IS 87-05

Intensive Survey of Segment 1013 Buffalo Bayou Tidal and Segment 1014 Buffalo Bayou Above Tidal

July 15-17, 1985 — May 13-15, 1986

Texas Water Commission

May 1987

INTENSIVE SURVEY
OF
SEGMENT 1013 - BUFFALO BAYOU TIDAL
AND
SEGMENT 1014 - BUFFALO BAYOU ABOVE TIDAL

JULY 15-17, 1985
MAY 13-15, 1986

Hydrology, Field Measurements,
Water Chemistry, Reaeration Rates,
Benthic Macroinvertebrates, Phytoplankton,
Zooplankton, Nekton, Riparian Vegetation,
and Fecal Coliforms

By
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Texas Water Commission

May 1987

TEXAS WATER COMMISSION

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Published and distributed
by the
Texas Water Commission
Post Office Box 13087
Austin, Texas 78711

ABSTRACT

Intensive surveys of Buffalo Bayou Segment 1014 (above tidal) and Segment 1013 (tidal) were conducted July 15-18, 1985 (field data, hydrology, water chemistry, biological data, fecal coliforms) and May 12-15, 1986 (field data, water chemistry, hydrology, reaeration data). Buffalo Bayou is a major stream in the Houston area which receives numerous wastewater discharges (135 into both segments). Primary uses of the bayou include drainage and non-contact recreation. Segment 1014 is designated as limited quality aquatic habitat. Low flows are partly sustained by drainage from irrigated lands, but mostly by treated sewage effluents from Houston and its suburbs.

One of 48 dissolved oxygen measurements was below the 3.0 mg/L criterion in Segment 1014. Two of 12 vertically averaged dissolved oxygen levels in Segment 1013 were below the 2.0 mg/L criterion. All temperature and pH measurements were within the designated criteria for both segments. Chloride, sulfate and total dissolved solids of Segment 1014 did not indicate any problem areas. Carbonaceous BOD_5, inorganic nitrogen and phosphorus levels were elevated throughout the bayou and are indicative of the volume of wastewater discharged to it. Chemical quality of the tributaries was fair. Houston's West District WWTP had the most significant impact on water quality and biological conditions of any wastewater discharge. Chlorine residuals of all wastewater discharges were excessive. Stream discharge increased from 44.5 ft^3/s at Station A to 108 ft^3/s at Station G in July 1985. Tributary inflow accounted for 7.27 ft^3/s, and the four measured wastewater discharges accounted for 46.7 ft^3/s. Discharge in May 1986 increased from 15.9 ft^3/s at Station CA to 89.6 ft^3/s at Station M. Stream width and depth of Buffalo Bayou increased from the headwaters area (36 feet wide, 1 foot deep) to the lower end of the tidal portion (121 feet wide, 11 feet deep). Stream velocity averaged about 0.62 ft/s, ranging from 0.39 to 1.1 ft/s. Reaeration rates ranged from 0.0884 to 1.6273 per day.

Benthic macroinvertebrates data showed that six miles (25%) of the upper part of Segment 1014 are presently exceeding the aquatic life use designation, and 10.3 miles (44%) are presently attaining the use designation. The remaining 7.3 miles (31%) are not meeting the limited aquatic life use designation, due mainly to chlorine toxicity and secondarily to organic enrichment and chronic ammonia toxicity downstream from Houston's West District WWTP. Phytoplankton, zooplankton and nekton data showed pollution-tolerant types of organisms were the most common inhabitants of Segment 1014. Populations of these organisms were virtually eliminated by chlorine emanating from the Houston West District WWTP. Emergent, floating-leaved, and submersed macrophytes were not observed in Segment 1014. Riparian vegetation was quite variable. The biological components of Segment 1013 are severly depressed due to poor water quality and other environmental conditions. Fecal coliform concentrations were generally high throughout both segments of the bayou.

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AND
BUFFALO BAYOU ABOVE TIDAL - SEGMENT 1014

INTRODUCTION

DIRECTIVE

This intensive survey was accomplished in accordance with the Texas Water Code, Section 26.127, as amended in 1985. The report is an integral part of the State Water Quality Management Program and is utilized 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 main survey was conducted July 15-18, 1985, by personnel from the Water Quality Assessment Unit (Jeff Kirkpatrick, Dick Respess, Steve Twidwell, Fred Werkenthin, Don Ottmers, Bob Winkler, Jack Davis, Charles Ezell and David Petrick) and the District 7 Field Office in Deer Park (Melanie Lejune). Wayne Crouch, Mark Bowles and John Ward of the District 7 Field Office and Dave Buzan and Patrick Roques of the Stream Monitoring Unit aided in biological data collection. Reaeration, hydrologic and additional water quality data were collected May 12-15, 1986, by personnel from the Water Quality Assessment Unit (Jeff Kirkpatrick, David Petrick, Don Ottmers, Dick Respess, Bob Winkler) and Modeling Unit (Phil Trowbridge). Laboratory analyses of water samples were conducted by the Texas Department of Health, Chemistry Laboratory, in Austin. Bacteriological analyses were conducted by survey personnel. Parametric coverages, sampling frequencies, and spatial relationships of sampling stations are consistent with the objectives of the survey and with known or suspected forms and variability of pollutants entering Buffalo Bayou.

RESULTS AND DISCUSSION

SITE DESCRIPTION

Buffalo Bayou is located in the San Jacinto River Basin in the coastal plains of Southeast Texas. It originates at the confluence of Willow Fork and Cane Island Branch in northern Fort Bend County, about one mile south of Katy, and flows approximately 50 miles (80 km) in an easterly direction to the Houston Ship Channel Turning Basin just east of downtown Houston (Figure 1). Major tributaries to Buffalo Bayou include South Mayde Creek and White Oak Bayou. Two flood control dams are located in the upper portion of the watershed which restrict the flow rate during flood events. Barker Dam is located on the mainstem of Buffalo Bayou upstream of SH 6, and Addicks Dam is located on South Mayde Creek upstream of IH 10. These flood control projects are necessary to prevent downstream flooding of the Houston metropolitan area. Mean annual total rainfall in the area is 48.2 inches (122.4 cm), which is usually relatively evenly distributed throughout the year. Since thunderstorms are the main source of rainfall, precipitation may vary substantially.

Segment 1014 (Buffalo Bayou above tidal) extends from a point 110 yards (100 m) downstream of Shepherd Drive in Houston upstream 23.7 miles (38.1 km) to SH 6 in Harris County. Segment 1013 (Buffalo Bayou tidal) extends from a point 110 yards (100 m) upstream of US 59 in Houston 4.3 miles (6.9 km) to a point 110 yards (100 m) downstream of Shepherd Drive in Houston. These segments are two of 31 additions to Texas' water quality segments which were added in the latest edition of Texas Surface Water Quality Standards (TWC, 1985).

All of Segment 1013 and most of Segment 1014 lie within the City of Houston, which has an estimated population of about 1.6 million. The Houston metropolitan area has an estimated population of over two and one-half million. Buffalo Bayou is a major stream in the Houston area. It bisects the primarily residential and commercial areas in the upper (western) part and flows through the central business area of Houston. The downstream portion bisects the commercial/industrial area east of downtown Houston. Besides receiving numerous wastewater discharges, the bayou serves as a drainage route and, to a limited extent, is used for non-contact recreation. Recreational development of Buffalo Bayou has not been implemented to an appreciable degree. The area between Shepherd Drive and IH 45, along Segment 1013 just west of downtown, has been landscaped and developed into a park. Although the bayou meanders through Memorial Park (Houston's largest park), it is not readily accessible.

WATER QUALITY STANDARDS

Pursuant to recommendations in the Houston Ship Channel (HSC) Waste Load Evaluation (WLE)(TDWR, 1984), segment boundaries and the dissolved oxygen (D.O.) criterion for HSC Segment 1007 were changed. These changes were approved by Region VI of the EPA in April 1984. The boundaries of Segment

1007 were expanded from the Houston Ship Channel Turning Basin to the HSC immediately upstream of Greens Bayou to Buffalo Bayou 110 yards (100 m) upstream of US 59, including tidal portions of tributaries. The D.O. criterion of Segment 1007 was lowered from 1.5 mg/L to 1.0 mg/L.

Because of these changes and the significance of Buffalo Bayou, the Texas Department of Water Resources (TDWR), predecessor agency of the Texas Water Commission (TWC), realized that water quality protective measures should be taken. Rapid population expansion over the past 15 years and the resultant increased waste loads to the bayou justified designation of the remainder of the tidal portion of Buffalo Bayou not included in Segment 1007, as well as Buffalo Bayou above tidal, as new segments. Designated water uses of these new segments are:

Segment 1013 - Noncontact Recreation
Segment 1014 - Noncontact Recreation
\- Limited Quality Aquatic Habitat

Following are the criteria which are intended to insure that water quality will be sufficient to maintain these desired uses for Buffalo Bayou:

Segment	Parameter	Criteria
1013	Dissolved Oxygen	Not less than 2.0 mg/L
	pH Range	6.5 - 9.0 standard units
	Temperature	Not to exceed 92°F (33.3°C)
	Fecal Coliform	Geometric mean not to exceed 2000/100 mL
1014	Dissolved Oxygen	Not less than 3.0 mg/L
	pH Range	6.5 - 9.0 standard units
	Temperature	Not to exceed 92°F (33.3°C)
	Fecal Coliform	Geometric mean not to exceed 2000/100 mL
	Chloride	Annual average not to exceed 110 mg/L
	Sulfate	Annual average not to exceed 65 mg/L
	Total Dissolved Solids	Annual average not to exceed 600 mg/L

These water quality standards for Segments 1013 and 1014 were supported by a recent use attainability analysis (Kirkpatrick, 1986).

CLASSIFICATION AND RANK

Both Segments 1013 and 1014 are classified as water quality limited and are ranked 59 and 62 respectively (TWC, 1986). Segments are classified as water quality limited if applicable water quality criteria cannot be met following incorporation of best practicable treatment for industries and/or secondary treatment for municipalities. Segments are classified as effluent limited if they are presently meeting or will meet applicable water quality criteria following incorporation of best practicable treatment for industries and/or secondary treatment for municipalities. Segments are ranked from one to 342 (total number of segments), with one indicating the segment with the most water quality problems and 342 the least water quality problems.

MONITORING STATIONS

The TWC, City of Houston and the United States Geological Survey (USGS) have routine monitoring stations on both Segments 1013 and 1014. Following are the monitoring frequencies and parametric coverages for each agency:

Segment	Number	Location	Sampling Agency	Frequency	Parameters*
1013	1013.2560	McKee Street	TWC	Quarterly	FD,CH,BA
1013	1013.2600	Main Street	Houston	Quarterly	FD,CH,BA, MT
1013	08074600	Main Street	USGS	Continuous	Gage Height
1014	1014.2700	Shepherd Drive	TWC	Quarterly	FD,CH,BA
1014	1014.2700	Shepherd Drive	Houston	Quarterly	FD,CH,BA, MT
1014	08074000	Shepherd Drive	USGS	Continuous	Discharge**
1014	08073700	Piney Point Road	USGS	Continuous	Discharge
1014	1014.2840	West Belt	Houston	Quarterly	FD,CH,BA, MT
1014	08073600	West Belt	USGS	Continuous	Discharge
1014	08073500	Dairy-Ashford Road	USGS	Continuous	Discharge

*FD = field data
CH = chemical data
BA = bacteriological
MT = metals in water
** Records poor

HYDROLOGY

Discharge records for the past 39 years, based on USGS records, indicate an average discharge of 212 ft^3/s (6.002 m^3/s), a maximum discharge of 11,200 ft^3/s (317 m^3/s), a minimum discharge of no flow, and a seven-day two-year low flow (7Q2) of 2.58 ft^3/s (0.073 m^3/s) of Buffalo Bayou at Dairy-Ashford Road. Discharge records for the past 13 years at West Belt Drive indicate an average discharge of 315 ft^3/s (8.921 m^3/s), a maximum discharge of 5350 ft^3/s (151.5 m^3/s), and a minimum discharge of 25 ft^3/s (0.708 m^3/s). Farther downstream, at Piney Point Road, discharge records for the past 13 years indicate an average discharge of 265 ft^3/s (7.5 m^3/s), a maximum discharge of 5,700 ft^3/s (161.5 m^3/s), and a minimum discharge of 6.0 ft^3/s (0.17 m^3/s). (USGS, 1984)

The drainage area of Segment 1014 is 358 mi^2 (927 km^2), most of which is used for urban and suburban development. Agricultural usage is predominant in the upper (western) part around Katy. Low flows, therefore, are partly sustained by drainage from irrigated lands, but are mostly sustained by treated sewage effluents from Houston and its suburbs. Industrial waste contributes only a small portion of the low flow. Following are the seven-day two-year low flows calculated for Segment 1014 and presented in the most recent Standards document (TWC, 1985):

Station	Location	7Q2, ft³/s	Time Period
1014.2900	Dairy-Ashford Road	7.9	1960 - 1982
1014.2850	West Belt Drive	37.3	1972 - 1982
1014.2825	Piney Point Road	20.3	1964 - 1976

The apparent anomaly of decreasing 7Q2 from West Belt Drive (37.3 ft^3/s) to Piney Point Road (20.3 ft^3/s) may be explained by the fact that the West Belt data covered ten recent years and the Piney Point data covered 12 years with only four years (1972 - 1976) in common.

The drainage area of Segment 1013 is about 470 mi^2 (1217 km^2). Most of the difference in the drainage area of Segment 1014 is due to the addition of the White Oak Bayou watershed. Discharge records for White Oak Bayou at Heights Boulevard in Houston for the past 48 years indicate an average discharge of 83.9 ft^3/s (2.377 m^3/s), a maximum discharge of 17,300 ft^3/s (490 m^3/s), and a minimum discharge of no flow (USGS, 1984). No 7Q2's are calculated for Segment 1013 since it is tidally influenced.

WASTEWATER DISCHARGERS

There are currently 131 permitted domestic facilities and 22 permitted industrial facilities in Segment 1014 (Table 2). Of these facilities that are currently in operation, 57.83 MGD (89.46 ft^3/s) daily average flow is authorized to be discharged from the domestic facilities and 0.98 MGD (1.5 ft^3/s) daily average flow is authorized to be discharged from the industrial facilities. A total of 58.81 MGD (90.98 ft^3/s) average daily flow is currently authorized to be discharged to Segment 1014 from those facilities that are actually in operation at this time. Self-reporting data from September 1985 through August 1986 show that 71 domestic facilities discharged 37.86 MGD (58.57 ft^3/s) and 10 industrial facilities discharged 3.04 MGD (4.70 ft^3/s) to Segment 1014, for a total of 40.9 MGD (63.27 ft^3/s) (Table 3). These data support the fact that most of the water in Segment 1014 of Buffalo Bayou, under low flow conditions, is wastewater effluent, since the actual return flow from wastewater discharges is 63.27 ft^3/s, and the 7Q2 is about 37.3 ft^3/s. Evaporation and seepage (transmission losses) of the wastewater discharges probably account for most of the difference.

There are currently 76 permitted domestic facilities and 11 permitted industrial facilities in Segment 1013. Of these facilities that are presently in operation, the daily average permitted flow from the domestic facilities is 35.48 MGD (54.89 ft^3/s), and from the industrial facilities, 0.19 MGD (0.29 ft^3/s). Total permitted average daily flow from existing facilities into Segment 1013 is 35.67 MGD (55.18 ft^3/s). Actual wastewater volume discharged to Segment 1013, based on self-reporting data from September 1985 through August 1986, totals 18.81 MGD (29.10 ft^3/s), of which 18.75 MGD (29.0 ft^3/s) is from domestic sources and 0.06 MGD (0.1 ft^3/s) is from industrial sources.

Combined permitted wastewater discharges into both Segments 1013 and 1014 total 240, of which 207 are domestic and 33 are industrial. Of those facilities that are currently in operation, the total daily average permitted flow is

94.48 MGD (146.16 ft^3/s), of which 93.31 MGD (144.35 ft^3/s) is from domestic sources and 1.17 MGD (1.81 ft^3/s) is from industrial sources. Actual wastewater discharged into both Segments 1014 and 1013, based on self-reporting data from September 1985 through August 1986, totals 59.71 MGD (92.37 ft^3/s), of which 56.61 MGD (87.58 ft^3/s) is from domestic sources and 3.1 MGD (4.80 ft^3/s) is from industrial sources. These data indicate that both Segments 1013 and 1014 are highly effluent dominated during low flow conditions.

INTENSIVE SURVEY DATA

Field measurements, water chemistry, flow measurements, cross-sections, reaeration rates, biological data and fecal coliform samples were collected during the two surveys. Station locations are described in Table 1 and shown in Figure 2.

Field Measurements - July 15-16, 1985

Field measurements consisted of temperature, dissolved oxygen (D.O.), conductivity and pH measurements at each station. Vertical profiles were made at stations in Segment 1013, and chlorine residual was measured at all stations. Dissolved oxygen declined from Station A (7.1 mg/L diel mean) to Station I (3.2 mg/L diel mean), then increased to Station L (4.8 mg/L diel mean), and decreased to Station Q (1.6 mg/L diel mean)(Table 4, Figure 3). The initial decline was caused by instream assimilation of the wasteloads directly entering Buffalo Bayou, all of which discharge above Station I. The D.O. increase from Station I to Station L is attributed to algal photosynthesis, as indicated by wide diurnal D.O. swings at these stations. The appreciable decline from Station M to Station Q is attributable to lower reaeration rates, and probable higher benthal oxygen demand and biotic production rates. One of 48 D.O. measurements in Segment 1014 was below the 3.0 mg/L criterion. This measurement was 2.2 mg/L at Station I, which was in the area of the D.O. sag. Two of 12 vertically averaged D.O. profiles in Segment 1013 were below the 2.0 mg/L segment criterion. One of four vertical profiles at Station O contained an average of 1.7 mg/L, and one of four vertical profiles at Station P contained an average D.O. of 1.5 mg/L. Station Q, located in Segment 1007 110 yards (100 m) downstream of the Segment 1013/1007 boundary, had a depth-integrated diel mean D.O. of 1.6 mg/L. One of four profiles averaged 0.5 mg/L, which is below the 1.0 mg/L segment criterion. All temperature measurements were below the 33.3°C (92°F) maximum criterion specified for both segments. All pH measurements were within the range (6.5 - 9.0 units) specified for both segments. Conductivity measurements were within expected ranges for both segments.

Stations S (Rummel Creek) and U (tributary at Memorial Drive) exhibited low D.O. levels ($<$ 2.0 mg/L) during two of the four sampling times. Station X exhibited a low D.O. (2.0 mg/L) in the early morning. Since these stations had relatively wide diel D.O. swings, the low D.O. levels were probably caused by biotic respiration. The remaining D.O. measurements and all temperature, pH and conductivity measurements of the tributaries and wastewater discharges did not indicate any problem areas.

Field Measurements - May 13-15, 1986

Grab field measurements were collected in Segment 1014 during the May sampling trip in conjunction with the hydrological and reaeration study (Table 5). D.O. concentrations at Stations CA through E in the upper portion of the bayou averaged 5.6 mg/L. The average at stations in the lower portion (Stations J through M) was 3.2 mg/L. Station J exhibited the only D.O. level (2.4 mg/L) that was below the 3.0 mg/L segment criterion. Temperature, pH and conductivity measurements did not reveal any problem areas.

Water Chemistry - July 15-16, 1985

Diurnally composited water samples collected in July revealed elevated carbonaceous BOD_5 ($CBOD_5$) and macronutrient concentrations of Buffalo Bayou (Table 6, Figures 4, 5 and 6). $CBOD_5$ was elevated at Stations F, G, H and I in Segment 1014 and at all stations in Segment 1013. Inorganic nitrogen, orthophosphorus (O-P) and total phosphorus (T-P) were elevated at every mainstream station. Concentrations of inorganic nitrogen (NH_3-N + NO_2-N + NO_3-N) increased significantly between Stations D (2.63 mg/L) and E (5.23 mg/L), then generally decreased downstream to the lower end of Segment 1013 (2.15 mg/L at Station Q). Ammonia nitrogen also increased between Stations D (0.14 mg/L) and E (2.86 mg/L), then decreased toward the downstream portion of Segment 1013 (0.83 mg/L at Station Q). Calculated un-ionized ammonia nitrogen concentrations at all mainstream stations sampled below Houston's West District WWTP (Stations E through Q) exceeded the EPA criteria for chronic toxicity of fishes other than sensitive coldwater species (EPA, 1986). Orthophosphorus levels increased from the headwater area (1.63 mg/L at Station A) to Stations H and I (2.97 mg/L each), then generally decreased in a downstream direction to Station Q (1.43 mg/L). Chlorophyll a and pheophytin a concentrations were generally low in the bayou. Chloride, sulfate, total dissolved solids and conductivity did not reveal any particular problem areas with respect to mineralized discharges. Total suspended solids were elevated in the headwaters area, but decreased in a downstream direction due to precipitation in areas of reduced velocities. Total alkalinity and pH measurements were normal for the area.

Chemical quality of the tributaries was fair. Station R (Turkey Creek) exhibited somewhat elevated orthophosphorus (1.18 mg/L) and total phosphorus (1.37 mg/L). Station S (Rummel Creek) had elevated $CBOD_5$ (4.5 mg/L), and Station Z (White Oak Bayou) had elevated $CBOD_5$ (4.0 mg/L), Kjeldahl nitrogen (2.2 mg/L), inorganic nitrogen (1.79 mg/L), orthophosphorus (1.98 mg/L) and total phosphorus (2.10 mg/L). Stations U, V, X, and Y exhibited relatively good water quality.

Water Chemistry - May 13-15, 1986

Grab water samples for laboratory analysis were collected near the dye peaks during the May hydrological survey (Table 7). Stations CA through E represented one dye release, while Stations J through M represented the other. Station CA had a high inorganic nitrogen level (4.59 mg/L), orthophosphorus (3.6 mg/L) and total phosphorus (4.16 mg/L). Station C had elevated nitrate nitrogen (NO_3-N)(6.15 mg/L), orthophosphorus (3.39 mg/L) and total phosphorus (3.68 mg/L). Station D had elevated NO_3-N (3.92 mg/L), orthophosphorus (3.25 mg/L) and total phosphorus (3.47 mg/L). Station E had elevated nitrite nitrogen (NO_2-N)(0.78 mg/L), NO_3-N (1.85 mg/L), orthophosphorus (4.32 mg/L) and total phosphorus (4.48 mg/L). Laboratory errors prevented the ammonia nitrogen analyses at Station C, D, and E. The observed levels of ammonia nitrogen at Stations J (3.47 mg/L), K (3.21 mg/L), L (2.78 mg/L) and M (2.62 mg/L) were elevated, however. The calculated concentrations of un-ionized ammonia exceeded the EPA (1986) criteria for chronic toxicity of fishes other than sensitive coldwater species. Station J had elevated $CBOD_5$ (5.5 mg/L), inorganic nitrogen (6.06 mg/L), orthophosphorus (2.58 mg/L) and total phosphorus (3.02 mg/L). Concentrations of these parameters decreased downstream at Stations K and L. The most downstream site, Station M, had a $CBOD_5$ concentration of 3.0 mg/L, inorganic nitrogen level of 5.13 mg/L, orthophosphorus level of 2.37 mg/L, and total phosphorus concentration of 2.58 mg/L. Laboratory error prevented total Kjeldahl nitrogen analyses at all stations. Chlorophyll a and pheophytin a levels were relatively low throughout the bayou. Chloride, sulfate and total dissolved solids levels were all below the established criteria. Total suspended solids levels were generally high, while alkalinity and pH were within expected ranges.

Wastewater Discharges

Wastewater discharges were sampled only during the July 1985 survey. Only those that discharge directly to the bayou were sampled. By far the greatest volume of wastewater was discharged by Houston's West District WWTP (Table 9), which discharged about 24.0 MGD (37.2 ft^3/s) of treated effluent at stream kilometer 82.8, about 0.6 km upstream of Station E. Organic constituents of this discharge, as indicated by $CBOD_5$, were relatively low (4.0 mg/L), as were total suspended solids (TSS) (< 5 mg/L)(Table 6). Nutrient levels were typical of secondary effluent (inorganic nitrogen was 9.85 mg/L, orthophosphorus was 3.36 mg/L and total phosphorus was 3.47 mg/L). Harris County MUD 107 discharged 3.0 MGD (4.64 ft^3/s) into the bayou at stream kilometer 90.9, about 0.6 km upstream of Station B. This effluent had low $CBOD_5$ and TSS levels (< 0.5 mg/L and 5 mg/L respectively), but nutrients were typical of secondary effluent (inorganic nitrogen was 5.78 mg/L, orthophosphorus was 8.19 mg/L and total phosphorus was 8.3 mg/L). Memorial Villages Water Authority WWTP discharged 2.24 MGD (3.46 ft^3/s) of treated effluent into the bayou at stream kilometer 73.7, about 0.8 km upstream of Station H. This effluent also had low $CBOD_5$ and TSS levels (3.5 mg/L and < 5 mg/L, respectively), as well as nutrient levels typical of secondary effluent (inorganic nitrogen was 7.46 mg/L, orthophosphorus was 3.38 mg/L and total phosphorus was 3.57 mg/L). Houston's Turkey Creek WWTP discharged 0.72 MGD (1.12 ft^3/s) of wastewater into the bayou at stream kilometer 89.9, about 2.1 km upstream of Station C. This effluent also had low concentrations of $CBOD_5$ (3.5 mg/L) and TSS (7 mg/L) as well as nutrients typical of secondary effluent (inorganic nitrogen was 12.09 mg/L, orthophosphorus was 6.51 mg/L and total phosphorus was 6.83 mg/L).

Chlorine (Cl_2) residuals of the wastewater discharges were excessive (Table 8). The time-weighted diel average Cl_2 residual of Houston's West District WWTP was 6.3 mg/L, Houston's Turkey Creek WWTP was 4.6 mg/L, Memorial

Villages Water Authority WWTP was 5.1 mg/L, and Harris County MUD 107 WWTP was 4.9 mg/L. Due to the large volume and high Cl_2 concentration, the West District WWTP discharged 1272 lb/day of Cl_2 into Buffalo Bayou during the July 1985 study period. This excessive loading resulted in instream Cl_2 residuals in the bayou at stations downstream of the discharge. Station E, located 0.6 km downstream of the discharge, had a diel mean of 1.0 mg/L Cl_2 residual, ranging from 1.6 mg/L at 0715 hours to 0.35 mg/L at 1425 hours. The highest concentration of the discharge was 11.6 mg/L at 0635 hours. Station F had a diel average Cl_2 residual of 0.5 mg/L (ranging from 1.0 to 0.3 mg/L) while the diel average at Station G was 0.1 mg/L (ranging from < 0.1 to 0.4 mg/L). Stations H, I and J had only traces of Cl_2 residual. Chlorine concentrations at Stations E, F and G exceeded the EPA (1986) criterion of 0.019 mg/L for acute toxicity in fresh water.

Flow Measurements

Stream discharge was higher during the July 1985 sampling period than during the May 1986 study (Table 9). Scattered thundershowers preceding the July 1985 study accounted for the difference and resulted in receding flows during the study. Discharge increased from 44.51 ft^3/s (1.262 m^3/s) at Station A to 108 ft^3/s (3.058 m^3/s) at Station G in July 1985. Tributary inflow accounted for 7.27 ft^3/s (0.206 m^3/s), while the four discharges accounted for 46.66 ft^3/s (1.322 m^3/s). Stream discharge in May 1986 increased from 15.94 ft^3/s (0.451 m^3/s) at Station CA to 89.59 ft^3/s (2.537 m^3/s) at Station M. The large increase in flow from Station D to Station E was mostly due to Houston's West District WWTP discharge.

Cross-Section Data

Stream width and depth of Buffalo Bayou increased from the headwaters area to the lower end of the tidal portion (Table 10). The stream is relatively homogeneous in cross-sectional area; little longitudinal variation occurred. Average width of Segment 1014 was 45.3 ft (13.8 m), ranging from 36.4 ft (11.1 m) between Stations CA and C in the upper end to 53.5 ft (16.3 m) between Stations L and M in the lower end. Average depth of the segment was 1.82 ft (0.56 m), ranging from 1.02 ft (0.31 m) between Stations CA and C to 2.82 ft (0.86 m) between Stations L and M. Average width of Segment 1013 was 88.5 ft (27.0 m), ranging from 57.4 ft (17.5 m) in the upper part of the segment between Stations M and N to 121.4 ft (37.0 m) between Stations P and Q in the lower portion. Average depth of the segment was 7.35 feet (2.24 m), ranging from 3.02 ft (0.92 m) between Stations M and N to 11.16 ft (3.4 m) between Stations P and Q.

Time-of-Travel Data

Stream velocity was slower in the upper portion of the segment between Stations CA and E, which averaged 0.44 ft/s (0.134 m/s), than in the lower portion between Stations J and M, which averaged 0.81 ft/s (0.246 m/s) (Table 11). Slowest velocity was 0.39 ft/s (0.119 m/s) between Stations D and E, while the highest velocity was 1.1 ft/s (0.335 m/s) between Stations J and K.

Reaeration Rates

Reaeration rates were measured during the May 1986 survey (Table 12). The lowest measured rate was 0.0884 per day in the reach between Stations K and L, while the highest measured rate was 1.6273 per day between Stations CA and C.

Benthic Macroinvertebrates (Segment 1014) (Davis, 1986)

As part of an evaluation of biological health in the study reach, benthic macroinvertebrates were collected at four stations (Tables 13 & 14). Forty-six species were collected, a number comparable to totals reported in similar studies on other southeastern Texas streams. Ten different biological indices were utilized to arrive at a macrobenthic health rating for each station, using a modification of Karr's (1981) classification system that includes six categories ranging from excellent to extremely poor (see footnote to Table 14).

Dairy-Ashford Road (Station C) had a small standing crop, indicating low levels of secondary production, and community trophic structure was well balanced. Species richness was moderate, diversity was within the range considered indicative of clean water, and equitability was near maximal values reported for unimpacted Texas streams. Clean water indicative mayfiles were well represented. The biotic index value identified the community as subpollutional - less tolerant, i.e., characteristic of clean water habitats but able to tolerate some organic enrichment if dissolved oxygen remains near 5 mg/L. Overall community characteristics indicated a prevalence of relatively clean water conditions and minimal levels of environmental stress. Using Karr's (1981) classification system, macrobenthic health was assigned a rating of good, slightly below the best expected situation due to diversity, species richness, and biotic index values that were slightly less than optimum.

Station F (Gessner Road) had a moderate standing crop, 3.6 times larger than that at Station C. Community trophic structure was grossly imbalanced, with miners of sedimented fine particulate organic matter assuming almost total dominance. Species richness, equitability, and diversity were greatly reduced, the latter approaching the range generally associated with severe organic pollution. Mayflies were absent, and the biotic index value identified the community as pollutional, i.e., characteristic of pollutional zones and able to withstand considerable periods of anoxic conditions. The index of similarity between Station C and Station F was very low and reflected a radical change in species composition. Overall community characteristics indicated severe water quality degradation and a very high degree of environmental stress. Stress-inducing factors included organic enrichment, and more importantly, chlorine toxicity, resulting from effluent from the City of Houston's West District WWTP. Using Karr's (1981) classification, macrobenthic health was assigned a rating of very poor, near the worst situation possible, in light of very low species richness, diversity, and equitability, extreme trophic structure imbalance, and almost total dominance by pollution-tolerant species.

Station J (Farther Point Road) had a large standing crop, reflecting elevated levels of secondary production. Community trophic structure was well balanced. Species richness, diversity, and equitability returned to near background levels and were in the lower end of ranges generally associated with clean water conditions. Mayflies reappeared, with two species represented. The biotic index indicated improvement from Station F, but still reflected a greater prevalence of pollution-tolerant species than at Station C. The index of similarity increased, indicating a shift in species composition toward background conditions. Overall community characteristics indicated considerable water quality improvement and relatively low levels of environmental stress. Using Karr's (1981) classification, macrobenthic health was assigned a rating of fair, slightly below the condition observed at control Station C, due to lower diversity and equitability, elevated secondary production, and greater prevalence of pollution-tolerant species.

The standing crop at Station M (Shepherd Drive) was 56% larger than that at Station J, indicating progressively-elevated secondary production. Community trophic structure was well balanced. Species richness, diversity, and equitability were the highest in the study, with diversity and equitability values in the upper end of ranges observed in clean water Texas streams. The magnitude of the diversity index value appears related to the intermediate-disturbance theory of Ward and Stanford (1981), which predicts that diversity is sometimes maximized by spatio-temporal heterogeneity imposed by moderate environmental disturbance and a resultant state of non-equilibrium. Mayflies were well represented. The biotic index and index of similarity were virtually the same as at Station J, indicating little change in species composition. Overall community characteristics indicated a degree of longitudinal water quality improvement and slightly reduced levels of environmental stress. Using Karr's (1981) classification, macrobenthic health was assigned a rating of good, slightly below optimum conditions due to elevated secondary production and greater prevalence of pollution-tolerant species than would be expected.

In summary, Segment 1014 can be divided into three subreaches on the basis of macrobenthic community structure and corresponding physicochemical characteristics:

(1) The upstream subreach extends 6.1 miles (9.8 km) from SH 6 to Houston's West District WWTP outfall. It was characterized by relatively clean water conditions, including dissolved oxygen minima > 5.3 mg/L, $CBOD_5$ concentrations ≤ 2.0 mg/L, and total residual chlorine levels generally below the detection limit. Macrobenthic health was good as represented by the community at Station C. Thus, the criteria for a "high quality aquatic habitat" use designation are apparently being met in this subreach.

(2) The middle subreach extends 7.3 miles (11.7 km) from Houston's West District WWTP to Voss Road. It was characterized by degraded water quality, with dissolved oxygen minima from 2.2 to 5.4 mg/L, $CBOD_5$ concentrations of 1.0 and 7.0 mg/L, and chlorine residual maxima of 0.4 to 1.6 mg/L. Macrobenthic health was very poor as indicated by community characteristics at Station F. The high level of environmental stress observed is attributable to the impact of effluent from Houston's West District WWTP, mainly in the form of chlorine toxicity and secondarily in the form of chronic ammonia toxicity and organic

enrichment. Maximum chlorine residual concentrations in this reach were at levels known to be acutely toxic to most freshwater aquatic life during the intensive survey. For example, a chlorine residual of 0.4 mg/L exceeds acute values for 26 to 28 freshwater genera (12 invertebrates, 16 fishes) listed by USEPA (1985). Although all four WWTP's sampled in the survey were overchlorinating their effluents, Houston's West District WWTP was by far the most significant contributor in light of its much greater flow and high chlorine residual levels (1.3, 3.2, 3.7, 11.6 mg/L). Its impact results in at least a 3.9 mile (6.3 km) reach of Buffalo Bayou being nearly devoid of aquatic life except for extremely tolerant forms. The data indicate that the middle subreach is not presently achieving the "limited quality aquatic habitat" use now in effect. It appears that this level would be attainable if chlorine toxicity were eliminated, because (a) dissolved oxygen minima were high enough to maintain a fairly diverse aquatic fauna, and (b) the potential for biological recovery appears to be fairly high based on Cairn's (1975) recovery criteria for damaged ecosystems. The clean water subreach upstream would serve as an epicenter that could provide organisms for reinvasion of the degraded zone. Also, a considerable amount of good physical macrobenthic habitat exists in the degraded zone, which would promote rapid restoration following elimination of severe environmental stress.

(3) The lower subreach extends 10.3 miles (16.6 km) from Voss Road to Shepherd Drive. It was characterized by fairly good water quality, with progressive longitudinal recovery from the effects of Houston's West District's WWTP discharge. Dissolved oxygen minima were ≧ 3.1 mg/L, $CBOD_5$ concentrations were 1.0 - 2.0 mg/L, and residual chlorine was generally below detection limits. Primary and secondary production were somewhat elevated, probably due mainly to the effects of point source contributions of nutrient compounds. Macrobenthic health was fair in the upper portion of the subreach at Station J, with longitudinal improvement resulting in good health at Station M. Thus, on the basis of dissolved oxygen criteria and the degree of biological health observed, the lower subreach is judged to be attaining the "limited quality aquatic habitat" use now in effect.

In conclusion, 6.1 miles (9.8 km) (25%) of the segment are presently exceeding the existing aquatic life use designation and 10.3 miles (16.6 km) (44%) of the segment are presently attaining the existing aquatic life use designation. The remaining 7.3 miles (11.7 km) (31%) are not meeting the aquatic life use designation, due mainly to chlorine toxicity downstream from Houston's West District WWTP. Elimination of toxic stresses would probably result in almost total attainment of the existing "limited quality aquatic habitat" use designation. Higher use categories might be attainable if more stringent wastewater treatment levels were instigated; this question should be answered by the updated wasteload evaluation currently in preparation.

Phytoplankton (Segment 1014)

Phytoplankton data (Table 15) indicate that most genera found in Buffalo Bayou were pollution-tolerant. The control station at Dairy-Ashford Road (Station C) had a concentration of 576 individuals per liter, composed of four pollution - tolerant genera. Below the major wastewater discharge (Houston's

West District WWTP) at Gessner Drive, the number of individuals declined to 96/L and were composed of two highly pollution-tolerant genera (Navicula and Oscillatoria). Standing crop increased downstream of Gessner Drive to 7,944 individuals/L at Farther Point Drive probably due to nutrient enrichment by the wastewater treatment plant. This station was represented by six genera, five of which are pollution-tolerant. Standing crop declined at Shepherd Drive to 792 individuals/L and was composed of nine genera, eight of which are pollution-tolerant. Diversity indices ($\bar{d}$) were indicative of a low quality phytoplankton assemblage. Nine of the eleven genera found in Buffalo Bayou were pollution-tolerant (Palmer, 1969).

Zooplankton (Segment 1014)

Zooplankton data (Table 16) indicated a dramatic increase in number of individuals and number of species from Dairy-Ashford Road (48 individuals/L, three species) to Gessner Drive (192 individuals/L, eight species). Buffalo Bayou at Farther Point Drive had 38 individuals/L composed of seven species, and the station at Shepherd Drive had 156 individuals/L composed of six species. A total of 16 species of zooplankton was collected in Buffalo Bayou. The standing crop was dominated by rotifers and ciliated protozoans, both of which flourish in poor quality water. Of the total number of individuals at Gessner Drive, 138 were rotifers and ciliated protozoans. The source of these organisms may be Houston's West District WWTP. Forty-eight percent of the total individuals collected in Buffalo Bayou were rotifers and ciliated protozoans, which also indicates a low quality zooplankton assemblage.

Nekton (Segment 1014)

Nekton data (Table 17) indicate a relatively diverse fish community at Dairy-Ashford Road. Forty-eight individuals representing nine species were collected at this station. The diversity index of 2.39 is indicative of a fairly normal fish assemblage. Only one mosquitofish was collected at Gessner Drive, however, in one of six seine hauls. Chlorine residual at this station, resulting from heavy chlorination of Houston's West District WWTP, most likely caused avoidance of the area (4-5 km) by nekton. All but one of the 916 total organisms collected at Farther Point Drive consisted of small forage fish. Sailfin mollies and mosquitofish, which are relatively pollution-tolerant species, comprised 798 (87%) of the total, while sheepshead minnows and red shiners accounted for 117 individuals. Only one gamefish, a largemouth bass, was collected at this station. All of the fish collected at Shepherd Drive were small forage fish, although several gar were observed. Most (889) of the total number of individuals (1,119) collected at this station were mosquitofish. Diversity indices were low at the stations below Houston's West District WWTP. Nekton populations were virtually eliminated by chlorine emanating from the West District Plant. Populations that were re-established downstream are mainly those considered pollution-tolerant. Only four game fish were collected from Buffalo Bayou, three of which were found at the upstream control station. These nekton data indicate that the 6.1 mile (9.8 km) reach of Buffalo Bayou from SH 6 to the West District WWTP outfall was suitable for high quality aquatic life habitat. The 7.3 mile (11.7 km) reach between this WWTP outfall and Voss Road was not suitable for any aquatic life, and the remaining 10.3 mile (16.6 km) reach between Voss Road and Shepherd Drive was suitable for limited quality aquatic life habitat.

Aquatic Macrophytes and Riparian Vegetation of Segment 1014 (Ward, 1985)

Observations of aquatic macrophytes and riparian vegetation were made during the intensive survey of Buffalo Bayou on July 17, 1985. The study area consisted of the area from Eldridge Road to Shepherd Drive in the western part of Houston.

Tidal influence extends as far upstream as Shepherd Drive, where the velocity is reduced and the stream takes on the characteristic slow-moving, sluggish appearance of coastal bayous. From Eldridge Road to near Shepherd Drive, the stream was generally free flowing with occasional riffles occurring in the more shallow portions. Aquatic macrophytes in general were not found in the study area. Periodic flooding, compounded by urban runoff, may exclude most aquatic macrophytes attached to the substratum. Recent rainfall in the area at the time of study resulted in a turbid, high water level in the stream. These conditions would have prevented the recording of emergent and submersed macrophytes, if present. Floating-leaved macrophytes also were not observed during the study.

Following is a qualitative analysis of the woody streamside vegetation along Buffalo Bayou (Table 18). Trees and shrubs were recorded as well as herbaceous vegetation noted on the stream bank. Collections were made when field determinations were not possible. Dominance, as used in this study, is based on qualitative observation.

The most prevalent streamside trees along Buffalo Bayou were ashes (*Fraxinus* spp.), black willow (*Salix nigra*), sycamore (*Plantanus occidentalis*), boxelder (*Acer negundo*), cottonwood (*Populus deltoides*), elms (*Ulmus* spp.), roughleaf dogwood (*Cornus drummondii*), water elm (*Planera aquatica*), cedar elm (*Ulmus crassifolia*) and water oak (*Quercus nigra*). The streamside forest along the bayou from Eldridge Road to West Belt consisted almost entirely of black willow, ashes, sycamore, elms, boxelder and cottonwood. Species richness increased downstream with the addition of such species as river birch (*Betula nigra*), water hickory (*Carya aquatica*), loblolly pine (*Pinus taeda*), American hornbeam (*Carpinus caroliniana*) and red mulberry (*Morus rubra*). Water elm and river birch oftentimes grew at the water's edge.

Vines were a conspicuous component of the streamside forest. Predominate vines included mustang grape (*Vitis mustangensis*), *Ampelopsis cordata*, poison ivy (*Rhus toxicodendron*), eardrop vine (*Brunnichia ovata*), muscadine grape (*Vitis rotundifolia*) and climbing hemp-weed (*Mikania scandens*). On exposed, sandy banks along the bayou, poison ivy, eardrop vine and the aquatic to semiterrestrial herb, alligator-weed (*Alternanthera philoxeroides*) commonly occurred.

Herbaceous species which were repeatedly encountered included Virginia button-weed (*Diodia virginica*), flatsedge (*Cyperus pseudovegetatus*), jungle-rice (*Echinochloa colona*), wild-rye (*Elymus virginicus*), inland sea-oats (*Chasmanthium latifolium*) and lance-leaved water-willow (*Justicia lanceolata*). In the more disturbed areas, giant ragweed (*Ambrosia trifida*) and johnson grass (*Sorghum halepense*) were common.

Subjective Analysis of Biological Conditions of Segment 1013

Observations of biological conditions of Buffalo Bayou tidal were made on July 15 and 16, 1985, during data collection for the intensive survey. The entire 4.3 mile (6.9 km) length of the segment was traversed diurnally by boat and the following observations were made:

1. Very large schools of sailfin mollies (*Poecilia latipinna*) were observed at the water surface, many of which appeared emaciated, deformed and diseased with a fungus-like growth;

2. One turtle, which appeared to be a cooter (*Pseudemys floridana*), was observed in a pre-mortum state; it could not dive (probably due to gas in the body cavity) and the skin was falling off in large patches;

3. A black-crowned night heron (*Nycticorax nycticorax*) fell from a bridge at the water's edge; this bird was obviously in the throes of death;

4. Several gar (*Lepisosteus* ssp.) were observed rolling at the water's surface;

5. Two fisherman observed at Allen's Landing Park in downtown Houston had not caught anything, but they said they had caught an occasional catfish and carp in the past;

6. Aquatic macrophytes and riparian vegetation are not abundant.

The dying turtle and bird may not have been directly related to poor water quality. They were, however, obviously related to poor environmental conditions. The large population of sailfin mollies was probably due to lack of predator species combined with the fact that this species is relatively pollution-tolerant. Gar, another environmentally hardy species, also inhabit the area.

These observations indicate that the biological components and habitat of Segment 1013 are severely depressed, due to poor water quality and other environmental conditions.

Fecal Coliforms

Fecal coliform concentrations were generally high throughout both segments of Buffalo Bayou (Table 19). Stations A, B, C, E, J, N, P, Q, V and Z experienced non-coliform bacteria overgrowth and could not be counted. The concentration at Station I was too numerous to count. Mainstream stations L, M and O had concentrations over the segments' criteria of 2,000/100 mL, although individual samples do not constitute standards compliance for fecal coliforms. All concentrations of wastewater discharges were < 1/100 mL, since all were chlorinated.

CONCLUSIONS

Water quality of Buffalo Bayou generally deteriorates from the upstream portion of Segment 1014 to the downstream portion of Segment 1013, due to the cumulative effects of wastewater discharges and low stream assimilative capacity of Segment 1013. Houston's West District WWTP had the most significant impact on water quality and biological conditions of any wastewater discharge. Consideration should be given to establishing a more stringent maximum chlorine residual of the sewage discharges to Buffalo Bayou since overchlorination was found to cause diminished biological populations of the stream.

These data will be utilized by the Commission, through mathematical modeling processes, to develop a waste load evaluation of Buffalo Bayou. This evaluation will specify certain treatment levels for wastewater discharges in order to maintain the existing stream standards for both Segment 1014 and Segment 1013.

PRESENTATION OF DATA

TABLE 1

Buffalo Bayou Sampling Stations

Station	SMN Number	Stream Kilometer	Location
A	1014.3000	92.6	Buffalo Bayou at SH 6
B	1000.5365	90.3 (0.8)*	South Mayde Creek at Memorial Drive
CA	1014.2950	90.0	Buffalo Bayou at Eldridge Drive
C	1014.2900	87.8	Buffalo Bayou at Dairy-Ashford Road
D	1014.2870	84.3	Buffalo Bayou at Wilcrest Drive
E	1014.2850	82.2	Buffalo Bayou at West Belt Drive
F	1014.2835	79.1	Buffalo Bayou at Gessner Drive
G	1014.2825	76.5	Buffalo Bayou at Piney Point Road
H	1014.2820	72.9	Buffalo Bayou at San Felipe Street
I	1014.2815	71.1	Buffalo Bayou at Voss Road
J	1014.2810	66.9	Buffalo Bayou off Farther Point Drive
K	1014.2803	63.3	Buffalo Bayou at Woodway Drive
L	1014.2750	58.6	Buffalo Bayou at Memorial Park
M	1014.2700	54.6	Buffalo Bayou at Shepherd Drive
N	1013.2670	52.9	Buffalo Bayou at Studemont Street
O	1013.2650	50.5	Buffalo Bayou at IH 45
P	1013.2590	48.9	Buffalo Bayou 160 m below White Oak Bayou at Fannin Street
Q	1007.3000	47.5	Buffalo Bayou at US 59
R	1000.6350	89.9 (0.5)*	Turkey Creek above confluence with Buffalo Bayou
S	1000.6600	82.2 (1.9)*	Rummel Creek at Memorial Drive
U	1000.6700	79.0 (1.2)*	Tributary at Memorial Drive and Stoney Creek Drive
V	1000.6800	77.2 (1.3)*	Piney Point Gully at Westheimer Street
X	1000.6900	70.5 (0.6)*	Bering Ditch at Woodway Drive
Y	1000.7000	66.3 (0.8)*	Spring Branch at Memorial Drive
Z	1000.2950	49.1 (0.2)*	White Oak Bayou at North Main Street
1	1000.9109	82.8	City of Houston - West District WWTP #10495.030
2	1000.9110	89.9	City of Houston - Turkey Creek WWTP #10495.085
3	1000.9111	73.7	Memorial Villages Water Authority WWTP #10584.001
4	1000.9112	90.9	Harris County MUD 107 WWTP #11619.001

* Numbers in parenthesis are distances from Buffalo Bayou.

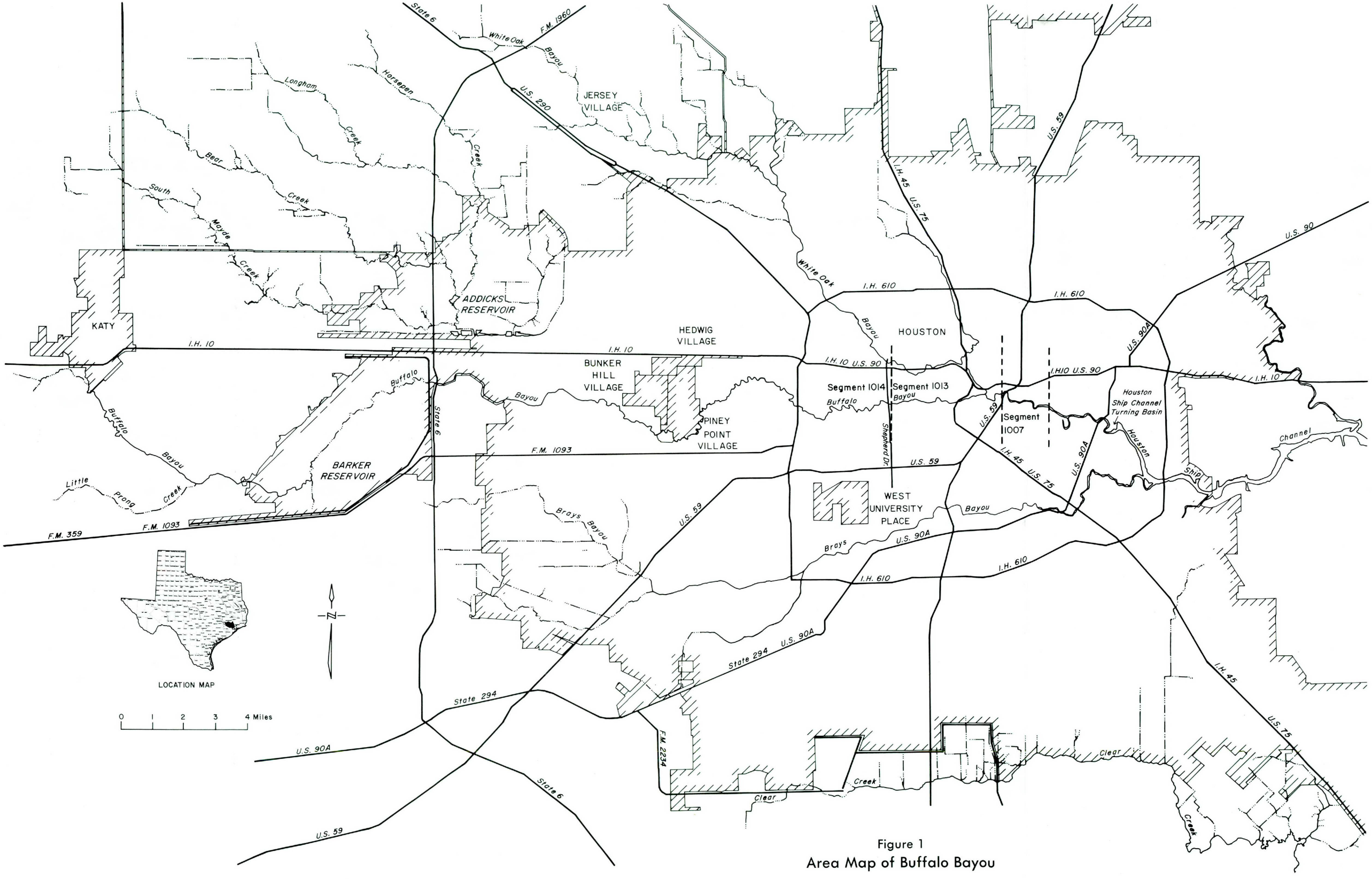

Figure 1
Area Map of Buffalo Bayou

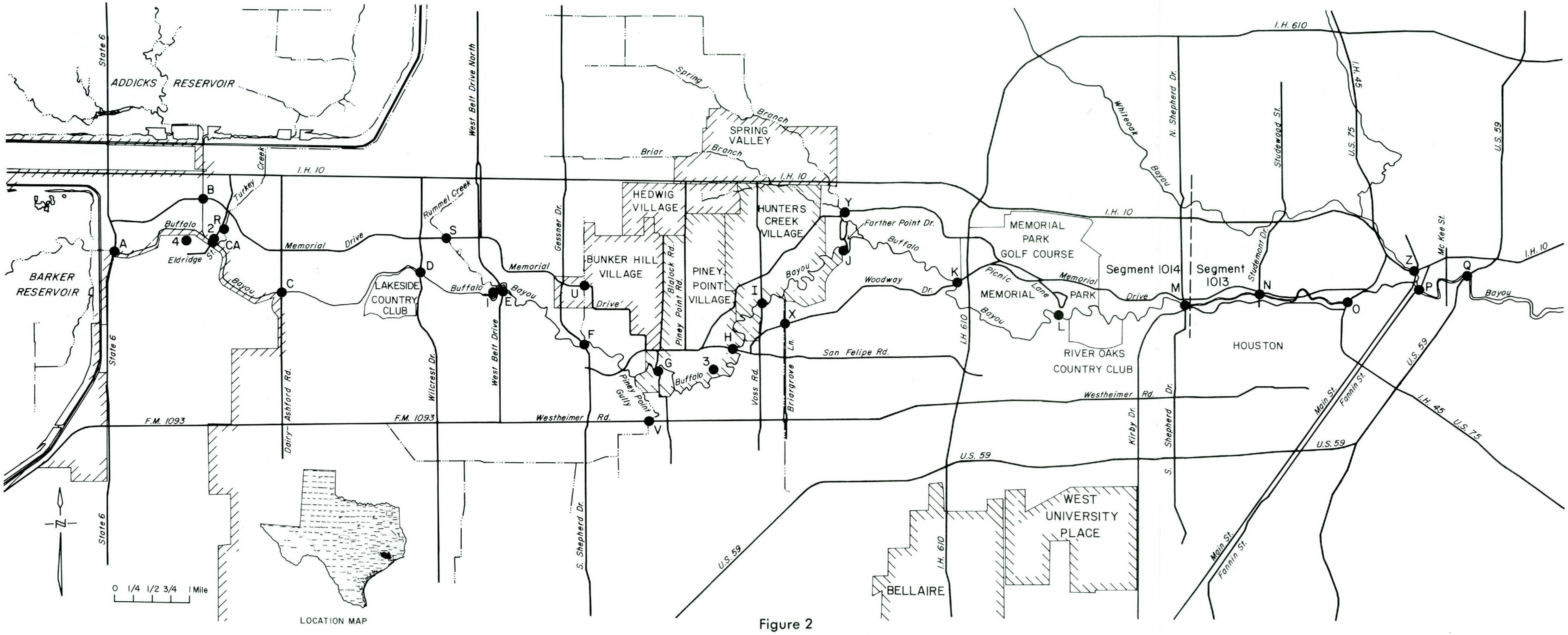

Figure 2

Map of Buffalo Bayou Segments 1014 and 1013

TABLE 2

Permitted Flow and Loading to Buffalo Bayou

Segment	Type	Number	Flow, MGD (ft^3/s)	BOD_5, lb/d	TSS, lb/d
1013	Domestic	76	35.48 (54.89)	2956.9	4437.3
1013	Industrial	11	0.19 (0.29)	6.2	27.7
1013	Total	87	35.67 (55.18)	2963.1	4465.0
1014	Domestic	131	57.83 (89.46)	4940.0	7297.9
1014	Industrial	22	0.98 (1.52)	72.5	174.7
1014	Total	153	58.81 (90.98)	5012.6	7472.6
Both	Domestic	207	93.31 (144.35)	7896.9	11735.2
Both	Industrial	33	1.17 (1.81)	78.8	202.4
Both	Total	240	94.48 (146.16)	7975.7	11937.6

TABLE 3

Actual Flow and Loading to Buffalo Bayou
(Based on September 1985 - August 1986 Self-Reporting Data)

Segment	Type	Number	Flow, MGD (ft^3/s)		BOD$_5$, lb/d	TSS, lb/d	NH$_3$-N, lb/d
1013	Domestic	46	18.75	(29.01)	604.6	896.8	235.1
1013	Industrial	8	0.06	(0.09)	1.6	4.1	0.0
1013	Total	54	18.81	(29.10)	606.2	900.9	235.0
1014	Domestic	71	37.86	(58.57)	2888.0	5357.0	2042.2
1014	Industrial	10	3.04	(4.70)	76.1	27.0	0.0
1014	Total	81	40.9	(63.27)	2964.1	5384.0	2042.2
Both	Domestic	117	56.61	(87.58)	3492.6	6253.9	2277.2
Both	Industial	18	3.10	(4.80)	77.7	31.0	0.0
Both	Total	135	59.71	(92.37)	3570.3	6284.9	2277.3

TABLE 4

Field Measurements - July 15-16, 1985

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
A 1014.3000	07/15/85	1800	1.0	29.7	483	6.8	89.8	7.5
	07/16/85	0610	1.0	26.8	484	6.3	79.1	7.3
	07/16/85	0930	1.0	27.5	1006	7.6	96.6	7.4
	07/16/85	1425	1.0	29.8	881	8.6	113.8	7.6
		DIEL MEAN		28.4	644	7.1	91.8	7.4
B 1000.5365	07/15/85	1815	1.0	28.6	657	7.1	92.0	7.7
	07/16/85	0625	1.0	26.7	459	6.0	75.2	7.4
	07/16/85	1000	1.0	26.6	459	7.1	88.8	7.4
	07/16/85	1340	1.0	28.1	480	8.7	111.8	7.5
		DIEL MEAN		27.6	532	7.0	89.4	7.5
C 1014.2900	07/15/85	1910	1.0	28.8	495	6.2	80.6	7.6
	07/16/85	0720	1.0	26.9	668	5.4	67.9	7.5
	07/16/85	1035	1.0	27.0	726	6.2	78.1	7.4
	07/16/85	1420	1.0	28.3	752	7.4	95.4	7.8
		DIEL MEAN		27.8	630	6.2	78.8	7.6
D 1014.2870	07/15/85	1745	1.0	28.8	723	5.7	74.1	7.6
	07/16/85	0655	1.0	27.1	573	5.3	66.9	7.7
	07/16/85	1055	1.0	27.3	650	5.6	70.9	7.7
	07/16/85	1410	1.0	28.2	709	5.5	70.8	7.6
		DIEL MEAN		27.9	656	5.5	70.6	7.7
E 1014.2850	07/15/85	1805	1.0	28.8	813	6.1	79.3	7.7
	07/16/85	0715	1.0	27.4	621	5.4	68.5	7.7
	07/16/85	1110	1.0	28.3	713	6.0	77.4	7.8
	07/16/85	1425	1.0	29.1	743	5.8	75.8	7.6
		DIEL MEAN		28.3	720	5.8	74.7	7.7

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
F 1014.2835	07/15/85	1858	1.0	28.6	949	5.3	68.7	7.8
	07/16/85	0630	1.0	27.3	616	4.6	58.3	7.8
	07/16/85	1040	1.0	27.6	617	4.5	57.3	7.6
	07/16/85	1425	1.0	29.4	704	4.9	64.4	7.6
		DIEL MEAN		28.1	743	4.9	62.7	7.7
G 1014.2825	07/15/85	1835	1.0	29.1	850	4.8	62.8	7.7
	07/16/85	0558	1.0	27.3	690	4.6	58.3	7.6
	07/16/85	1015	1.0	27.6	612	4.2	53.5	7.7
	07/16/85	1402	1.0	29.2	627	4.5	58.9	7.5
		DIEL MEAN		28.3	719	4.6	59.1	7.6
H 1014.2820	07/15/85	1750	1.0	29.0	849	3.4	44.4	7.5
	07/16/85	0535	1.0	27.5	761	4.1	52.1	7.9
	07/16/85	0940	1.0	27.5	712	4.1	52.1	7.7
	07/16/85	1340	1.0	28.8	636	4.0	52.0	7.5
		DIEL MEAN		28.2	761	3.9	49.5	7.7
I 1014.2815	07/15/85	1735	1.0	28.9	827	2.2	28.7	7.5
	07/16/85	0520	1.0	27.6	845	3.7	47.1	7.8
	07/16/85	0933	1.0	27.4	778	3.8	48.2	7.8
	07/16/85	1329	1.0	29.0	682	3.6	47.0	7.3
		DIEL MEAN		28.2	800	3.2	41.2	7.6
J 1014.2810	07/15/85	1915	1.0	28.6	787	4.1	53.1	7.3
	07/16/85	0710	1.0	27.4	879	3.3	41.9	7.4
	07/16/85	1103	1.0	28.1	777	3.1	39.8	7.5
	07/16/85	1502	1.0	30.1	767	4.0	53.2	7.6
		DIEL MEAN		28.4	812	3.7	47.3	7.4

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
K 1014.2803	07/15/85	1800	1.0	29.6	643	6.2	81.8	7.3
	07/16/85	0600	1.0	27.4	665	3.7	46.9	7.3
	07/16/85	1005	1.0	27.7	834	3.5	44.6	7.5
	07/16/85	1403	1.0	30.3	783	5.0	66.8	7.6
		DIEL MEAN		28.7	705	4.7	61.4	7.4
L 1014.2750	07/15/85	1825	1.0	29.3	688	6.0	78.7	7.4
	07/16/85	0620	1.0	27.2	665	3.9	49.3	7.4
	07/16/85	1023	1.0	27.8	752	4.6	58.8	7.5
	07/16/85	1420	1.0	29.6	826	4.5	59.4	7.6
		DIEL MEAN		28.4	714	4.8	62.4	7.5
M 1014.2700	07/15/85	1838	1.0	29.0	675	5.4	70.5	7.4
	07/16/85	0635	1.0	27.2	522	3.7	46.8	7.3
	07/16/85	1035	1.0	27.7	676	4.1	52.3	7.4
	07/16/85	1435	1.0	30.1	750	4.9	65.2	7.7
		DIEL MEAN		28.4	637	4.5	58.7	7.4
N 1013.2670	07/15/85	1725	1.0	28.5	820	3.8	49.2	8.5
	07/15/85	1725	5.0	28.5	835	3.9	50.5	8.4
	07/16/85	0650	1.0	28.0	525	2.6	33.3	8.0
	07/16/85	0650	4.0	28.0	525	2.6	33.3	8.0
	07/16/85	0945	1.0	27.5	570	2.3	29.2	8.0
	07/16/85	0945	5.0	27.5	570	2.3	29.2	8.0
	07/16/85	1330	1.0	28.2	720	3.2	41.2	8.1
	07/16/85	1330	5.0	28.0	720	3.2	41.0	8.1
		DIEL MEAN		28.1	672	3.1	40.0	8.2

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
O 1013.2650	07/15/85	1745	1.0	28.3	760	3.3	42.5	8.4
	07/15/85	1745	5.0	28.3	760	3.3	42.5	8.4
	07/16/85	0710	1.0	28.2	725	2.2	28.3	8.0
	07/16/85	0710	4.0	28.2	725	2.1	27.0	8.0
	07/16/85	1000	1.0	28.0	750	1.7	21.8	8.0
	07/16/85	1000	5.0	28.0	745	1.6	20.5	8.0
	07/16/85	1343	1.0	28.3	560	2.2	28.4	8.1
	07/16/85	1343	5.0	28.2	560	2.1	27.0	8.1
		DIEL MEAN		28.2	714	2.5	32.2	8.2
P 1013.2590	07/15/85	1813	1.0	28.3	600	3.3	42.5	8.3
	07/15/85	1813	5.0	28.2	585	2.3	29.6	8.3
	07/15/85	1813	10.0	28.0	580	1.5	19.2	8.1
	07/16/85	0730	1.0	28.0	660	1.3	16.7	7.9
	07/16/85	0730	5.0	28.0	590	1.6	20.5	7.9
	07/16/85	0730	10.0	27.8	490	2.6	33.2	8.0
	07/16/85	0730	13.0	27.5	490	3.1	39.4	8.0
	07/16/85	1018	1.0	28.0	660	3.2	41.0	8.0
	07/16/85	1018	5.0	27.5	585	3.4	43.2	8.0
	07/16/85	1018	10.0	27.0	485	4.0	50.4	8.0
	07/16/85	1018	14.0	27.0	460	2.5	31.5	8.0
	07/16/85	1402	1.0	28.5	670	1.4	18.1	8.0
	07/16/85	1402	5.0	27.7	620	1.5	19.1	8.0
	07/16/85	1402	10.0	27.5	520	1.7	21.6	8.0
		DIEL MEAN		27.9	575	2.3	29.2	8.1

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
Q 1007.3000	07/15/85	1827	1.0	29.8	570	2.8	37.1	8.3
	07/15/85	1827	5.0	29.0	570	1.2	15.7	8.3
	07/15/85	1827	10.0	28.2	560	0.2	2.6	8.0
	07/15/85	1827	14.0	28.0	560	0.0	0.0	8.0
	07/16/85	0740	1.0	27.8	535	2.9	37.1	8.0
	07/16/85	0740	5.0	27.8	535	2.9	37.1	8.0
	07/16/85	0740	10.0	27.8	535	3.0	38.3	8.0
	07/16/85	0740	13.0	27.8	535	2.8	35.8	8.0
	07/16/85	1030	1.0	27.7	545	2.0	25.5	8.0
	07/16/85	1030	5.0	27.5	540	1.4	17.8	8.0
	07/16/85	1030	10.0	27.5	540	1.2	15.3	7.9
	07/16/85	1030	15.0	27.5	540	1.0	12.7	7.9
	07/16/85	1415	1.0	29.0	565	1.6	20.9	8.0
	07/16/85	1415	5.0	27.7	570	0.4	5.1	7.9
	07/16/85	1415	10.0	27.4	570	0.1	1.3	7.9
	07/16/85	1415	15.0	27.2	570	0.0	0.0	7.9
		DIEL MEAN		28.1	552	1.6	21.0	8.0
R 1000.6350	07/15/85	1900	1.0	30.9	665	8.7	117.4	8.4
	07/16/85	0700	1.0	26.7	673	5.1	63.9	7.6
	07/16/85	1020	1.0	27.2	770	7.3	92.3	7.6
	07/16/85	1410	1.0	31.2	674	13.3	180.3	8.2
		DIEL MEAN		29.1	685	8.2	107.9	8.0
S 1000.6600	07/15/85	1725	1.0	31.1	472	7.9	106.9	8.2
	07/16/85	0620	1.0	27.3	242	1.3	16.5	7.6
	07/16/85	1030	1.0	27.3	281	1.9	24.1	7.6
	07/16/85	1340	1.0	30.3	302	6.2	82.8	7.9
		DIEL MEAN		29.1	336	4.4	58.6	7.9

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
U 1000.6700	07/15/85	1830	1.0	32.3	443	12.6	174.1	8.7
	07/16/85	0555	1.0	26.2	202	1.2	14.9	7.7
	07/16/85	0935	1.0	26.9	197	1.7	21.4	7.7
	07/16/85	1330	1.0	30.7	242	4.4	59.2	7.9
		DIEL MEAN		29.2	291	5.8	78.6	8.1
V 1000.6800	07/15/85	1843	1.0	27.2	288	5.0	63.2	8.0
	07/16/85	0618	1.0	25.6	318	4.0	49.1	8.0
	07/16/85	1028	1.0	26.0	340	4.1	50.7	7.9
	07/16/85	1414	1.0	28.3	338	6.4	82.5	8.0
		DIEL MEAN		26.7	315	4.8	59.8	8.0
X 1000.6900	07/15/85	1733	1.0	32.0	431	11.9	163.6	8.4
	07/16/85	0530	1.0	27.1	446	2.0	25.2	7.3
	07/16/85	0948	1.0	27.2	492	3.1	39.2	7.6
	07/16/85	1350	1.0	31.8	506	9.3	127.4	8.3
		DIEL MEAN		29.5	459	6.6	89.3	7.9
Y 1000.7000	07/15/85	1908	1.0	28.7	322	6.7	87.0	7.3
	07/16/85	0658	1.0	26.7	227	4.1	51.4	7.3
	07/16/85	1130	1.0	28.7	250	4.3	55.8	7.5
	07/16/85	1450	1.0	30.5	252	5.4	72.3	7.7
		DIEL MEAN		28.3	267	5.2	67.4	7.4

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
Z 1000.2950	07/15/85	1803	1.0	30.0	700	5.2	69.1	8.4
	07/15/85	1803	5.0	30.0	700	5.1	67.7	8.4
	07/15/85	1803	10.0	30.0	700	4.9	65.1	8.4
	07/16/85	0720	1.0	26.5	415	4.9	61.2	8.1
	07/16/85	0720	5.0	26.5	415	4.9	61.2	8.1
	07/16/85	0720	7.0	26.5	415	4.9	61.2	8.1
	07/16/85	1012	1.0	26.5	420	5.9	73.7	8.1
	07/16/85	1012	5.0	26.5	420	5.6	69.9	8.1
	07/16/85	1012	10.0	26.5	420	5.8	72.4	8.1
	07/16/85	1355	1.0	27.8	450	4.5	57.5	8.0
	07/16/85	1355	5.0	27.3	445	3.8	48.1	8.0
	07/16/85	1355	9.0	27.3	450	3.8	48.1	8.0
		DIEL MEAN		27.9	525	4.9	63.3	8.2
1 1000.9109	07/15/85	1645	1.0	29.6	907	8.0	105.5	7.6
	07/16/85	0635	1.0	22.8	919	7.5	87.4	7.9
	07/16/85	1040	1.0	28.7	859	7.3	94.8	7.8
	07/16/85	1355	1.0	29.2	867	7.3	95.6	7.7
		DIEL MEAN		26.9	899	7.6	95.9	7.8
2 1000.9110	07/15/85	1845	1.0	29.8	1070	6.8	90.0	7.5
	07/16/85	0650	1.0	28.8	902	6.9	89.7	7.5
	07/16/85	1020	1.0	29.3	877	7.7	101.0	7.3
	07/16/85	1405	1.0	30.0	889	8.6	114.2	7.3
		DIEL MEAN		29.4	955	7.3	95.8	7.4
3 1000.9111	07/16/85	0955	1.0	26.8	782	6.5	81.6	7.7
	07/16/85	1350	1.0	28.0	887	6.4	82.1	7.3
		DIEL MEAN		27.4	834	6.4	81.8	7.5

TABLE 4 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
4 1000.9112	07/15/85	1830	1.0	29.1	847	6.5	85.0	7.2
	07/16/85	0640	1.0	27.9	795	7.0	89.6	7.3
	07/16/85	1010	1.0	28.0	802	7.1	91.1	7.1
	07/16/85	1350	1.0	29.2	854	7.9	103.5	7.2
		DIEL MEAN		28.6	825	7.0	90.6	7.2

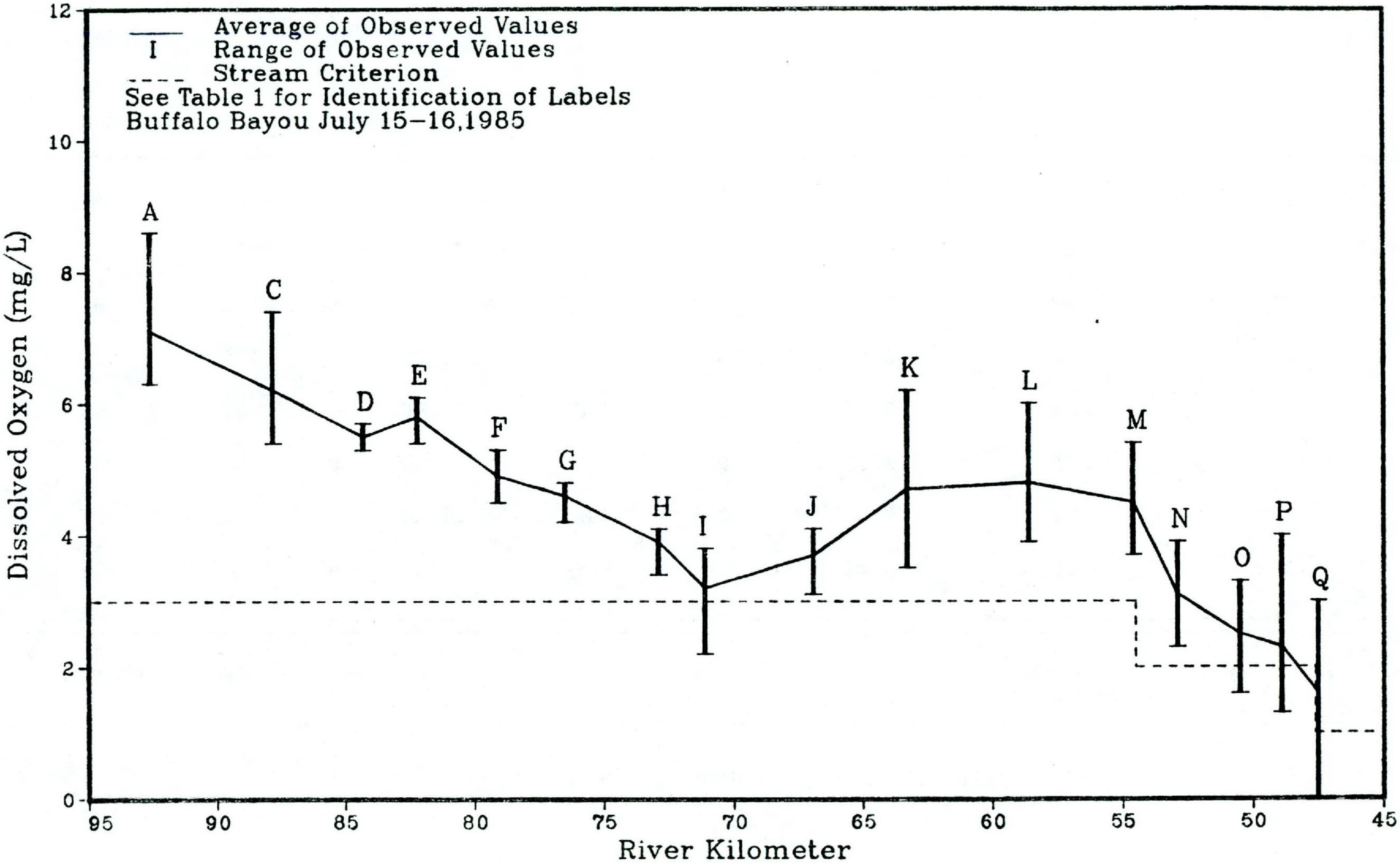

Figure 3. Ranges and Mean Dissolved Oxygen Concentrations of Buffalo Bayou (July 15 & 16, 1985)

TABLE 5

Field Measurements - May 13-15, 1986

Station	SMN Number	Date	Time	Depth ft.	Temperature °C	Conductivity µmhos/cm	D.O., mg/L	pH Units
CA	1014.2950	05/14/86	0930	1.0	24.6	701	5.6	7.6
C	1014.2900	05/14/86	1350	1.0	26.0	707	5.2	7.5
D	1014.2870	05/14/86	2100	1.0	25.7	723	5.1	7.7
E	1014.2850	05/15/86	0200	1.0	25.9	832	6.1	7.7
J	1014.2810	05/13/86	0915	1.0	25.2	687	2.4	6.6
K	1014.2803	05/13/86	1221	1.0	26.5	686	3.8	7.4
L	1014.2750	05/13/86	1741	1.0	28.6	677	3.6	7.5
M	1014.2700	05/13/86	2358	1.0	27.5	694	3.1	7.5

TABLE 6

Water Chemistry - July 15-16, 1985

Map Code and Station Number	Date	Time	Depth ft	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 1014.3000	07/16/85	COMP	0.3	2.0	0.3	5.5	3.0	6	1.80	0.09	0.09	1.62	1.63	2.09	6	8	170	20	338	44	470	113	882	7.8
B 1000.5365	07/16/85	COMP	0.3	2.0	0.3	5.0	3.5	7	1.50	0.12	0.10	2.40	2.76	3.11	8	6	54	20	145	20	292	125	507	7.9
C 1014.2900	07/15/85	1910	0.3	2.0	0.3	6.0	2.5	6	1.70	0.26	0.13	2.18	2.26	2.75	5	5	59	23	318	39	298	110	489	7.8
C 1014.2900	07/16/85	COMP	0.3	1.5	0.3	5.5	3.5	5	1.50	0.17	0.12	2.14	2.26	2.62	4	6	98	21	236	29	358	121	648	7.8
C 1014.2900	07/16/85	0720	0.3	1.5	0.5	4.5	2.5	6	1.40	0.16	0.12	2.01	2.30	2.70	4	6	101	21	200	22	372	121	665	7.7
C 1014.2900	07/16/85	1035	0.3	1.5	0.3	5.0	3.0	6	1.60	0.18	0.11	2.04	2.20	2.55	4	8	121	21	192	27	400	127	750	7.7
D 1014.2870	07/16/85	COMP	0.3	2.0	0.3	5.0	2.5	5	1.50	0.14	0.14	2.35	2.23	2.61	5	12	96	24	205	30	364	126	675	7.8
E 1014.2850	07/16/85	COMP	0.3	1.0	0.5	5.0	4.0	7	5.30	2.86	0.49	1.88	2.56	2.98	5	6	91	28	121	20	410	172	725	7.9
F 1014.2835	07/16/85	COMP	0.3	5.5	5.5	10.0	6.5	7	4.00	2.09	0.73	1.73	2.51	2.95	2	7	90	30	128	19	406	166	720	7.9
G 1014.2825	07/16/85	COMP	0.3	5.5	5.0	10.0	8.5	7	3.70	1.98	0.75	1.70	2.73	3.08	<2	3	89	26	123	16	402	164	695	7.8
H 1014.2820	07/15/85	1750	0.3	6.0	4.5	10.3	8.5	7	2.90	2.00	0.82	1.55	2.86	3.18	3	3	114	30	37	8	468	191	846	7.7
H 1014.2820	07/16/85	COMP	0.3	7.0	6.0	13.0	10.0	7	4.40	2.34	0.77	1.63	2.97	3.36	3	5	88	28	97	19	418	172	740	7.8
H 1014.2820	07/16/85	0535	0.3	6.0	5.0	10.5	9.0	7	4.40	2.22	0.77	1.90	2.75	3.14	4	5	95	28	109	16	404	166	756	7.6
H 1014.2820	07/16/85	0940	0.3	6.5	4.5	13.0	9.0	7	4.60	2.50	0.78	1.65	3.17	3.54	2	5	79	27	117	17	400	173	705	7.7
H 1014.2820	07/16/85	1340	0.3	7.0	5.0	13.0	8.5	8	4.40	2.26	0.74	1.35	2.97	3.50	2	4	67	24	122	19	368	162	628	7.8
I 1014.2815	07/16/85	COMP	0.3	4.0	2.0	9.0	5.0	6	5.10	2.44	0.76	1.62	2.97	3.50	3	4	110	29	77	16	426	180	780	7.8
J 1014.2810	07/16/85	COMP	0.3	2.5	1.5	7.0	4.5	6	3.90	2.44	0.75	1.70	2.87	3.11	7	4	100	29	37	7	442	181	804	7.8
K 1014.2803	07/16/85	COMP	0.3	2.5	1.5	6.5	4.5	6	4.00	2.09	0.71	1.64	2.28	2.51	5	5	95	27	62	9	424	171	755	7.9
L 1014.2750	07/16/85	COMP	0.3	2.5	1.5	6.5	4.0	7	3.30	1.82	0.70	1.50	2.07	2.21	7	3	94	27	52	13	432	176	760	7.8
M 1014.2700	07/15/85	1838	0.3	3.0	2.0	7.0	5.5	9	3.00	0.38	0.57	1.11	1.63	1.80	10	2	83	24	11	1	386	162	680	7.7
M 1014.2700	07/16/85	COMP	0.3	3.0	1.5	6.0	5.0	7	3.00	1.21	0.59	1.26	1.87	2.04	9	2	81	24	34	6	374	162	665	7.8
M 1014.2700	07/16/85	0635	0.3	3.0	2.0	6.0	4.5	7	2.70	1.34	0.37	0.83	1.63	1.76	6	4	54	19	51	7	298	137	516	7.6
M 1014.2700	07/16/85	1035	0.3	2.5	2.0	5.5	4.5	7	3.40	1.52	0.56	1.20	2.29	2.54	9	4	80	24	23	7	374	162	675	7.7
M 1014.2700	07/16/85	1435	0.3	2.0	1.5	5.0	4.0	6	2.90	1.16	0.75	1.67	1.99	2.20	10	2	94	27	8	3	416	189	750	7.8
N 1013.2670	07/16/85	COMP	COMP	4.0	2.0	8.0	5.0	7	3.50	1.32	0.47	0.36	1.90	2.18	9	2	70	22	28	8	340	155	620	7.6
O 1013.2650	07/16/85	COMP	COMP	3.5	2.0	8.0	4.5	7	3.20	1.76	5.00	0.33	2.10	2.28	10	3	73	23	20	8	370	169	660	7.7
P 1013.2590	07/16/85	COMP	COMP	4.0	2.0	8.5	4.5	7	3.70	0.82	0.34	1.10	1.65	1.88	13	5	57	21	29	9	309	143	548	7.6
Q 1007.3000	07/15/85	1830	COMP	4.0	2.0	8.0	5.5	7	2.10	0.69	0.42	0.36	1.24	1.44	19	4	61	21	25	12	293	134	536	7.6
Q 1007.3000	07/16/85	COMP	COMP	3.5	2.5	7.5	5.5	7	2.40	0.83	0.32	0.30	1.43	1.72	6	2	57	20	29	10	293	135	524	7.7
Q 1007.3000	07/16/85	0740	COMP	4.0	2.5	8.5	6.0	8	5.20	0.86	0.24	0.93	1.53	1.63	5	3	51	19	36	5	270	131	495	7.6
Q 1007.3000	07/16/85	1030	COMP	6.0	4.5	14.0	8.0	9	2.60	0.86	0.26	0.97	1.51	1.73	7	5	55	20	30	7	296	135	520	7.6
Q 1007.3000	07/16/85	1415	COMP	3.5	2.0	8.0	6.0	8	3.00	0.84	0.33	0.33	1.56	1.75	10	5	60	21	26	12	318	140	552	7.6

TABLE 6 CONTINUED

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
R 1000.6350	07/16/85	COMP	0.3	1.5	1.5	3.5	3.0	3	1.30	0.13	0.06	0.37	1.18	1.37	4	4	68	19	6	2	393	221	715	8.3
S 1000.6600	07/16/85	COMP	0.3	4.5	3.0	5.5	8.0	11	0.90	0.09	0.04	0.08	0.23	0.35	4	4	35	12	7	4	195	87	322	7.6
U 1000.6700	07/16/85	COMP	0.3	3.5	3.5	9.5	9.0	10	0.80	<0.02	0.01	0.05	0.18	0.28	<2	2	21	12	7	6	160	90	276	7.5
V 1000.6800	07/16/85	COMP	0.3	3.0	2.0	7.5	6.0	11	0.70	0.02	<0.01	0.05	0.19	0.30	3	5	20	11	9	4	193	114	318	7.9
X 1000.6900	07/16/85	COMP	0.3	4.0	3.0	9.5	7.0	8	0.80	<0.02	0.01	0.07	0.32	0.45	5	5	37	15	25	6	277	163	480	8.1
Y 1000.7000	07/16/85	COMP	0.3	3.0	2.0	6.0	5.5	7	1.10	<0.02	0.02	0.23	0.19	0.29	4	5	18	10	19	5	155	95	276	7.7
Z 1000.2950	07/16/85	COMP	COMP	4.0	2.5	8.0	6.0	7	2.20	0.45	0.12	1.22	1.98	2.10	4	9	43	21	33	5	259	127	465	7.8
1 1000.9109	07/16/85	COMP	0.3	4.0	4.0	11.5	9.0	7	11.10	8.93	0.73	0.19	3.36	3.47	<2	2	91	30	<5	<5	494	265	900	8.0
2 1000.9110	07/16/85	COMP	0.3	3.5	3.5	8.5	6.5	5	7.30	4.83	0.30	6.96	6.51	6.83	<2	<2	108	60	7	6	554	195	980	7.8
3 1000.9111	07/16/85	COMP	0.3	3.5	3.0	13.0	6.5	7	8.50	6.30	0.06	1.10	3.38	3.57	2	2	87	23	<5	<5	470	252	870	7.8
4 1000.9112	07/16/85	COMP	0.3	<0.5	<0.5	4.5	2.5	4	6.50	4.62	0.24	0.92	8.19	8.30	2	2	94	39	5	2	462	198	846	7.7

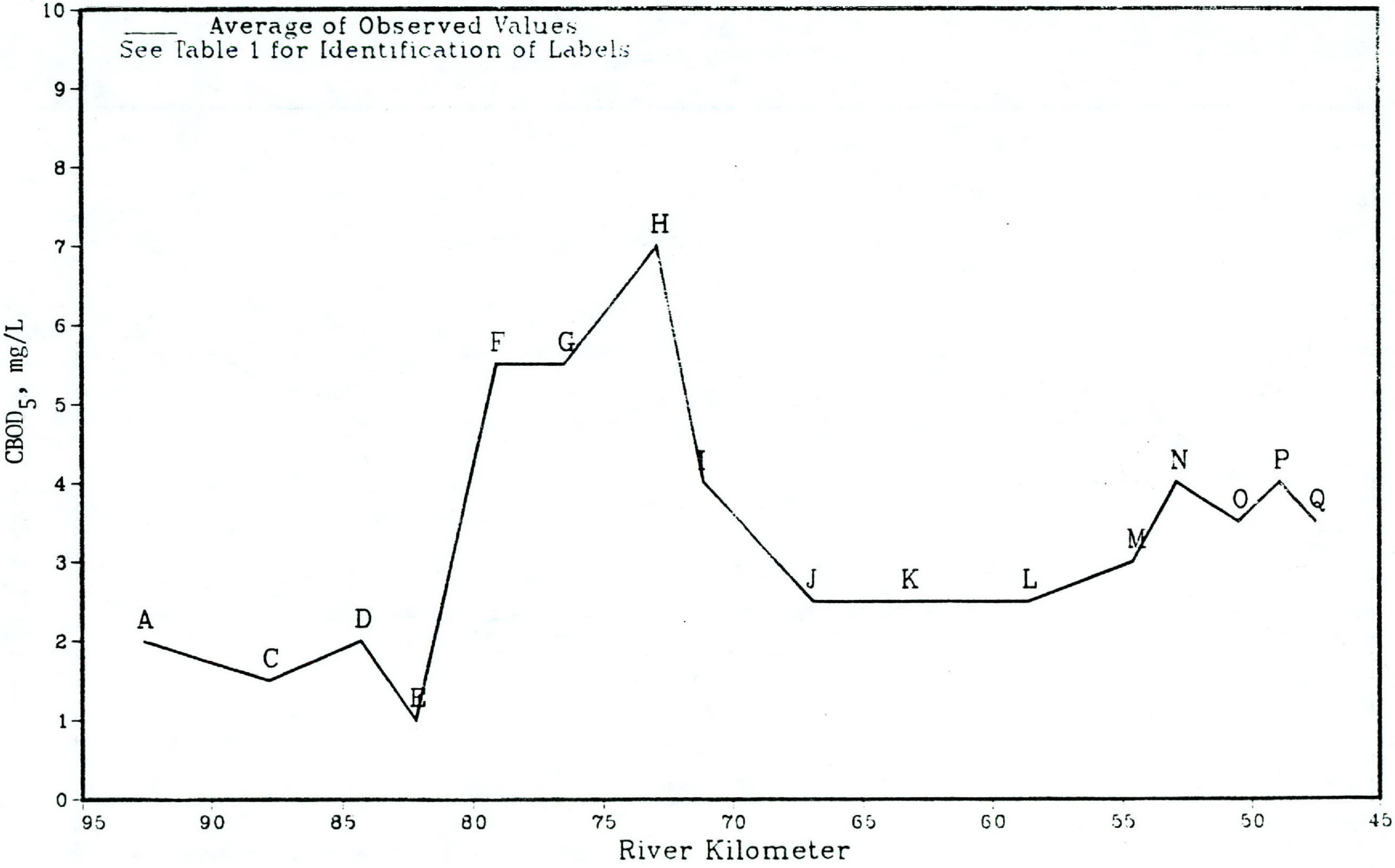

Figure 4. Carbonaceous BOD$_5$ Concentrations of Buffalo Bayou (July 15 & 16, 1985)

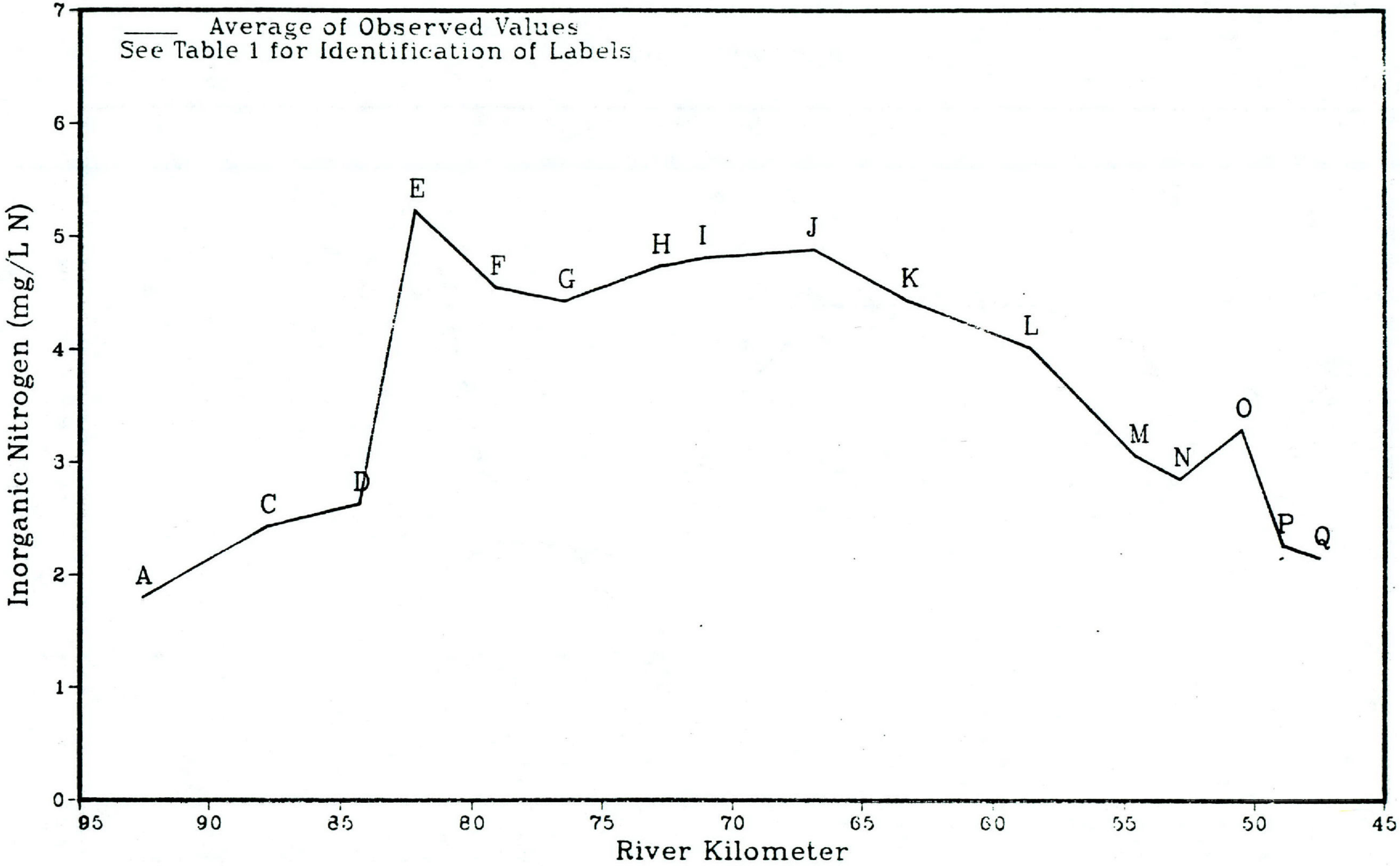

Figure 5. Total Inorganic Nitrogen (NH_3-N + NO_2-N + NO_3-N) Concentrations of Buffalo Bayou (July 15-16, 1985)

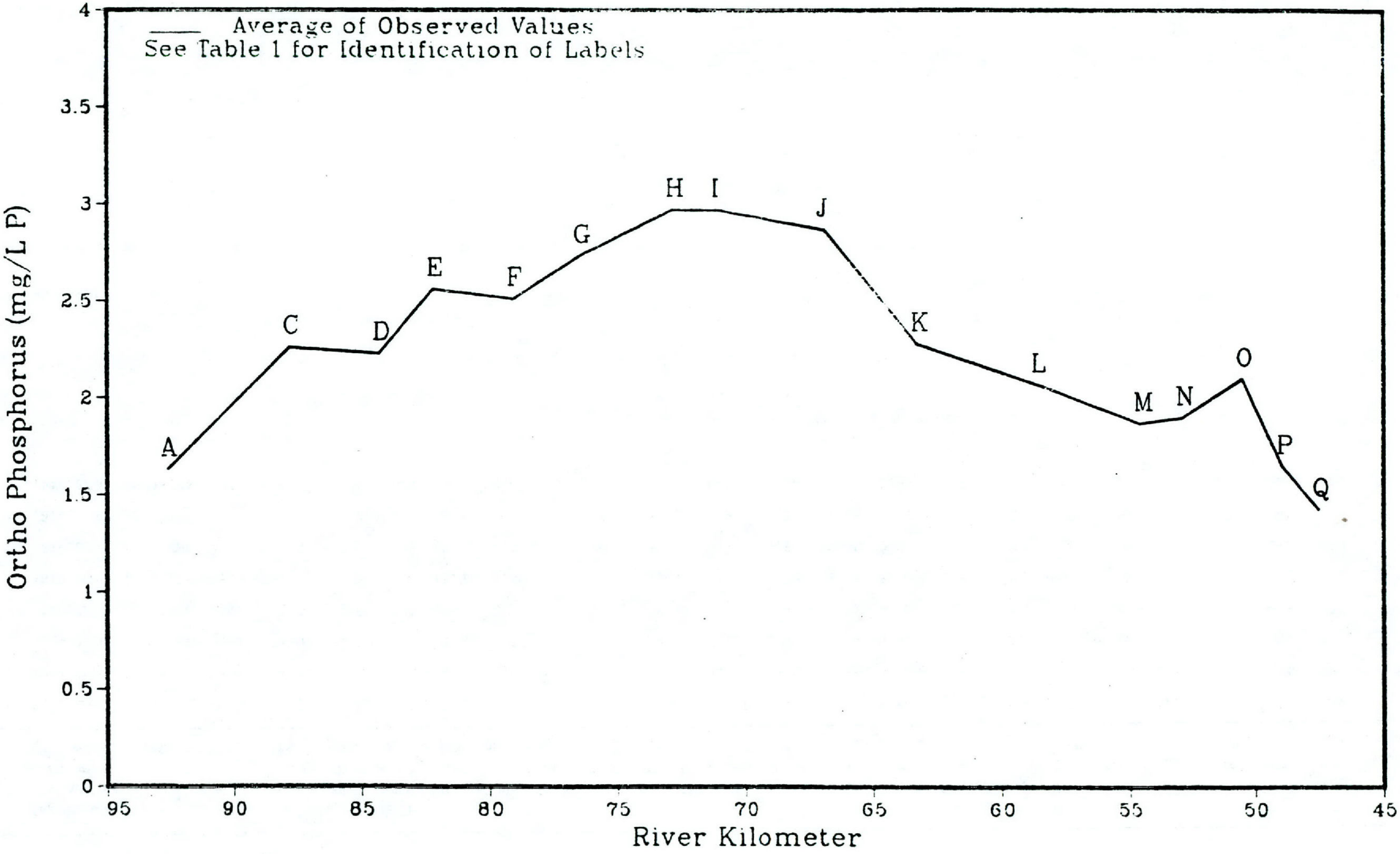

Figure 6. Orthophosphorus Concentrations of Buffalo Bayou (July 15-16, 1985)

TABLE 7

Water Chemistry - May 13-15, 1986

Map Code and Station Number	Date	Time	Depth ft	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
CA 1014.2950	05/14/86	0910	1.0	1.0	1.0	3.5	2.0	5	*	0.20	0.11	4.28	3.60	4.16	6	5	77	34	115	21	392	153	672	7.7
C 1014.2900	05/14/86	1350	1.0	1.0	1.0	4.0	2.5	5	*	*	0.25	6.15	3.39	3.68	6	2	80	38	103	17	392	162	745	7.4
D 1014.2870	05/14/86	2100	1.0	1.0	0.5	3.5	2.5	5	*	*	0.22	3.92	3.25	3.47	<2	2	81	36	80	12	396	165	725	7.5
E 1014.2850	05/15/86	0200	1.0	3.0	1.0	10.0	6.5	7	*	*	0.78	1.85	4.32	4.48	<2	<2	89	36	49	12	468	227	840	7.7
J 1014.2810	05/13/86	0830	1.0	5.5	1.0	11.0	5.5	6	*	3.47	1.01	1.58	2.58	3.02	2	4	67	32	127	23	372	186	695	7.6
K 1014.2803	05/13/86	1220	1.0	5.5	1.5	10.0	4.0	7	*	3.21	0.93	1.51	2.46	2.9	<2	5	65	27	135	25	348	175	650	7.7
L 1014.2750	05/13/86	1740	1.0	4.0	1.0	8.5	3.5	6	*	2.78	0.97	1.56	2.35	2.66	<2	5	65	26	99	20	360	186	675	7.7
M 1014.2700	05/13/86	2350	1.0	3.0	3.0	6.0	4.0	5	*	2.62	0.87	1.64	2.37	2.58	2	<2	65	26	55	21	356	184	648	7.7

* Lab Error

TABLE 8

Chlorine Residuals

Station	Date	Time	Chlorine Residual, mg/L	Station	Date	Time	Chlorine Residual, mg/L
A	07/15/85	1800	0.0	I	07/15/85	1735	<0.1
	07/16/85	0610	0.0		07/16/85	0520	<0.1
		0930	0.0			0933	<0.1
		1425	0.0			1329	<0.1
B	07/15/85	1815	0.0	J	07/15/85	1915	0.0
	07/16/85	0625	0.0		07/16/85	0710	0.0
		1000	0.0			1103	0.2
		1340	0.0			1502	0.0
C	07/15/85	1910	0.0	K	07/15/85	1800	0.0
	07/16/85	0720	0.0		07/16/85	0600	0.0
		1035	0.2			1005	0.0
		1420	0.0			1403	0.0
D	07/15/85	1745	0.0	L	07/15/85	1825	0.0
	07/16/85	0655	0.0		07/16/85	0620	0.0
		1055	0.0			1023	0.0
		1410	0.0			1420	0.1
E	07/15/85	1805	0.7	M	07/15/85	1838	0.0
	07/16/85	0715	1.6		07/16/85	0635	0.0
		1110	0.9			1035	0.0
		1425	0.35			1435	0.0
F	07/15/85	1858	0.3	N	07/15/85	1725	0.0
	07/16/85	0630	0.3		07/16/85	0650	0.0
		1040	1.0			0945	0.0
		1425	0.5			1330	0.0
G	07/15/85	1835	<0.1	O	07/15/85	1745	0.0
	07/16/85	0558	<0.1		07/16/85	0710	0.0
		1015	0.1			1000	0.0
		1402	0.4			1343	0.0
H	07/15/85	1750	<0.1	P	07/15/85	1813	0.0
	07/16/85	0535	<0.1		07/16/85	0730	0.0
		0940	<0.1			1018	0.0
		1340	<0.1			1402	0.0

TABLE 8 CONTINUED

Station	Date	Time	Chlorine Residual, mg/L	Station	Date	Time	Chlorine Residual, mg/L
Q	07/15/85	1827	0.0	1	07/15/85	1645	3.7
	07/16/85	0740	0.0		07/16/85	0635	11.6
		1030	0.0			1040	3.2
		1430	0.0			1355	1.3
R	07/15/85	1900	1.7	2	07/15/85	1845	3.7
	07/16/85	0700	0.0		07/16/85	0650	7.1
		1020	0.0			1020	2.5
		1410	0.0			1405	3.7
S	07/15/85	1725	0.0	3	07/16/85	0955	5.3
						1350	4.9
U	07/15/85	1830	0.0				
				4	07/15/85	1830	5.0
V	07/15/85	1843	0.0		07/16/85	0640	6.5
						1010	3.0
X	07/15/85	1733	0.0			1350	3.1
	07/16/85	0530	0.0				
	07/16/85	0948	0.3				
	07/16/85	1350	0.0				
Y	07/15/85	1908	0.0				
	07/16/85	0658	0.0				
	07/16/85	1130	0.1				
	07/16/85	1450	0.1				
Z	07/15/85	1803	0.0				
	07/16/85	0720	0.0				
		1012	0.0				
		1355	0.0				

TABLE 9

Flow Measurements

Station	Location	Date	Time	Discharge ft^3/s	(m^3/s)	Method
A	Buffalo Bayou at SH 6	07/15/85	1525	44.51	(1.2618)	FM*
B	South Mayde Creek at Memorial Drive	07/15/85	1600	9.76	(0.2764)	FM
CA	Buffalo Bayou at Eldridge Drive	07/17/85 07/15/85	1038 Comp	40.89 60	(1.1584) (1.6997)	FM USGS**
C	Buffalo Bayou at Dairy-Ashford Road	07/16/85 07/15/85	Comp Comp	53 86	(1.5014) (2.4363)	USGS USGS
E	Buffalo Bayou at West Belt Drive	07/16/85 07/15/85	Comp Comp	77 108	(2.1813) (3.0595)	USGS USGS
G	Buffalo Bayou at Piney Point Road	07/16/85	Comp	108	(3.0595)	USGS
R	Turkey Creek above WWTP	07/15/85	1650	2.67	(0.0757)	FM
S	Rummel Creek at Memorial Drive	07/16/85	1020	0.57	(0.0161)	FM
U	Tributary at Memorial Drive and Stoney Creek	07/16/85	0955	0.76	(0.0216)	FM
V	Piney Point Gully at Westheimer Street	07/15/85	1630	0.11	(0.0031)	FM
X	Bering Ditch at Woodway Drive	07/16/85	0935	0.76	(0.0215)	FM
Y	Spring Branch at Memorial Drive	07/16/85	1120	2.40	(0.0679)	FM

TABLE 9 CONTINUED

Station	Location	Date	Time	Discharge		Method
				ft^3/s	(m^3/s)	
CA	Buffalo Bayou at Eldridge Drive	05/14/86	1040	15.94	(0.4516)	FM
C	Buffalo Bayou at Dairy-Ashford Road	05/14/86	1332	19.87	(0.5629)	FM
D	Buffalo Bayou at Wilcrest Drive	05/14/86	2045	23.08	(0.5638)	FM
E	Buffalo Bayou at West Belt Drive	05/15/86	0150	47.47	(1.3448)	FM
J	Buffalo Bayou off Farther Point Drive	05/13/86	0920	60.80	(1.7224)	FM
K	Buffalo Bayou at Woodway Drive	05/13/86	1155	77.36	(2.1913)	FM
L	Buffalo Bayou at Memorial Park	05/13/86	1705	65.78	(1.8634)***	FM
M	Buffalo Bayou at Shepherd Drive	05/13/86	2305	89.59	(2.5378)	FM
1	City of Houston-West District WWTP	07/15-16/85	Comp	37.20	(1.0535)	Totalizer
2	City of Houston-Turkey Creek WWTP	07/15-16/85	Comp	1.12	(0.0316)	Totalizer
3	Memorial Villages Water Authority	07/15-16/85	Comp	3.46	(0.0979)	Self-Reporting
4	Harris County MUD 107 WWTP	07/15-16/85	Comp	4.64	(0.1315)	Totalizer

* Electronic Flow Meter
** U.S. Geological Survey gaging station (mean daily flow)
*** Flow may be low due to uneven substrate

TABLE 10

Buffalo Bayou Cross-Section Data
July 17, 1985

Reach	Number of Measurements	Width Range, m	Average Width (Depth), m
Station CA to Station C	6	9.0 - 13.5	11.1 (0.31)
Station C to Station D	3	10.0 - 12.4	11.5 (0.39)
Station D to Station E	2	11.0 - 12.2	11.6 (0.72)
Station E to Station F	2	14.2 - 14.7	14.5
Station F to Station G	2	13.5 - 14.5	14.0
Station G to Station H	2	12.5 - 13.5	13.0
Station H to Station I	3	11.5 - 15.0	13.5
Station I to Station J	4	12.0 - 14.5	13.7
Station J to Station K	3	14.5 - 16.5	14.8 (0.39)
Station K to IH 610	1	15.4	15.4 (0.61)
IH 610 to Station L	3	15.2 - 17.6	16.1 (0.61)
Station L to Station M	6	14.5 - 17.8	16.3 (0.86)
Station M to Station N	2	17.0 - 18.0	17.5 (0.92)
Station N to Station O	4	19.0 - 24.0	20.9 (1.60)
Station O to Station P	2	28.0 - 37.0	32.5 (3.04)
Station P to Station Q	1	37.0	37.0 (3.4)

TABLE 11

Time-of-Travel Data

Date	From Station	To Station	Distance ft	Distance (m)	Travel Time hours:min	Velocity ft/s	Velocity (m/s)
05/14/86	CA	C	7,218.2	(2200)	4:11	0.479	(0.1461)
05/14/86	C	D	11,483.5	(3500)	7:07	0.448	(0.1366)
05/14/86	D	E	6,890.1	(2100)	4:52	0.393	(0.1197)
05/13/86	J	K	11,811.6	(3600)	2:59	1.100	(0.3352)
05/13/86	K	L	15,748.8	(4800)	5:40	0.772	(0.2353)
05/13/86	L	M	12,795.9	(3900)	6:28	0.550	(0.1675)

TABLE 12

Reaeration Rates
(May 13-15, 1986)

Reach	K_2 @ Temp. (per day)	Average Temp. °C	K_2 @ 20°C (per day)
Station CA to Station C	1.7946	25.2	1.6273
Station C to Station D	0.6041	25.7	0.5426
Station D to Station E	1.1302	25.8	1.0133
Station J to Station K	*	----	*
Station K to Station L	0.1016	27.4	0.0884
Station L to Station M	0.4702	28.3	0.4022

* Liquid Scintillation Counter malfunction

TABLE 13

Macrobenthic Community Indices and Checklist of Species Collected from Buffalo Bayou Segment 1014, July, 1985*

	Dairy-Ashford Road	Gessner Drive	Farther Point Drive	Shepherd Drive
Station	C	F	J	M
Number of Species	17	7	20	27
Number of Individuals/m^2	484	1,723	5,088	7,953
Diversity	3.23	1.44	3.01	4.06
Redundancy	0.32	0.52	0.32	0.15
Equitability	0.79	0.51	0.70	0.85

Taxon	Number of Individuals/m^2			
NEMATODA				
unidentified species				86
HIRUDINEA				
Helobdella elongata			27	11
** *Mooreobdella microstoma*^{3,d}			38	678
OLIGOCHAETA				
Aeolosoma sp.				156
** *Allonais paraguayensis*^{3,g}		11		
Chaetogaster diastrophus			48	
Dero nivea			16	
Dero pectinata				409
** *Dero trifida*^{3,g}				565
Enchytraeidae				102
Limnodrilus cervix			81	285
** *Limnodrilus hoffmeisteri*^{4,g}		183	81	285
** *Limnodrilus udekemianus*^{4,g}		22		

TABLE 13 CONTINUED

Station	Dairy-Ashford Road C	Gessner Drive F	Farther Point Drive J	Shepherd Drive M
Taxon	Number of Individuals/m^2			
OLIGOCHAETA CONTINUED				
Pristina leidyi				307
Pristina sima	5			
** *Sparganophilus tamesis* [3,g]		11		11
GASTROPODA				
** *Ferrissia rivularis* [1,f]	22		167	59
Hebetancylus excentricus			97	
Helisoma anceps				43
Physa virgata				344
AMPHIPODA				
Hyallela azteca				11
ISOPODA				
Asellus obtusus				11
MYSIDACEA				
** *Taphromysis louisianae* [2,a]	22			
COLEOPTERA				
** *Stenelmis grossa* [2,b]	91			
** *Stenelmis sexlineata* [2,b]	16			
DIPTERA				
** *Ablabesmyia annulata* [2,d]			124	689
Ablabesmyia mallochi	5			
** *Chironomus decorus* gr. [4,g]		1,184	371	
Chironomus sp.			124	

TABLE 13 CONTINUED

Station	Dairy-Ashford Road C	Gessner Drive F	Farther Point Drive J	Shepherd Drive M
Taxon	Number of Individuals/m^2			
DIPTERA CONTINUED				
** *Cricotopus bicinctus* [2,i]			205	48
** *Dicrotendipes neomodestus* [3,g]	5	43		
** *Enfeldia* sp. [3,g]			291	689
** *Hemerodromia* sp. [2,c]	27			
Nanocladius distinctus				97
Orthocladius sp.			43	
Polypedilum convictum	11		43	393
** *Polypedilum illinoense* [2,h]	5	269	1,819	1,227
Polypedilum nr *scalaenum*			124	296
** *Rheotanytarsus exiguus* gr. [2,a]	161		1,281	490
Tanytarsus glabrescens gr.	11			
Thienemanniella nr *fusca*	5			
EPHEMEROPTERA				
Caenis sp.			22	91
** *Stenacron* sp. [2,b]	38		86	565
** *Tricorythodes albilineatus* gr. [2,e]	22			
ODONATA				
** *Argia* sp. [2,d]	22			5
TRICHOPTERA				
** *Cheumatophyche* sp. [2,a]	16			

TABLE 13 CONTINUED

Footnotes:

* Two subsamples collected at each station using a Surber square foot sampler.

** Among the six most abundant species at one or more station; utilized in calculations of biotic index and percentage composition of functional feeding groups according to criteria listed below:

1 clean water - sensitive
2 subpollutional - less tolerant
3 subpollutional - unusually tolerant
4 pollutional
a filterer
b 50% grazer, 50% gatherer
c 50% gatherer, 50% predator
d predator
f grazer
g miner
h 33% miner, 33% shredder, 33% predator
i 50% miner, 50% shredder

TABLE 14

Additional Benthic Macroinvertebrate Community Indices

Station	Percentage Composition of Functional Feeding Groups[a]						Mayflies		Biotic Index[b]	Similarity Index[c]	Macrobenthic Health Rating[d]
	gr	ga	mi	fi	sh	pr	# of Species	Percent of Community			
C (Dairy-Ashford Road)	21.6	24.7	0.0	45.5	0.0	8.1	2	12.4	1.9	----	good
F (Gessner Drive)	0.0	0.0	89.6	0.0	5.2	5.2	0	0.0	3.3	0.17	very poor
J (Father Point Drive)	4.1	0.0	33.1	31.0	17.1	14.6	2	2.1	2.5	0.27	fair
M (Shepherd Drive)	5.8	5.8	33.9	10.1	8.3	36.2	2	8.2	2.6	0.27	good

a - determined using the six most abundant species at each station; gr = grazers, ga = gatherers, mi = miners, f = filterers, sh = shredders, pr = predators

b - determined using the six most abundant species at each station

c - with reference to control Station C

d - based on the biotic integrity classification system of Karr (1981), with classes including excellent, good, fair, poor, very poor, and extremely poor

TABLE 15

Phytoplankton Data
(July 17, 1985)

ORGANISMS	Sta. C DAIRY-ASHFORD ROAD #/L	Sta. F GESSNER DRIVE #/L	Sta. J FARTHER POINT DRIVE #/L	Sta. M SHEPHERD DRIVE #/L	TOTAL INDIVIDUALS #/L
* *Anabaena* sp.	144			24	168
* *Anacystis* sp.	24			24	48
* *Ankistrodesmus* sp.	24		24	24	48
Cosmarium sp.				24	24
Microspora sp.			24		24
* *Navicula* sp.	264	72	4,152	576	5,064
* *Nitzschia* sp.				24	24
* *Oscillatoria* sp.	144	24	3,696	24	3,888
* *Scenedesmus* sp.			24		24
* *Spirogyra* sp.			24	24	48
* *Synedra* sp.				48	48
# Individuals/L	576	96	7,944	792	
# Species	4	2	6	9	
Diversity Index ($\bar{d}$)	1.71	0.81	1.1	1.65	
Redundancy (R)	0.51	0.21	0.57	0.50	
Equitability (E)	0.85	0.81	0.43	0.52	

* Pollution-tolerant genera (Palmer, 1969)

TABLE 16

Zooplankton Data
(July 17, 1985)

ORGANISMS	Sta. C DAIRY-ASHFORD ROAD #/L	Sta. F GESSNER DRIVE #/L	Sta. J FARTHER POINT DRIVE #/L	Sta. M SHEPHERD DRIVE #/L	TOTAL INDIVIDUALS #/L
Asplanchna sp.		6	6		12
Bdelloidea sp.		24			24
Brachionus sp.	6			12	18
Calanoida sp.		6	6	12	24
Cephalodella sp.			6		6
Ciliated Protozoa		78			78
Ciliophora			18		18
Copepod nauplius			24		24
Cyclopoida sp.				12	12
Diptera sp.		6			6
Epiphanes sp.			6		6
Lecane sp.	6	6		12	24
Nemata sp.		6			6
Philodina sp.			72		72
Rotifera sp.	36	60		84	180
Trichocerca sp.				24	24
# Individual/L	48	192	138	156	
# Species	3	8	7	6	
Diversity Index ($\bar{d}$)	1.06	2.21	2.10	2.03	
Redundancy (R)	0.40	0.30	0.29	0.24	
Equitability (E)	0.67	0.74	0.75	0.79	

TABLE 17

Nekton Data
(July 17, 1985)

Organisms	Station C Dairy-Ashford Rd.	Station F Gessner Dr.	Station J Farther Point Dr.	Station M Shepherd Dr.	Totals Individuals
Minnow - Fathead *Pimephales promelas*	14				14
Bass - Largemouth *Micropterus salmoides*			1		1
Catfish - Channel *Ictalurus punctatus*	1				1
Crappie - White *Pomoxis annularis*	1				1
Minnow - Sheepshead *Cyprinodon variegatus*			90	50	140
Molly - Sailfin *Poecilia latipinna*	1		353	176	530
Mosquitofish *Gambusia affinis*	15	1	445	889	1,350
Shad - Gizzard *Dorosoma cepedianum*	1			1	2
Shiner - Golden *Notemigonus crysoleucas*				1	1
Shiner - Red *Notropis lutrensis*	10		27	2	39
Shrimp - Grass *Palaemonetes* sp.	4				4
Sunfish - Green *Lepomis cyanellus*	1				1
INDIVIDUALS/STATION	48	1	916	1,119	
NUMBER SPECIES	9	1	5	6	
Number of Seine Hauls	6	6	4	4	
Number Individuals/Seine Haul	8.0	0.2	229.3	279.8	
Diversity Index ($\bar{d}$)	2.39	0.0	1.54	0.92	

TABLE 18

Woody and Herbaceous Species Observed along Buffalo Bayou (July 17, 1985

Trees

Acer negundo L.	boxelder
Betula nigra L.	river birch
Carya aquatica (Michx. f.) Nutt.	water hickory
Celtis laevigata Willd.	sugarberry
Fraxinus spp. (americana and pensylvanica)	ash
Liquidambar styraciflua L.	sweetgum
Magnolia grandiflora L.	southern magnolia
Morus rubra L.	red mulberry
Pinus taeda L.	loblolly pine
Platanus occidentalis L.	sycamore
Planera aquatica (Walt.) J. F. Gmel.	water elm
Populus deltoides Marsh	eastern cottonwood
Prunus caroliniana (Mill.) Ait.	laurel cherry
Quercus falcata Michx.	southern red oak
Q. nigra L.	water oak
Salix nigra Marsh	black willow
Sapium sebiferum (L.) Roxb.	chinese tallow
Tilia sp.	basswood
Ulmus alata Michx.	winged-elm
Ulmus crassifolia Nutt.	cedar elm
Ulmus spp. (americana and rubra)	elm

Shrubs to Small Trees

Arundinaria gigantea (Walt.) Muhl.	giant cane
Carpinus caroliniana Walt.	American hornbeam
Cornus drummondii C.A. Mey	roughleaf dogwood
Sabal minor (Jacq.) Pers.	dwarf palmetto
Sambucus canadensis L.	common elder-berry
Viburnum dentatum L.	southern arrow-wood

Woody Vines

Ampelopsis arborea (L.) Koehne	pepper vine
Ampelopsis cordata Michx.	No common name
Brunnichia ovata (Walt.) Shinners	eardrop vine
Cocculus carolinus (L.) DC.	snailseed
Mikania scandens (L.) Willd.	climbing hemp-weed

Woody Vines Continued

Parthenocissus quinquefolia (L.) Planch.	Virginia creeper
Pueraria lobata (Willd.) Ohwi	kudzu
Rhus toxicodendron L. var. *vulgaris* Michx.	poison ivy
Smilax rotundifolia L.	common green-brier
Vitis mustangensis Buckl.	mustang grape
Vitis rotundifolia Michx.	muscadine grape

Herbaceous

Alternanthera philoxeroides (Mart.) Griseb.	alligator-weed
Ambrosia trifida L.	giant ragweed
Chasmanthium laxifolia (Michx.) Yates	inland sea oats
Cyperus pseudovegetatus Steud.	flatsedge
Diodia virginica L.	virginia buttonweed
Echinochloa colona (L.) Link	jungle-rice
Eleusine indica (L.) Gaertn.	goosegrass
Elymus virginicus L.	wild-rye
Equisetum hyemale var. *affine* (Englm.) A.A. Eat.	horsetail
Eupatorium coelestinum L.	mist flower
Hydrocotyle sp.	water pennywort
Justicia lanceolata (chapm.) Small	lance-leaved water-willow
Persicaria hydropiperoides (Michx.) Small	smartweed
Physalis angulata L. var. *angulata*	ground cherry
Sagitteria sp.	arrowhead
Samolus parviflorus Raf.	water pimpernell
Sorghum halepense (L.) Pers.	johnson grass
Tillandsia usneoides (L.) L.	Spanish moss

TABLE 19

Fecal Coliform Concentrations
(July 16, 1985)

Station	Fecal Coliforms, #/100 mL
A	OG*
B	OG
C	OG
D	600
E	OG
F	300
G	1,050
H	1,750
I	TNTC**
J	OG
K	650
L	8,350
M	10,700
N	OG
O	2,350
P	OG
Q	OG
R	125
S	1,500
U	1,700
V	OG
X	2,850
Y	950
Z	OG
1	<1
2	<1
3	<1
4	<1

* Non-coliform bacterial overgrowth

** Too numerous to count

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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.

Paddle Frequency

$$f = 36\ v$$

where: f = Paddle frequency in revolutions per minute

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

Benthic Oxygen Uptake

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

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)

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

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

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

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).

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

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 fluorometers. 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:

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

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:

$$\frac{K_{kr}}{K_{ox}} = 0.83 \pm 0.04 \tag{2}$$

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:

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

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