water quality at Pearsall Road. The water quality data collected by these three entities are retrievable through the Commission's Stream Monitoring Program (SMN).

HISTORICAL WATER QUALITY

Historical stream monitoring data collected at IH-35 (Station P), Pearsall Road (Station I), and US 90 (Station B) are presented in Tables 3 and 4. While the numerical criteria shown in Table 3 apply only to the IH-35 station, they are also utilized to gage water quality at the two upstream stations.

Surface water temperatures and all but two pH measurements have been within the criteria (temperature maximum 34.9°C, pH range 6.5-9.0 standard units) at the three monitoring stations over the past five years (January 1981 - December 1985). Excepting one chloride measurement, levels of chloride, sulfate and total dissolved solids have conformed to segment criteria at the IH-35 station. Levels for these three conservative parameters at the other two stations exceeded the criteria more frequently, but less than 25 percent of occurrence. Fecal coliform densities have been elevated at all three stations over the past five years and maximum levels were high (> 30,000/100 mL). Fecal coliform levels in 47 percent of the samples collected at IH-35 exceeded the segment criterion (200/100 mL) over the past five years. Fecal coliform levels from samples collected at US 90 and Pearsall Road infrequently exceeded (< 25 percent) the general criterion (2,000/100 mL), but they were in excess of the criterion (200/100 mL) established for waters deemed desirable for contact recreation much more frequently (> 50 percent).

Dissolved oxygen levels less than the segment criterion (4 mg/L) have occurred infrequently (< 10 percent) at IH-35 over the past five years (Table 4). Farther upstream at Pearsall Road and US 90, dissolved oxygen levels have almost always exceeded the general criterion (3 mg/L) over the past five years. Low dissolved oxygen was the suspected cause of fish kills on the U. S. Air Force Lackland Training Annex in February 1981 and near the Hidden Valley Campground in March 1980 (Table 5)(TWC, 1986c).

WASTEWATER DISCHARGES

The Texas Water Commission has issued permits to seven domestic wastewater treatment plants that discharge to Medio Creek. Of these, five were discharging wastewater at the time of the study. The five facilities are located upstream of Covel Road, and excepting the one on the Lackland Training Annex, serve residential developments. The Oak Creek Environmental Management, Inc., facility which is located upstream of FM 1604 was not sampled during the survey. Its flow infiltrates the rocky strata and does not communicate, at least on the surface, with stream flow at US 90 during low flow conditions.

Four of five of the facilities which were discharging during the study have monthly average permit limitations of 20 mg/L five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS)(Table 6). The Lackland City Water Company's Dwyer Road Plant utilizes oxidation ponds and an irrigation overland flow system. This facility has monthly average permit limitations of 30 mg/L, BOD_5 and 90 mg/L TSS. The permitted average flow from the five discharges total 0.207 m^3/s (4.8 MGD) and resulting permitted loadings total 374 kg/d (825 lb/d) BOD_5 and 445 kg/d (980 lb/d) TSS.

PREVIOUS INTENSIVE SURVEYS

The Texas Water Commission conducted a previous intensive survey of Medio Creek in June 1982 (Twidwell, 1983). The study was conducted during low flow conditions. Diurnal field measurements indicate that a dissolved oxygen sag zone occurred in the upper portion of Medio Creek near US 90 and extended downstream through the Lackland Training Annex. The depressed dissolved oxygen levels (< 3 mg/L) were attributed to the assimilation of domestic wastewater effluents. Nutrient levels were elevated in the upper portion of the stream and there was little indication of their uptake by aquatic plants. The O. R. Mitchell Reservoir, located on Medio Creek, substantially reduced nutrient levels and stabilized other water quality parameters.

Medio Creek was also sampled during an intensive survey of the Medina River (Segment 1903) in August 1976 (Twidwell, 1976). Diurnal dissolved oxygen levels ranged from 4.6 - 6.6 mg/L at IH-35. These levels were generally 2-3 mg/L lower than those observed in the Medina River. The Medio Creek discharge had minimal effects on various field and lab parameters of the Medina River.

CLASSIFICATION AND RANK

Due to occasional low levels of dissolved oxygen and elevated fecal coliform levels, Segment 1912 has recently been classified water quality limited and ranked 67 of 342 segments by the Commission (TWC, 1986c). Segments are classified water quality limited if effluent limitations for point source dischargers required by Section 301(b)(1)(A) and Section 301(b)(1)(B) of Public Law 97-117 are not stringent enough for the receiving waters to meet the appropriate water quality standards. Segments were ranked from 1 to 342 by the Commission with 1 indicating the highest need for stringent water quality controls and 342 indicating the least feasible necessity of stringent water quality controls other than for public health considerations.

INTENSIVE SURVEY DATA

Hydraulics

The San Antonio area was dry preceding this intensive survey as no precipitation was recorded between March 19-31, 1986, (NOAA, 1986). The largest accumulation, 0.38 cm (0.15 in), occurred on March 11, followed by lesser amounts 0.25 cm (0.10 in) on March 15 and 18. Traces of precipitation were recorded on March 3, 9, and 13. Temperatures ranged from 2.2 (36°F) to 27.3°C (81°F) during a two week period prior to the survey. Winds prevailed from the southeast at an average speed of 15.8 kph (9.8 mph) during this same time period (NOAA, 1986).

Stream widths of Medio Creek exhibited a downstream trend for generally increasing width (Table 7). The widest portion of the creek (30 m, 98.4 ft), excepting O.R. Mitchell Reservoir and the small pond in Hidden Valley Park, was measured in the reach between the Lackland Training Annex WWTP (Station F) and Covel Road (Station G). Located within this reach on the Lackland Training Annex is a large secluded marshy area with an extensive natural pool. Wide pools (> 15 m) created by small dams to form recreational pools on the Lackland Training Annex or by culvert crossings elsewhere, were also observed in reaches between US 90 (Station B) and the lower dam on the Lackland Training Annex (Station D), Covel Road (Station G) and low water crossing (Station H), O. R. Mitchell Reservoir dam (Station O) and IH-35 (Station P), and within Hidden Valley Park (Station Q to R). Between these large pools were short and long runs with gravelly riffle areas alternating with smaller pools. Within almost every reach of Medio Creek stream widths less 3 m (9.8 ft) were typically observed.

Medio Creek is impounded 3.7 km (2.3 mi) upstream of the Medina River confluence to form a reservoir on the Medio Creek Ranch. The reservoir covers approximately 247,676 m^2 (61.2 acres) and impounds 733,927 m^3 (595 ac ft) of water at the normal operating level. The drainage area above the reservoir is approximately 130.8 km^2 (50.5 mi^2)(TWC, 1986a). The reservoir is approximately 2.5 km (1.6 mi) long and is 400 m (1312 ft) wide near the dam site (Table 8, Figure 2). Medio Creek is again impounded in Hidden Valley Park just upstream of the Medina River. This small reservoir is approximately 13.5 m (44.3 ft) long and 210 m (689 ft) wide near the dam site (Table 9, Figure 3).

Stream flow generally increased from upstream to downstream and was less than 0.17 m^3/s (5.8 ft^3/s) throughout (Table 7). The variability in stream flows was due primarily to diel variations of the four principal wastewater dischargers (Table 10). Very little flow (0.0015 m^3/s, 0.05 ft^3/s) was measured upstream of the Community Treatment Medio Creek WWTP and the stream was dry at FM 1604 farther upstream. The flows in two of the unnamed tributaries at Stations AA and DA were due to treated WWTP effluents from Bexar County WCID No. 16 and Lackland City Water Company, respectively. The source of flow in the unnamed tributary (Station FA) on the Lackland Training Annex was not determined. None of the tributaries contributed more than 0.01 m^3/s (0.5 ft^3/s) to Medio Creek (Table 10).

Stream velocity was generally slow ($\leq$ 0.04 m/s, 0.13 ft/s) in the area between US 90 and the low water crossing near Covel Road (Station H), where Medio Creek is repeatedly dammed (Table 7). Much swifter velocities ($\geq$ 0.11 m/s, 0.36 ft/s) were measured in reaches between Community Treatment's Medio Creek WWTP outfall and US 90 and O. R. Mitchell Reservoir Dam to Hidden Valley Park. Recent channel improvements by Community Treatment upstream of US 90 have substantially increased velocity within this reach since the last study in June 1982 (Twidwell, 1983). The time of travel decreased in the reach between the Community Treatment Medio Creek WWTP outfall and US 90 from 9.6 to 4.1 hours, while velocity increased from 0.05 m/s (0.16 ft/s) to 0.11 m/s (0.36 ft/s).

Field Measurements

The diel field measurements indicate that a major sag in dissolved oxygen levels occurred in the upper portion of the study area (Table 11, Figure 4). Dissolved oxygen levels at Station A upstream of the influence of treated wastewater averaged 9.5 mg/L, but the range between minimum and maximum values (5.6-15.1 mg/L) indicate unstable conditions. The stream at this location was nearly dry and periphyton were abundant on the substrate.

The treated effluents from the Community Treatment Medio Creek Plant, Bexar County WCID No. 16, Lackland City Water Company, and the U. S. Air Force Lackland Training Annex enter Medio Creek between the headwaters at Station A and Covel Road (Station G). The discharge and assimilation of these combined effluents reduced the ambient dissolved oxygen levels in Medio Creek appreciably. The two unnamed tributaries, Station AA and Station DA, which carry the treated effluents from Bexar County WCID No. 16 and Lackland City Water Company, respectively, exhibited depressed dissolved oxygen levels (< 5 mg/L) throughout the diel sampling period. The bottom of the sag occurred at Medina Base Road (Station E) where the diel average was 4.5 mg/L. Early morning dissolved oxygen levels were less than the 3 mg/L criterion established for this portion of Medio Creek at Medina Base Road (Station E) and immediately upstream of the Lackland Training Annex WWTP outfall (Station F). Dissolved oxygen levels began a trend for recovery at Covel Road (Station G) and were near background conditions at the headwaters of O. R. Mitchell Reservoir (Station J).

Dissolved oxygen levels within O. R. Mitchell Reservoir were high (diel averages > 7 mg/L) and increased from up-reservoir to down-reservoir. While the ranges between minimum and maximum surface dissolved oxygen levels at any of the reservoir stations were not excessive, they were wide enough to indicate the reservoir is very productive. Dissolved oxygen levels and water temperature values indicate that the reservoir was vertically well mixed, excepting the lower, deeper part near Station N. At this station there was usually a 3°C difference between top and bottom measurements with most of the change occurring between the 1.5 and 3 m (5 and 10 ft) depths. This difference observed in the spring suggests that the reservoir, despite its shallow nature, probably stratifies thermally in the warmer summer months.

Very substantial differences (> 9 mg/L) between top and bottom dissolved oxygen levels occurred in the deeper portion of the reservoir at Station N during each sampling run. Very sharp declines in the dissolved oxygen levels occurred between the 1.5 and 3 m depths, and the bottom water (3.9 m, 13 ft) was nearly depleted. This clinograde curve is typical of highly productive, shallow lakes where the loss of oxygen in the hypolimnion results primarily from biological oxidation of organic matter, both in the water and at the sediment-water interface (Wetzel, 1983).

Downstream of O. R. Mitchell Reservoir a secondary dissolved oxygen sag occurred in Medio Creek (Table 11, Figure 4). The bottom of the sag occurred within the Hidden Valley Park at Station Q. Dissolved oxygen levels at this station remained depressed below the Segment 1912 criterion (4 mg/L) throughout the diel sampling period and the diel average (2.8 mg/L) was the lowest of any station sampled. The early morning dissolved oxygen minima at Station Q and farther downstream near the headwaters of a small pond within Hidden Valley Park (Station R) were acutely low (≤ 2.7 mg/L). This secondary sag in dissolved oxygen is apparently created by the death and bacterial decomposition of phytoplankton discharged from O. R. Mitchell Reservoir. Downstream of the small pond within Hidden Valley Park at Station S, dissolved oxygen levels were again near background conditions indicating nearly complete recovery prior to the water entering the Medina River.

Measurements of pH ranged between 7.1 and 8.2 standard units in Medio Creek upstream of O. R. Mitchell Reservoir. Within the reservoir and downstream they were higher (range 7.4 - 9.2). Elevated pH levels with appreciable diel variation occur commonly in highly productive reservoirs like O. R. Mitchell. Phytoplankton dissociate the bicarbonate ions into carbon dioxide, carbonate ions, and hydroxide ions. Carbon dioxide is utilized photosynthetically and the increase in hydroxide ions drives up the pH. Three of four measurements at IH-35 (Station P) and one measurement at Station S immediately upstream of the Medina River exceeded the maximum segment criterion (9.0 units). All of the water temperatures measured were less than the segment criterion (34.9°C, 95°F).

Performance of Treatment Plants

During the study, the carbonaceous five-day biochemical oxygen demand ($CBOD_5$) loading Medio Creek received from the four facilities which were sampled was only 19 percent of the 359 kg/d (792 lb/d) permitted monthly average loading (Tables 6 and 12). The TSS loading the stream received was 24 percent of the 429 kg/d (947 lb/d) permitted monthly average loading. At the time of the study, the effluents from the four WWTP's accounted for better than 95 percent of the flow in Medio Creek. The observed effluent quantities and qualities for three of the treatment plants were substantially less than their permitted monthly average limitations. The U. S. Air Force Lackland Training Annex Plant's effluent marginally exceeded limitations for flow and BOD_5.

Carbonaceous Biochemical Oxygen Demand

The five day and twenty day carbonaceous biochemical oxygen demand tests are indirect measures of the amount of short and longer term degradable organic matter present in stream water and wastewater effluents. Levels of $CBOD_5$ in Medio Creek upstream of O. R. Mitchell Reservoir were highest ($\leq$ 5.0 mg/L) at US 90 (Station B), reflecting inputs upstream from the Community Treatment and Bexar County WCID No. 16 effluents (Table 12). The highest $CBOD_{20}$ level (10.5 mg/L) in this portion of the stream also occurred at US 90. The small difference between the filtered and non-filtered samples indicates that most of the oxygen demanding materials in the samples were soluble. The $CBOD_5$ levels decreased in concentration downstream from US 90 and were $\leq$ 2.0 mg/L from Medina Base Road (Station E) to the headwaters of O. R. Mitchell Reservoir (Station J).

Levels of $CBOD_5$ and $CBOD_{20}$ increased again within O. R. Mitchell Reservoir; however, most of the oxygen demand was removed by filtration. Chlorophyll a levels increased dramatically within the reservoir (range 20-166 µg/L), suggesting most of the oxygen demand was due to algal respiration.

Nutrients and Chlorophyll a

No water quality criteria have been established for orthophosphorus (OP), ammonia (NH_3-N), nitrite (NO_2-N), or nitrate (NO_3-N) nitrogen, but their involvement in nuisance aquatic plant growth warrants their consideration. In addition, high concentrations of ammonia nitrogen are toxic to aquatic organisms, deplete available oxygen through bacterial nitrification, and are frequently an indicator of recent sewage pollution. Abundance of orthophosphorus, a principle ingredient in household detergents, in the water is also an indication of recent sewage pollution. Chlorophyll a analyses were utilized to provide an estimate of the relative planktonic algal standing crops that were present at the Medio Creek sampling stations.

Ammonia (0.08 mg/L), nitrate nitrogen (0.88 mg/L), and orthophosphorus (< 0.01 mg/L) levels were generally low at the headwater control station (Table 12). The levels for these parameters increased to 0.65, 10.0, and 8.7 mg/L, respectively, at US 90 (Station B) and reflect input to the stream from Community Treatment's and Bexar County WCID No. 16 effluents. The nitrogen series data measured in the effluents from the four wastewater treatment plants indicate that substantial nitrification occurred in all but the Lackland Training Annex facility. Their effluent had high levels of ammonia (9.6 mg/L) and nitrate (12.9 mg/L) nitrogen. The other three facilities discharged effluents with much lower ammonia levels (range < 0.01 - 2.04 mg/L). Although input of ammonia nitrogen to Medio Creek was minor, its gradual downstream decrease in concentrations, the presence of nitrite nitrogen at all stream stations, and general downstream increases in nitrate nitrogen indicate that nitrification was occurring in Medio Creek (Table 12, Figure 5). Although the nitrification rate was probably low in Medio Creek, as evidenced by the gradual downstream decline in concentrations, the nitrogenous oxygen demand contributed to the major sag observed in dissolved oxygen levels observed in the upper portion of Medio Creek (Figure 4).

In the reach between US 90 (Station B) and the headwaters of O. R. Mitchell Reservoir (Station J) orthophosphorus and nitrate nitrogen levels were high (> 5.5 and > 6.9 mg/L, respectively) (Table 12, Figure 6). The levels for these two nutrient parameters measured at the headwaters of O. R. Mitchell Reservoir were 560 x and 7.8 x, respectively, higher than those from the control station. The decline in orthophosphorus levels from 8.7 mg/L at US 90 to 5.5 mg/L at the headwaters of O. R. Mitchell Reservoir and nitrate nitrogen from 10.0 mg/L to 6.9 mg/L over the same reach indicates substantial uptake by aquatic plants. Chlorophyll a levels remained generally low (< 8 μg/L) within this reach indicating the nutrients were not being assimilated by the phytoplankton. Large mats of periphyton (principally Cladophora sp.), covering the entire stream bottom and several decimeters deep, were observed in Medio Creek between Medina Base Road (Station E) and Pearsall Road (Station I). Presumably, the loss of nutrient compounds within this reach was due to uptake by the periphyton. The reach between Stations E and I corresponds to the area in which the lowest dissolved oxygen levels were recorded (Figure 4) and implies that the metabolism of the periphyton mats contributed to the decline. Although uptake of nutrients by aquatic plants upstream of O. R. Mitchell Reservoir was appreciable, the levels of orthophosphorus and nitrate nitrogen measured at the headwaters (Station J) indicate that recovery from upstream input was incomplete and that Medio Creek was discharging substantial amounts of nutrients to the reservoir.

O. R. Mitchell Reservoir located on the Medio Creek Ranch significantly reduced nutrient compounds. Station J was located near the headwaters of the reservoir and Station O was located immediately downstream of the dam. Nitrate nitrogen was reduced from 6.9 mg/L at Station J to 0.05 mg/L at Station O and orthophosphorus was reduced from 5.6 mg.L to 0.71 mg/L between the same stations. These nutrient reductions between Stations J and O were accompanied by responding increases in chlorophyll a (< 2 μg/L - 108 μg/L), indicating nutrient uptake by phytoplankton. Chlorophyll a levels throughout most of the reservoir were greater than 60 μg/L and greatly exceeded the 30 μg/L level suggested as characteristic of eutrophic reservoirs (Wetzel, 1983). The moderate temporal variations in dissolved oxygen levels, near oxygen depletion in the bottom water of the reservoir, and elevated nutrient and pH levels also indicate the reservoir is very productive. These limnological conditions measured in April signal potentially serious water quality problems for the reservoir later in the summer when the reservoir may stratify and conditions are more conducive for aquatic plant growth.

Downstream of O. R. Mitchell Reservoir nutrient levels remained generally stable (OP < 1.0 mg/L, NO_3-N < 0.25 mg/L), while chlorophyll a levels declined sharply (Table 12, Figure 6). The downstream trend for decreasing chlorophyll a levels directly parallels the secondary sag in dissolved oxygen levels that occurred between O. R. Mitchell Reservoir (Station O), and the small impoundment within Hidden Valley Park (Station R). This secondary sag was as severe in terms of magnitude (early morning lows ≤ 2.5 mg/L) as the primary one that occurred in the upper portion of Medio Creek. The low dissolved oxygen levels downstream of the reservoir are likely due to phytoplankton succession of the high densities contained in the reservoir. Changing physical conditions from a nutrient enriched, quiescent reservoir to a highly shaded, flowing stream could cause such a decline in algal standing crop in Medio Creek.

Dissolved oxygen levels began a trend toward recovery within Hidden Valley Park and were near ambient conditions just upstream of the Medina River (Station S). Chlorophyll a levels again increased within the small impoundment within the park and temporal variations in dissolved oxygen levels were wide (range 2.7 - 8.1) indicating instability due to phytoplankton metabolism. The water discharged from the impoundment to the Medina River contained a low level of nitrate nitrogen (0.11 mg/L), but orthophosphorus (0.79 mg/L) and chlorophyll a (52 µg/L) levels far exceeded background levels and indicate incomplete recovery in Medio Creek prior to its union with the Medina River.

Chloride, Sulfate, and Total Dissolved Solids

All of the chloride, sulfate, and total dissolved solids levels from stations within Segment 1912 (downstream of O. R. Mitchell Reservoir) conformed to segment criteria (100, 125, and 550 mg/L, annual averages, respectively) (Table 12). Upstream of the reservoir total dissolved solids levels greater than 550 mg/L were common, but none exceeded 600 mg/L. Instream levels for all three of the conservative parameters exhibited downstream trends toward decreasing concentrations due to dilution.

Fecal Coliform Bacteria

Fecal coliform levels were low throughout Medio Creek and most were less than the Segment 1912 criterion (200/100 mL)(Table 13). Of the four wastewater effluents sampled, only the Lackland City Water Company's had an elevated level (4,290/100 mL). The elevated level (4,675/100 mL) in the unnamed tributary (Station DA) which carries Lackland City Water Company's effluent to Medio Creek was due to their effluent. Fecal coliform levels in Medio Creek downstream of Station DA were slightly elevated at Medina Base Road (265/100 mL), but recovered farther downstream. The only other location with an elevated fecal coliform level (690/100 mL) was IH-35 (Station P).

Tributary Water Quality

Two of three (Stations AA and DA) unnamed tributaries (Table 12) exhibited poorer water quality than Medio Creek. These two streams transport the respective effluents from Bexar County WCID No. 16 and Lackland City Water Company which made up their total stream flow at the time of the study.

Both streams had depressed dissolved oxygen levels and elevated levels of nutrient compounds. Water quality in the unnamed tributary (Station FA) on the Lackland Training Annex was similar to that of Medio Creek at its headwaters.

Comparison to Previous Intensive Survey

The longitudinal dissolved oxygen profiles of Medio Creek from the intensive survey in June, 1982, and the data collected during this intensive survey are similar (Figure 4). Both show the existence of two dissolved oxygen sags, one in the upper portion of the stream upstream of O. R. Mitchell Reservoir and one downstream of the reservoir. The dissolved oxygen sags in the upper portion of Medio Creek and downstream of O. R. Mitchell Reservoir increased in magnitude (lower levels) and longitudinal extent during the April 1986 study. These poor water quality conditions existed even though the four wastewater discharges were cumulatively discharging only 19 and 24 percent of their permitted monthly average $CBOD_5$ and TSS loadings (Table 6). The difference in the two dissolved oxygen sags can not be explained by increased $CBOD_5$, TSS, and ammonia nitrogen loadings. Although plant flows increased between the time the two surveys were conducted, effluent qualities improved substantially. The $CBOD_5$, TSS, and ammonia nitrogen cumulative loadings Medio Creek received from the Community Treatment, Bexar County WCID No. 16, Lackland Water Company's and Lackland Training Annex plants were reduced by 15, 19, and 20 percent, respectively, between the dates of the two studies (loadings from the Community Treatment Hunt Lane Plant included in 1982 computations).

The orthophosphorus and nitrate nitrogen loadings Medio Creek cumulatively received from the four plants increased from 33.6 kg/d (74 lb/d) and 56.2 kg/d (124 lb/d), respectively, in June 1982 to 76.2 kg/d (168 lb/d) and 123 kg/d (271 lb/d) in April 1986, more than a two-fold increase. As a result of the increased nutrient loadings, dense algal mats were observed in Medio Creek between Medina Base Road and Pearsall Road and much higher levels of chlorophyll <u>a</u> occurred in O. R. Mitchell Reservoir.

CONCLUSIONS

The results of this intensive survey indicate that water quality throughout Medio Creek is stressed by the effluents from four domestic wastewater treatment plants. A sag in dissolved oxygen levels occurred in the upper portion of the stream between US 90 and Pearsall Road. This sag was attributed to the carbonaceous and nitrogenous oxygen demand of the four domestic effluents discharged to this reach. This area of Medio Creek exhibited elevated nutrient levels and their assimilation by periphyton also contributed to development of the dissolved oxygen sag.

A secondary sag in dissolved oxygen levels occurred downstream of O. R. Mitchell Reservoir located on the Medio Creek Ranch. The reservoir functions much like an oxidation pond in that nutrients are stabilized and assimilated into phytoplankton biomass. The water discharged from the reservoir contained large quantities of phytoplankton and their succession in Medio Creek downstream contributed to the development of the secondary dissolved oxygen sag.

Water quality throughout Medio Creek has deteriorated between the dates of this survey and one conducted in June 1982. The magnitude and extent of the dissolved oxygen sags increased appreciably. This deterioration occurred even though stream flow was slightly higher, temperatures were cooler, and the cumulative carbonaceous and nitrogenous oxygen demand loadings from four domestic treatment plants were reduced by about 20 percent from the former study. Substantial increases in the abundance of periphyton upstream of O. R. Mitchell Reservoir and phytoplankton within the reservoir occurred between the dates of the surveys due to increased nutrient loadings. The metabolism of the algal mats in the upper portion of Medio Creek and the succession of phytoplankton discharged from O. R. Mitchell Reservoir to the lower portion of Medio Creek were contributary to the differences noted in the two dissolved oxygen sags between the two dates.

The goal of the Commission is to maintain a dissolved oxygen minimum of 3 mg/L in unclassified stream segments such as the upper portion of Medio Creek. The lower portion of Medio Creek was recently established as a stream segment by the Commission, and a dissolved oxygen minimum of 4 mg/L was assigned to protect aquatic life. Both dissolved oxygen criteria were violated during this intensive survey. These poor water quality conditions existed even though three of four wastewater treatment plants were discharging effluents with qualities substantially less than their permitted limitations. The present water quality conditions of Medio Creek have been documented and are likely to exist as long as the current levels of treatment at the four domestic treatment plants are maintained. However, suburban areas within the Medio Creek drainage basin, and particularly the area north of US 90, are rapidly growing. As the population continues to increase and effluent volumes increase, more stringent treatment levels, including reduction of nutrient compounds, may be required of dischargers to Medio Creek to reduce the severity of water quality problems.

The hydraulic and water quality data collected on this intensive survey will be utilized by the Commission, through mathematical modeling processes, to evaluate existing and proposed discharges to Medio Creek, and to write a wasteload evaluation for Segment 1912.

PRESENTATION OF DATA

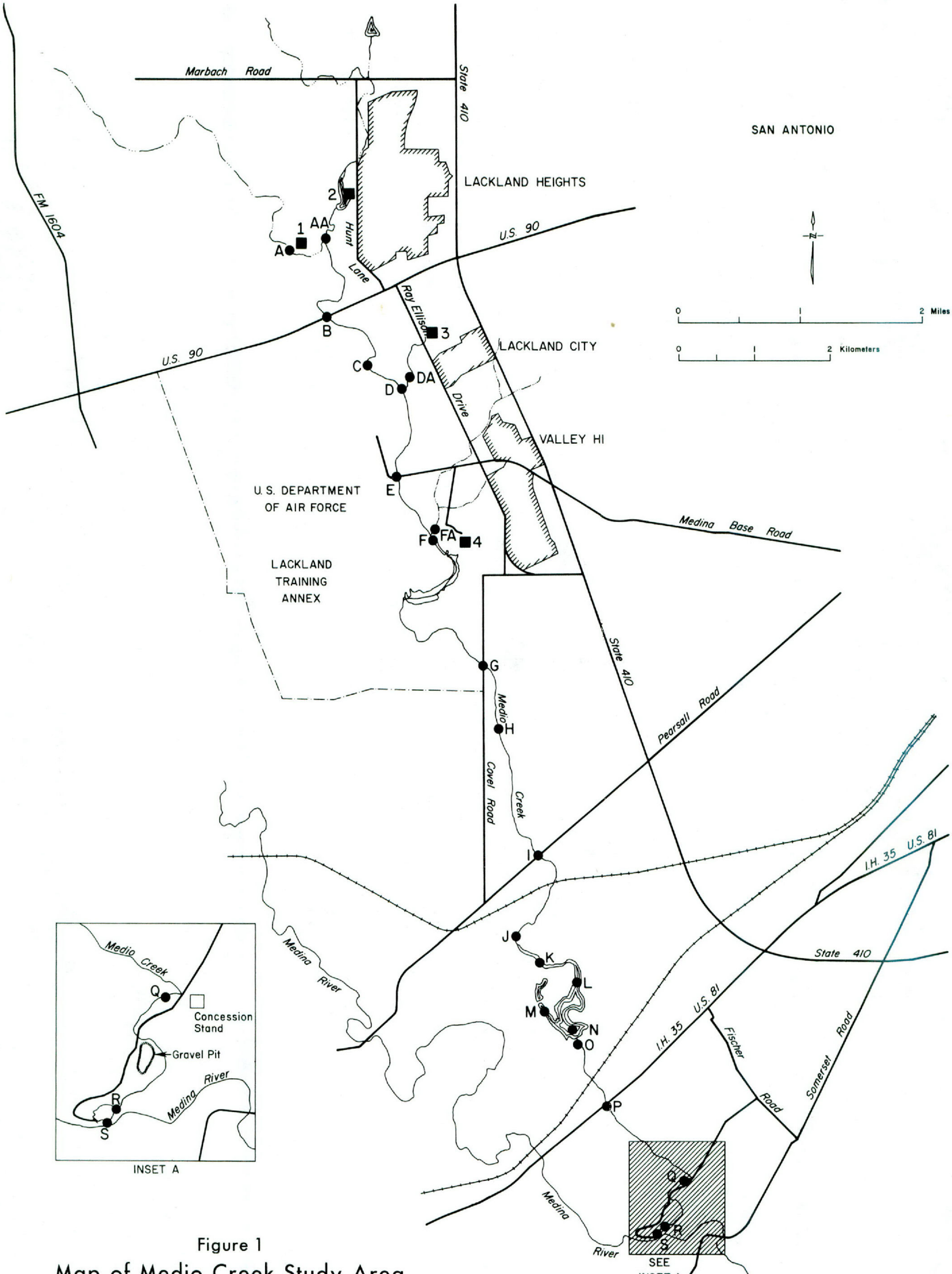

Figure 1

Map of Medio Creek Study Area

TABLE 1

Medio Creek Sampling Stations

Map Code	SMN Number	River Kilometer	River Mile	Location
A	1900.2612	18.9	11.7	Medio Creek 0.1 Km upstream of Community Treatments Outfall
B	1900.2610	17.2	10.6	Medio Creek at US 90
C	1900.2609	16.3	10.1	Medio Creek at headwaters of impoundment to the Lackland Training Annex, 0.9 Km downstream of US 90
D	1900.2608	15.6	9.7	Medio Creek upstream of the dam structure of a small impoundment on the Lackland Training Annex, 1.6 Km downstream of US 90
E	1900.2607	14.3	8.9	Medio Creek at Medina Base Road
F	1900.2606	13.3	8.3	Medio Creek 0.1 Km upstream of the Lackland Annex WWTP outfall, 1.0 Km downstream of Medina Base Road
G	1900.2605	10.1	6.3	Medio Creek at Covel Road
H	1900.2603	9.1	5.7	Medio Creek at low water crossing, 1.0 Km downstream of Covel Road
I	1900.2600	7.3	4.5	Medio Creek at Pearsall Road
J	1900.2595	6.2	3.9	Medio Creek upstream of O. R. Mitchell Reservoir on the Medio Creek Ranch, 0.2 Km downstream at high line crossing
K	1900.2590	5.5	3.4	O. R. Mitchell Ranch Reservoir
L	1900.2585	4.5	2.8	O. R. Mitchell Ranch Reservoir
M	1900.2580	3.9/0.4	2.4/0.2	O. R. Mitchell Ranch Reservoir
N	1900.2575	3.8	2.4	O. R. Mitchell Ranch Reservoir

TABLE 1 CONTINUED

Medio Creek Sampling Stations

Map Code	SMN Number	River Kilometer	River Mile	Location
O	1912.2593	3.6	2.2	Medio Creek 0.1 Km downstream of O. R. Mitchell Dam
P	1912.2590	2.8	1.7	Medio Creek at IH 35
Q	1912.2580	1.2	0.7	Medio Creek near Hidden Valley Park Concession area
R	1912.2570	0.1	0.06	Medio Creek 0.1 Km upstream of Medina River
S	1912.2560	0.005	0.003	Medio Creek 5 m upstream of Medina River
AA	1900.2650	18.7/0.1	11.6/0.06	Unnamed Tributary, 1.5 Km upstream of US 90
DA	1900.2645	15.6/0.1	9.7/0.06	Unnamed Tributary, 1.3 Km upstream of Medina Base Road
FA	1900.2640	13.4/0.1	8.3/0.06	Unnamed Tributary, 0.9 Km downstream of Medina Base Road
1	1900.9013	18.8	11.7	Community Treatment WWTP Outfall
2	1900.9011	18.7/1.1	11.6/0.7	Bexar County WCID No. 16 WWTP Outfall
3	1900.9012	15.6/0.9	9.7/0.6	Lackland City Water Company WWTP Outfall
4	1900.9015	13.2	8.2	U. S. Air Force Lackland Training Annex WWTP Outfall

TABLE 2

Active Water Quality Stations on Medio Creek

Station	Map Code	Sampling Agency/ Station Number	Frequency of Sampling/ Type of Record	Period of Record
Medio Creek at US 90 West of San Antonio	B	SARA - 1900.2610 TWC - 1900.2610	1 FD,CH,BA 2 FD,CH,BA	October 1978 - Present January 1983 - Present
Medio Creek at Pearsall Road	I	CSN - 1900.2600 SARA - 1900.2600	1 FD,CH,BA 1 FD,CH,BA	July 1974 - Present October 1978 - Present
Medio Creek at IH 35	P	SARA - 1912.2590 TWC - 1912.2590	1 FD,CH,BA 1 FD,CH,BA	May 1980 - Present January 1983 - Present

Frequency of Sampling

1. Monthly
2. Quarterly

Type of Record

FD Field Measurements in Water
CH Chemical Measurements in Water
BA Bacteriological Measurements in Water

TABLE 3

Historical Water Temperature, pH, Chloride, Sulfate, Total Dissolved Solids, and Fecal Coliform Data Collected by the Texas Water Commission, San Antonio River Authority and the City of San Antonio at Three Locations on Medio Creek
January 1, 1981 - December 31, 1985

Monitoring Station SMN Number	Map Code	Sampling Criteria →	Parameter: Water Temperature 34.9°C	pH Units 6.5-9.0	Chloride 100 mg/L	Sulfate 125 mg/L	Total Dissolved Solids 550	Fecal Coliform 200*
Medio Creek at	B	No. of Observations	40	36	23	21	22	22
US 90		Mean	20.5	---	71	65	528	504**
SMN 1900.2610		Range	9.0-29.0	6.9-8.0	25-101	40-140	412-608	40-32,200
		Percent > Criterion	0	0	4	5	23	23
Medio Creek at	I	No. of Observations	83	24	73	72	14	73
Pearsall Road		Mean	21.3	--	84	58	505	341**
SMN 1900.2600		Range	7.2-31.1	7.1-8.3	37-150	21-139	324-720	10-31,000
		Percent > Criterion	0	0	21	1	21	5
Medio Creek at	P	No. of Observations	69	62	55	53	53	51
IH-35		Mean	21.8	--	52	57	402	253
SMN 1912.2590		Range	9.0-32.5	7.2-9.1	24-106	18-90	248-516	4-50,000
		Percent > Criterion	0	3	2	0	0	47

* Geometric Mean
** Geometric Mean of 2,000/100 mL applies to this location.

TABLE 4

Historical Dissolved Oxygen Data Collected by the Texas Water Commission, San Antonio River Authority and City of San Antonio at Three Locations on Medio Creek January 1, 1981 - December 31, 1985

Monitoring Station SMN Number	Map Code		Water Year				
			1981	1982	1983	1984	1985
Medio Creek at US 90	B	No. of Observations	1	5	13	12	9
		Mean, mg/L	---	4.2	4.5	6.4	7.1
		Range, mg/L	4.0	2.7-6.4	3.1-7.5	4.6-9.1	4.5-8.5
SMN 1900.2610		Percent < 3.0 mg/L	0	20	0	0	0
Medio Creek at Pearsall Road	I	No. of Observation	1	5	8	5	6
		Mean, mg/L	---	7.8	9.0	6.7	7.8
		Range, mg/L	3.9	7.7-9.6	6.8-12.2	5.9-7.4	6.1-9.5
SMN 1900.2600		Percent < 3.0 mg/L	0	0	0	0	0
Medio Creek at IH-35	P	No. of Observations	1	10	21	20	17
		Mean, mg/L	---	7.3	7.3	7.4	6.3
		Range, mg/L	9.1	4.5-9.8	2.0-11.8	3.5-15.2	3.5-11.8
SMN 1912.2590		Percent < 4.0 mg/L	0	0	5	5	6

TABLE 5

Medio Creek Fish Kills

Date	Location	Total Fish Killed	Suspected Cause
03/11/74	IH 35 to Medina River	900	Unknown
03/11/80	IH 35 to Hidden Valley Campground	100	Oxygen Depletion
03/21/80	Lackland Air Force Base Annex	100	Pesticides
02/26/81	Lackland Air Force Base Annex	25	Oxygen Depletion

TABLE 6

Permitted and Observed Effluent Flows and Carbonaceous Five-Day Biochemical Oxygen Demand (BOD_5) and Total Suspended Solids (TSS) Loadings for Five Wastewater Dischargers to Medio Creek

Map Code	Wastewater Discharger (SMN Number) (Permit Number)	Permitted								Observed							
		Flow		BOD_5			TSS			Flow		$CBOD_5$			TSS		
		m^3/s	MGD	mg/L	kg/d	lb/d	mg/L	kg/d	lb/d	m^3/s	MGD	mg/L	kg/d	lb/d	mg/L	kg/d	lb/d
1	Community Treatment Medio Creek Plant 1900.9013 10827	0.15	3.5	20	264	583	20	264	583	0.075	1.7	3.0	20	43	5.0	32	71
2	Bexar County WCID #16 1900.9011 10130	0.022	0.5	20	38	83	20	38	83	0.013	0.3	4.0	5	10	15.0	17	38
3	Lackland City Water Co. Dwyer Road Plant 1900.9012 10212	0.014	0.31	30	35	78	90	106	233	0.013	0.3	3.5	4	9	14.0	16	35
4	U.S. Department of Air Force 1900.9015 12033	0.013	0.29	20	22	48	20	22	48	0.021	0.49	21.0	39	86	20.0	37	82
5	Oakcreek Environment Management, Inc. 11687	0.008	0.2	20	15	33	20	15	33	-----	----	----	---	---	----	---	---
	Totals	0.207	4.8		374	825		445	980	0.122	2.79		68	148		102	226

TABLE 7

Medio Creek Discharge, Width, and Velocity Data

Stream Reach: From (Map Code)	Stream Reach: To (Map Code)	Date	Stream Widths (m): No. of Meas.	Stream Widths (m): Range	Stream Widths (m): Average	Distance: Mi.	Distance: Km	Travel Time (hours)	Velocity: ft/s	Velocity: m/s	Discharge, m^3/s Upstream Station/ Downstream Station
Community Treatment WWTP WWTP Outfall (1)*	US 90 (B)	04/01/86	25	2.1-11.0	5.2	1.0	1.6	4.05	0.36	0.1097	0.17/0.0607
US 90 (B)	Headwaters of Impoundment (C)*	04/01-02/86	19	2.0-17.0	6.3	0.6	0.9	13.00	0.06	0.0192	0.0607/0.0802
Headwaters of Impoundment (C)*	Dam on Lackland Annex (D)	04/02/86	11	2.6-17.0	8.4	0.4	0.7	7.87	0.08	0.0247	0.0511/0.0869
Dam on Lackland Annex (D)	Medina Base Road (E)	04/02-03/86	26	3.3-12.0	6.4	0.8	1.3	8.83	0.13	0.0409	0.0869/0.1187
Medina Base Road (E)*	Lackland Annex WWTP (F)	04/01/86	21	2.9-17.0	6.8	0.6	1.0	7.62	0.12	0.0365	0.0778/0.1451
Lackland Annex WWTP (F)	Covel Road (G)	04/01-02/86	48	2.9-30.0	8.8	2.0	3.2	24.38	0.12	0.0365	0.1451/0.1046
Covel Road (G)*	Low Water Crossing (H)	04/02-03/86	12	6.0-20.3	10.9	0.6	1.0	17.17	0.05	0.0162	0.1169/0.0831
Low Water Crossing (H)*	Pearsall Road (I)	03/31/86	18	4.5-15.0	8.0	1.1	1.8	11.63	0.14	0.0430	0.1332/0.1133
Pearsall Road (I)*	Mitchell Ranch Impoundment (J)	04/01/86	14	2.7-12.3	6.4	0.7	1.1	6.85	0.15	0.0446	0.1131/0.1349
Mitchell Dam (O)*	IH-35 (P)	04/01/86	13	2.9-24.0	9.2	0.5	0.8	2.22	0.33	0.1003	0.2405/0.1792
IH-35 (P)	Hidden Valley Ranch (Q)	04/01/86	16	2.9-5.5	4.4	1.0	1.6	3.62	0.40	0.1229	0.1792/0.2074
Hidden Valley Ranch (Q)	Impoundment in Hidden Valley Ranch (R)	04/01-02/86	19	3.5-20.0	9.9	0.7	1.1	13.00	0.08	0.0235	0.2074/0.1722

*Dye Injections:

Community Treatment WWTP (Sta 1)	04/01/86	0812
Headwaters of Impoundment on Lackland Annex (Sta C)	04/02/86	0748
Medina Base Road (Sta E)	04/01/86	0938
Covel Road (Sta G)	04/02/86	1020
Low Water Crossing (Sta H)	03/31/86	1222
Pearsall Road (Sta I)	04/01/86	0619
Dam on Mitchell Ranch (Sta O)	04/01/86	1450

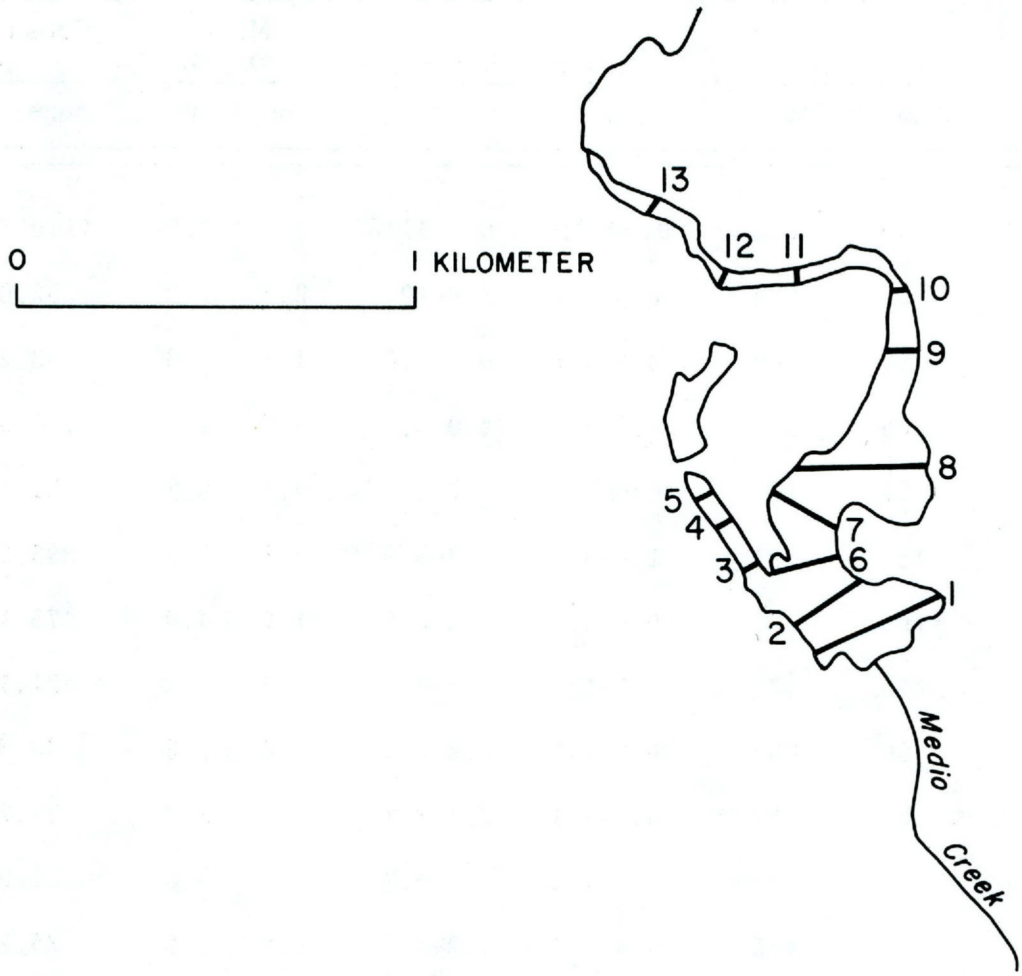

Figure 2
Location of Width and Depth Measurements From
O. R. Mitchell Reservoir, April 1-2, 1986

TABLE 8

Widths, Depths, and Cross Sectional Area Data from O. R. Mitchell Reservoir, March 31 - April 1, 1986

Cross Section Number	Width		Depth Range		Mean Depth		Cross Sectional Area	
	m	ft	m	ft	m	ft	m^2	ft^2
1	400	1,312	0.09-3.6	0.3-11.8	2.8	9.2	1110.7	11,951
2	300	984	0.5-3.2	1.8-10.4	2.2	7.2	652.0	7,016
3	82	269	0.2-1.9	0.6-6.3	1.1	3.6	93.2	1,003
4	65	213	0.6-1.0	2.0-3.2	0.7	2.3	46.8	504
5	52	171	0.03-0.4	0.1-1.4	0.2	0.7	11.4	123
6	180	591	1.0-3.0	3.3-9.9	1.8	5.9	335.2	3,607
7	190	623	0.4-2.0	1.4-6.5	1.5	4.9	275.1	2,960
8	450	1,477	0.9-1.2	2.8-4.0	0.9	3.0	421.1	4,531
9	86	282	0.2-0.7	0.6-2.4	0.4	1.3	33.3	358
10	57	187	0.3-1.1	1.1-3.7	0.7	2.3	37.7	406
11	29	95	0.7-1.6	2.4-5.2	1.1	3.6	31.0	334
12	41	135	0.4-1.4	1.2-4.7	0.9	3.0	35.2	379
13	13.2	43	0.4-1.1	1.3-3.7	0.7	2.3	9.7	104

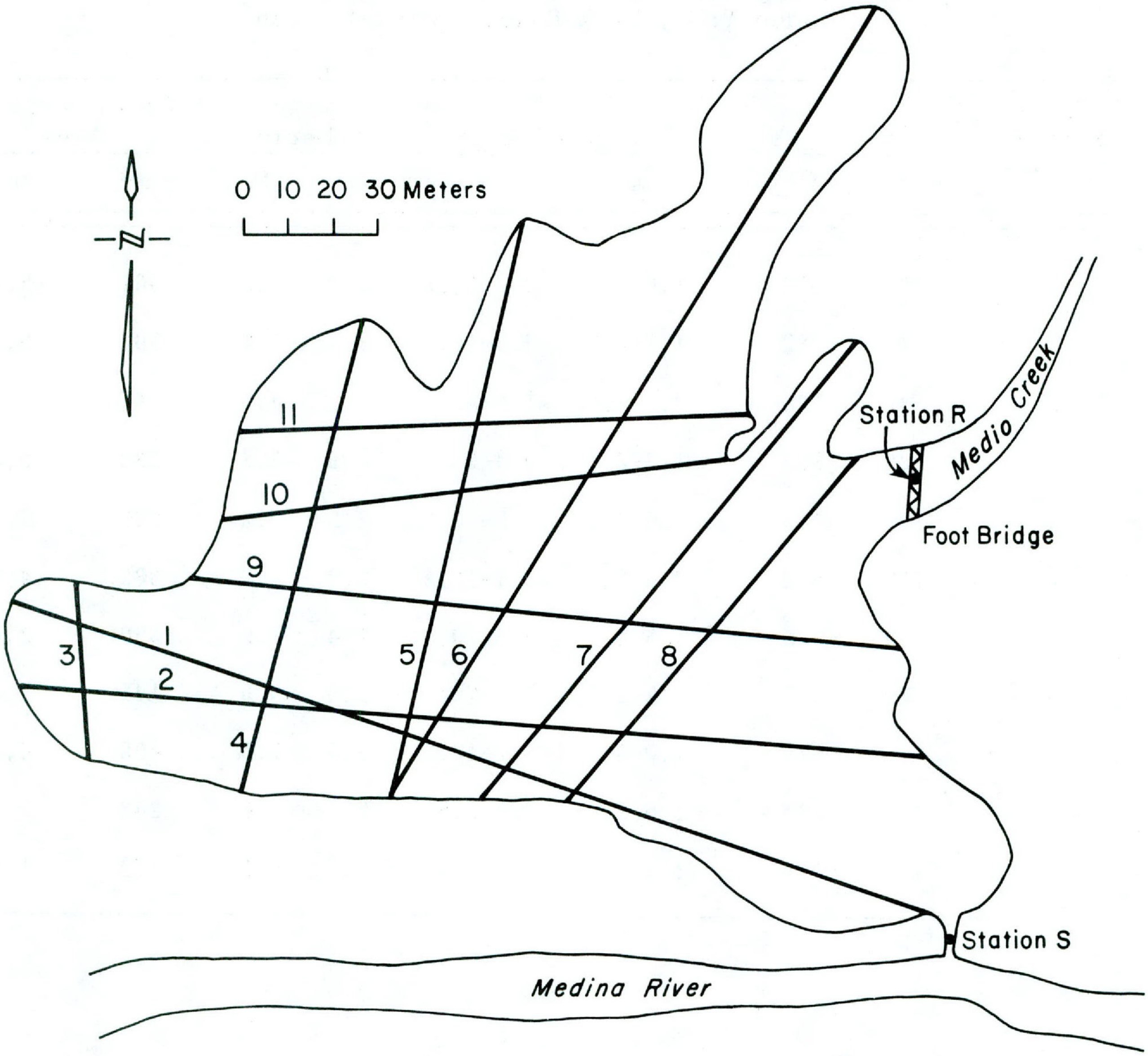

Figure 3
Location of Width and Depth Measurements From
Hidden Valley Park Pond, April 1-2, 1986

TABLE 9

Widths, Depths, and Cross Sectional Area Data from Hidden Valley Park Pond, April 1-2, 1986

Cross Section Number	Width		Depth Range		Mean Depth		Cross Sectional Area	
	m	ft	m	ft	m	ft	m^2	ft^2
1	220	722	1.0-3.2	3.2-10.5	2.3	7.5	501	5,391
2	210	689	1.1-3.3	3.7-10.7	2.4	7.9	502	5,402
3	39	128	0.5-1.6	1.6-5.2	1.1	3.6	41	441
4	120	394	1.3-2.8	4.4-9.1	1.9	6.2	233	2,507
5	135	443	1.0-3.1	3.3-10.3	2.2	7.2	296	3,185
6	175	574	0.6-3.1	2.1-10.2	2.2	7.2	383	4,121
7	105	345	1.5-3.2	5.0-10.5	2.4	7.9	250	2,690
8	80	263	1.7-2.3	5.5-7.5	1.8	5.9	141	1,517
9	175	574	1.0-3.1	3.2-10.2	2.3	7.5	408	4,390
10	120	394	1.5-2.9	4.8-9.5	2.0	6.6	243	2,615
11	115	378	1.0-2.0	3.4-6.4	1.7	5.6	172	1,851

TABLE 10

Tributary and Wastewater Treatment Plant Discharge Data

Map Code	Station Location	Date	Time	Method*	Discharge m³/s	ft³/s	MGD
1	Community Treatment WWTP	03/31/86	1455	F	0.096	3.40	2.196
			1845		0.070	2.47	1.596
		04/01/86	0450		0.027	0.95	0.615
			1046		0.134	4.72	3.052
2	Bexar County WCID #16	03/31/86	1630	F	0.015	0.54	0.35
			1920		0.020	0.71	0.46
		04/01/86	0533		0.010	0.36	0.23
			1129		0.018	0.62	0.40
3	Lackland City Water Company	03/31/86	1650	W	0.011	0.39	0.25
			1930		0.005	0.17	0.11
		04/01/86	0545		0.012	0.45	0.29
			1140		0.018	0.63	0.41
4	Lackland Training Annex	03/31/86 04/01/86		T	0.022	0.76	0.49
A	Medio Creek 0.1 km upstream of Community Treatment's Outfall	04/01/86	0830	M	0.0015	0.05	
AA	Unnamed Tributary	04/01/86	0841	M	0.014	0.49	
DA	Unnamed Tributary	04/02/86	1700	M	0.010	0.35	
FA	Unnamed Tributary	04/01/86	1331	M	0.009	0.31	

* F = Flow Recorder at Plant
W = Wier Measurement at Plant
T = Totalizer Measurement at Plant
M = Instream Measurement

TABLE 11

Medio Creek Field Measurements

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
A 1900.2612	03/31/86	1545	0.3	21.7	768	12.7	144.9	7.8
	03/31/86	1906	0.3	21.2	760	15.1	170.6	7.8
	04/01/86	0515	0.3	19.2	774	5.6	60.8	7.8
	04/01/86	1113	0.3	19.4	781	5.9	64.3	7.5
		DIEL MEAN		20.2	771	9.5	106.3	7.7
AA 1900.2650	03/31/86	1524	0.3	23.3	830	4.8	56.5	7.2
	03/31/86	1856	0.3	23.7	845	4.1	48.6	7.6
	04/01/86	0505	0.3	21.1	844	3.8	42.9	7.5
	04/01/86	1103	0.3	21.3	827	4.4	49.8	7.1
		DIEL MEAN		22.2	838	4.2	48.2	7.4
B 1900.2610	03/31/86	1355	0.3	22.7	890	7.4	86.1	7.1
	03/31/86	1822	0.3	22.7	890	8.2	95.4	7.6
	04/01/86	0425	0.3	21.3	906	5.7	64.5	7.5
	04/01/86	1015	0.3	21.2	904	6.6	74.6	7.1
		DIEL MEAN		21.9	898	6.9	79.5	7.4
C 1900.2609	03/31/86	1415	0.3	21.5	949	7.6	86.4	8.5
	03/31/86	1805	0.3	22.6	930	5.8	67.3	7.3
	04/01/86	0545	0.3	21.0	938	5.7	64.2	7.4
	04/01/86	1010	0.3	21.1	937	5.8	65.4	7.5
		DIEL MEAN		21.6	937	6.1	69.1	7.6
D 1900.2608	03/31/86	1440	0.3	22.1	947	6.2	71.3	7.6
	03/31/86	1820	0.3	22.0	945	6.8	78.0	7.7
	04/01/86	0528	0.3	21.1	934	5.1	57.5	7.4
	04/01/86	1020	0.3	21.1	931	5.1	57.5	7.5
		DIEL MEAN		21.5	939	5.8	66.1	7.5

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
DA 1900.2645	03/31/86	1450	0.3	21.4	833	4.1	46.5	7.7
	03/31/86	1825	0.3	21.8	828	3.7	42.3	7.7
	04/01/86	0600	0.3	18.5	911	4.7	50.3	7.6
	04/01/86	1025	0.3	20.0	892	4.9	54.1	7.7
		DIEL MEAN		20.3	868	4.3	47.8	7.7
E 1900.2607	03/31/86	1455	0.3	21.7	934	7.6	86.7	7.8
	03/31/86	1833	0.3	21.6	928	5.4	61.5	7.7
	04/01/86	0620	0.3	20.4	939	2.6	28.9	7.3
	04/01/86	1035	0.3	20.6	930	3.7	41.3	7.5
		DIEL MEAN		21.0	933	4.5	51.2	7.5
FA 1900.2640	04/01/86	0930	0.3	20.2	486	7.0	77.6	7.8
		DIEL MEAN		20.2	486	7.0	77.6	7.8
F 1900.2606	03/31/86	1535	0.3	21.7	893	7.0	79.9	7.8
	03/31/86	1849	0.3	21.1	918	7.2	81.2	7.6
	04/01/86	0630	0.3	20.4	907	2.5	27.8	7.4
	04/01/86	1042	0.3	20.3	901	3.6	40.0	7.5
		DIEL MEAN		20.8	907	4.9	55.5	7.5
G 1900.2605	03/31/86	1630	0.3	21.2	895	6.5	73.5	7.6
	03/31/86	1930	0.3	21.3	906	6.1	69.1	7.9
	04/01/86	0630	0.3	20.2	910	3.0	33.2	8.0
	04/01/86	1158	0.3	20.5	900	4.1	45.7	7.8
		DIEL MEAN		20.7	904	4.7	52.6	7.9

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
H 1900.2603	03/31/86	1614	0.3	21.7	897	7.2	82.2	7.9
	03/31/86	1915	0.3	21.3	900	6.8	77.0	7.9
	04/01/86	0620	0.3	19.9	903	4.6	50.7	8.1
	04/01/86	1144	0.3	20.5	900	4.9	54.6	7.9
		DIEL MEAN		20.7	901	5.7	64.1	8.0
I 1900.2600	03/31/86	1550	0.3	21.3	885	8.7	98.5	7.9
	03/31/86	1905	0.3	20.7	897	7.2	80.6	8.0
	04/01/86	0605	0.3	19.9	904	5.5	60.6	8.2
	04/01/86	1130	0.3	20.6	894	7.4	82.6	8.2
		DIEL MEAN		20.5	897	6.9	77.0	8.1
J 1900.2595	03/31/86	1505	0.3	21.4	848	7.6	86.2	7.7
	03/31/86	1850	0.3	21.5	843	7.2	81.8	7.3
	04/01/86	0610	0.3	20.7	816	6.3	70.5	7.8
	04/01/86	1100	0.3	20.8	836	7.4	83.0	7.8
		DIEL MEAN		21.1	833	7.0	78.9	7.6
K 1900.2590	03/31/86	1450	0.3	22.9	832	7.5	87.6	7.8
	03/31/86	1450	1.2	21.0	875	4.4	49.5	7.5
	03/31/86	1835	0.3	22.7	856	10.0	116.3	7.6
	03/31/86	1835	1.2	22.6	840	7.7	89.4	7.4
	04/01/86	0600	0.3	21.3	843	5.5	62.3	8.1
	04/01/86	0600	1.2	21.1	851	4.8	54.1	7.9
	04/01/86	1040	0.3	21.5	852	5.8	65.9	7.7
	04/01/86	1040	1.2	20.9	857	4.3	48.3	7.6
		DIEL MEAN		21.8	850	6.4	73.8	7.7

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
L 1900.2585	03/31/86	1440	0.3	22.2	688	10.9	125.6	8.5
	03/31/86	1440	1.5	21.9	689	10.0	114.6	8.6
	03/31/86	1440	2.1	21.8	689	9.3	106.3	8.5
	03/31/86	1825	0.3	22.2	693	10.2	117.5	7.9
	03/31/86	1825	1.5	22.1	692	10.0	115.0	8.2
	03/31/86	1825	2.1	22.1	691	9.7	111.5	8.2
	04/01/86	0540	0.3	21.3	687	7.5	84.9	8.8
	04/01/86	0540	1.5	21.3	688	7.5	84.9	8.8
	04/01/86	0540	2.1	21.3	689	7.2	81.5	8.8
	04/01/86	1025	0.3	21.4	690	8.8	99.8	8.6
	04/01/86	1025	1.5	21.3	695	8.0	90.6	8.6
	04/01/86	1025	2.1	21.3	697	7.2	81.5	8.6
		DIEL MEAN		21.7	690	8.8	100.0	8.5
M 1900.2580	03/31/86	1430	0.3	22.9	613	12.2	142.5	8.2
	03/31/86	1430	1.5	22.8	615	12.3	143.4	8.3
	03/31/86	1815	0.3	23.6	601	13.1	155.0	8.6
	03/31/86	1815	1.5	23.5	594	12.7	150.0	8.6
	04/01/86	0530	0.3	21.8	651	8.2	93.7	8.9
	04/01/86	0530	1.5	21.8	652	8.2	93.7	8.9
	04/01/86	1015	0.3	22.0	635	9.2	105.6	8.4
	04/01/86	1015	1.5	21.8	622	9.1	104.0	8.4
		DIEL MEAN		22.5	624	10.5	122.4	8.6

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
N 1900.2575	03/31/86	1410	0.3	21.9	663	11.6	132.9	8.9
	03/31/86	1410	1.5	21.1	673	8.2	92.5	8.8
	03/31/86	1410	3.1	20.1	703	1.0	11.1	8.5
	03/31/86	1410	4.0	18.8	711	0.7	7.5	8.4
	03/31/86	1800	0.3	21.7	661	11.4	130.1	8.8
	03/31/86	1800	1.5	21.1	678	6.8	76.7	8.7
	03/31/86	1800	3.1	20.0	702	0.9	9.9	8.4
	03/31/86	1800	4.0	18.8	714	0.6	6.5	8.3
	04/01/86	0510	0.3	21.2	661	9.8	110.7	9.0
	04/01/86	0510	1.5	21.2	665	9.3	105.1	9.0
	04/01/86	0510	3.1	20.1	699	0.7	7.7	8.7
	04/01/86	0510	4.0	18.8	708	0.6	6.5	8.6
	04/01/86	1000	0.3	21.2	665	10.3	116.4	8.7
	04/01/86	1000	1.5	21.0	674	7.8	87.8	8.6
	04/01/86	1000	3.1	20.5	689	1.3	14.5	8.5
	04/01/86	1000	4.0	18.8	710	0.7	7.5	8.3
		DIEL MEAN		20.4	686	5.1	57.4	8.7
O 1912.2593	03/31/86	1525	0.3	21.8	666	8.6	98.3	8.7
	03/31/86	1920	0.3	21.6	660	8.2	93.4	8.8
	04/01/86	0645	0.3	21.0	670	8.8	99.0	8.4
	04/01/86	1120	0.3	21.1	671	9.1	102.6	8.2
		DIEL MEAN		21.3	666	8.6	97.8	8.5
P 1912.2590	03/31/86	1524	0.3	22.7	692	6.4	74.5	8.7
	03/31/86	1850	0.3	21.5	693	5.4	61.4	9.1
	04/01/86	0548	0.3	20.4	704	5.0	55.6	9.2
	04/01/86	1107	0.3	21.3	696	6.0	67.9	9.2
		DIEL MEAN		21.3	697	5.5	62.8	9.1

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
Q 1912.2580	03/31/86	1500	0.3	22.1	699	3.5	40.2	8.7
	03/31/86	1840	0.3	22.3	712	2.7	31.2	8.9
	04/01/86	0530	0.3	20.5	713	2.5	27.9	8.9
	04/01/86	1040	0.3	20.9	705	3.0	33.7	8.8
		DIEL MEAN		21.4	709	2.8	32.1	8.8
R 1912.2570	03/31/86	1447	0.3	21.4	702	5.8	65.8	8.5
	03/31/86	1810	0.3	21.9	700	8.1	92.8	8.8
	04/01/86	0520	0.3	21.1	720	2.7	30.5	8.7
	04/01/86	1015	0.3	21.1	714	3.0	33.8	8.7
		DIEL MEAN		21.4	710	4.9	55.8	8.7
S 1912.2560	03/31/86	1430	0.3	22.1	689	9.8	112.7	8.1
	03/31/86	1800	0.3	22.3	685	10.5	121.2	9.1
	04/01/86	0510	0.3	20.8	709	8.6	96.4	8.8
	04/01/86	0955	0.3	21.2	710	7.4	83.6	8.8
		DIEL MEAN		21.6	698	9.1	104.2	8.8
1 1900.9013	03/31/86	1455	0.3	23.5	725	5.0	59.1	7.1
	03/31/86	1845	0.3	23.1	927	5.5	64.5	6.9
Community	04/01/86	0450	0.3	22.2	900	5.5	63.4	7.4
Treatment	04/01/86	1046	0.3	22.0	914	4.8	55.1	7.1
Medio Creek								
Plant		DIEL MEAN		22.6	882	5.3	61.2	7.1
2 1900.9011	03/31/86	1630	0.3	24.3	814	5.5	65.9	7.1
	03/31/86	1920	0.3	24.0	816	7.4	88.2	7.6
Bexar County	04/01/86	0533	0.3	20.6	793	7.8	87.1	7.5
WCID No. 16	04/01/86	1129	0.3	23.7	848	7.1	84.2	7.4
		DIEL MEAN		22.8	815	7.2	83.3	7.4

TABLE 11 CONTINUED

Map Code and Station Number	Date	Time	Depth (m)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
3 1900.9012	03/31/86	1650	0.3	23.8	800	4.1	48.7	7.8
	03/31/86	1930	0.3	21.0	815	2.7	30.4	7.7
Lackland City	04/01/86	0545	0.3	18.1	875	3.5	37.2	7.2
Water Company	04/01/86	1140	0.3	20.0	850	4.3	47.5	7.2
		DIEL MEAN		20.2	841	3.6	39.6	7.4
4 1900.9015	03/31/86	1520	0.3	23.2	875	6.5	76.3	7.3
	03/31/86	1845	0.3	22.9	843	6.3	73.6	7.4
United States	04/01/86	0635	0.3	22.4	787	6.4	74.0	6.9
Department	04/01/86	1048	0.3	22.6	808	6.0	69.7	7.3
Air Force								
		DIEL MEAN		22.7	823	6.3	73.5	7.2

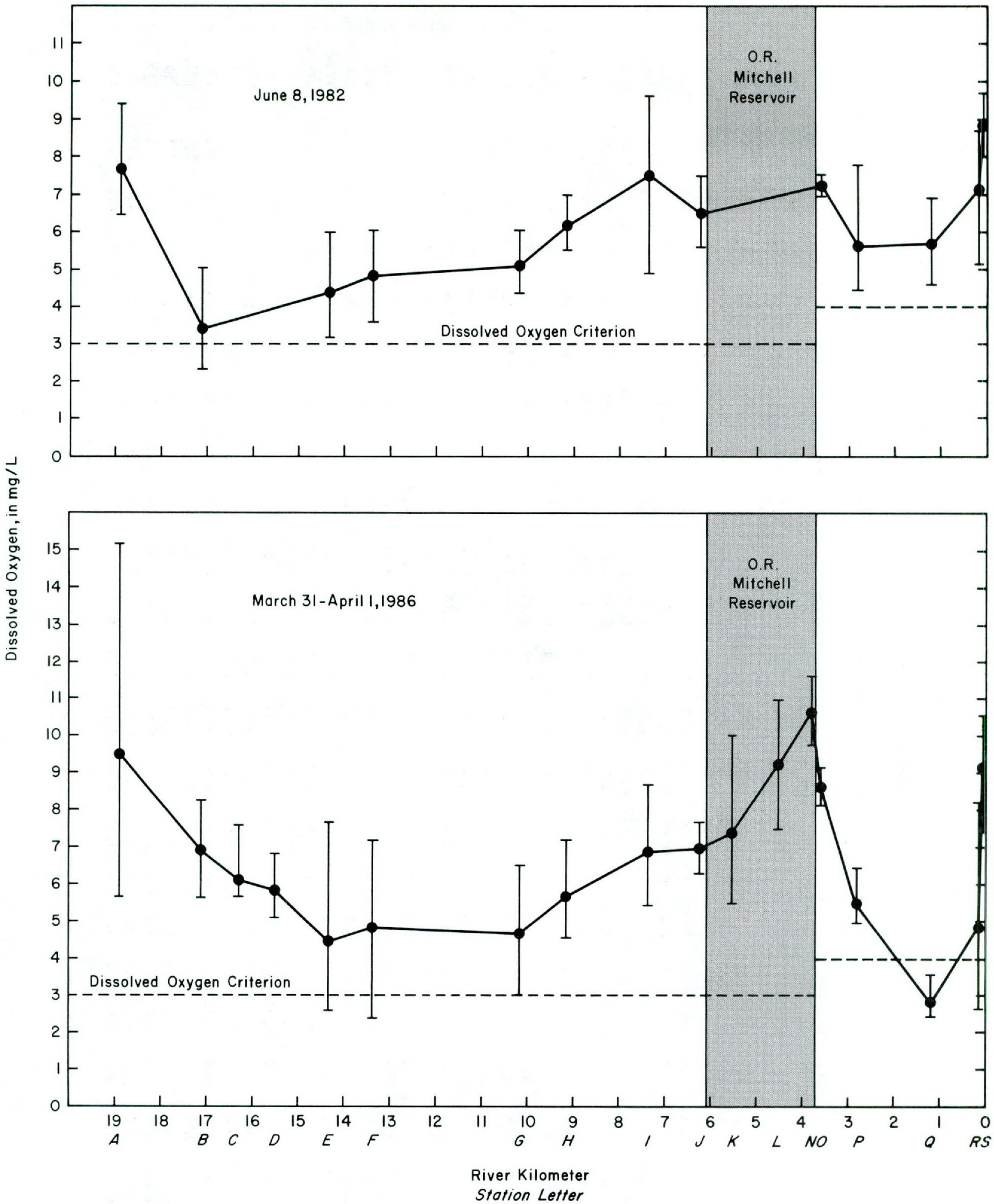

Figure 4
Mean and Range of Dissolved Oxygen Levels From Medio Creek by River Kilometer and Station Letter

TABLE 12

Medio Creek Laboratory Water Analyses

Map Code and Station Number	Date	Time	Depth m	5day CBOD mg/L	Filt. 5day CBOD mg/L	20day CBOD mg/L	Filt. 20day CBOD mg/L	Filt. TOC mg/L	TKN mg/L	NH_3-N mg/L	NO_2-N mg/L	NO_3-N mg/L	Ortho P mg/L	Total P mg/L	Chl. a µg/L	Pheo. a µg/L	Cl^- mg/L	$SO_4^=$ mg/L	TSS mg/L	VSS mg/L	TDS mg/L	Total Alk. mg/L	Cond. µmhos/cm	pH
A 1900.2612	03/31/86	COMP	0.3	2.5	2.0	4.5	3.5	3	0.50	0.08	0.05	0.88	<0.01	0.03	5	<2	37	106	12	3	480	248	880	8.3
AA 1900.2650	03/31/86	COMP	0.3	2.0	2.0	6.5	6.0	6	4.00	2.73	1.34	8.43	6.55	6.60	4	<2	66	86	16	3	492	207	942	8.2
B 1900.2610	03/31/86	COMP	0.3	3.0	3.0	7.0	6.0	6	1.90	0.65	0.16	10.00	8.72	8.99	4	3	96	75	24	7	552	196	996	8.1
B 1900.2610	03/31/86	1355	0.3	5.0	4.0	10.0	7.0	7	2.80	1.11	0.15	6.42	8.99	9.28	8	<2	95	75	66	13	548	215	1002	8.1
B 1900.2610	03/31/86	1822	0.3	4.0	3.5	10.5	7.0	6	1.80	0.49	0.14	5.55	8.82	9.07	3	2	97	74	14	5	538	211	996	8.1
B 1900.2610	04/01/86	0425	0.3	3.0	2.5	7.0	6.0	5	2.10	0.48	0.15	11.99	8.44	8.57	5	<2	100	75	11	3	548	183	1008	8.0
B 1900.2610	04/01/86	1015	0.3	2.5	2.0	7.0	5.0	3	1.90	0.50	0.18	14.33	8.51	8.90	8	<2	95	72	14	5	560	180	996	8.1
C 1900.2609	03/31/86	COMP	0.3	2.5	2.0	7.5	7.0	6	1.40	0.99	0.26	7.57	8.78	8.84	3	4	98	75	19	7	572	208	1014	8.2
D 1900.2608	03/31/86	COMP	0.3	2.5	1.5	6.5	4.5	6	1.90	0.98	0.26	6.80	9.07	9.43	2	2	98	76	16	5	580	213	1014	8.2
DA 1900.2645	03/31/86	COMP	0.3	3.5	2.5	8.0	6.5	13	1.60	0.29	0.29	2.40	2.88	3.11	21	18	65	60	19	6	522	277	936	8.3
E 1900.2607	03/31/86	COMP	0.3	2.0	1.5	5.5	4.5	6	1.60	0.41	0.36	6.72	8.44	8.57	3	2	93	74	12	6	576	222	1002	8.2
E 1900.2607	03/31/86	1455	0.3	2.0	1.5	6.0	4.5	6	1.30	0.16	0.30	7.87	8.40	8.42	<2	4	93	74	16	6	548	220	1014	8.3
E 1900.2607	03/31/86	1833	0.3	2.0	1.5	7.0	5.0	6	1.20	0.16	0.28	7.01	8.00	8.55	<2	5	91	72	10	4	556	228	1002	8.2
E 1900.2607	04/01/86	0620	0.3	2.0	1.5	5.5	4.0	5	1.70	0.76	0.45	6.31	8.40	8.93	<2	4	95	73	8	4	546	222	1008	8.1
E 1900.2607	04/01/86	1035	0.3	2.0	1.5	5.5	4.5	7	1.60	0.58	0.44	6.01	7.90	8.40	<2	4	93	73	11	3	558	225	996	8.2
FA 1900.2640	04/01/86	0930	0.3	1.0	1.0	3.0	2.5	3	0.50	<0.02	<0.01	0.01	0.05	0.10	2	4	26	45	9	2	290	162	518	8.3
F 1900.2606	03/31/86	COMP	0.3	1.5	1.0	3.5	3.5	6	-----	0.15	-----	14.07	7.56	7.96	2	3	85	72	14	4	548	211	984	8.2
G 1900.2605	03/31/86	COMP	0.3	1.5	1.5	4.5	4.0	5	1.20	0.27	0.28	9.25	6.68	7.20	<2	<2	87	70	20	4	532	204	978	8.3
G 1900.2605	03/31/86	1630	0.3	1.5	1.5	4.0	4.0	6	1.20	0.17	0.25	10.04	6.68	6.95	<2	3	87	71	19	5	562	201	978	8.3
G 1900.2605	03/31/86	1930	0.3	1.5	1.5	4.0	3.5	6	1.10	0.11	0.20	9.69	6.62	7.06	<2	3	89	71	17	6	562	202	978	8.2
G 1900.2605	04/01/86	0630	0.3	1.5	1.5	3.5	3.5	5	1.10	0.12	0.23	9.72	7.14	7.46	<2	<2	89	72	13	4	548	205	984	8.2
G 1900.2605	04/01/86	1158	0.3	2.0	2.0	4.5	4.5	5	1.70	0.53	0.40	8.86	7.10	7.31	<2	4	85	69	17	5	564	211	978	8.2
H 1900.2603	03/31/86	COMP	0.3	2.0	2.0	5.0	4.0	5	1.50	0.09	0.15	9.13	6.97	7.20	6	7	87	72	61	12	558	205	978	8.4
I 1900.2600	04/01/86	1130	0.3	1.5	1.0	4.0	3.0	5	1.10	0.04	0.12	8.95	6.89	7.10	4	4	89	74	28	7	556	205	966	8.4
J 1900.2595	03/31/86	COMP	0.3	1.0	1.0	2.5	2.5	5	0.90	0.05	0.04	6.95	5.59	5.88	<2	4	78	67	15	4	524	208	918	8.4
K 1900.2590	03/31/86	COMP	COMP	2.0	1.0	5.0	3.0	5	1.20	0.08	0.07	5.20	4.30	4.66	22	21	80	70	50	10	520	216	936	8.4
L 1900.2585	03/31/86	COMP	COMP	6.0	2.0	11.0	3.5	5	1.90	0.08	0.02	0.36	0.92	1.36	112	37	61	61	22	6	432	213	780	9.0
M 1900.2580	03/31/86	COMP	COMP	5.0	1.0	9.0	3.0	4	1.50	0.08	0.01	0.22	0.60	0.83	166	23	50	53	35	8	398	213	730	8.9
N 1900.2575	03/31/86	COMP	COMP	2.5	1.0	5.0	2.5	4	1.50	0.18	0.02	0.05	0.92	1.23	62	37	57	59	24	8	426	216	775	9.0
N 1900.2575	03/31/86	COMP	0.3	6.0	1.0	9.5	2.5	4	1.30	0.03	<0.01	<0.01	0.64	0.91	118	17	56	58	23	12	418	216	765	9.2
N 1900.2575	03/31/86	COMP	2.1	6.0	1.0	11.0	3.0	4	1.90	0.14	0.01	0.05	0.95	1.30	69	28	57	60	22	9	420	218	775	8.9
N 1900.2575	03/31/86	COMP	4.0	2.5	2.0	6.0	3.0	4	1.50	0.30	0.03	0.01	1.29	1.72	62	18	59	61	29	3	418	223	780	8.7
O 1912.2593	03/31/86	COMP	0.3	6.0	1.5	12.0	3.5	4	1.50	0.05	0.01	0.05	0.71	0.99	108	26	59	59	20	9	420	217	770	9.1

TABLE 12 CONTINUED

Map Code	Station Number	Date	Time	Depth m	5day CBOD mg/L	Filt. 5day CBOD mg/L	20day CBOD mg/L	Filt. 20day CBOD mg/L	Filt. TOC mg/L	TKN mg/L	NH_3-N mg/L	NO_2-N mg/L	NO_3-N mg/L	Ortho P mg/L	Total P mg/L	Chl. a µg/L	Pheo. a µg/L	Cl^- mg/L	$SO_4^=$ mg/L	TSS mg/L	VSS mg/L	TDS mg/L	Total Alk. mg/L	Cond. µmhos/cm	pH
P	1912.2590	03/31/86	COMP	0.3	5.0	1.5	9.0	3.5	4	1.40	0.20	0.06	0.14	0.90	1.02	86	21	59	62	19	7	424	218	775	8.8
P	1912.2590	03/31/86	1524	0.3	4.5	1.0	7.5	3.0	5	1.50	0.17	0.06	0.14	0.75	0.97	42	14	60	62	21	8	430	216	775	8.9
P	1912.2590	03/31/86	1850	0.3	4.0	1.5	8.0	3.0	5	1.40	0.19	0.06	0.14	0.76	0.99	48	27	59	63	27	6	440	218	775	9.0
P	1912.2590	04/01/86	0548	0.3	4.5	1.5	9.0	3.5	5	1.50	0.25	0.06	0.11	0.84	1.05	97	25	58	62	24	7	446	218	775	8.9
P	1912.2590	04/01/86	1107	0.3	5.0	1.5	9.5	3.5	5	1.40	0.19	0.06	0.12	0.84	1.05	96	25	58	62	25	8	420	219	780	8.9
Q	1912.2580	03/31/86	COMP	0.3	3.0	1.0	6.5	3.5	5	1.40	0.32	0.14	0.23	0.87	0.99	39	28	56	61	16	4	424	217	775	8.7
R	1912.2570	03/31/86	COMP	0.3	3.5	1.5	6.0	3.5	5	1.20	0.25	0.14	0.22	0.88	0.99	31	22	58	61	17	4	424	218	780	8.5
S	1912.2560	03/31/86	COMP	0.3	4.0	1.5	8.5	4.0	5	1.30	0.07	0.08	0.11	0.79	0.97	52	15	58	61	20	7	434	218	780	8.7
1	1900.9013	04/01/86	COMP	0.3	3.0	2.5	5.5	4.5	5	1.10	<0.02	<0.01	12.60	8.44	8.86	<2	<2	102	69	5	3	584	185	1015	7.8
2	1900.9011	04/01/86	COMP	0.3	4.0	3.0	9.0	6.0	6	4.00	2.04	0.21	14.43	6.77	7.08	2	2	68	76	15	9	532	182	930	8.1
3	1900.9012	04/01/86	COMP	0.3	3.5	2.0	7.5	5.0	13	3.00	1.18	0.13	1.20	3.20	3.37	8	11	65	58	14	6	552	287	948	8.3
4	1900.9015	03/31/86	COMP	0.3	21.0	16.0	40.0	30.0	12	14.30	9.62	0.41	12.99	5.76	6.70	4	<2	80	40	20	16	504	196	870	8.0

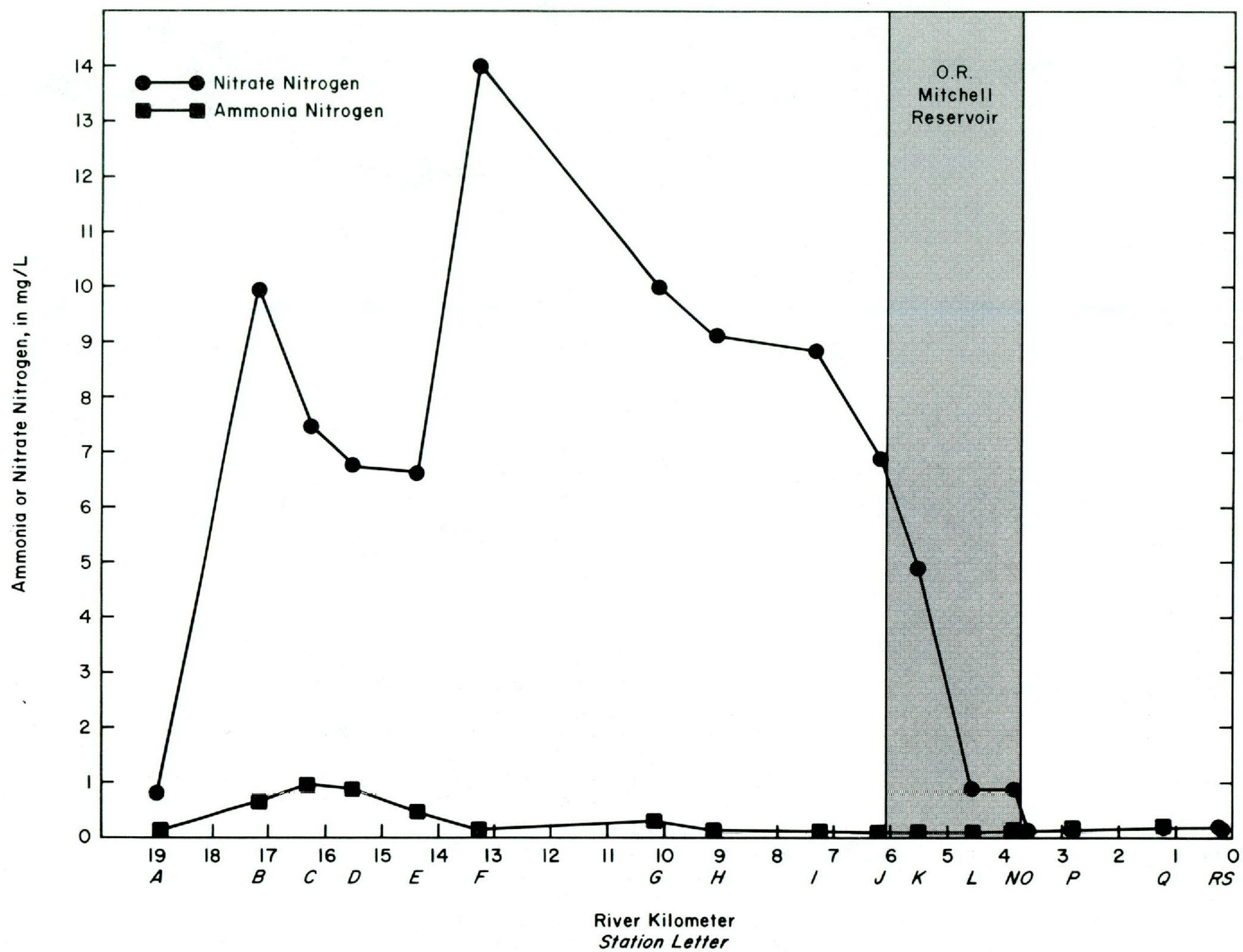

Figure 5

Ammonia and Nitrate Nitrogen Levels From Medio Creek by River Kilometer and Station Letter, March 31—April 1, 1986

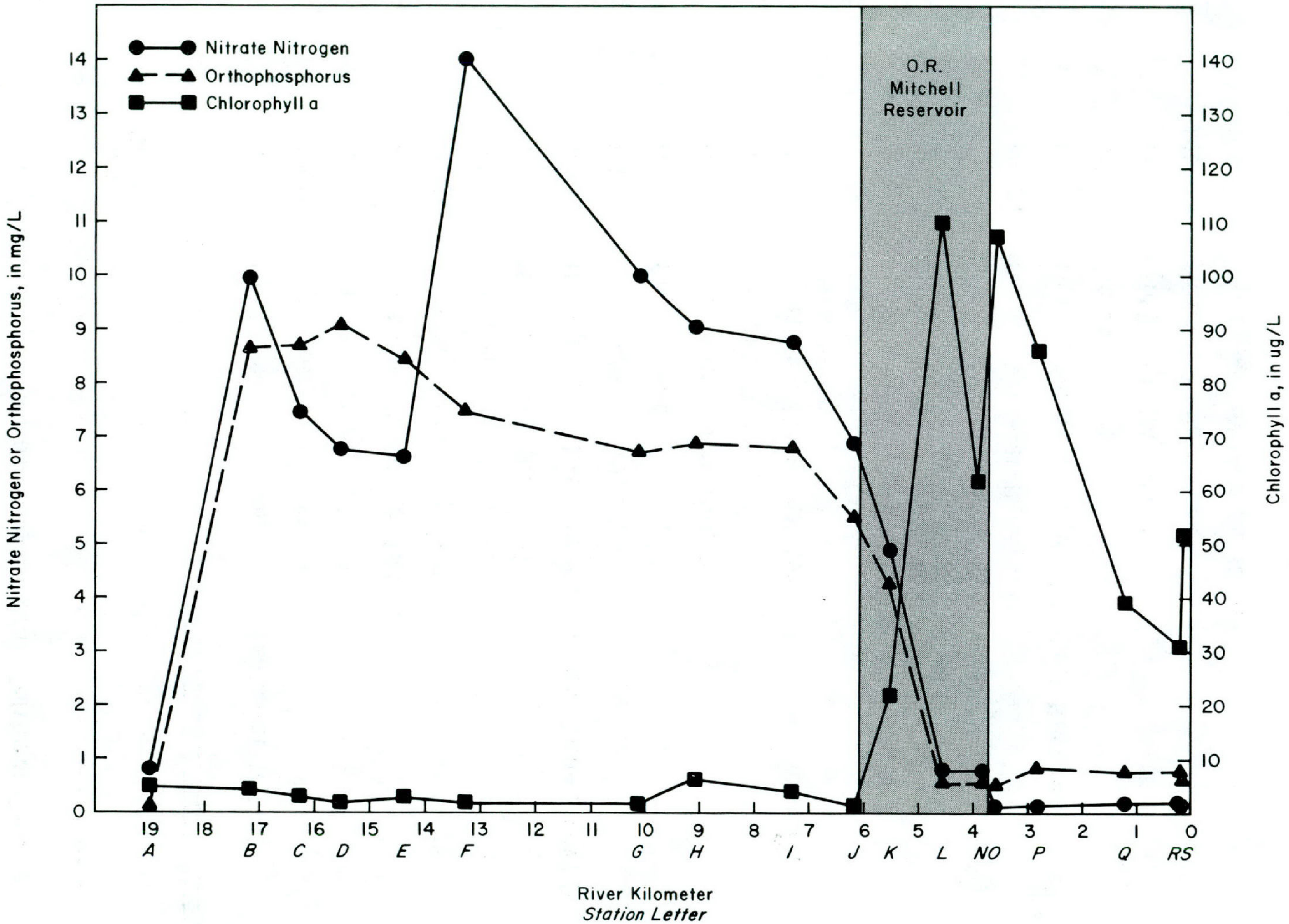

Figure 6

Nitrate Nitrogen, Orthophosphorus, and Chlorophyll a Levels From Medio Creek by River Kilometer and Station Letter, March 31—April 1, 1986

TABLE 13

Medio Creek Fecal Coliform Data

Map Code	Location	Fecal Coliform #/100 mL
A	Upstream of Community Treatment WWTP	130
AA	Unnamed Tributary	10
B	US 90	20
C	Lackland Training Annex	40
D	Lackland Training Annex	110
DA	Unnamed Tributary	4,675
E	Medina Base Road	265
F	Upstream of Lackland Training Annex WWTP	55
FA	Unnamed Tributary	10
G	Covel Road	10
H	Low Water Crossing	70
I	Pearsall Road	120
J	Upstream of Headwaters of O. R. Mitchell Reservoir	20
K	O. R. Mitchell Reservoir	40
L	O. R. Mitchell Reservoir	10
M	O. R. Mitchell Reservoir	<10
N	O. R. Mitchell Reservoir	<10
O	Downstream of O. R. Mitchell Reservoir	20
P	IH-35	690
Q	Hidden Valley Park	100
R	Hidden Valley Park	80
S	Upstream of Medina River	80
1	Community Treatment, Medio Creek WWTP	<5
2	Bexar County WCID No. 16, WWTP	<10
3	Lackland City Water Company WWTP	4,290
4	Lackland Training Annex WWTP	40

LITERATURE CITED

Glass Environmental Consultants, Inc. 1981. Identification of Wastewater Management Alternatives for the Medio Creek Watershed, Bexar, County, Texas. Glass Environmental Consultants, Inc., Austin, 65 p.

National Oceanic and Atomospheric Administration. 1986. Local Climatological Data, San Antonio, Texas. NOAA, Asheville, North Carolina.

Texas Water Commission. 1986a. Dam Inspection Report O. R. Mitchell Reservoir, Bexar County. Application Number 3931. Texas Water Commission, Austin.

Texas Water Commission. 1986b. Fish Kill Report. Texas Water Commission, Austin.

Texas Water Commission. 1986c. The State of Texas Water Quality Inventory, 8th Edition. Informational Draft Copy, Texas Water Commission, Austin.

Texas Water Commission. 1985. Texas Surface Water Quality Standards. Informational Draft Copy. Texas Water Commission, Austin.

Twidwell, S. R. 1976. Intensive Survey of the Medina River (Segment 1903), Report No. IMS 46, Texas Water Commission, Austin, 41 p.

Twidwell, S. R. 1983. Intensive Survey of Medio Creek. Report No. IS 51, Texas Water Commission, Austin, 46 p.

Wetzel, R. G. 1975. Limnology. W. B. Sanders Company, Philadephia.

APPENDIX A

FIELD AND LABORATORY PROCEDURES

The following methods are utilized for field and laboratory determinations of specified physical and chemical parameters. Unless otherwise indicated composite water samples are collected at each sampling station and stored in polyethylene containers on ice until delivery to the laboratory. Sediment samples are collected with a dredge or coring device, decanted, mixed, placed in appropriate containers (glass for pesticides analyses and plastic for metals analyses), and stored on ice until delivery to the laboratory. Laboratory chemical analyses are conducted by the Water Chemistry Laboratory of the Texas Department of Health unless otherwise noted.

WATER ANALYSES

Field Measurements

Parameter	Unit of Measure	Method
Temperature	°C	Hand mercury thermometer, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
Dissolved Oxygen (DO)	mg/l	Azide modification of Winkler titration method, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
pH	Standard Units	Hydrolab Model 60 Surveyor, Hydrolab 4041 or Sargent-Welch portable pH meter.
Conductivity	µmhos/cm	Hydrolab Model 60 Surveyor, Hydrolab 4041, or Hydrolab TC-2 conductivity meter
Phenolphthalein Alkalinity (P-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid using phenolphthalein indicator(1).
Total Alkalinity (T-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid acid using phenolphthalein and methyl red/bromcresol green indicators(1).
Chlorine Residual	mg/l	N,N-diethyl-p-phenylene-diamine (DPD) Ferrous Tetrimetric method(1).
Transparency	m or cm	Secchi disc

Laboratory Analyses

Parameter	Unit of Measure	Method
Five Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using 2-chloro-6-(trichloromethyl)-pyridine (TCMP) method(2).
Five Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, Filt., N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analysis conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, Filt., (N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analyses conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
One through Seven Day, Nitrogen-Suppressed, Biochemical Oxygen Demand (BOD_{1-7}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Total Suspended Solids (TSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Volatile Suspended Solids (VSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Kjeldahl Nitrogen (Kjel-N)	mg/l as N	Micro-Kjeldahl digestion and automated colorimetric phenate method(3).
Ammonia Nitrogen (NH_3-N)	mg/l as N	Distillation and automated colorimetric phenate method(3).
Nitrite Nitrogen (NO_2-N)	mg/l as N	Colorimetric method(1).
Nitrate Nitrogen (NO_3-N)	mg/l as N	Automated cadmium reduction method(3).

Laboratory Analyses - Continued

Parameter	Unit of Measure	Method
Total Phosphorus (T-P)	mg/l as P	Persulfate digestion followed by ascorbic acid method(1).
Orthophosphorus (O-P)	mg/l as P	Ascorbic acid method(1).
Sulfate (SO_4)	mg/l	Turbidimetric method(1).
Chloride (Cl)	mg/l	Automated thiocyanate method(3).
Total Dissolved Solids (TDS)	mg/l	Evaporation at 180°C(3).
Total Organic Carbon (TOC)	mg/l	Beckman TOC analyzer
Conductivity	µmhos/cm	Wheatstone bridge utilizing 0.01 cell constant(1).
Chlorophyll a	µg/l	Trichromatic method(1).
Pheophytin a	µg/l	Pheophytin correction method(1).

SEDIMENT ANALYSES

Field Measurements

Sediment Oxygen Demand

A benthic respirometer, constructed of clear plexiglass, is utilized on intensive surveys to measure benthal oxygen demand(14). A dissolved oxygen probe, paddle, solenoid valve and air diffuser are mounted inside the test chamber. The paddle issued to simulate stream velocity and produce circulation over the probe. The solenoid valve allows air to escape from the test chamber during aeration. The air diffuser is connected by plastic tubing to a 12-volt air compressor which is used to pump air into the test chamber if required.

The paddle, solenoid valve, and air compressor are actuated by switches on a control panel which is housed in an aluminum box. The control box also contains two 12-volt batteries, the air compressor, a stripchart recorder (for automatic recordings of dissolved oxygen meter readings), a battery charger, and a battery test meter.

Selection of a specific test site must be made in the field by the investigator with the depth, velocity, and benthic substrate taken into consideration. At the test site the dissolved oxygen meter, and strip-chart recorder are calibrated, the respirometer is dry tested by opening and closing switches and testing batteries; a stream velocity measurement is taken (for paddle calibration), and a water sample is collected just above the stream bottom near the sampling site. Portions of this water sample are poured into separate BOD bottles, one of which is opaque. The opaque bottle is placed on the respirometer and left for the remainder of the test. The initial dissolved oxygen value in the other bottle is measured when the test begins, while the dissolved oxygen in the opaque bottle is measured at the end of the benthic uptake test. The difference in the two dissolved oxygen values represents the oxygen demand of the water column.

The respirometer can be lowered from a boat or bridge, or can be placed by hand in shallow streams. Care is taken to insure that the sediment at the test location is not disturbed and that a good seal between the base of the instrument and bottom of the stream is made. After the respirometer has been placed in the stream, the dissolved oxygen is recorded. In shallow, clear streams the instrument is covered to prevent photosynthesis from occurring within the chamber. The test chamber is then closed and the paddle frequency adjusted. Recordings of dissolved oxygen are made until oxygen is depleted within the chamber or 6 hours has elapsed.

<u>Paddle Frequency</u>

$$f = 36\ v$$

where: f = Paddle frequency in revolutions per minute

v = Velocity to be simulated in m/s (measureed with current meter)

<u>Benthic Oxygen Uptake</u>

$$B^{T}DO_1\text{-}DO_2 = 196\ \frac{(DO_1 - DO_2) - BOD_t}{\Delta t}$$

where: $B^{T}DO_1\text{-}DO_2$ = Oxygen uptake rate in $g/m^2/d$ corresponding to the sample temperature, T

DO_1 = Initial DO reading in mg/l

DO_2 = Final DO reading in mg/l

Δt = Time interval between DO_1 and DO_2

T = Temperature of sample in °C

BOD_t = Measured difference in DO between the two BOD bottles

Laboratory Analyses

Parameter	Unit of Measure	Method
Arsenic (As)	mg/kg	Silver diethylidithcocarbonate method(3).
Mercury (Hg)	mg/kg	Potassium permanganate digestion followed by atomic absorption(3,4).
All other metals	mg/kg	Atomic absorption(3,4).
Volatile Solids	mg/kg	Ignition in a muffle furnace(3).
Chemical Oxygen Demand (COD)	mg/kg	Dichromate reflux method(3).
Kjeldahl Nitrogen (Kjel-N)	mg/kg	Micro-Kjeldahl digestion and automated colorimetric method(3).
Total Phosphorus (T-P)	mg/kg as P	Ammonium molybdate(3).
Pesticides	µg/kg	Gas chromatographic method(4,5).
Oil and Grease	mg/kg	Soxhlet extraction method(3).

BACTERIOLOGICAL

Bacteriological samples are collected in sterilized bottles to which 0.5 ml of sodium thiosulfate is added to dechlorinate the sample. Following collection, the samples are stored on ice until delivery to a laboratory or until cultures are set up by survey personnel (within 6 hours of collection). Bacteriological analyses are conducted by survey personnel or a suitable laboratory in the survey area.

Parameter	Unit of Measure	Method
Total Coliform	Number/100 ml	Membrane filter method(1)
Fecal Coliform	Number/100 ml	Membrane filter method(1)
Fecal Streptococci	Number/100 ml	Membrane filter method(1)

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are collected with a Surber sampler (0.09 m^2) in riffles and an Ekman dredge (0.02 m^2) in pools. Samples are preserved in 5 percent formalin, stained with Rose Bengal, and sorted, identified, and enumerated in the laboratory.

Diversity ($\bar{d}$) is calculated according to Wilhm's(6) equation:

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

where n is the total number of individuals in the sample, n_i is the number of individuals per taxon, and s is the number of taxa in the sample.

Redundancy ($\bar{r}$) is calculated according to the equations derived by Young et al.(7)

$$(1) \quad \bar{d}\,max = \log_2 s$$

$$(2) \quad \bar{d}\,min = - \frac{s-1}{n} \log_2 \frac{1}{n} - \frac{n-(s-1)}{n} \log_2 \frac{n-(s-1)}{n}$$

$$(3) \quad \bar{r} = \frac{\bar{d}\,max - \bar{d}}{\bar{d}\,max - \bar{d}\,min}$$

where s is the number of taxa in the sample and n is the total number of individuals in the sample.

Equitability is (e) is calculated according to Pielow's(8) equation:

$$e = \frac{\bar{d}}{\log_2 s}$$

where $\bar{d}$ is the calculated diversity value and s is the number of taxa in the sample.

The number of individuals per square meter is determined by dividing the total number of individuals by the area sampled.

PERIPHYTON

Periphyton are collected from streams and reservoirs from natural substrates or from artificial substrates placed in the water. Standard size, frosted microscope slides are commonly used as artificial substrates and are held in place a few centimeters beneath the water surface at the sampling sites in floating periphytometers. Following a 25 to 30 day incubation period the accrued materials are analyzed for chlorophyll a, pheophytin a, and for identification and enumeration of the attached organisms.

In the field, following retrieval of the periphytometer, two slides are placed in a brown glass container containing 100 ml of 90 percent aqueous acetone. The material from these two slides is used for pigment measurements. Two slides are placed in another brown glass container containing 100 ml of 5 percent buffered formalin. The material from these two slides is used for biomass measurements. The remaining slides are also placed in buffered formalin and utilized for identification and enumeration of organisms according to procedures discussed for the phytoplankton. The brown glass jars containing the material for laboratory analyses (pigment and biomass measurements) are placed in a deep freeze and kept frozen prior to analysis.

The autotrophic index is calculated according to the equation given by Weber and McFarland(9).

$$\text{Autotrophic Index} = \frac{\text{Biomass (g/m2)}}{\text{Chlorophyll } \underline{a} \text{ (g/m}^2\text{)}}$$

Periphyton samples may also be collected from natural substrates by scraping areas from each type of substrate available at each sampling location. Scrapings are made from a range of depths from subsurface to the stream bottom, from bank to bank, and at points spanning the range in stream velocity. The scrapings from each sampling location are composited into a container, preserved with Lugols solution and returned to the laboratory for identification and enumeration following procedures discussed in the phytoplankton section. Diversity, redundancy, and equitability statistics are calculated as described previously.

PLANKTON

Phytoplankton

Stream phytoplankton are collected immediately beneath the water surface with a Van Dorn sampler or by immersing a sampling container. Phytoplankton samples are collected with a Van Dorn water sampler at depths evenly spaced throughout the water column of reservoirs.

Samples are stored in quart cubitainers on ice and transferred to the laboratory where aliquots of each sample are analyzed live to aid in taxonomic identification. Samples (950 ml) are then preserved with 50 ml of 95 percent buffered formalin or 9.5 ml of Lugols solution and stored in the dark until examination is completed. The phytoplankton are concentrated in sedimentation chambers, and identification and enumeration are conducted with an inverted microscope utilizing standard techniques. If diatoms are abundant in the samples, slide preparations are made using Hyrax mounting medium(10). The diatoms are identified at high magnification under oil until a minimum of 250 cells are tallied. Diversity, redundancy, and equitability statistics are calculated as described previously.

Zooplankton

Zooplankton are concentrated at the site by either filtering a known volumne of water through a number 20 mesh standard Wisconsin plankton net or vertically towing the net a known distance or time. Concentrated samples are preserved with Lugols solution or in a final concentration of 5 percent buffered formalin. The organisms are identified to the lowest taxonomic level possible, and counts are made utilizing a Sedgwick-Rafter cell. Diversity, redundancy, and equitability statistics are calculated as described previously.

NEKTON

Nekton samples are collected by the following methods(1):

Common-sense minnow seine	- 6 m x 1.8 m with 0.6 cm mesh
Otter trawl	- 3 m with 3 cm outer mesh and 1.3 cm stretch mesh liner
Chemical fishing	- rotenone
Experimental gill nets	- 38.1 m x 2.4 m (five 7.6 m sections ranging in mesh size from 1.9 to 6.4 cm).
Electrofishing	- backpack and boat units (both equipped with AC or DC selection). Boat unit is equipped with variable voltage pulsator.

Nekton are collected to determine: (1) species present, (2) relative and absolute abundance of each species, (3) species diversity (4) size distribution, (5) condition, (6) success of reproduction, (7) incidence of disease and parasitism, (8) palatability, and (9) presence or accumulations of toxins.

Nekton collected for palatability are iced or frozen immediately. Samples collected for heavy metals analyses are placed in leak-proof plastic bags and placed on ice. Samples collected for pesticides analyses are wrapped in alumnium foil, placed in a waterproof plastic bag, and placed on ice.

As special instances dictate, specimens necessary for positive identification or parasite examination are preserved in 10 percent formalin containing 3 borax and 50 ml glycerin per liter. Specimens over 15 cm in length are slit at least one-third of the length of the body to enhance preservation of the internal organs. As conditions dictate, other specimens are weighed and measured before being returned to the reservoir or stream.

ALGAL ASSAYS

The "Selenastrum capricornutum Printz Algal Assay Bottle Test" procedure(11) is utilized in assaying nutrient limitation in freshwater situations, whereas the "Marine Algal Assay Procedure Bottle Test"(12) is utilized in marine and estuarine situations. Selenastrum capricornutum is the freshwater assay organism and Dunaliella tertiolecta is the marine assay alga.

PHOTOSYNTHESIS AND RESPIRATION

In areas where restricted flow produces natural or artifical ponding of sufficient depth, standard light bottle-dark bottle techniques are used. In flowing water the diurnal curve analysis is utilized.

Light Bottle-Dark Bottle Analyses

The light and dark bottle technique is used to measure net production and respiration in the euphotic zone of a lentic environment. The depth of the euphotic zone is considered to be three times the Secchi disc transparency. This region is subdivided into three sections. Duplicate light bottles (300 ml BOD bottles) and dark bottles (300 ml BOD bottles covered with electrical tape, wrapped in aluminum foil, and enclosed in a plastic bag) are filled with water collected from the mid-point of each of the three vertical sections, placed on a horizontal metal rank, and suspended from a flotation platform to the mid-point of each vertical section. The platform is oriented in a north-south direction to minimize shading of the bottles. An additional BOD bottle is filled at each depth for determining initial dissolved oxygen concentrations (modified Winkler method). The bottles are allowed to incubate for a varying time interval, depending on the expected productivity of the waters. A minimum of 4 hours incubation is considered necessary.

The following equations are used to calculate respiration and photosynthesis:

(1) For plankton community respiration (R), expressed as mg/l O_2/hour,

$$R = \frac{DO_I - DO_{DB}}{\text{Hours incubated}}$$

where DO_I = initial dissolved oxygen concentration

and DO_{DB} = average dissolved oxygen concentration of the duplicate dark bottles

(2) For plankton net photosynthesis (P_N), expressed as mg/l O_2/hour,

$$P_N = \frac{DO_{LB}-DO_I}{\text{Hours incubated}}$$

where DO_{LB} = average dissolved oxygen concentration of duplicate light bottles.

(3) For plankton gross photosynthesis (P_G), expressed as mg/l O_2/hour,

$$P_G = P_N + R$$

Conversion of respiration and phtotsynthesis volumetric values to an aerial basis may be accomplished by multiplying the depth of each of the three vertical zones (expressed in meters) by the measured dissolved oxygen levels expressed in g/m^3. These products are added and the result is expressed in g $O_2/m^2/d$ by multiplying by the photoperiod. Conversion from oxygen to carbon may be accomplished by multiplying grams O_2 by 0.32 [1 mole of O_2 (32 g) is released for each mole of carbon (12 g) fixed].

Diurnal Curve Analysis

In situations where the stream is flowing, relatively shallow, and may contain appreciable growths of macropytes or filamentous algae, the diurnal curve analysis is tuilized to determine productivity and respiration. The procedure is adopted from the United States Geological Survey(13). Both the dual station and single station analyses are utilized, depending upon the various controlling circumstances.

Dissolved oxygen and temperature data are collected utilizing the Hydrolab surface units, sondes, data scanners, and strip chart recorders. Diffusion rate constants are directly measured in those instances where atmospheric reaeration rate studies have been conducted. In situations where direct measurements are not made, either the diffusion dome method is utilized, or an appropriate alternative. These alternatives are: (1) calculations from raw data, (2) substitution into various published formulas for determination of K_2, and (3) arbitrary selection of a value from tables of measured diffusion rates for similar streams.

HYDROLOGICAL

Parameter	Unit of Measure	Method
Flow Measurement	m^3/s	Pygmy current meter (Weather Measure Corporation Model F583), Marsh-McBirney Model 201 electronic flow meter, Price current meter (Weather Measure Corporation Model F582), or gage height readings at USGS gaging stations.
Time-of-Travel	m/s	Tracing of Rhodamine WT dye using a Turner Model 110 or 111 fluorometer(15).
Stream Width	m	Measured with a range finder
Tidal Period	hours	Level recorder
Tidal Amplitude	m	Level recorder
Changes in Stream Surface Level	m	Level recorder

Stream Reaeration Measurements

The stream reaeration technique is utilized to measure the physical reaeration capacity of a desired stream segment(16). The method depends on the simultaneous release of three tracers in a single aqueous solution: a tracer for detecting dilution and dispersion (tritiated water molecules), a dissolved gaseous tracer for oxygen (krypton-85), and Rhodamine WT dye to indicate when to sample for the radiotracers in the field. The tracer release location is chosen to meet two requirements: (1) it must be upstream of the segment for which physical reaeration data are desired, and (2) it must be at least 0.6 m deep and where the most complete mixing takes place. Before the release, samples are collected at the release site and at designated sampling stations to determine background levels of radiation. The first samples are collected 15 to 60 m downstream from the release site in order to establish the initial ratio of drypton 85 to tritium. Sampling sites are located downstream to monitor the dye cloud every 4 to 6 hours over a total period of 35 to 40 hours. The Rhodamine WT dye is detected with Turner 111 flow-through flucrometers. Samples are collected in glass bottles (30 ml) equipped with polyseal caps which are sealed with black electrical tape. Samples are generally collected every 2 to 5 minutes during the passage of the dye cloud peak. The three samples collected nearest the peak are designated for analysis in the laboratory (three alternate samples collected near the peak are also designated). Extreme caution is exercised throughout the field and laboratory handling of samples to prevent entrainment of air.

Samples are transferred to the laboratory for analyses within 24 hours of the collection time. Triplicate counting vials are prepared from each primary sample. All counting vials are counted in a Tracor Analytic 6892 LSC Liquid Scintillation Counter which has been calibrated. For each vial, counting extends for a minimum of three 10-minute cycles. The data obtained are analyzed to determine the changes in the krypton-85 to tritium ratio as the tracers flow downstream.

The calculations utilized in determining the physical reaeration raes from a stream segment from the liquid scintillation counter data are included here. Krypton-85 transfer in a well-mixed water system is described by the expression:

$$\frac{dC_{kr}}{dt} = - K_{kr}(C_{kr},t) \qquad (1)$$

where: C_{kr},t = concentration of krypton-85 in the water at time(t)

K_{kr} = gas transfer rate coefficient for krypton-85

The concentration of krypton-85 present in the earth's atmosphere can be assumed zero for practical purposes. Therefore, any krypton-85 dissolved in water which is exposed to the atmosphere will be steadily lost from the water to the atmosphere according to equation 1.

The gas transfer rate coefficient for oxygen (K_{ox}) is related to K_{kr} by the equation:

$$\frac{K_{kr}}{K_{ox}} = 0.83 \pm 0.04 \qquad (2)$$

Equation 2 is the basis for using krypton-85 as a tracer for oxygen transfer in stream reaeration because the numerical constant (0.83) has been experimentally demonstrated to be independent of the degree of turbulent mixing, of the direction in which the two gases happen to be moving, and of temperature. The disperion or dilution tracer (tritiated water) is used simultaneously with the dissolved gas tracer (krypton-85) to correct for the effects of dispersion and dilution in the stream segment being studied.

A single homogeneous solution containing the dissolved krypton-85 gas, tritiated water, and dye is released at the upstream reach of the stream segment being studied. As the tracer mass moves downstream, multiple samples are collected as the peak concentration passes successive sampling stations. In the laboratory, peak concentration samples from each station are analyzed and the krypton-85/tritium concentration ratio (R) is established by the equation:

$$R = \frac{C_{kr}}{C_h} \qquad (3)$$

where: C_{kr} = concentration of krypton-85 in water at time of peak concentration

C_h = concentration of tritium in the water at time of peak concentration

Applying this ratio concept, equation 1 can be modified to:

$$\frac{dR}{dt} = - K_{kr} R \qquad (4)$$

with terms as previously defined

Equation 4 can be transformed to:

$$K_{kr} = \frac{n(R_d/R_u)}{- t_f} \qquad (5)$$

where: R_u and R_d = peak ratios of krypton-85 to tritium concentrations at an upstream and downstream station

t_f = travel time between the upstream and downstream station determined by dye peaks

The tracers are used to evaluate the actual krypton-85 transfer coefficient (K_{kr}), and the conversion to the oxygen transfer coefficient (K_{ox}) is from the established gas exchange ratio:

$$K_{ox} = \frac{K_{kr}}{0.83}$$

REFERENCES CITED

1. American Public Health Association. 1975. Standard Methods for the Examination of Water and Wastewater, 14th Ed. APHA, New York. 1134 pp.

2. Young, J.C. 1973. Chemical methods for nitrification control. J. Water Poll. Control Fed. 45: 637-646.

3. U. S. Environmental Protection Agency. 1979. Methods for Chemical Analyses of Water and Wastes. Report No. EPA-600/4-79-020, U.S.E.P.A., Washington, D. C. 298 pp.

4. U. S. Environmental Protection Agency. 1979. Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. U.S.E.P.A., Washington, D.C.

5. U. S. Environmental Protection Agency. 1977. Analysis of Pesticide Residues in Human and Environmental Samples. U.S.E.P.A., Washington, D.C.

6. Wilhm, J.L. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Water Poll. Control Fed. 42: R221-224.

7. Young, W.C., D.H. Kent, and B.G. Whiteside. 1976. The influence of a deep-storage reservoir on the species diversity of benthic macroinvertebrate communities of the Guadalupe River, Texas. Texas J. of Sci. 27:213-224.

8. Pielou, E.C. 1966. The measurements of diversity in different types of biological collections. J. Theoretical Biol. 13:131-144.

9. Weber, C.I., and B. McFarland. 1969. Periphyton biomass - chlorophyll ratio as an index of water quality. Presented at the 17th Annual Meeting, Midwest Benthological Society, Gilbertsville, Ky., April, 1969.

10. U.S. Environmental Protection Agency. 1973. Biological Field and Laboratory Methos for Measuring the Quality of Surface Waters and Effluents. Report No. EPA-670/4-73-001, U.S.E.P.A., Cincinnati.

11. Miller, W.E., J.C. Greene, and T. Shiroyama. 1978. The Selenastrum capricornutum Printz Algal Assay Bottle Test. Report No. EPA-600/9-78-018, U.S. Environmental Protection Agency, Corvallis. 126 pp.

12. U.S. Envoronmental Protection Agency. 1974. Marine Algal Assay Procedure: Bottle Test. U.S.E.P.A., Coravllis, Oregon. 43 pp.

13. U.S. Geological Survey. 1977. Methods for the Collection and Analysis of Aquatic Biological and Microbiological Samples. Bood 5, Chapter A4, U.S.G.S., Washington, D.C. 332 pp.

14. URS/Forrest and Cotton, Inc. 1979. Benthic respirometer users guide. URS/Forrest and Cotton, Austin. 14 p.

15. U.S. Geological Survey. 1970. Measurement of Time-of-Travel and Dispersion by Dye Tracing. In: Techniques of Water Resources Investigations of the United States, Book 3, U.S.G.S., Washington, D.C. 25 pp.

16. Neal, Larry A. 1979. Method for tracer measurement of reaeration in free-flowing Texas streams. Law Engineering and Testing Company, Atlanta, Georgia. 53 p.