NITROGEN AND PHOSPHOROUS DYNAMICS IN A 153-KILOMETER STRETCH OF THE GUADALUPE RIVER, TEXAS

THESIS

Presented to the Graduate Council of
Southwest Texas State University
in Partial Fulfillment of
the Requirements

For the Degree of

MASTER OF ARTS

By

Joe J. Mayhew, B.A.
(Wimberley, Texas)

San Marcos, Texas

May, 1970

ACKNOWLEDGMENTS

The author would like to express his appreciation to Dr. Herbert H. Hannan for his valuable time spent in constructive guidance of this thesis.

Acknowledgment is given to committee members Drs. Willard C. Young and Billy J. Yager for their constructive criticism and helpful suggestions. Sincere appreciation is given to Dr. Bobby G. Whiteside for his assistance in statistical matters and computer analyses.

Research for this thesis was supported in part by a Texas Water Quality Board Grant.

Finally, the author wishes to express his sincere appreciation to his wife, Charlotte, for her encouragement and assistance in the preparation of this paper.

Joe J. Mayhew

Southwest Texas State University
San Marcos, Texas
May, 1970

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CHAPTER I

INTRODUCTION

The role of nitrogen and phosphorous as nutrients for autotrophic organisms is well documented.[1,2,3,4] However, the degree to which nitrogen and phosphorous determine the productivity of different ecosystems is one of the basic research needs of limnology.

The importance of nitrogen and phosphorous is due to their relative paucity when compared with other nutrients. Leibig's Law of the Minimum states that plant growth is dependent on the nutrient which is presented to it in minimum quantity.[5] Because either or both of these elements may be limiting, the need to know their distribution and abundance is apparent.

The natural aging of an aquatic ecosystem is termed eutrophication and is associated with an increase in productivity of the ecosystem.[6] Cultural eutrophication is the accelerated

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[1]S. P. Chu, "The Influence of the Mineral Composition of the Medium on Growth of Planktonic Algae," Part II, "The Influence of the Concentration of Inorganic Nitrogen and Phosphate Phosphorous," pp. 109-148.

[2]W. A. Kratz and J. Myers, "Nutrition and Growth of Several Blue-Green Algae," pp. 282-287.

[3]J. F. Talling, "Freshwater Algae," p. 747.

[4]G. E. Fogg, Algal Cultures and Phytoplankton Ecology, p. 7.

[5]E. P. Odum, Fundamentals of Ecology, p. 88.

[6]H. B. N. Hynes, The Biology of Polluted Waters, p. 10.

process of aging due to the activities of man.[7] An increase in addition of nitrogen and phosphorous can be partially or wholly responsible for the cultural eutrophication of a body of water.

Problems caused by eutrophication can be direct. The oxygen balance of a body of water may be affected by addition of organic compounds. Problems may arise indirectly through the increase in the productivity and thus in the standing crop of primary producers to nuisance conditions. Large diel oxygen pulses are associated with hyper-eutrophic situations and may reduce oxygen to deleterious levels.[8] If the primary producer is phytoplankton, large die-offs produce organic matter which reduces the oxygen level. Blue-green algae that can survive under low oxygen conditions release large amounts of toxin which affect both aquatic and terrestrial organisms.[9]

More subtle changes may occur as the result of eutrophication. Changes in assemblages of organisms may seriously affect the recreational and commercial uses of a body of water.[10] Reduced aesthetic values are often associated with

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[7]A. D. Hassler, "Cultural Eutrophication is Reversible," p. 425.

[8]A. M. O'Connel and N. A. Thomas, "Effect of Benthic Algae on Stream Dissolved Oxygen," p. 4345.

[9]K. M. Mackenthun, E. F. Herman, and A. F. Bartsch, "A Heavy Mortality of Fishes Resulting from the Decomposition of Algae in the Yahara River, Wisconsin," pp. 175-180.

[10]A. D. Hassler, _op_. _cit_., p. 426.

algal blooms and with increases in marginal vegetation.

To determine the rate of eutrophication, one must first determine the sources of nitrogen and phosphorous and the quantity of their contributions to an ecosystem. Nitrogen and phosphorous sources include the atmosphere, ground water, surface runoff, urban drainage, and waste water effluents.

Atmospheric sources, largely in the form of rainfall, may make significant contributions of nitrogen and phosphorous.[11] Weibel, et al.,[12] report average concentrations of 0.69 mg/l of inorganic nitrogen and 0.08 mg/l of phosphate-phosphorous in rainwater. Nitrogen fixation from the atmosphere by blue-green algae is also an important source.[13] Stumm and Morgan[14] conclude that because nitrogen can be fixed from the atmosphere, phosphorous is more important as a fertilizing element. Hutchinson[15] maintains that the presence of a considerable amount of organic nitrogen will depress nitrogen fixation.

Ground water is of great importance as a source of nitrogen, especially in river systems such as the Guadalupe River which

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[11] G. E. Hutchinson, A Treatise on Limnology, Vol. I, 455.

[12] S. R. Weibel, et al., "Pesticides and Other Contaminants in Rainfall and Runoff," pp. 1075-1084.

[13] V. A. Billaud, "Aspects of the Nitrogen Nutrition of Some Naturally Occurring Populations of Blue-Green Algae," p. 37.

[14] W. Stumm and J. J. Morgan, "Stream Pollution by Algal Nutrients," pp. 16-26.

[15] G. E. Hutchinson, op. cit., p. 846.

receive a large quantity of water from limestone springs. Ground waters are usually rich in nitrate-nitrogen.[16] The addition of phosphorous from ground water sources is not considered of great significance.

Surface runoff may be an important source of nitrogen and phosphorous to natural water, depending on edaphic factors, vegetative cover, and agricultural uses of watershed lands. High concentrations of phosphorous are characteristic of run-off from limestone due to accumulation of phosphorous compounds in ancient plant and animal remains.[17] Since the upper portion of the Guadalupe River is in a limestone area, high concentrations of phosphorous might be expected.

Urban drainage is of importance in areas with large urban centers, where runoff and storm sewers make significant contributions of nitrogen and phosphorous.[18] Waste water effluents, especially sewage outfalls, have been cited by many workers as a cause of eutrophication through addition of nitrogen and phosphorous.[19,20,21] The form in which nitrogen

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[16]*Ibid*., p. 832.

[17]L. E. Keup, "Phosphorous in Flowing Waters," pp. 373-386.

[18]S. R. Weibel, R. J. Anderson, and R. L. Woodward, "Urban Land Runoff as a Factor in Stream Pollution," pp. 914-920.

[19]W. Stumm and J. J. Morgan, *op. cit*., pp. 16-26.

[20]A. D. Hassler, *op. cit*., pp. 425-431.

[21]L. E. Keup, *op. cit*., pp. 373-386.

and phosphorous compounds enter the water from sewage outfalls is also of importance. Contributions in the form of organic substances cause an immediate oxygen demand on the water.[22] Nitrification of 1 kg of organic nitrogen or amonia-nitrogen consumes 4.5 kg of oxygen. In contrast, oxidation of carbonaceous material consumes only 2.0 kg of oxygen per kilogram of carbonaceous material.[23] If nitrogen and phosphorous compounds are added in inorganic forms, the immediate oxygen demand is eliminated, but subsequent oxygen demand through production of animal and plant material remains. Stumm and Morgan[24] estimate that 1 mg of phosphorous in one single pass through the phosphorous cycle has an oxygen demand of 160 mg of oxygen.

The degree to which various nitrogen and phosphorous forms interact with each other and with other environmental factors is important in the determination of the productivity of an ecosystem. Odum[25] maintains that a subsidiary principle, factor interaction, should be included in the concept of limiting factors. Such interacting factors include physical, chemical, and biological parameters. The object of this study

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[22]A. F. Bartsch, "Biological Aspects of Stream Pollution," pp. 292-302.

[23]D. J. O'Conner, "Water Quality Analysis of the Mohawk River-Barge Canal," p. 47.

[24]W. Stumm and J. J. Morgan, op. cit., pp. 16-26.

[25]E. P. Odum, op. cit., p. 89.

has been to determine the spatial and temporal distribution of nitrogen and phosphorous compounds in a 153-kilometer stretch of the Guadalupe River system. In conjunction with this study, a study was made of physical, biological, and other chemical factors. The interaction with nitrogen and phosphorous of additional factors such as dams, nutrient sources, seasonal variation in river discharge, temperature, and day-length has also been studied.

CHAPTER II

DESCRIPTION OF STUDY AREA

General Description

The Guadalupe River rises 610 m above sea level in Hunt and Kerr Counties, Texas, and flows southeastward through two main physiographic regions, the Edwards Plateau of the Grand Plains Province and the West Gulf Coast Plain of the Coastal Plains Province. In the Edwards Plateau section the river is characterized by deep valleys with steep limestone cliffs, in the West Gulf Plain by a meandering pattern with low, broad valleys.[1,2]

Drainage area of the basin is more than 15,500 sq km. Its principle tributaries are Johnson Creek, the Comal River, the San Marcos River, Peach Creek, Sandies Creek, and Coleto Creek. In 1960, the population of the basin was about 170,000. Agriculture and the manufacture of gravel, tile, brick, cement, and textiles contribute to the economy of the basin.[3]

The average annual rainfall in the basin varies from 66 cm in the western section to 91 cm in the eastern part. Minimum

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[1]Jack Rawson, _Reconnaissance of the Chemical Quality of Surface Waters of the Guadalupe River Basin, Texas_, pp. 2-6.

[2]R. A. Kuehne, _Stream Surveys of the Guadalupe and San Antonio Rivers_, p. 9.

[3]Jack Rawson, _op. cit._, p. 3.

rainfall occurs usually in the winter, the maximum in late spring or early fall.[4] Springs located throughout the Edwards Plateau make a large contribution to the river flow. The Comal River is primarily fed by Comal Springs and has an average discharge of 8.0 m^3/sec.[5] Over the past decade the springs at the headwaters of the San Marcos River have had an average discharge of 6.3 m^3/sec.[6] These two springs give the Guadalupe River the highest and most stable summertime flow of any Texas stream.[7]

There are four main-stream reservoirs of more than 6×10^6 m^3 on the Guadalupe River. The largest is Canyon Reservoir, located in the Edwards Plateau, with a capacity of 9×10^8 m^3. Five reservoirs of greater than 6×10^6 m^3 and three smaller reservoirs are located in the West Gulf Coastal Plain. These reservoirs are primarily used for hydroelectric power and municipal water.

Description of Stations

A 153-km stretch of the Guadalupe River from New Braunfels (below the confluence of the Comal River) to Gonzales, Texas,

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[4] Ibid., p. 4.

[5] Ibid., p. 6.

[6] Edwards Underground Water District, Records of Wells and Springs, San Antonio Area, Texas, p. 19.

[7] R. A. Kuehne, op. cit., p. 9.

was studied. This stretch of the river is characterized by a meandering pattern, eight riverine impoundments, and no major tributaries. Soil types are clay-limestone associations in the New Braunfels-Seguin stretch and sandy-clay associations below Seguin.[8] For locations of stations, impoundments, and effluents, see Figure 1. Table XVII in the appendix contains station locations in river kilometers and mean water depths.

Station 1 was located below the Interstate 35 highway bridge approximately 1.6 km below the confluence of the Comal and Guadalupe Rivers. The flow was relatively constant at this station due to the influence of the Comal River. Water depth varied from 1.8 to 3.2 m over a substrate of gravel and pockets of mud which supported *Ludwigia* sp. throughout the year. Littoral vegetation included *Typha* sp., *Nuphar* sp., and occasionally *Eichornia crassipes* lodged in the emergent vegetation. Large clumps of cropped aquatic macrophytes from Comal Springs were observed floating past Station 1.

Station 2 was located at Leibsch's farm approximately 4.2 km downstream from Station 1. Effluents from the New Braunfels municipal sewage treatment plant and the new Mission Valley Textile Mill entered the river approximately 1.6 km and 0.6 km, respectively, upstream from Station 2. Station 2 was situated to show the influence on water quality of effluents from New Braunfels sewage treatment plant and Mission Valley

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[8] Jack Rawson, *op. cit.*, p. 7.

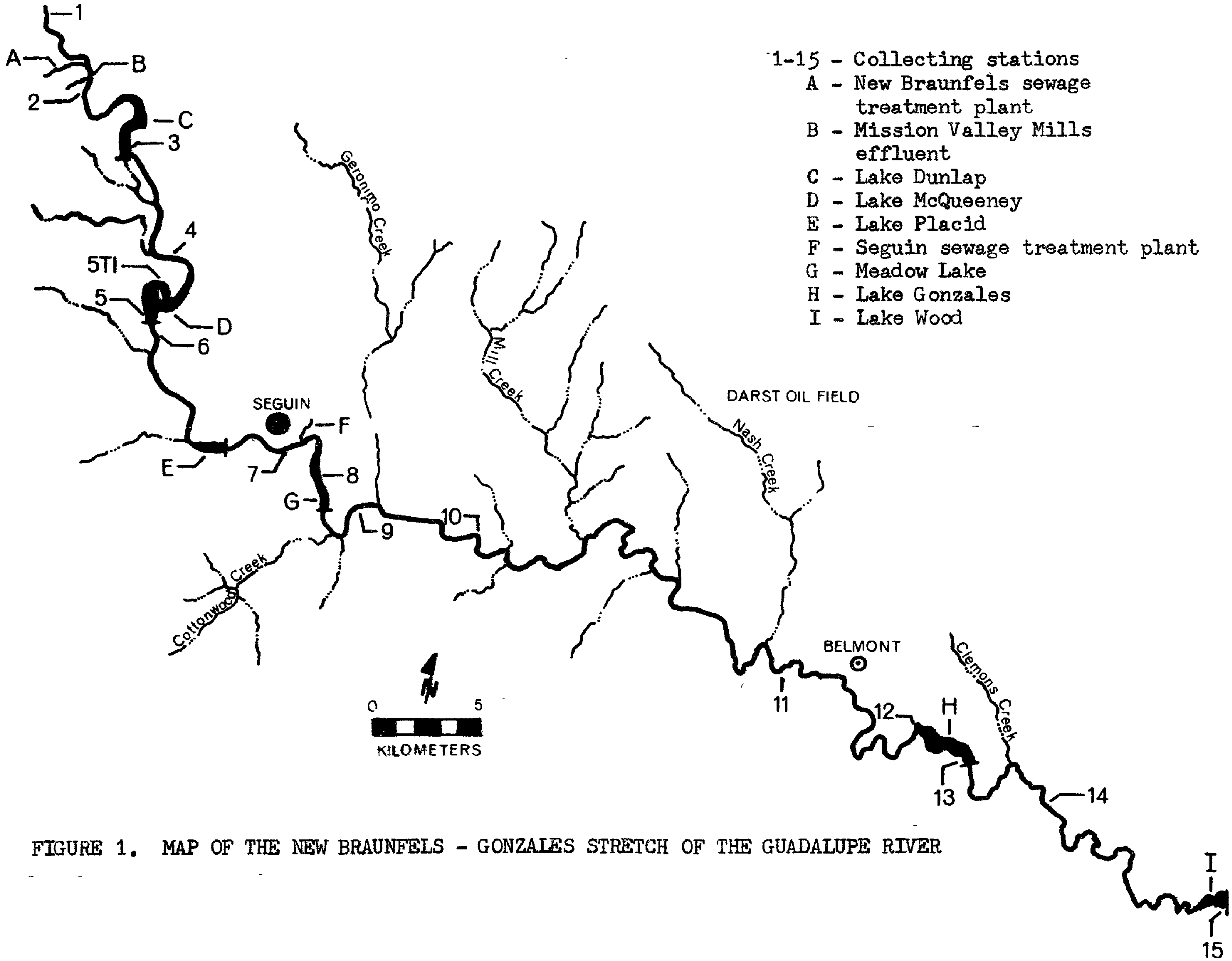

FIGURE 1. MAP OF THE NEW BRAUNFELS - GONZALES STRETCH OF THE GUADALUPE RIVER

Textile Mill. The water depth varied from 3.0 to 4.3 m over a brown mud substrate which supported a large crop of Ludwigia sp. during the summer months. Mats of cropped aquatic macrophytes from Comal Springs were observed floating past Station 2. Emergent vegetation included Typha sp., Nuphar sp., and Eichornia crassipes.

Station 3 was located 0.1 km above Lake Dunlap Dam and 7.4 km downstream from Station 2. The substrate was brown mud similar to that found at Station 2. Water depth varied from 7.3 to 8.0 m. Station 3 was situated to show the influence of Lake Dunlap on water quality. The only aquatic macrophytes at Station 3 were found in the emergent zone, which contained large areas of Nuphar sp. and Typha sp. Large mats of Cladophora sp., Oscillatoria sp., and Eichornia Crassipes were stacked on the leeward side of the lake during the summer months.

Station 4 was located 6.8 km below Lake Dunlap Dam at Elm Grove camp. Water depth ranged from 3.9 to 4.3 m. The substrate at Station 4 was brown mud with no macrophytes. Station 4 was located to indicate the amount and forms of nitrogen and phosphorous entering Lake McQueeney. Sparse emergent vegetation included Typha sp., Nuphar sp., mats of Cladophora sp., and mats of Oscillatoria sp.

Station 5-TI was located behind Treasure Island on the north side of Lake McQueeney. Water depth ranged from 3.6

to 4.4 m over a substrate of mud and organic detritus. The area of Lake McQueeney typified by Station 5-TI is cut off from the flow of the river by Treasure Island. Station 5-TI was established because it was found to differ significantly from other areas of Lake McQueeney. Large areas of Nuphar sp., floating mats of Cladophora sp., and Oscillatoria sp. were found at Station 5-TI.

Station 5 was located 0.1 km above Lake McQueeney Dam and approximately 5.3 km below Station 4. Water depth varied from 7.3 to 8.0 m. Station 5 was located to show the influence of Lake McQueeney on water quality. Emergent vegetation including Typha sp. and Nuphar sp. was abundant. Eichornia crassipes was present in large mats except during the winter months.

Station 6 was located 0.4 km downstream from Lake McQueeney Dam. Its purpose was to indicate the amount and form of nitrogen and phosphorous released from Lake McQueeney. Water depth ranged from 1.0 to 2.7 m. The substrate at Station 6 was mud, gravel, and rock. Only small amounts of littoral vegetation were found at Station 6.

Station 7 was located in Starke Park downstream from State Highway 123 bridge and 12.6 km downstream from Station 6. The Seguin municipal sewage treatment plant outfall was 0.6 km downstream from Station 7. The substrate was mud and organic detritus. Water depth varied from 1.2 to 2.5 m. Eichornia crassipes caught in the branches of overhanging limbs of trees was the only macrophytic vegetation observed.

Station 8 was located in Meadow Lake approximately 5.1 km below Seguin municipal sewage treatment plant and 1.6 km above Nolte Dam. Water depth was 5.9 to 6.7 m over a light-colored mud bottom. Only small areas of *Nuphar* sp. and *Typha* sp. were observed at Station 8. Station 8 was situated to show the influence of both the Seguin sewage treatment plant and Meadow Lake on water quality.

Station 9 was located below Ranch Road 466 highway bridge and 4.1 km downstream from Station 8. Water depth varied from 0.8 to 1.4 m. The substrate at Station 9 was composed of rock of uneven distribution. Large clumps of *Philodendron* sp. were observed during the summer months. Station 9 was situated to indicate the amount and kinds of nitrogen and phosphorous released from Meadow Lake.

Station 10 was located on Hugo Pape's Pecan Valley Ranch 8.0 km below Station 9. Water depth showed a large diel fluctuation at Stations 9, 10, and 11 due to intermittent discharge from Nolte Dam. Water depth varied from 0.8 to 1.3 m over a gravel substrate. Only small quantities of littoral vegetation were observed at this station.

Station 11 was located 35.5 km below Station 10 on the J. E. Hopwood, Lazy Day Ranch. Nash Creek, which drains a portion of the Darst oil field, enters the river 2.2 km above Station 11. Water depth ranged from 0.4 to 1.1 m. The only aquatic macrophytes observed were scattered clumps of *Philodendron* sp.

Station 12 was located at the beginning of Lake Gonzales, 22.7 km downstream from Station 11. Water depth varied from 4.6 to 5.6 m over a substrate of brown mud. Large stands of *Philodendron* sp. and *Nuphar* sp. were observed in the littoral region; no submerged macrophytes were observed. Station 12 was situated to show the amount and form of nitrogen and phosphorous entering Lake Gonzales.

Station 13 was located 0.05 km upstream from Lake Gonzales Dam and 4.6 km below Station 12. Water depth varied from 3.0 to 7.3 m over a mud bottom. The large variation in water depth was due mainly to different areas being sampled rather than to any actual fluctuations in water depth. Station 13 was established to show the influence of Lake Gonzales on water quality. Littoral vegetation included large areas of *Typha* sp., *Nuphar* sp., and *Philodendron* sp.

Station 14 was located 11.1 km below the Lake Gonzales Dam and 1.6 km south of Oak Forest, Texas. Samples were taken from a bridge on an unnumbered farm road which links Alternate U.S. 90 and Ranch Road 466. Water depth at Station 14 ranged from 2.4 to 3.1 m over a mud and gravel substrate. No aquatic macrophytes were observed.

Station 15 was located in Lake Wood 22.5 km downstream from Station 14 and 20 m upstream from Lake Wood Dam. Water depth at Station 15 varied from 3.0 to 8.1 m over a substrate of mud. As with Station 13, the variation in water depth was due more to shifting the area of sampling than to actual fluctuation of the water level. Littoral macrophytes included large growths of *Nuphar* sp. and *Philodendron* sp. Station 15 was established to show the influence of Lake Wood on water quality.

CHAPTER III

MATERIALS AND METHODS

Collection and Storage of Water Samples

Water samples were collected monthly at 16 stations on the Guadalupe River between New Braunfels and Gonzales, Texas. In February, May, August, and November, 1969, samples were collected at 4-hour intervals over a diel period. Because of the time involved in collection and analysis, samples from Stations 1 through 9 were taken over one diel period, and samples from Stations 10 through 15 were taken over a diel period 7 days later. In March, April, June, July, September, October, December, 1969, and January, 1970, samples were taken at each of the 16 stations at 12-hour intervals over a diel period. Station 5-TI was established in June, 1969, when it became obvious that Station 5 was not entirely representative of that stretch of the river.

Two depths were sampled at Stations 3, 4, 5, 5-TI, 8, 9, 12, 13, and 15: a surface sample was taken approximately 0.5 m below the surface and a bottom sample was collected approximately 1 m above the bottom. At Stations 1, 2, 6, 7, 9, 10, 11, and 14, only surface samples were taken. All samples were collected with a 2-liter Kemmerer water sampler.

Samples for nitrate and nitrite analyses were placed in 1-liter polyethylene bottles and immediately placed on ice for transportation to the laboratory. Samples for nitrate and nitrite analyses were stored at 4 C without a preservative. Jenkins[1] suggests that nitrate samples be preserved with 2 ml of 5 per cent sulfuric acid and stored at 4 C. This method cannot be used if the sample is also to be analyzed for its nitrite content since acid treatment will produce a rapid decrease in nitrite.[2] Because nitrite is easily oxidized to nitrate or reduced to ammonia, the samples were analyzed for their nitrite content immediately upon return to the laboratory.[3] In all cases, nitrite analyses were completed within 6 hours, and nitrate analyses were completed within 48 hours after the samples had been obtained.

Samples for the determination of total Kjeldahl nitrogen were placed in either duplicate 200-ml glass BOD bottles or a 500-ml polyethylene bottle. The samples were immediately fixed with concentrated sulfuric acid at a ratio of 2 ml per 300 ml of sample. The sulfuric acid served to maintain the nitrogen balance and later to digest the sample.[4,5] The samples were

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[1]D. Jenkins, "The Differentation, Analysis, and Preservation of Nitrogen and Phosphorous Forms in Natural Waters," pp. 265-280.

[2]*Ibid.*

[3]American Public Health Association, *Standard Methods for Examination of Water and Wastewater*, pp. 205-206.

[4]*Ibid.*

[5]H. L. Golterman, *Methods for Chemical Analysis of Fresh Waters*, pp. 17-18.

stored in this form until analyses could be run. Analyses were usually completed within 15 days of the sampling date.

Samples for ammonia analyses were placed in 1-liter polyethylene bottles and put on ice for transportation to the laboratory. Upon return to the laboratory the samples were immediately frozen.[6] Samples were analyzed within 48 hours from sampling time.

Samples for phosphorous analyses were placed in 500-ml polyethylene bottles and preserved with 3 ml of chloroform. Samples were stored in a refrigerator for a maximum of 5 days prior to analysis. Jenkins,[7] Fitzgerald and Faust,[8] and Heron[9] have found that samples stored in polyethylene or glass containers with chloroform as a preservative exhibit an increase in orthophosphate for the first 6 to 9 days of storage. However, the amount released was 1 to 1.5 µg/l of phosphorous and well below the lower limit of detection (0.018 mg/l P) of the phosphate determination used in this study.

Nutrient Determinations

Nitrate - The method used for nitrate analysis has been

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[6] *Ibid*.

[7] D. Jenkins, *op. cit*., pp. 265-280.

[8] G. P. Fitzgerald and S. L. Faust, "Effect of Water Sample Preservation Methods on the Release of Phosphorous from Algae," pp. 332-334.

[9] J. Heron, "Determination of Phosphate in Water After Storage in Polyethylene," pp. 316-321.

described by West and Ramachandran[10] and is based on the reaction of nitrate with chromotropic acid (1,8 dihydroxy-3, 6-naphthalene disulfonic acid) in concentrated sulfuric acid to produce a yellow compound which conforms to Beer's Law at nitrate concentrations between 0.1 and 10 mg/l in 5 ml of sample. A 0.1-per-cent (w/v) solution of chromotropic acid in concentrated sulfuric acid was freshly prepared from technical grade chromotropic acid (Eastman Organic Chemicals), which had been purified by recrystallization and decolorization from ethanol.[11] It was found that in the recrystallization procedure it was best not to chill the solution below 0 C to speed crystallization. Ice, which sometimes resulted from such refrigeration, could not be removed during the washing procedure. It was also necessary to use 100-per-cent ethanol to wash the crystals because of the solubility of the chromotropic acid crystals in water. Sulfite-urea and antimony solutions were also necessary in the procedure. Sulfite-urea solution was prepared from 5 g of urea and 4 g of anhydrous sodium sulfite diluted to 100 ml with distilled water. One-half gram of antimony metal was heated in 80 ml of concentrated sulfuric acid to prepare the antimony solution. The solution was cooled and added to 20 ml of ice water.

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[10]P. W. West and T. P. Ramachandran, "Spectrophotometric Determination of Nitrate Using Chromotropic Acid," pp. 317-324.

[11]*Ibid.*

Prior to analysis, the sample was filtered through a 0.45 μ Millipore filter. Two 5-ml aliquants of the filtrate were then pipetted into 25-ml volumetric flasks. To eliminate interference by nitrite, two drops of sulfite-urea solution were added to each flask. The flasks were then placed in a water bath at 10 to 20 C, and 4 ml of antimony solution were added to eliminate interference by chloride. The flasks were cooled for 4 minutes, and 2 ml of chromotropic acid solution were added to each flask. The samples were allowed to cool an additional 3 minutes and then removed from the water bath. The volume was made up to 25 ml with concentrated sulfuric acid, and the solution was mixed by inverting three or four times. The solution was allowed to cool for 45 minutes, and the volume again was adjusted to 25 ml with concentrated sulfuric acid. After an additional 15 minutes and before 4 hours, the absorbance was read at 420 mμ in a 1-cm cuvette with a Bausch and Lomb Spectronic 20 colorimeter. The absorbance was used to determine nitrate-nitrogen concentration in milligrams per liter with a standard curve prepared for each chromotropic acid solution.

The accuracy attained with known samples was 2 per cent and precision was 28 parts per thousand.

<u>Nitrite</u> - The method used for nitrite analysis is described by the American Public Health Association,[12] and involves the

[12]American Public Health Association, <u>op</u>. <u>cit</u>., pp. 205-209.

formation of a reddish-purple azo dye which is produced by the coupling of diazotized sulfanilic acid with naphthylamine hydrochloride. The absorbance of the colored complex is determined with a colorimeter at 520 mμ. The range of the test, with a 1-cm light path, is from 0.001 mg/l to 0.18 mg/l of nitrite-nitrogen.[13]

Sulfanilic acid reagent was prepared by the addition of 0.60 g of sulfanilic acid to 20 ml of concentrated hydrochloric acid. The mixture was then diluted to 100 ml with distilled water. Naphthylamine hydrochloride reagent was prepared from 0.60 g of 1-naphthylamine hydrochloride in 100 ml of distilled water to which 1 ml of concentrated hydrochloric acid had been added. A 2 M sodium acetate solution was prepared from 16.4 g of anhydrous sodium acetate dissolved in 100 ml of distilled water. EDTA solution was prepared from 0.5 g of EDTA disodium salt dissolved in distilled water and diluted to 100 ml.

A 125- to 150-ml aliquant of the sample was filtered through a 0.45 μ Millipore filter, and 50-ml aliquants of filtrate were pipetted into duplicate 125-ml Erlenmeyer flasks. One milliliter of EDTA solution and 1 ml of sulfanilic acid reagent were added to the sample. After 3 to 10 minutes the absorbance of the solution was measured at 520 mμ in a 1-cm cuvette with a Bausch and Lomb Spectronic 20 colorimeter. Absorbance was used to determine nitrite-nitrogen concentration

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[13] Ibid.

in milligrams per liter with a previously prepared standard curve.

Recovery in samples of known concentration was acceptable with an accuracy of 3 per cent. At levels below 0.002 mg/l of nitrite-nitrogen, accuracy decreased rapidly.

Total Kjeldahl nitrogen - A micro-Kjeldahl method was used to determine the total Kjeldahl nitrogen content of the samples. The method used is outlined in Aminco Reprint No. 104[14] with modifications as suggested by Woods.[15] The Kjeldahl method involves the catalytic digestion of organic nitrogen to ammonia which is then steam-distilled and analyzed by titrametric or colorimetric means. Total Kjeldahl nitrogen includes free ammonia and organic nitrogen.[16]

The sample was well mixed and the volume measured. If the sample was in a 500-ml polyethylene bottle, 250-ml aliquots were placed in duplicate 800-ml beakers. If the sample was in duplicate 300-ml BOD bottles, the entire contents of each were poured into each of two 800-ml beakers. The beakers were placed in a sand bath and their contents evaporated to approximately 30 ml. Care was taken to avoid spattering of the sample

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[14]Aminco Reprint No. 104, "The Determination of Nitrogen by the Kjeldahl Procedure Including Digestion, Distillation, and Titration," pp. 1-4.

[15]W. Woods, "Physical and Chemical Limnology of the Upper Ohio River," pp. 7-8.

[16]American Public Health Association, *op. cit.*, p. 404.

during evaporation. The sample was washed into a 100-ml Kjeldahl flask which contained 0.13 g of mercuric oxide (red) and 1.2 g of potassium sulfate. The samples were then digested on an Aminco rotary-Kjeldahl-digestion apparatus which permits the digestion of 12 samples simultaneously. The digestion temperature was maintained at 370 to 410 C. Timed from the start of the evolution of sulfur trioxide fumes, digestion was continued for exactly 1 hour. After digestion, 20 ml of water were added to each flask to prevent the formation of potassium sulfate crystals. Samples were then quantitatively transferred to a 100-ml vacuum-jacketed distillation flask which was attached to an Aminco distillation assembly. The tip of the condenser was placed in 5 ml of 4 per cent (w/v) boric acid solution, which contained 4-5 drops of mixed bromcresol-methyl red indicator. The indicator was prepared from 0.1-per-cent solutions of bromcresol green and methyl red in 95-per-cent ethanol, and then mixed at a ratio of five parts bromcresol green to one part methyl red solution. The contents of the distillation flask were made basic with 10 ml of 40-per-cent (w/v) sodium hydroxide solution which also contained 5-per-cent (w/v) sodium thiosulfate. If the contents of the distillation flask were not basic at this point, an additional 10 ml of 40-per-cent-5-per-cent sodium thiosulfate solution were added. The distillate was collected at a rate of one drop per second for 3 minutes. The flask which contained the distillate and boric acid was lowered from the condenser, and the distillation was continued for 1 minute in order to drain the condenser tip. The distillation apparatus was purged with steam for at least 1 minute prior to the distillation of another sample. The distillate was then titrated to a pink end point with 0.01 N hydrochloric acid. Total Kjeldahl nitrogen was calculated with the following equation:

$$\text{mg/l nitrogen} = \frac{(\text{ml acid})(\text{N of acid})(14)(1000)}{\text{ml sample}}$$

Because ammonia is a weak base, the color change of the mixed bromcresol green-methyl red indicator is gradual, and the end point is difficult to determine. Solutions of lysine monohydrochloride of known concentration were analyzed and the color at their equivalence point noted. With experience a titrator could see the end point easily. The American Public Health Association[17] has recommended that the distillate be Nesslerized and the optical density determined with a spectrophotometer. This method offers superior sensitivity; however, interference with Nessler's reagent occurs when the atmosphere has trace amounts of acetone or chloroform. Both acetone and chloroform were being used in the same laboratory at the same time Kjeldahl nitrogen samples were being analyzed. For this reason, the titrametric method was used.

The Kjeldahl method is not noted for its precision or

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[17]American Public Health Association, op. cit., pp. 209-210.

accuracy.[18] An accuracy of 2 per cent with solid samples[19] and 5 per cent with aqueous samples has been attained in other studies.[20] A major problem with Kjeldahl analyses on water samples is poor precision. The Department of Health, Education, and Welfare[21] has determined that the mean error in Kjeldahl analyses on water samples conducted by independent laboratories is ± 0.14 mg/l on samples containing 0.2 mg/l of organic nitrogen. Jenkins[22] has reported the poor precision of unfiltered samples to be due to heterogeneity of suspended materials. Data from the present study seem to support this observation since tests run on aliquots from the same bottle were less precise than aliquants taken from separate bottles. Precision attained in this study was ± 0.07 mg/l of nitrogen.

Ammonia - Ammonia reacts with Nessler's reagent in a strongly alkaline medium to form a brown substance which conforms to Beer's law between 5 and 100 µg of ammonia-nitrogen in 50 ml of solution.[23] A number of interferences with

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[18]Department of Health, Education, and Welfare, Water Nutrients No. 1, Study No. 27, p. 45.

[19]Aminco Reprint No. 104, op. cit., p. 5.

[20]American Public Health Association, op. cit., pp. 210-211.

[21]Department of Health, Education, and Welfare, op. cit., p. 45.

[22]D. Jenkins, op. cit., pp. 265-280.

[23]H. L. Golterman, op. cit., p. 54.

Nessler's reagent exist in most natural waters; therefore, it is usually necessary to separate ammonia from the sample by steam distillation and to Nesslerize the distillate.[24,25] Steam distillation of ammonia samples is a lengthy process; therefore, a method described by the American Public Health Association[26] was used to eliminate the steam distillation step. However, interferences resulted and this method was abandoned.

The steam distillation process used in this study is described by Golterman.[27] A 100-ml aliquant of the sample was poured into a 100-ml vacuum-jacketed distillation flask which was then attached to an Aminco distillation assembly. A 25-ml Erlenmeyer flask which contained 2.5 ml of 0.04 N sulfuric acid was positioned at the condenser tip so that the liquid level was above the condenser tip. One milliliter of saturated sodium borate buffer solution was added to the distillation flask and the steam distillation initiated. The sodium borate buffer solution was prepared from 4 g of sodium borate-decahydrate dissolved and diluted to 100 ml with distilled water. Distillation was carried on at a rate not

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[24] Ibid.

[25] American Public Health Association, op. cit., pp. 186-187.

[26] Ibid.

[27] H. L. Golterman, op. cit., pp. 54-55.

in excess of one drop per second until 20 ml of the distillate had been collected. The 25-ml flask containing the 20 ml of distillate was then removed, and its volume was made up to 25 ml with deionized water. Twenty milliliters of distillate were drawn off with a pipette and placed in a 25-ml volumetric flask. The volumetric flask was stoppered in order to prevent interference from fumes in the laboratory. The steam distillation apparatus was purged with steam for 1 minute prior to the distillation of another sample.

Blanks of deionized water were processed before and after each series of six samples were distilled. Nessler's reagent was added to each sample, and the color was allowed to develop for 30 minutes prior to a determination of the absorbance in a 1-cm cuvette at 420 mμ with a Bausch and Lomb Spectronic 20 colorimeter. The absorbance was used to determine ammonia-nitrogen concentration in milligrams per liter with a previously prepared standard curve.

An accuracy of 4 per cent was attained when 100 ml of sample were distilled. Reproducibility became erratic when ammonia-nitrogen levels were less than 0.05 mg/l. Distillation of larger samples as recommended by the American Public Health Association[28] would have allowed analysis of levels below 0.05 mg/l. An internal known was analyzed to determine if analysis of a sample was complete. Recovery was 92 per cent.

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[28]American Public Health Association, op. cit., pp. 186-187.

Phosphate - The method of Murphy and Riley[29] was used to determine inorganic phosphate, total organic phosphate, and total phosphate concentrations of samples. This method involves formation of phosphomolybdic acid which is subsequently reduced by ascorbic acid to the molybdenum-blue color. Rigler[30] has criticized the molybdenum-blue method for erroneously measuring polyphosphates and other organic phosphates as orthophosphate. His criticism is based on a method which used stannous chloride as the reducing agent. Murphy and Riley[31] maintain that the use of ascorbic acid vice stannous chloride as the reducing agent and the use of antimony to speed color development avoids hydrolysis of polyphosphates. In this paper the term inorganic phosphate will be used to include orthophosphates and polyphosphates. Total organic phosphate includes soluble organic phosphate and particulate organic phosphate.

Another possible source of error is from the Millipore filters used to filter the samples for inorganic phosphate

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[29] J. Murphy and J. P. Riley, "A Modified Single Solution Method for the Determination of Phosphate in Natural Waters," pp. 31-36.

[30] F. H. Rigler, "Further Observations Inconsistent with the Hypothesis that the Molybdenum Blue Method Measures Orthophosphate in Lake Water," pp. 7-13.

[31] J. Murphy and J. P. Riley, op. cit., pp. 31-36.

determination. Rigler[32] and Jenkins[33] have found that Millipore filters contain as much as 1 µg of phosphorous which could be washed out with distilled water. Filtered and unfiltered samples were analyzed to determine if the Millipore filters were a source of error. It was found that inorganic phosphate was added, but it amounted to less than 0.001 mg/l of phosphate-phosphorous.

The mixed phosphate reagent was prepared from 125 ml of 5 N sulfuric acid, 37.5 ml of ammonium molybdate solution, 75 ml of ascorbic acid solution, and 12.5 ml of potassium antimonyl tartrate solution. The ammonium molybdate solution was prepared from 20 g of ammonium molybdate dissolved in distilled water and diluted to 500 ml. The ascorbic acid solution was prepared from 1.32 g of ascorbic acid dissolved in 75 ml of distilled water. The potassium antimonyl tartrate solution was prepared from 0.2743 g of potassium antimonyl tartrate dissolved in distilled water and diluted to 100 ml.

Total phosphate was determined as follows: samples were shaken vigorously to obtain a uniform suspension, unfiltered 50-ml aliquants were pipetted into 125-ml Erlenmeyer flasks, 8 ml of 5-per-cent potassium persulfate (w/v) were added to each flask, and the mixture was digested for 1 hour on a hot

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[32] F. H. Rigler, "The Phosphorous Fractions and the Turnover Time of Inorganic Phosphorous in Different Types of Lakes," pp. 511-518.

[33] D. Jenkins, *op. cit.*, pp. 265-280.

plate. The sample was cooled and the volume was diluted to 50 ml with deionized water in a 50-ml volumetric flask. Forty milliliters of the solution were transferred to a 125-ml Erlenmeyer flask with a volumetric pipette. Eight milliliters of mixed phosphate reagent and 2 ml of deionized water were added, and the color allowed to develop for 15 minutes. It was found that the maximum period of color development for the inorganic phosphate portion of the sample was critical and should be less than 2 hours to prevent hydrolysis of other phosphate compounds. The absorbance was determined in a 1-cm cuvette at 700 mμ with a Bausch and Lomb Spectronic 20 colorimeter. Absorbance was used to determine phosphate-phosphorous concentration in milligrams per liter with a previously prepared standard curve.

The inorganic phosphate portion of the sample was determined after filtration through a 0.22 μ Millipore filter. Forty milliliters of the filtrate were transfered to a 125-ml Erlenmeyer flask. Eight milliliters of mixed phosphate reagent and 2 ml of deionized water were added to the flask, and the color was allowed to develop for 15 minutes. Optical density was determined in the same manner as the total phosphate.

Organic phosphate was determined by subtraction of the concentration of inorganic phosphate from the concentration of total phosphate. An accuracy of 3 per cent and a precision of 14 parts per thousand were attained over the range 0.02 to 0.16 mg/l of phosphate-phosphorous.

Statistical Analyses

Correlation coefficients and t values were computed with an IBM 1130 computer.[34] The computer program was written by Dr. B. G. Whiteside. Precision and accuracy were determined by the method given by the American Public Health Association.[35]

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[34] G. G. Simpson, A. Roe, and G. C. Lewontin, Quantitative Zoology, pp. 213-258.

[35] American Public Health Association, op. cit., pp. 47-49.

CHAPTER IV

RESULTS AND DISCUSSION

Nitrogen

Table XV in the appendix contains results of the nitrate-nitrogen, nitrite-nitrogen, and total Kjeldahl nitrogen analyses for all stations. Table XVI of the appendix contains results of ammonia-nitrogen analyses.

In Table I inorganic nitrogen concentrations observed in the Guadalupe River are compared with concentrations observed in natural waters of other areas. Inorganic nitrogen concentrations observed in the Guadalupe River are, in general, as high or higher than in other areas reported.

Nitrate-nitrogen - Ranges in concentration of nitrate-nitrogen at each station for the 12-month period of study are shown in Table II. There is no large accrual of nitrate-nitrogen from one station to the next, nor is there a large accrual over the entire stretch of the river studied. If a continuous downstream addition of nitrate-nitrogen from various sources is assumed, an increase in the concentration of nitrate-nitrogen would be expected at each downstream station.[1] Similarity in concentrations between stations could be the result

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[1] C. E. Cushing, "Plankton and Water Chemistry in the Montreal River-Lake Stream System," pp. 306-313.

TABLE I

COMPARISON OF NITROGEN AND PHOSPHOROUS LEVELS IN NATURAL WATERS IN OTHER PARTS OF THE WORLD WITH LEVELS IN THE GUADALUPE RIVER, TEXAS

	Total Phosphorous mg/l	Inorganic Phosphorous mg/l	Inorganic Nitrogen mg/l
Northeastern Wisconsin[a]	0.008-0.140	-	-
Connecticut[a]	0.004-0.210	-	-
Japan[a]	0.004-0.043	-	-
Austrian Alps[a]	0.000-0.046	-	-
S. Sweden[a]	0.002-0.162	-	-
N. Sweden[a]	0.007-0.064	-	-
Tennessee[b]	-	0.03-0.09	0.02-2.50
Washington State[c]	0.019-0.140	0.00-0.02	0.02-0.15
Texas (Highland Lakes)[d]	0.01	-	0.03
Texas (Lake Travis)[e]	-	0.01-0.56	0.01-0.55
Texas (Guadalupe River)[f]	0.020-0.240	0.02-0.13	0.02-2.40

[a] from G. E. Hutchinson, A Treatise on Limnology, p. 728.

[b] from W. H. Peltier and E. B. Welch, "Factors Affecting Growth of Rooted Aquatic Plants," p. 24.

[c] from E. G. Fruh, "The Overall Picture of Eutrophication," pp. 14-15.

[d] from B. A. Floyd, et al., "Limnological Investigations of Texas Impoundments for Water Quality Management Purposes," p. 15.

[e] from R. B. Higgins and E. G. Fruh, "Relationship Between the Chemical Limnology and Raw Water Quality of a Subtropical Texas Impoundment," pp. 23-28.

[f] from present study.

TABLE II

RANGE OF NITRITE-NITROGEN, NITRATE-NITROGEN, AND TOTAL KJELDAHL NITROGEN CONCENTRATIONS AT 16 STATIONS ON THE GUADALUPE RIVER, TEXAS, FROM FEBRUARY 22, 1969, THROUGH JANUARY 17, 1970

Station	Nitrite-Nitrogen mg/l	Nitrate-Nitrogen mg/l	Total Kjeldahl Nitrogen mg/l
1	0.002-0.023	0.40-1.20	0.18-0.65
2	0.003-0.030	0.40-1.30	0.19-0.56
3	0.003-0.019	0.20-1.20	0.23-0.80
4	0.002-0.014	0.50-1.30	0.30-0.71
5	0.002-0.016	0.20-1.40	0.32-0.94
*5-TI	0.002-0.007	0.02-0.80	0.42-0.76
6	0.002-0.015	0.40-1.40	0.28-0.67
7	0.002-0.020	0.50-1.70	0.28-0.68
8	0.003-0.016	0.40-1.60	0.28-1.08
9	0.003-0.017	0.30-1.40	0.20-0.76
10	0.003-0.015	0.60-1.80	0.27-0.86
11	0.002-0.012	0.60-1.80	0.21-1.11
12	0.003-0.015	0.60-2.40	0.19-1.14
13	0.003-0.019	0.50-1.60	0.33-0.86
14	0.002-0.017	0.50-1.60	0.33-0.72
15	0.002-0.019	0.40-1.50	0.23-0.79

*Range from June 14, 1969, through January 17, 1970.

of two factors. First, any local source of nitrate-nitrogen is unimportant. Second, seasonal uptake of nitrogen by autotrophic organisms is of sufficient magnitude to consume any increase in nitrate-nitrogen that would accumulate with distance downstream.[2]

Variation in concentration of nitrate-nitrogen with respect to distance downstream from Station 1 and time of year are shown in Figure 2. The isopleth for nitrate-nitrogen is largely subdivided into horizontal lines of equal concentration with the exception of a large increase in nitrate-nitrogen at Stations 1 and 2 in June, July, and August. The horizontal lines of equal concentration indicate seasonal variation of nitrate-nitrogen due to increased uptake by autotrophic organisms during the spring and summer months.

The high concentrations of nitrate-nitrogen at Stations 1 and 2 during June, July, and August are associated with increases in nitrite-nitrogen and inorganic phosphate-phosphorous (Figures 4 and 6, respectively). The sewage outfall above Station 2 and low discharge of the river during June, July, and August could account for the increased nitrate-nitrogen concentration at Station 2. In June and July an increase in nitrate-nitrogen occurred above the sewage outfall upstream from Station 2. It is, therefore, reasonable to assume that the source of nitrate-nitrogen is not the sewage

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[2] <u>Ibid</u>.

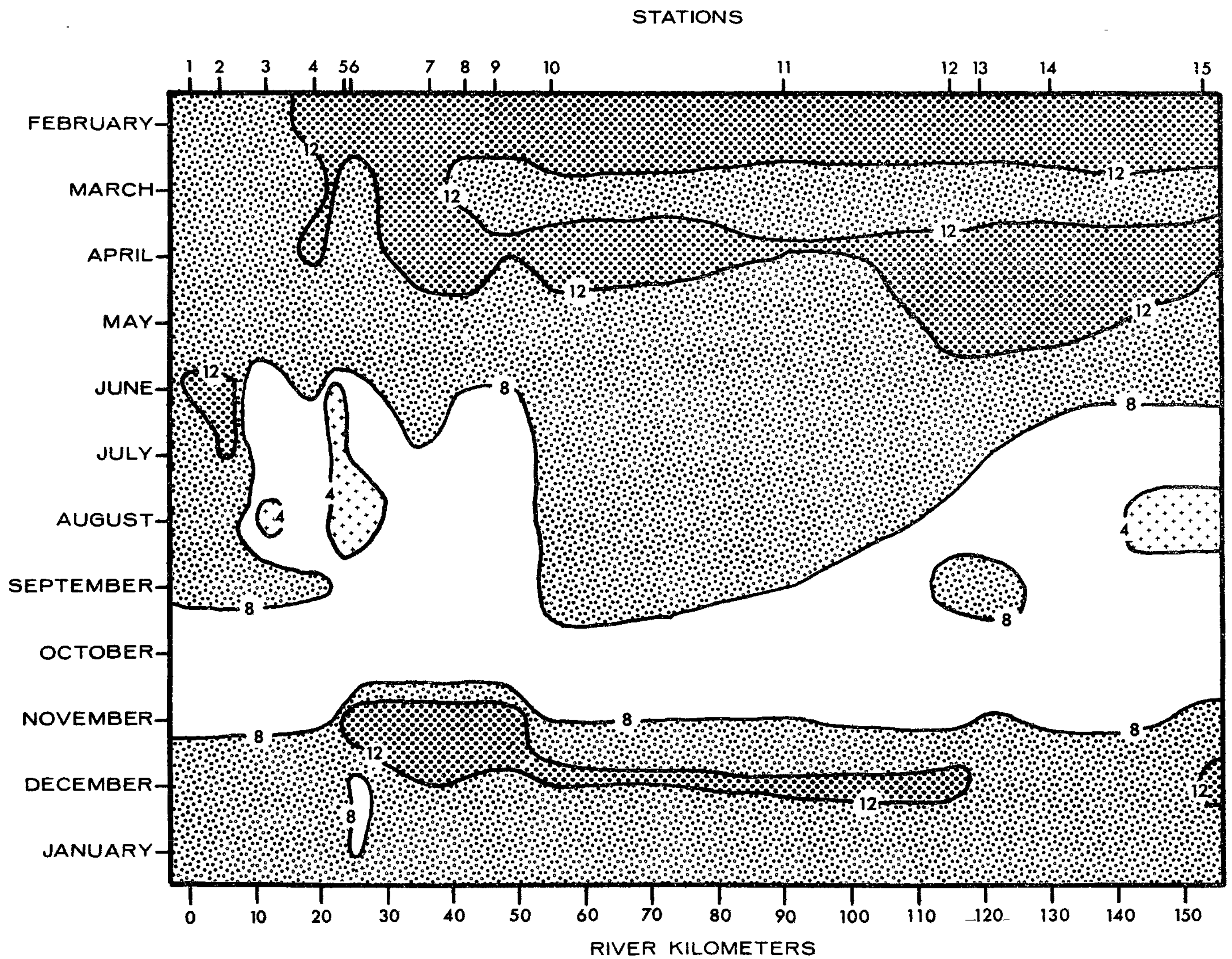

FIGURE 2. SEASONAL VARIATION OF SURFACE NITRATE-NITROGEN IN MG/L x 10^{-1} AT 15 STATIONS IN THE GUADALUPE RIVER

outfall above Station 2 alone, but some source above Station 1, perhaps in the city of New Braunfels.[3]

The sewage outfall between Stations 7 and 8 is unimportant as a source of nitrate-nitrogen because no accrual between Stations 7 and 8 was evident (Figure 2).

Comal Springs is an important source of nitrate-nitrogen in the Guadalupe River due to high nitrate-nitrogen concentrations (Table III) and the high constant discharge of the springs (Table IV). The springs have had an average discharge of 8.0 m^3/sec over the past decade.[4] Water samples taken from Canyon Reservoir tail race during July and November had low concentrations of nitrate-nitrogen (0.17 and 0.47 mg/l, respectively). If there are no large additions of nitrate-nitrogen to the Guadalupe River between Canyon Reservoir tail race and the downstream confluence of the Comal and Guadalupe Rivers, Comal Springs would increase the nitrate-nitrogen concentration of the Guadalupe River appreciably. From 28 to 67 per cent of the total discharge of the Guadalupe River at Station 1 was from Comal Springs during the period of study. These large fluctuations in flow were largely due to variations in discharge from Canyon Reservoir (Table IV). Since 1939, surveys by the U. S. Geological Survey indicate that nitrate-nitrogen

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[3] S. R. Weibel, R. H. Anderson, and R. L. Woodward, "Urban Land Runoff as a Factor in Stream Pollution," pp. 914-920.

[4] J. Rawson, _Reconnaissance of the Chemical Quality of Surface Waters of the Guadalupe River Basin, Texas_, pp. 2-6.

TABLE III

NITRATE-NITROGEN CONCENTRATION IN COMAL AND SAN MARCOS SPRINGS, TEXAS

	Comal Springs Nitrate-Nitrogen mg/l	San Marcos Springs Nitrate-Nitrogen mg/l
[a]April, 1939	1.13	-
June, 1941	0.84	-
April, 1942	0.90	-
January, 1944	1.24	-
September, 1944	0.99	-
October, 1945	1.27	-
August, 1951	1.02	-
March, 1955	-	1.03
June, 1957	1.08	-
August, 1957	1.02	-
October, 1957	0.95	-
January, 1958	1.08	-
April, 1958	1.15	-
July, 1958	1.20	-
January, 1959	1.54	-
June, 1959	-	1.92
February, 1963	-	1.92
*July, 1969	1.63	1.60
*December, 1969	1.51	-

[a] from unpublished U.S. Geological Survey Data.

* from this study on the Guadalupe River.

TABLE IV

MONTHLY AVERAGE DISCHARGE IN CUBIC METERS PER MINUTE FROM CANYON RESERVOIR, COMAL RIVER, AND LAKE DUNLAP FROM FEBRUARY, 1969, THROUGH JANUARY, 1970

	Canyon Reservoir	Comal River	Lake Dunlap
February	358	530	1046
March	358	554	1070
April	358	547	1167
May	649	586	1592
June	581	534	1330
July	234	449	795
August	108	374	635
September	183	437	708
October	1125	455	1706
November	904	486	1453
December	691	516	1432
January	1283	520	1908

concentrations have been consistently high in the Edwards aquifer, which feeds Comal and San Marcos Springs (Table III). Nitrate-nitrogen concentrations have increased markedly in Comal and San Marcos Springs since 1959. Nitrate-nitrogen concentrations from years prior to 1959 were compared with nitrate-nitrogen concentrations since 1959 by the use of a two-grouped t test. Before 1959, nitrate-nitrogen concentrations were found to be significantly different from nitrate-nitrogen concentrations after 1958 at the 0.001 alpha level ($t_{cal} = 8.71 > t_{0.001,\ 20\ d.f.} = 3.85$). The mean concentration of nitrate-nitrogen prior to 1959 was 1.08 mg/l and after 1958, 1.69 mg/l, which represents a 63 per cent increase. The increased level of nitrate-nitrogen in the aquifer is probably due to increased urbanization and agriculture on the Edwards Plateau. The abrupt increase may be due to a recharging of the aquifer after the drought which ended in 1956. Comal Springs increased from zero flow to normal discharge during the period from 1957 to 1959.[5]

The effect of reservoirs on nitrate-nitrogen concentrations is shown in Figure 2. Seasonal reduction of nitrate-nitrogen concentrations below 0.40 mg/l was observed at Stations 3, 5, 6, and 15. These stations represent Lake Dunlap, Lake McQueeney, Lake McQueeney tail race, and Lake Woods, respectively. Increased retention times and increased standing crops of autotrophic organisms associated with reservoirs apparently

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[5]Edwards Underground Water District Publication, pp. 4-6.

cause decreased concentrations of nitrate-nitrogen. Symons, *et al.*,[6] and Cushing[7] have come to similar conclusions.

Nitrate-nitrogen concentrations at Station 5-TI were consistently lower than in other areas studied (Table II). An increase in discharge from Lake Dunlap in October was associated with an increase in nitrate-nitrogen concentrations at Station 5-TI. Apparently, during periods of normal and low flow of the river, exchange of water at Station 5-TI is restricted, but during periods of high flow, water is exchanged. Throughout the year, consistently high chlorophyll *a* concentrations were found at Station 5-TI, a fact which could be attributed to low nitrate-nitrogen concentrations (Figure 3). An increase in nitrate-nitrogen concentration in December was associated with an increase in chlorophyll *a* at Station 5-TI. It is doubtful that nitrate-nitrogen alone was a limiting factor since the correlation between the increase in nitrate-nitrogen and chlorophyll *a* was not significant at the 0.05 alpha level (Table XIII).

Nitrite-nitrogen - Variation in the concentration of nitrite-nitrogen with respect to month and distance downstream is shown in Figure 4.

Throughout the study period, concentrations of nitrite-nitrogen ranged from 0.002 to 0.010 mg/l. In June, July, and

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[6]J. M. Symons, W. H. Irwin, J. DeMarco, and C. G. Robect, "Effects of Impoundments on Water Quality," p. 28.

[7]C. E. Cushing, *op. cit.*, pp. 306-313.

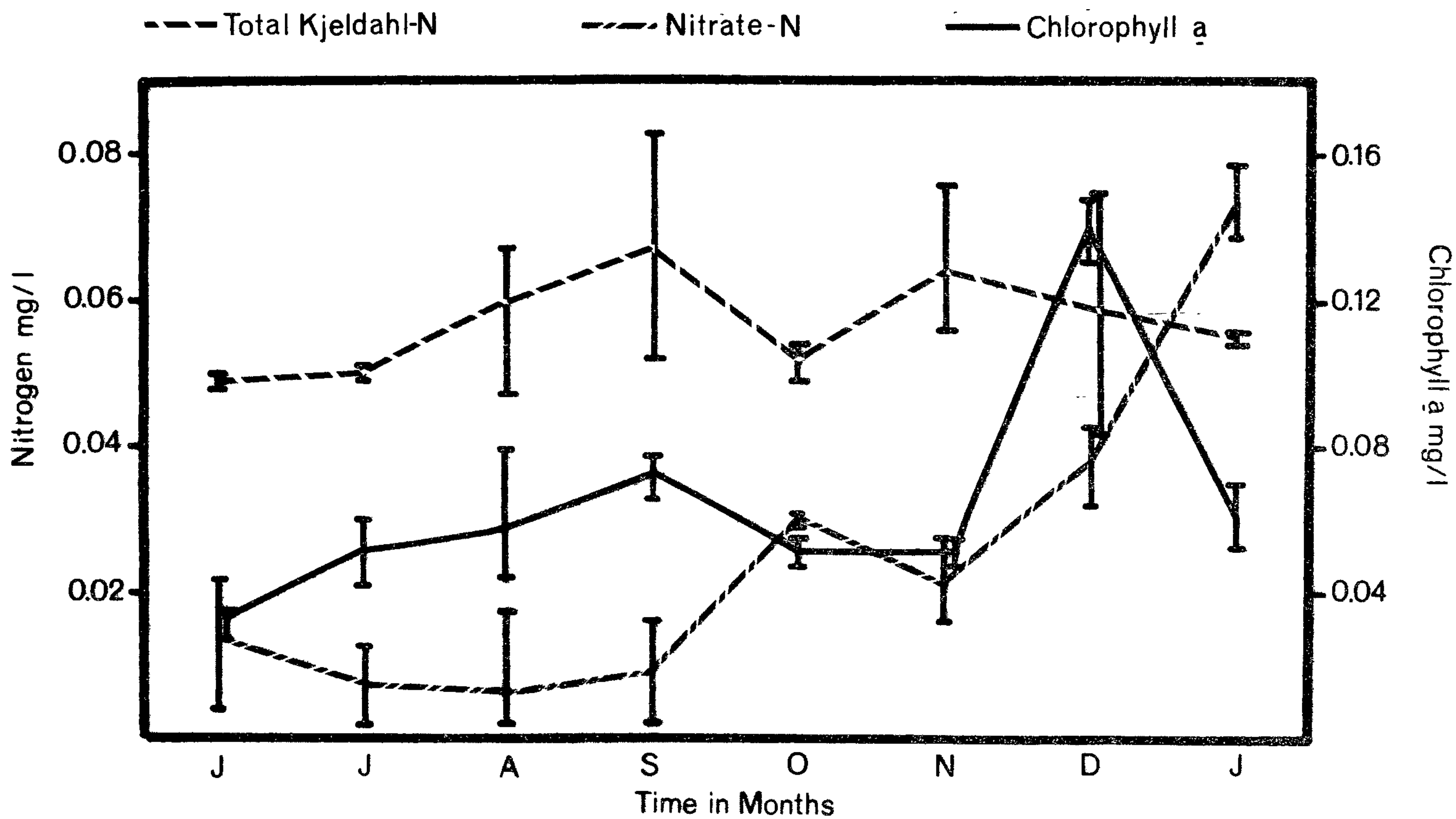

FIGURE 3. SEASONAL VARIATION OF TOTAL KJELDAHL NITROGEN, NITRATE-NITROGEN, AND CHLOROPHYLL A AT STATION 5-TI FROM JUNE 14, 1969 THROUGH JANUARY 17, 1970

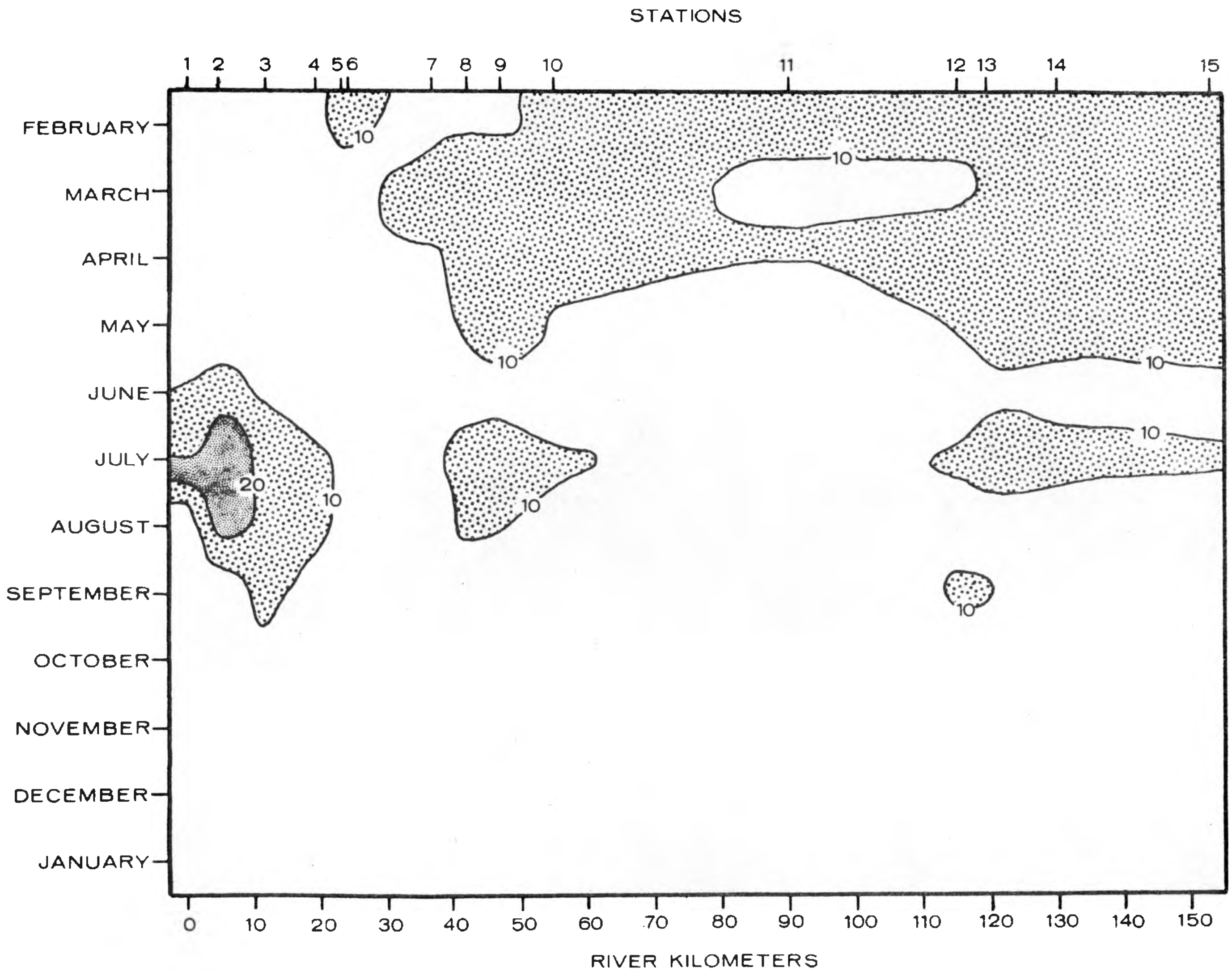

FIGURE 4. SEASONAL VARIATION OF SURFACE NITRITE-NITROGEN IN MG/L x 10^{-3} AT 15 STATIONS IN THE GUADALUPE RIVER

August, concentrations of nitrite-nitrogen greater than 0.020 mg/l were observed at Station 2. In July, concentrations greater than 0.020 mg/l of nitrite-nitrogen were observed at Station 1. Large amounts of nitrite-nitrogen are considered by some workers to be an indication of pollution by sewage.[8,9] The low river flow during June, July, and August decreased the dilution of the effluent from the sewage outfall above Station 2, a condition which caused an increase in nitrite-nitrogen concentration of the river at Station 2. The increased concentration of nitrite-nitrogen in June and July at Station 1 cannot be attributed to the sewage outfall above Station 2 but may be due to a combination of low flow and some source of nitrite-nitrogen in New Braunfels.[10]

Total Kjeldahl nitrogen - The ranges of concentration of total Kjeldahl nitrogen for each station over the year of study are shown in Table II. As with nitrate-nitrogen, there is no significant accrual of total Kjeldahl nitrogen downstream except at Station 5-TI. The lowest concentration of total Kjeldahl nitrogen observed at Station 5-TI was 0.42 mg/l. Higher total Kjeldahl nitrogen concentrations at Station 5-TI were probably due to consistently high standing crops of

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[8] G. K. Reid, Ecology of Inland Waters and Estuaries, p. 187.

[9] G. E. Hutchinson, A Treatise on Limnology, I, 861.

[10] S. R. Weibel, R. J. Anderson, and R. L. Woodward, op. cit., pp. 914-920.

phytoplankton. Autotrophic assimilation of total Kjeldahl nitrogen would account for the lack of build-up in concentration with distance downstream.[11,12]

Seasonal variation in the concentration of total Kjeldahl nitrogen with respect to month and distance downstream is shown in Figure 5. Concentrations of total Kjeldahl nitrogen were between 0.30 and 0.60 mg/l at all stations during a major portion of the year. Concentrations greater than 0.60 mg/l of total Kjeldahl nitrogen were correlated with a large increase in chlorophyll a concentrations during March, April, and May at Stations 12 through 15. An increase of total Kjeldahl nitrogen at Station 2 in August and September was associated with the combined effect of low river flow and the sewage outfall above Station 2.

There is a large amount of similarity between the isopleths for nitrite-nitrogen (Figure 4) and total Kjeldahl nitrogen (Figure 5). Apparently nitrification occurs rapidly since high concentrations of total Kjeldahl nitrogen were spatially associated with high concentrations of nitrite-nitrogen. Klein[13] states that the first stage of nitrification (Organic N $\longrightarrow NH_3$) and the second stage ($NH_3 \longrightarrow NO_2$) can occur simultaneously. Additionally, the reduction of high

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[11]C. E. Cushing, op. cit., pp. 306-313.

[12]J. M. Symons, et al., op. cit., p. 28.

[13]L. Klein, River Pollution II, Causes and Effects, p. 219.

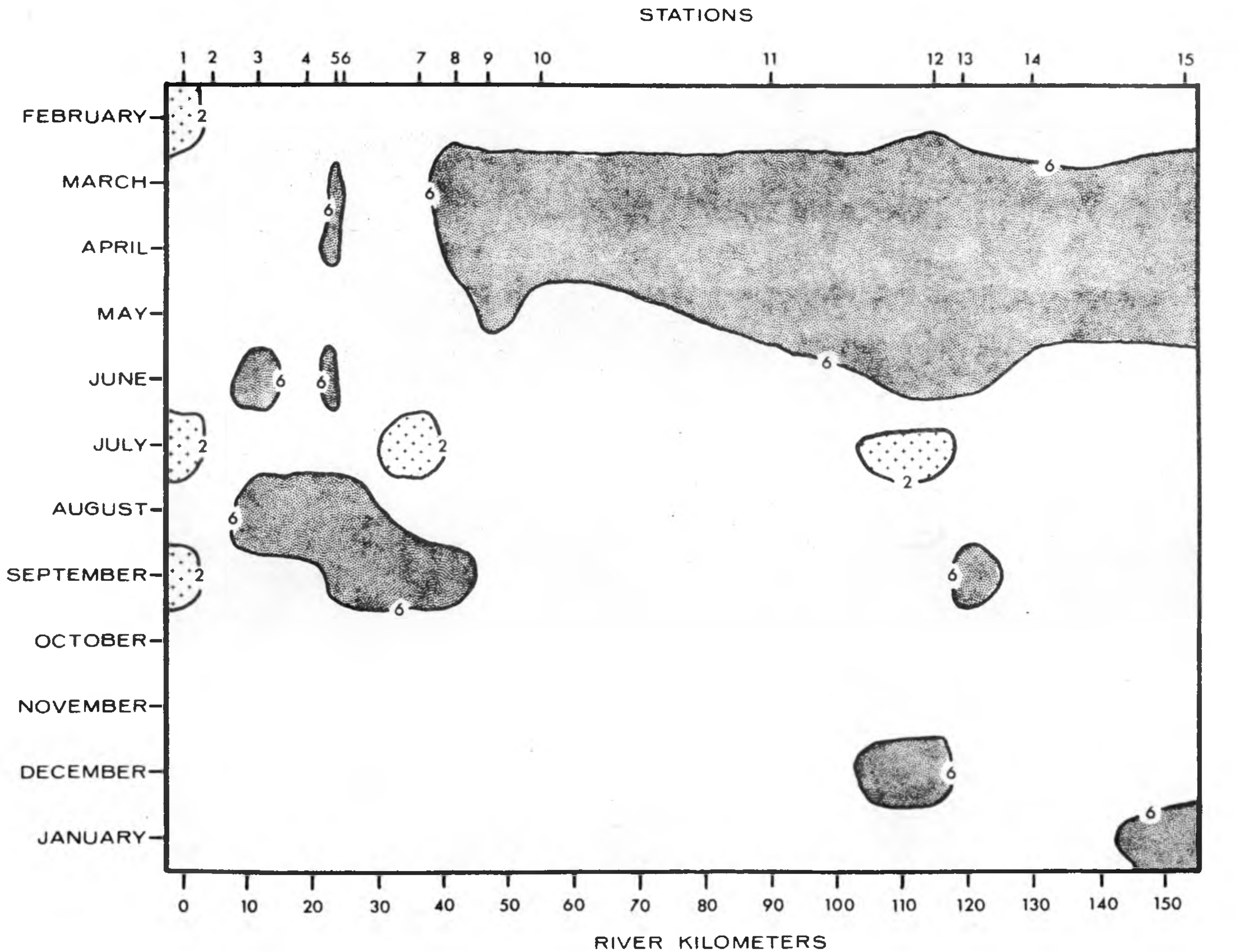

FIGURE 5. SEASONAL VARIATION OF SURFACE TOTAL KJELDAHL NITROGEN IN MG/L x 10^{-1} AT 15 STATIONS IN THE GUADALUPE RIVER

concentrations of any segment of the nitrogen cycle is a manifestation of the increased retention times associated with damming of free-flowing streams.[14,15]

Ammonia-nitrogen - Results of the ammonia-nitrogen analyses are given in Table XVI in the appendix. The majority of samples collected contained less than 0.10 mg/l of ammonia-nitrogen. All stations except Stations 2 and 8 had concentrations of less than 0.05 mg/l of ammonia-nitrogen during the summer months.

Apparently the sewage effluents entering the river above Stations 2 and 8 increased the ammonia-nitrogen concentrations in the river; however, the ammonia-nitrogen was quickly assimilated by autotrophic organisms or nitrified to nitrite-nitrogen. Ammonia-nitrogen is utilized, preferentially to other nitrogen forms, by cells.[16,17] Increased uptake of ammonia-nitrogen by autotrophic organisms during the summer months would account for low concentrations during that period.

Anoxic conditions are necessary for the release of ammonia-nitrogen from bottom deposits.[18] Such conditions were seldom found in the shallow impoundments of the Guadalupe River;

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[14]J. M. Symons, et al., op. cit., p. 28.

[15]P. A. Krenkel, E. L. Thackston, and F. L. Parker, "The Influence of Impoundments on Waste Assimilative Capacity," p. 15.

[16]G. E. Hutchinson, op. cit., p. 851.

[17]R. Gaser and J. S. Jeris, "Comparison of Various Nitrogen Sources in Anaerobic Treatment," pp. 91-100.

[18]G. E. Hutchinson, op. cit., p. 861.

therefore, bottom deposits were not a major source of ammonia-nitrogen.[19]

Phosphorous

Table XV in the appendix contains results of inorganic phosphate-phosphorous, total organic phosphate-phosphorous, and total phosphate-phosphorous analyses. Total phosphate-phosphorous and inorganic phosphate-phosphorous concentrations are compared with phosphorous concentrations found in other natural waters in Table I. As with nitrogen, phosphorous levels in the stretch of the river studied were as high as or higher than other areas reported.

Table V summarizes the ranges of inorganic and total organic phosphate-phosphorous concentrations found at each station during the year of study. There was no accrual of phosphorous forms over the stretch of the river studied. The lack of build-up was probably due to the autotrophic assimilation of phosphorous.

Inorganic phosphate-phosphorous - Fluctuations in the concentration of inorganic phosphate-phosphorous with respect to distance downstream and month are shown in Figure 6. Vertical lines of equal concentration were associated with sewage outfalls above Stations 2 and 8, which indicated their

[19] J. W. Tatum, "Physicochemical Limnology and Chlorophyll a of the New Braunfels-Gonzales, Texas, Stretch of the Guadalupe River," Master's thesis in progress.

TABLE V

RANGE OF INORGANIC PHOSPHATE-PHOSPHOROUS AND TOTAL ORGANIC PHOSPHATE-PHOSPHOROUS CONCENTRATIONS AT 16 STATIONS ON THE GUADALUPE RIVER, TEXAS, FROM FEBRUARY 22, 1969, THROUGH JANUARY 17, 1970

	Inorganic Phosphate-Phosphorous mg/l	Total Organic Phosphate-Phosphorous mg/l
Station 1	0.02-0.09	0.02-0.03
Station 2	0.02-0.13	0.02-0.07
Station 3	0.02-0.09	0.02-0.07
Station 4	0.03-0.09	0.02-0.09
Station 5	0.02-0.09	0.02-0.11
*Station 5-TI	0.02-0.04	0.02-0.05
Station 6	0.02-0.08	0.02-0.07
Station 7	0.02-0.08	0.02-0.09
Station 8	0.02-0.10	0.02-0.14
Station 9	0.03-0.11	0.02-0.11
Station 10	0.04-0.10	0.02-0.11
Station 11	0.02-0.10	0.02-0.11
Station 12	0.03-0.08	0.02-0.13
Station 13	0.02-0.10	0.02-0.12
Station 14	0.02-0.09	0.02-0.09
Station 15	0.02-0.08	0.02-0.10

* Range from June 14, 1969, through January 17, 1970

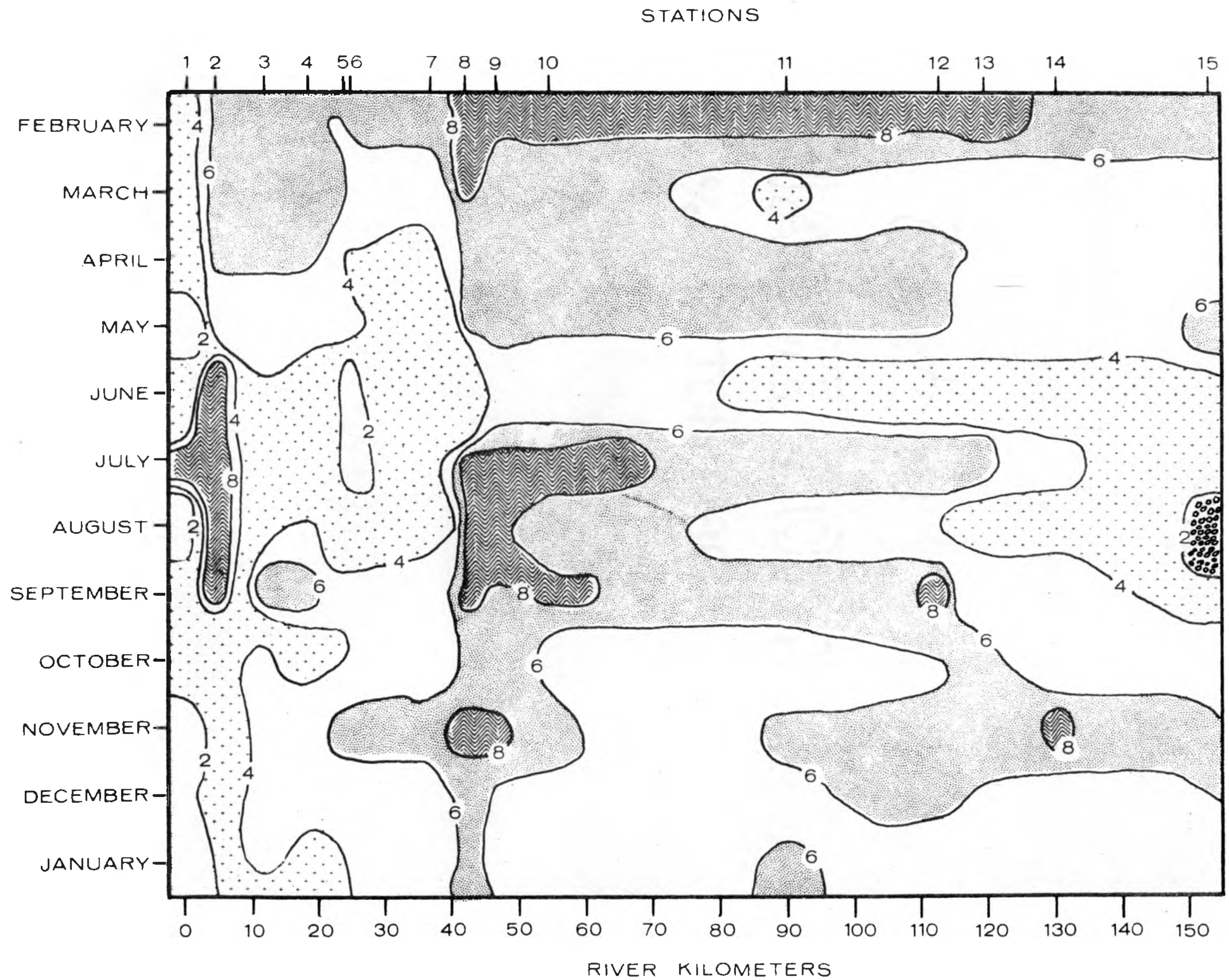

FIGURE 6. SEASONAL VARIATION OF SURFACE INORGANIC PHOSPHATE-PHOSPHOROUS IN MG/L x 10^{-2} AT 15 STATIONS IN THE GUADALUPE RIVER

importance as a source of phosphorous to the river. Klein[20] reports that the phosphate content of sewage has risen appreciably as a result of widespread use of synthetic detergents which always contain phosphorous. Horizontal lines of equal concentration in other parts of the river indicate a seasonal decrease in inorganic phosphate-phosphorous due to increased autotrophic assimilation during the spring and summer months. Exceptions to the spring and summer decrease of inorganic phosphate-phosphorous occur in areas associated with sewage outfalls. Heron[21] has reported a similar cycle in an English lake.

A comparison of the isopleths for nitrate-nitrogen (Figure 2) and inorganic phosphate-phosphorous (Figure 6) shows two major differences. First, higher concentrations of inorganic phosphate-phosphorous were associated with sewage outfalls, while high concentrations of nitrate-nitrogen were not associated with sewage outfalls except during periods of low flow. Second, the seasonal low concentrations of nitrate-nitrogen were distributed evenly over the stretch of the river studied, while low concentrations of inorganic phosphate-phosphorous were not distributed as evenly. Heron[22] has observed similar

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[20]L. Klein, op. cit., p. 85.

[21]J. Heron, "The Seasonal Variation of Phosphate, Silicate, and Nitrate in Waters of the English Lake District," pp. 338-346.

[22]Ibid.

non-seasonal changes in inorganic phosphate-phosphorous concentrations which he attributes to rainfall, release from dead cells of a bloom, and contamination by zooplankton excretia.

On the basis of one sample taken in July, Comal Springs is judged an important source of inorganic phosphate-phosphorous. Concentrations of less than 0.02 mg/l of inorganic phosphate-phosphorous were observed at both Comal and San Marcos Springs.

Regeneration of inorganic phosphate-phosphorous from bottom deposits is of importance in ecosystems where dissolved oxygen is depleted in the hypolimnion.[23] In the stretch of the river studied, dissolved oxygen concentrations were such that it is doubtful that regeneration of inorganic phosphate-phosphorous from bottom deposits is of great importance.[24]

Inorganic phosphate-phosphorous concentrations rarely exceeded 0.02 mg/l at Station 5-TI. Since the standing crop of phytoplankton and macrophytes was as large at Station 5-TI as in any other area of the river, inorganic phosphate-phosphorous was probably not a limiting factor. A high, stable turnover rate of phosphorous might account for the large standing crop of primary producers at Station 5-TI. Cooke[25]

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[23] D. J. O'Conner, "Water Quality Analysis of the Mohawk River-Barge Canal," p. 30.

[24] J. W. Tatum, op. cit.

[25] G. D. Cooke, "The Pattern of Autotrophic Succession in Laboratory Microcosms," pp. 717-722.

has observed a similar phenomenon in his work with microcosms.

Total organic phosphate-phosphorous - Variations in concentrations of total organic phosphate-phosphorous with respect to distance downstream and month are shown in Figure 7. Throughout most of the year, total organic phosphate-phosphorous concentrations remained below 0.02 mg/l at Stations 1, 2, and 3. At all other stations, there was a seasonal variation of total organic phosphate-phosphorous with the highest concentrations observed in February, March, and April. The lowest concentrations were found in October, November, and December. If autotrophic assimilation was responsible for variations in total organic phosphate-phosphorous, an increase in the organic portion would be expected in the spring and summer, with a decrease in the fall due to die-off of plankton and demineralization of living tissue.[26]

A comparison of the isopleths for total organic phosphate-phosphorous (Figure 7) and total Kjeldahl nitrogen (Figure 5) shows some degree of correlation between the highest levels of total organic phosphate-phosphorous and total Kjeldahl nitrogen. Apparently the autotrophic assimilation of nitrogen and phosphorous increased at Stations 8 through 15 in February, March, and April. Chlorophyll a concentrations increased during this same period (Table XII).

There are no vertical lines of equal concentration

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[26]J. Heron, op. cit., pp. 338-346.

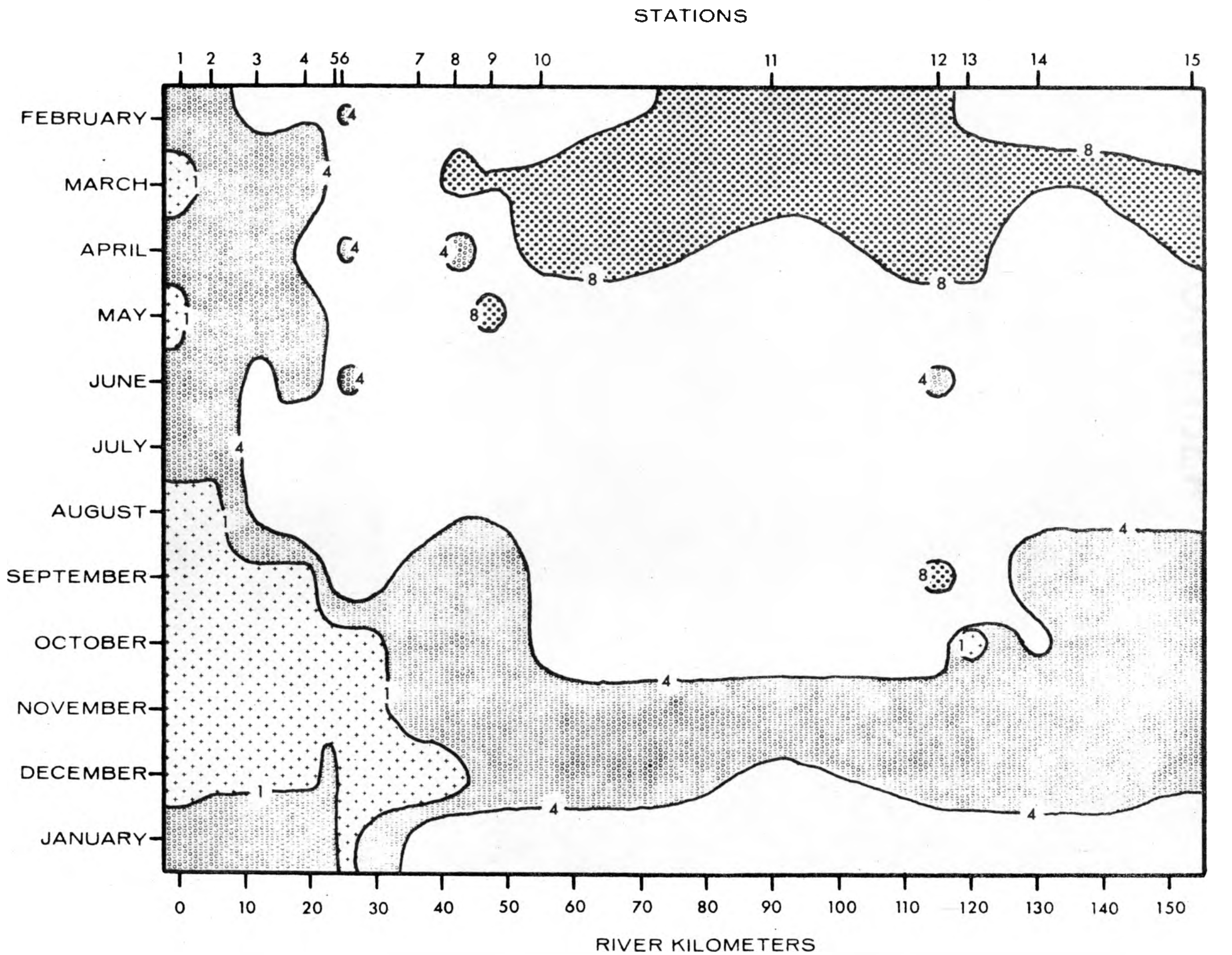

FIGURE 7. SEASONAL VARIATION OF SURFACE TOTAL ORGANIC PHOSPHATE-PHOSPHOROUS IN MG/L x 10^{-2} AT 15 STATIONS IN THE GUADALUPE RIVER

associated with the sewage outfalls above Stations 2 and 8, evidence which indicates their unimportance as a source of total organic phosphate-phosphorous. Because there were significant additions of inorganic phosphate-phosphorous from local sources (Figure 6), the bulk of phosphorous added to the river must be in the inorganic form.

Total organic phosphate-phosphorous concentrations at Station 5-TI were consistently higher than were the inorganic phosphate-phosphorous concentrations. However, both inorganic and total organic phosphate-phosphorous remained at lower concentrations throughout the 7 months that Station 5-TI was sampled than at any other station of the study area.

Diel Fluctuations

Diel fluctuations of nitrogen and phosphorous showed no consistent pattern. Bamforth[27] has demonstrated that in a shallow aquatic habitat with nitrogen and phosphorous levels similar to those found in the Guadalupe River, the inorganic phosphorous concentrations declined during the day while the inorganic nitrogen concentration remained at the same level.

Intermittent releases of water from the hydroelectric dams and low storage ratios of the impoundments studied would tend to obscure any diel rhythm. Even Station 5-TI, which is

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[27] S. S. Bamforth, "Diurnal Changes in Shallow Aquatic Habitats," pp. 348-353.

isolated from the flow of the river, showed no rhythmic diel pattern (Figure 8).

Nitrogen and Phosphorous Budgets

It has been postulated by several workers that by accumulating nitrogen and phosphorous compounds lakes and impoundments act as partial nutrient traps.[28,29,30,31] In a test of this hypothesis, nitrogen and phosphorous budgets were calculated for the three largest impoundments, Lake Dunlap, Lake McQueeney, and Lake Gonzales. The model used was adapted from work by Waldichuk.[32]

Inflow of nitrogen and phosphorous into each impoundment was estimated by the conversion of daily mean concentrations of total nitrogen or total phosphorous to a volume basis. Volumes used were derived from monthly average discharges from upstream reservoirs. Outflow was computed in a similar manner using monthly average discharge data from each reservoir. The difference between inflow and outflow for each month was taken as a measure of the amount of nutrient trapped or released

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[28] C. E. Cushing, op. cit., pp. 306-313.

[29] P. A. Krenkel, et al., op. cit., p. 26.

[30] J. M. Symons, et al., op. cit., pp. 28-36.

[31] W. Stumm and J. J. Morgan, "Stream Pollution by Algal Nutrients," pp. 16-26.

[32] M. Waldichuk, "Eutrophication Studies in a Shallow Inlet on Vancouver Island," p. 761.

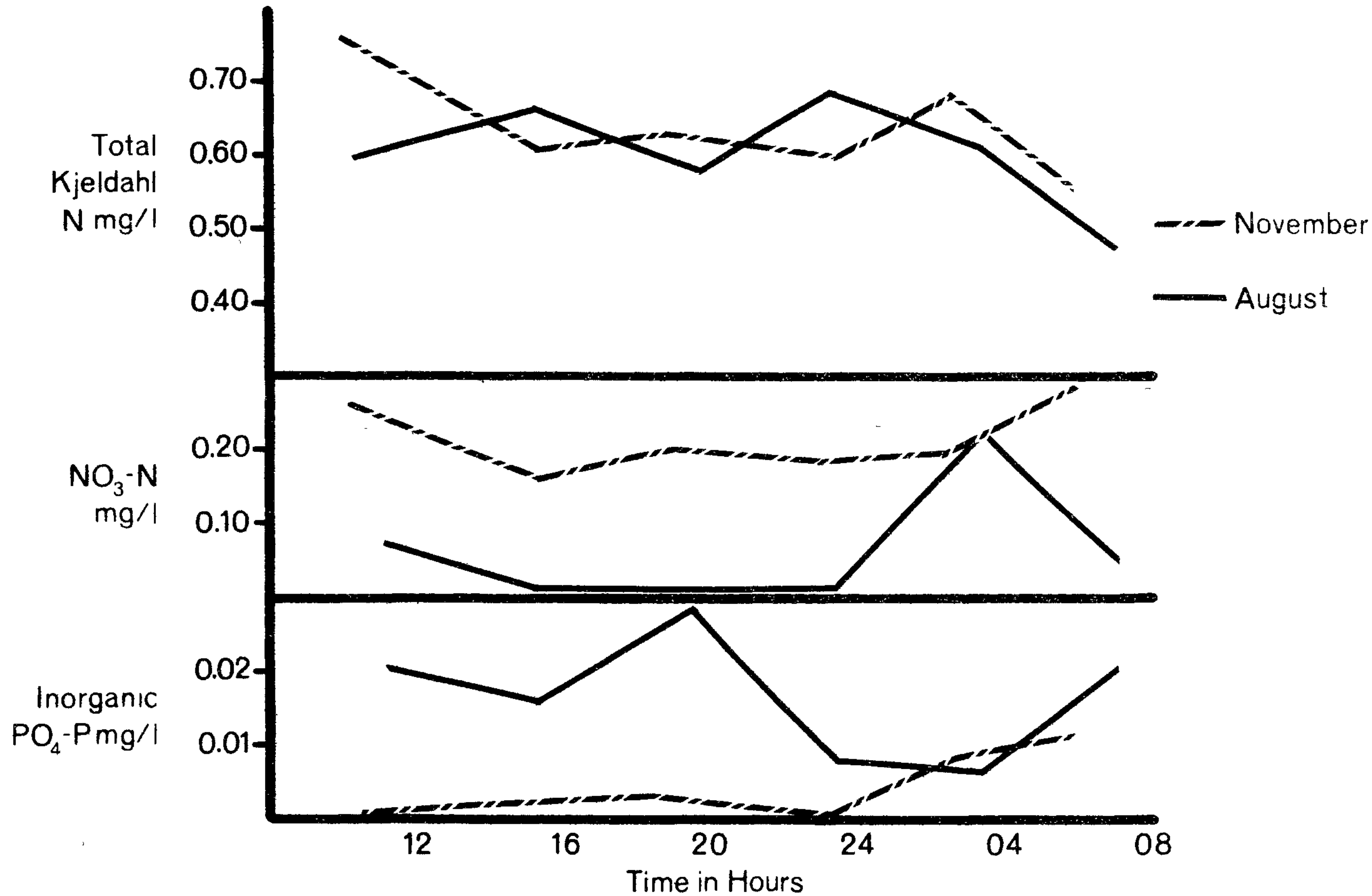

FIGURE 8. DIEL VARIATION OF TOTAL KJELDAHL NITROGEN, NITRATE-NITROGEN, AND INORGANIC PHOSPHATE-PHOSPHOROUS AT STATION 5-TI ON AUGUST 2, 1969 AND NOVEMBER 15, 1969

during that month. Negative values indicate that nutrients were trapped by the impoundment, and positive values indicate that nutrients were lost from the system. The algebraic sum of the monthly budgets is an estimate of the yearly budget of the impoundment.

In addition, the dissolved and suspended nitrogen and phosphorous in the impoundment were estimated by the conversion of the observed mean concentrations of nitrogen and phosphorous to a volume basis. The change from month to month in amounts of dissolved and suspended nitrogen and phosphorous was then calculated. Negative values indicate the quantity of nutrients lost from the dissolved and suspended component of the total nitrogen and phosphorous in the impoundment. Positive values indicate the quantity added to the dissolved and suspended component.

Several assumptions were made to calculate the budget: (1) the daily mean concentrations of nitrogen and phosphorous were representative of the monthly average values, (2) local additions of nutrients to the impoundments did not cause erroneous budgets, and (3) all losses of nitrogen and phosphorous from the impoundments occurred through discharge from the dam and were in a form that could be analyzed.

Nitrogen budgets - Nitrogen budgets for Lake Dunlap, Lake McQueeney, and Lake Gonzales are presented in Tables VI, VII, and VIII, respectively. In Lake Dunlap the monthly nitrogen

TABLE VI

LAKE DUNLAP NITROGEN BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	61,460	59,192	+2,268	10,220	
					+226
March	68,076	68,324	-248	10,446	
					+854
April	74,130	78,030	-3,900	11,300	
					-1,357
May	95,821	96,689	-868	9,943	
					-1,964
June	94,650	62,970	+31,680	7,979	
					-431
July	52,762	36,549	+16,213	7,548	
					-781
August	42,563	26,152	+16,411	6,767	
					+2,840
September	46,860	40,260	+6,600	9,607	
					-3,110
October	74,958	67,580	+7,378	6,497	
					+2,686
November	73,800	78,870	-5,070	9,183	
					+2,161
December	82,708	99,231	-16,523	11,344	
					-1,577
January	114,111	114,886	-775	9,767	
			= +53,166		

[a] All values expressed in kilograms of nitrogen.

[b] Includes only dissolved and suspended nitrogen.

TABLE VII

LAKE MCQUEENY NITROGEN BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	65,240	70,812	-5,572	10,217	
					-683
March	66,681	74,617	-7,936	9,534	
					+781
April	83,370	85,230	-1,860	10,315	
					-2,159
May	102,021	94,922	+7,099	8,156	
					-1,956
June	75,750	57,870	+17,880	6,191	
					-1,018
July	40,145	29,968	+10,177	5,173	
					+848
August	33,170	27,838	+5,332	6,021	
					+2,287
September	41,370	41,670	-300	8,308	
					-2,812
October	75,950	68,417	+7,433	5,496	
					+4,850
November	77,760	106,350	-28,590	10,346	
					-2,989
December	95,976	77,004	+18,972	7,357	
					-1,195
January	113,863	120,404	-6,541	8,552	
			= +16,094		

[a] All values expressed in kilograms of nitrogen.

[b] Includes only dissolved and suspended nitrogen.

TABLE VIII

LAKE GONZALES NITROGEN BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	79,016	82,544	-3,528	16,201	
March	105,803	77,996	+27,807	13,562	-2,639
April	100,950	103,530	-2,580	17,048	+3,486
May	141,701	137,578	+4,123	16,085	-863
June	91,410	86,280	+13,130	12,433	-3,652
July	39,804	45,136	-5,332	10,599	-1,834
August	33,294	30,473	+2,821	8,964	-1,635
September	47,970	48,720	-750	13,214	+4,250
October	81,561	87,048	-5,487	9,512	-3,702
November	71,340	74,100	-2,760	9,811	+299
December	113,553	102,703	+10,850	13,346	+3,652
January	132,153	122,450	+9,703	11,836	-1,510
			= +47,997		

[a] All values expressed in kilograms of nitrogen.

[b] Includes only dissolved and suspended nitrogen.

budget was positive in February and in June through October (Figure 9). Apparently the retention of nitrogen in an impoundment is a function of the increase in autotrophic assimilation during the spring and summer seasons. The months with highest positive values also coincide with low discharges from Canyon Reservoir, evidence that assimilation was greater in periods of low flow. Sedimentation of nitrogen may also increase during periods of low flow.

Figure 10 shows the relationship between flow and import of nitrogen. Months with high average flow were correlated with increased import of nitrogen. The large amount of nitrogen imported during periods of high flow occurred during a time when conditions for assimilation were least favorable. Grzenda, et al.,[33] have observed a similar phenomenon in Michigan streams.

The yearly budget for Lake Dunlap was +53,000 kg of nitrogen. Apparently this impoundment acts as a trap for nitrogen throughout the year. Nitrogen was probably being trapped in sediments and macrophytes.

The change in dissolved and suspended nitrogen is similar to the nitrogen budget for Lake Dunlap. Negative values, which indicate a loss from the dissolved and suspended component of total nitrogen in the impoundment, are found in the spring and summer months.

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[33] A. R. Grzenda, et al., "Primary Production, Energetics and Nutrient Utilization in a Warm Water Stream," p. 41.

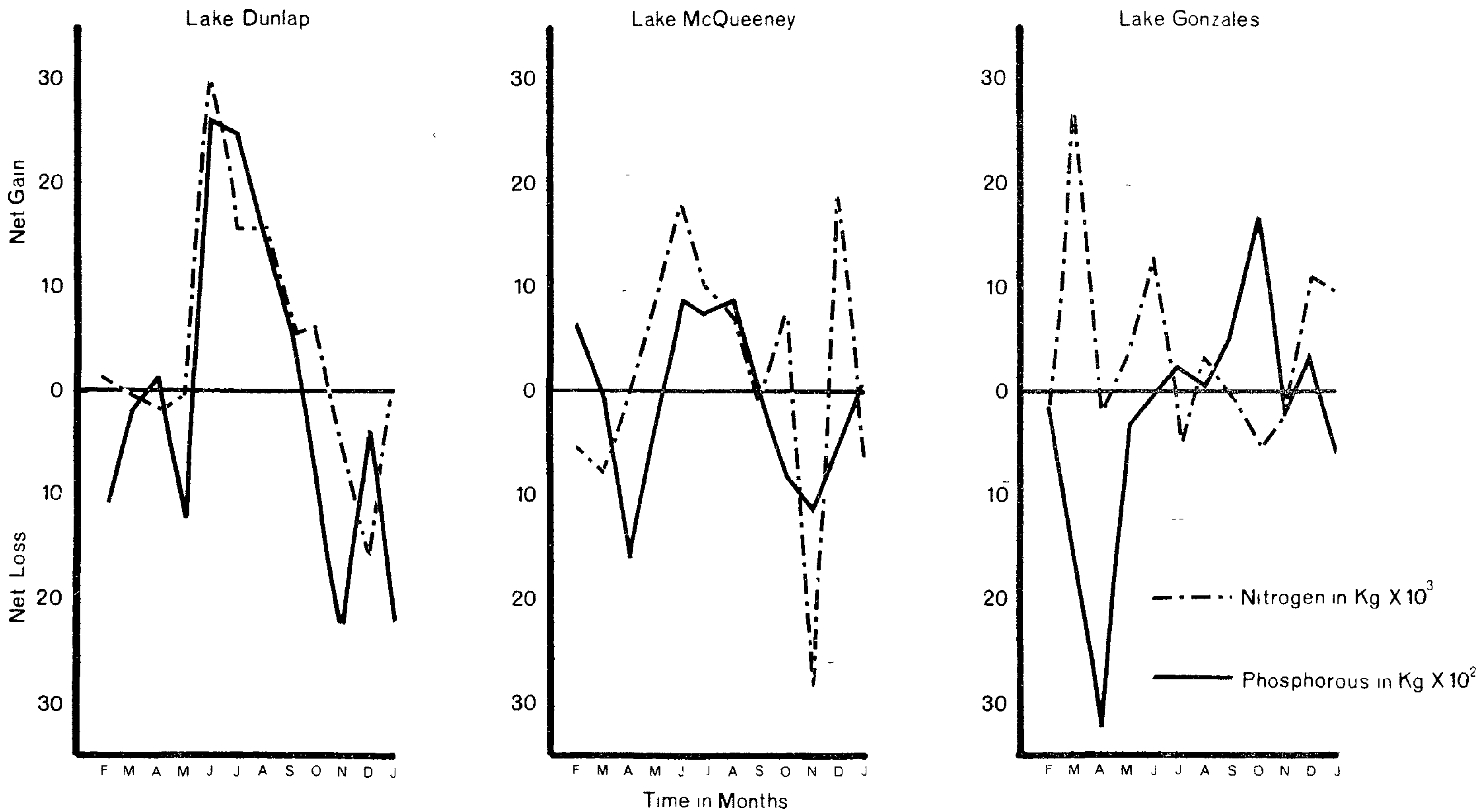

FIGURE 9. MONTHLY NITROGEN AND PHOSPHOROUS BUDGETS IN KILOGRAMS FOR THREE IMPOUNDMENTS ON THE GUADALUPE RIVER

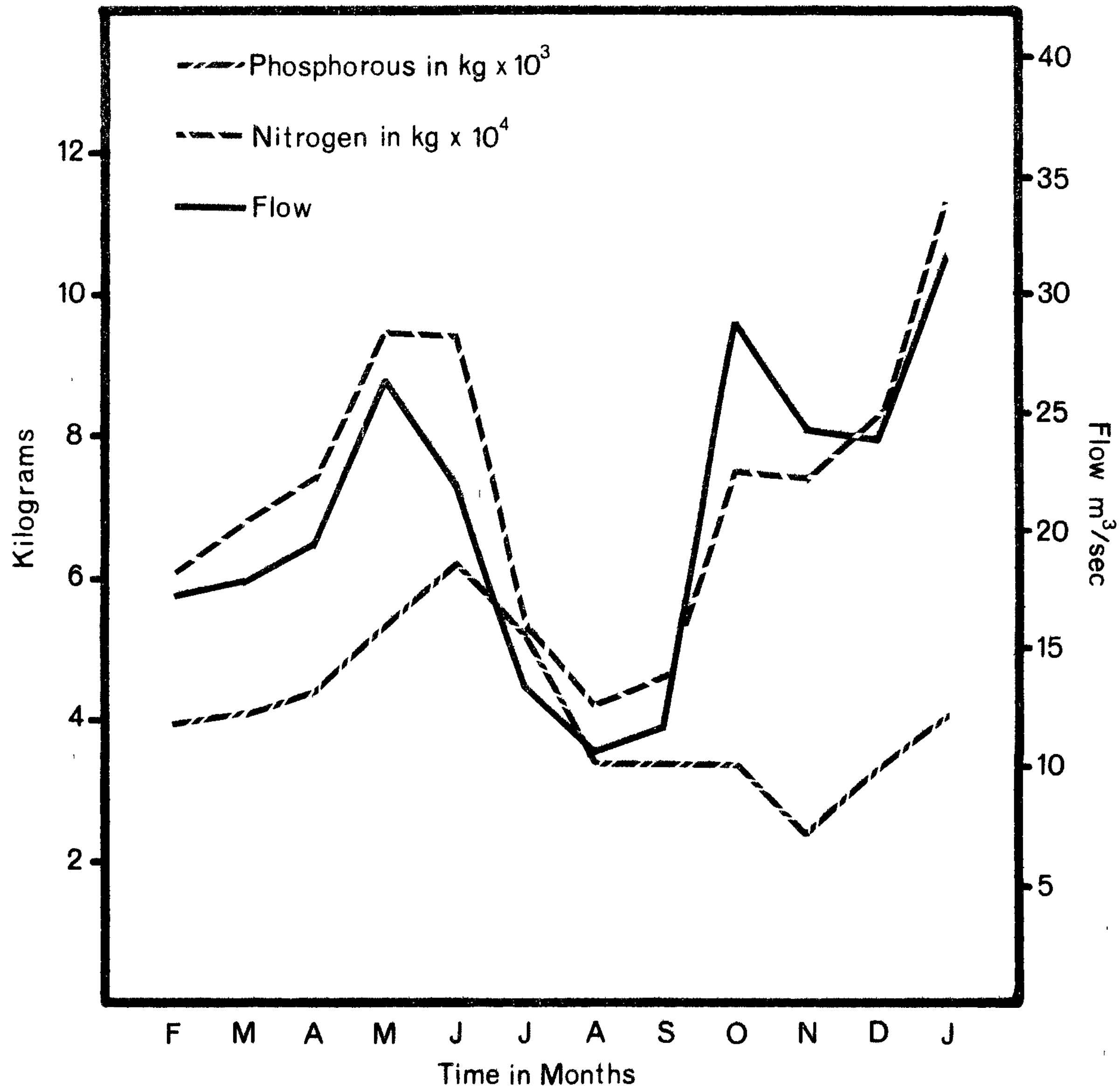

FIGURE 10. COMPARISON OF MONTHLY IMPORT OF NITROGEN AND PHOSPHOROUS COMPOUNDS AND RIVER FLOW INTO LAKE DUNLAP

The nitrogen budget for Lake McQueeney shows the same pattern of retention of nitrogen during the spring and summer months (Figure 9). There was also a net gain of nitrogen to the system, although not as large (16,000 kg) as in Lake Dunlap. A large degree of correlation between the nitrogen import and river discharge is shown in Figure 11. The change in amount of nitrogen in the dissolved and suspended component of the total nitrogen in the lake was erratic and shows no consistent seasonal pattern.

The monthly nitrogen budget for Lake Gonzales (Figure 9) does not indicate seasonal retention of nitrogen as does the budget for Lake Dunlap or for Lake McQueeney. The sum of the monthly budgets shows a net gain of 47,997 kg of nitrogen to the impoundment. The non-seasonal pattern of the monthly budget and the large amount of nitrogen trapped indicate that sedimentation rather than autotrophic assimilation was responsible for retention of nitrogen. Greater turbidity observed in Lake Gonzales, as compared to Lake Dunlap or Lake McQueeney, would explain an increase in sorption and sedimentation of nitrogen.[34] The monthly change in dissolved and suspended nitrogen in Lake Gonzales was also nonseasonal.

The relationship between high flow and increased import of nitrogen is similar to that shown in Lake Dunlap and Lake McQueeney (Figure 12).

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[34]D. Parsons, "A Limnological Study of the New Braunfels-Gonzales Stretch of the Guadalupe River," pp. 35-40.

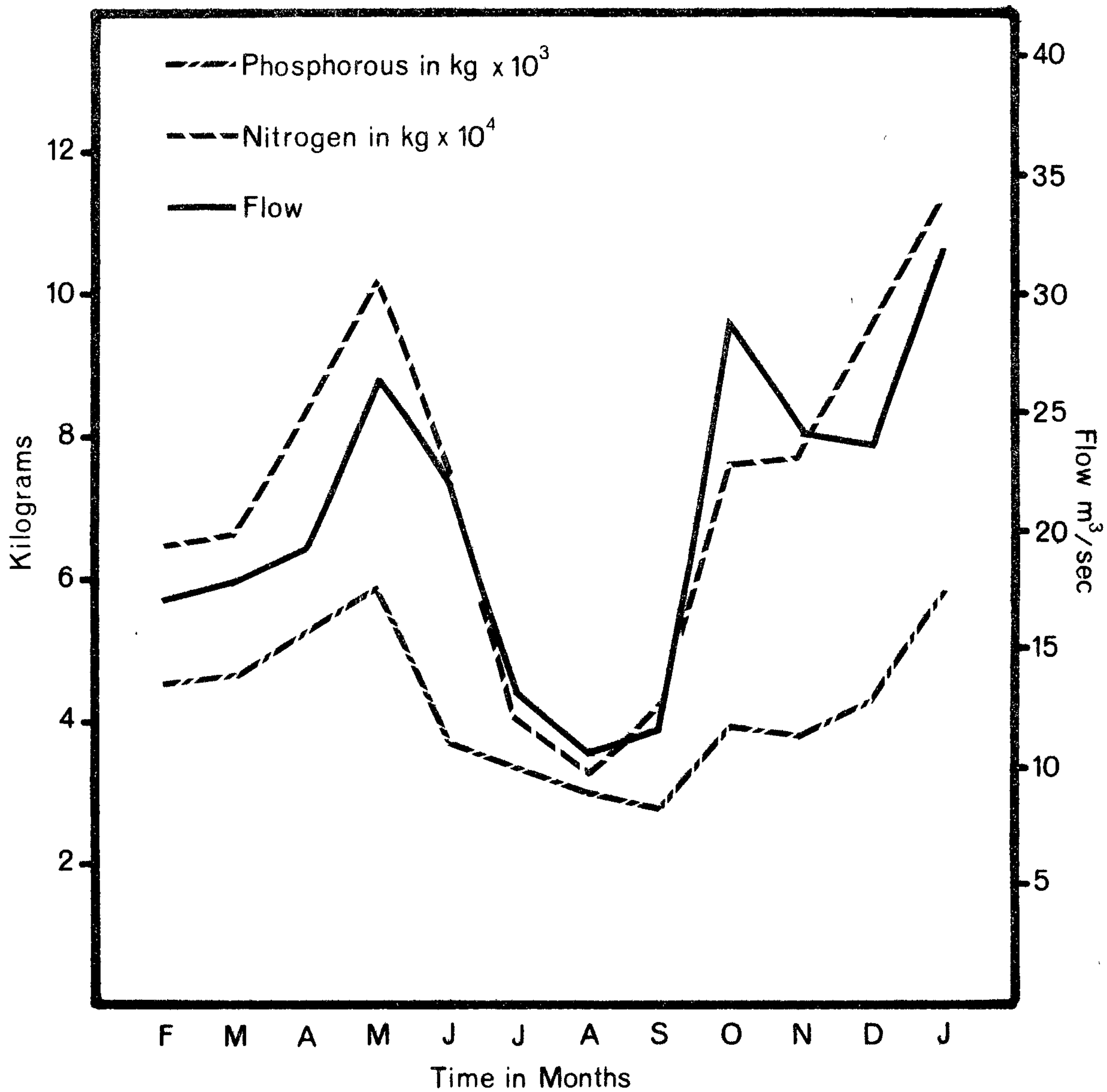

FIGURE 11. COMPARISON OF MONTHLY IMPORT OF NITROGEN AND PHOSPHOROUS COMPOUNDS AND RIVER FLOW INTO LAKE MCQUEENEY

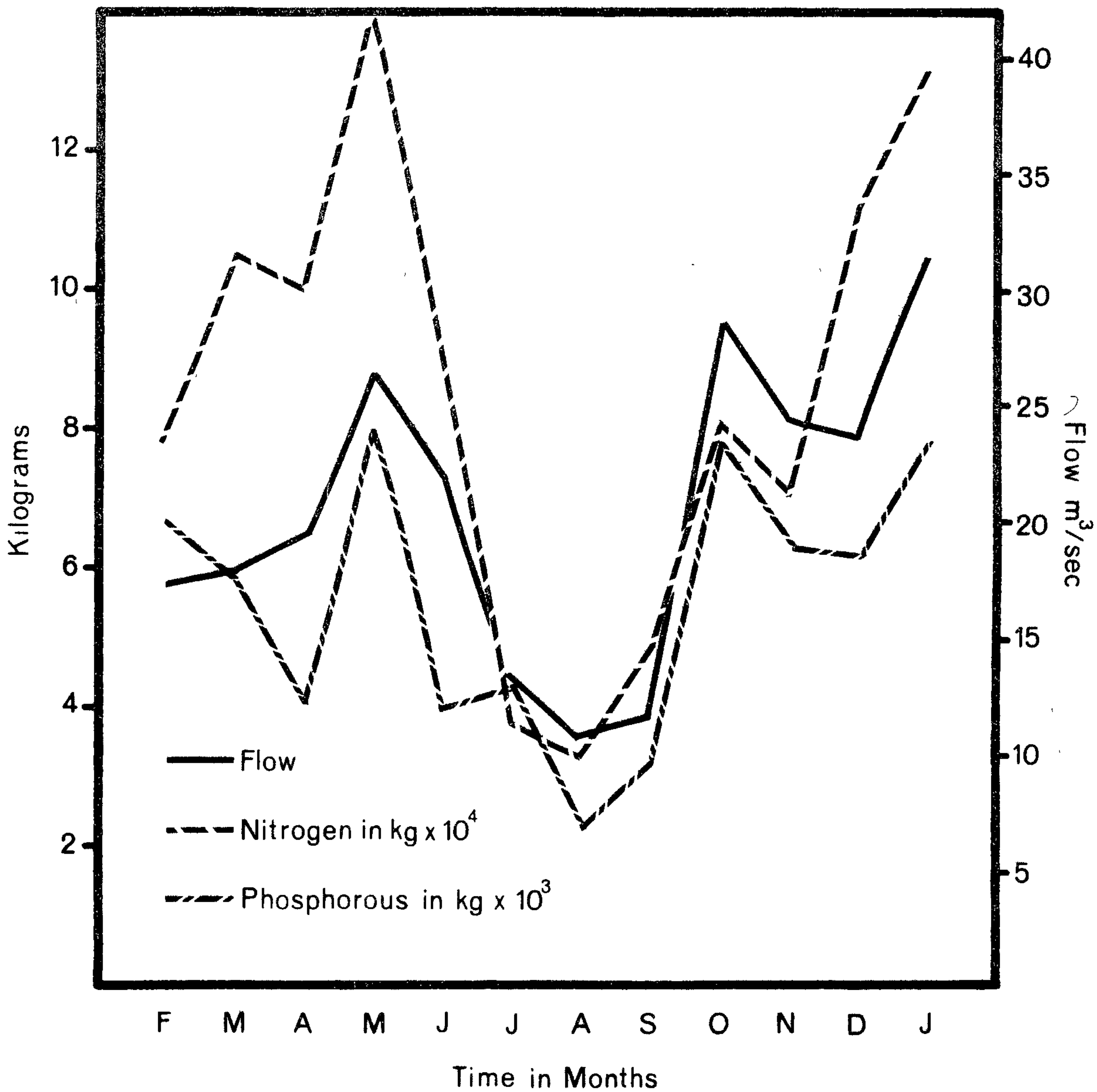

FIGURE 12. COMPARISON OF MONTHLY IMPORT OF NITROGEN AND PHOSPHOROUS COMPOUNDS AND RIVER FLOW INTO LAKE GONZALES

Phosphorous budgets - Phosphorous budgets for Lake Dunlap, Lake McQueeney, and Lake Gonzales are presented in Tables IX, X, and XI, respectively. Figure 9 shows the amount of phosphorous gained or lost from each of the impoundments with respect to month.

The Lake Dunlap phosphorous budget has a pattern similar to the nitrogen budget. Maximum retention of phosphorous occurred during the summer months. Apparently autotrophic assimilation and sedimentation were maximum during the summer months.

As with nitrogen, the largest import of phosphorous occurred during periods of high discharge (Figure 11). Deviation from the expected relationship in November, December, and January may be attributed to increased discharge during those periods from Canyon Reservoir, rather than from local rain which occurred during March. Canyon Reservoir tail race had total phosphate-phosphorous concentrations of less than 0.02 mg/l both before and after overturn. Therefore, local rainfall in the study area could be expected to add more phosphorous to the system than increased discharge from Canyon Reservoir.

Unlike nitrogen, there was a net loss of 1,525 kg of phosphorous from Lake Dunlap during the period studied. Loss of phosphorous from Lake Dunlap may have resulted from a combination of two factors. First, the requirements for phosphorous

TABLE IX

LAKE DUNLAP PHOSPHOROUS BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	3,690	5,032	-1,072	870	
					-190
March	4,104	4,296	-192	680	
					-80
April	4,386	4,272	+114	600	
					+70
May	5,323	6,532	-1,209	670	
					-200
June	6,279	3,687	+2,592	470	
					+110
July	5,267	2,792	+2,475	580	
					-50
August	3,497	2,058	+1,439	530	
					+80
September	3,366	2,724	+642	650	
					-240
October	3,432	4,346	-914	410	
					-140
November	2,445	4,764	-2,229	550	
					-130
December	3,255	3,639	-384	420	
					+120
January	3,960	6,105	-2,145	540	
			= -1,525		

[a] All values expressed in kilograms of phosphorous.

[b] Includes only dissolved and suspended phosphorous.

TABLE X

LAKE MCQUEENEY PHOSPHOROUS BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	4,609	3,973	+636	811	
					-49
March	4,678	4,727	-49	762	
					+13
April	5,292	3,729	-1,563	775	
					-226
May	5,893	6,389	-496	549	
					-98
June	3,801	2,937	+864	451	
					-36
July	3,323	2,545	+778	415	
					+116
August	3,047	2,173	+874	513	
					+79
September	2,814	2,907	-93	610	
					-250
October	3,949	4,783	-834	360	
					+128
November	3,888	5,016	-1,128	488	
					-85
December	4,278	4,789	-511	403	
					+128
January	5,754	5,667	+87	531	
			= -1,435		

[a] All values expressed in kilograms of phosphorous.

[b] Includes only dissolved and suspended phosphorous.

TABLE XI

LAKE GONZALES PHOSPHOROUS BUDGET

	Inflow[a]	Outflow	Net Loss or Gain	Contents[b] of Lake	Change in Lake Contents[b]
February	6,681	3,973	-123	1,336	
					-58
March	5,825	7,353	-1,538	1,278	
					-91
April	3,981	7,206	-3,225	1,187	
					-208
May	8,023	8,376	-353	979	
					-406
June	3,975	3,975	0	573	
					+390
July	4,312	4,098	+214	963	
					-307
August	2,229	2,229	0	656	
					+33
September	3,120	2,540	+580	689	
					0
October	7,973	6,302	+1,671	689	
					+182
November	6,399	6,582	-183	871	
					-107
December	6,194	5,874	+320	764	
					+24
January	7,558	8,156	-598	788	
			= -3,225		

[a] All values expressed in kilograms of phosphorous.

[b] Includes only dissolved and suspended phosphorous.

by the biota of the impoundment may have been only very small by comparison with the requirements for nitrogen. During the year of study, the ratio of nitrogen to phosphorous inflow varied from 10:1 to 30:1, with a mean of 19:1. Gerloff, Fitzgerald, and Skoog[35,36,37] have reported that nitrogen-phosphorous ratios of 75:1, 60:1, and 30:1 are required to maintain maximum growth of different species of planktonic algae. In waters which contain less than this ratio of nitrogen to phosphorous, nitrogen was considered to be a limiting factor. The second factor, addition of phosphorous from allocthonous sources around the lake, might then have masked any small retention of phosphorous by the lake throughout the year. The net loss of 1,525 kg of phosphorous may be an estimate of the amount of phosphorous introduced to the lake from local sources.

The Lake McQueeney phosphorous budget was similar to the phosphorous budget for Lake Dunlap (Figure 9). A major portion of retention of phosphorous occurred during the spring and summer months. The amount of phosphorous import varied directly with the flow (Figure 11). There was a net loss of 1,435 kg of phosphorous from Lake McQueeney during the year of study. The

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[35]G. C. Gerloff, G. P. Fitzgerald, and F. Skoog, "The Mineral Nutrition of _Microcystus aeruginosa_," pp. 26-32.

[36]G. C. Gerloff and F. Skoog, "Nitrogen as a Limiting Factor for the Growth of _Microcystus aeruginosa_ in the Southern Wisconsin Lakes," pp. 556-561.

[37]G. C. Gerloff, G. P. Fitzgerald, and F. Skoog, "The Mineral Nutrition of _Coccochloris peniosystis_," pp. 835-840.

nitrogen-phosphorous ratio for water flowing into Lake McQueeney varied from 11:1 to 22:1, with a mean of 17:1. Apparently phosphorous was abundant and therefore not trapped over the year as was nitrogen. The negative value for the yearly phosphorous budget could be attributed to entrance of phosphorous into the impoundment from sources other than upstream.

The monthly phosphorous budget for Lake Gonzales showed more seasonal uptake than did the nitrogen budget (Figure 9). Nitrogen-phosphorous ratios of inflow varied from 9:1 to 25:1, with a yearly mean of 16:1. There was a yearly loss of 3,225 kg of phosphorous from Lake Gonzales. In the months of July through October, less phosphorous was released from the lake than flowed into the lake from the river. The relationship between flow and import of phosphorous also holds for Lake Gonzales (Figure 12).

Effect of Nitrogen and Phosphorous on Primary Productivity

The primary productivity of most lentic systems depends largely on the kind and numbers of phytoplankton present. Chlorophyll a was used in this study as a measure of the quantity of phytoplankton present. Goldman and Carter[38] report that, although chlorophyll a and carbon fixation are poorly

[38] C. R. Goldman and R. C. Carter, "An Investigation by Rapid Carbon-14 Bioassay of Factors Affecting Cultural Eutrophication of Lake Tahoe, California-Nevada," pp. 887-1066.

correlated, chlorophyll a does give a relative index of the abundance of organisms. Chlorophyll a analyses were made in conjunction with the present study by Tatum[39] and Parsons.[40] A summary of their analyses is given in Table XII.

The correlation between chlorophyll a concentrations and the amount of nitrogen and phosphorous present was determined by the use of correlation coefficients (r). Correlation coefficients were not determined for stations which represented lotic ecosystems since flow was probably the limiting factor in such situations and any correlation found would probably have been spurious.

Nitrogen - Correlation coefficients for nitrate-nitrogen versus chlorophyll a and total Kjeldahl nitrogen versus chlorophyll a are given in Table XIII.

The only correlation coefficient for nitrate-nitrogen and chlorophyll a significantly different from zero was at Station 3. A negative value of r indicates that greater quantities of chlorophyll a, and thus greater numbers of phytoplankton in the water, caused a direct reduction in the amount of nitrate-nitrogen in the water. The correlation coefficient for nitrate-nitrogen and chlorophyll a at Station 3 was -0.40, which is only significant at the 0.01 alpha level. The lack of significance at the other five stations tested was probably due to

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[39]J. Tatum, op. cit.

[40]D. Parsons, op. cit., p. 45.

TABLE XII

DAILY MEAN[a] CHLOROPHYLL A CONCENTRATIONS IN MILLIGRAMS PER LITER AT STATIONS 1 THROUGH 9 ON THE GUADALUPE RIVER FROM FEBRUARY 22, 1969, THROUGH JANUARY 17, 1970[b]

	Stations									
	1	2	3	4	5	5TI	6	7	8	9
February 22	0.01	0.01	0.01	0.02	0.02	-	0.02	0.02	0.01	0.01
March 29	0.02	0.01	0.02	0.01	0.07	-	0.03	0.04	0.11	0.07
April 19	0.02	0.02	0.02	0.03	0.09	-	0.04	0.05	0.07	0.04
May 10	0.01	0.02	0.01	0.01	0.04	-	0.03	0.02	0.01	0.02
June 14	0.02	0.02	0.02	0.03	0.07	0.03	0.04	0.03	0.03	0.03
July 12	0.01	0.02	0.07	0.04	0.07	0.05	0.06	0.02	0.02	0.02
August 2	0.01	0.01	0.06	0.03	0.06	0.06	0.03	0.02	0.03	0.03
September 20	0.02	0.01	0.04	0.05	0.10	0.07	0.06	0.03	0.03	0.04
October 18	0.03	0.03	0.02	0.03	0.03	0.05	0.03	0.02	0.02	0.03
November 8	0.03	0.03	0.02	0.02	0.02	0.07	0.03	0.03	0.03	0.02
December 13	0.02	0.02	0.02	0.02	0.03	0.14	0.02	0.02	0.02	0.03
January 17	0.02	0.02	0.03	0.02	0.02	0.06	0.02	0.03	0.03	0.02

[a] Mean of two samples
[b] From Jack Tatum, Unpublished Masters Thesis

TABLE XII (CONT.)

DAILY MEAN[a] CHLOROPHYLL A CONCENTRATIONS IN MILLIGRAMS PER LITER AT STATIONS 10 THROUGH 15 ON THE GUADALUPE RIVER FROM FEBRUARY 22, 1969, THROUGH JANUARY 17, 1970[b]

	Stations					
	10	11	12	13	14	15
March 1	0.03	0.03	0.03	0.03	0.03	0.03
March 29	0.11	0.11	0.15	0.07	0.05	0.05
April 19	0.04	0.04	0.05	0.06	0.04	0.03
May 17	0.03	0.03	0.04	0.03	0.01	0.03
June 14	0.03	0.03	0.03	0.03	0.02	0.02
July 12	0.03	0.02	0.02	0.02	0.02	0.03
August 8	0.02	0.03	0.02	0.03	0.02	0.03
September 20	0.03	0.03	0.03	0.03	0.04	0.03
October 18	0.03	0.03	0.03	0.03	0.03	0.02
November 15	0.01	0.02	0.01	0.01	0.01	0.02
December 13	0.03	0.03	0.02	0.02	0.03	0.03
January 17	0.02	0.02	0.03	0.02	0.03	0.03

[a] Mean of two samples
[b] From Jack Tatum, Unpublished Masters Thesis

TABLE XIII

CORRELATION COEFFICIENTS WITH 95 PER CENT CONFIDENCE INTERVALS FOR CHLOROPHYLL *A* VERSUS NITRATE-*N* AND TOTAL KJELDAHL-N AT SEVEN STATIONS ON THE GUADALUPE RIVER BETWEEN FEBRUARY 22, 1969, AND JANUARY 17, 1970

	r[a] for Nitrate-N vs Chl *a*	95 per cent Confidence Intervals for ρ[b]		r for Total Kjeldahl-N vs Chl *a*	95 per cent Confidence Interval for ρ	
		L.L.[c]	U.L.[d]		L.L.	U.L.
Station 3	-0.60	-0.26	-0.80	0.40*	0.00	0.68
Station 4	-0.29*	-0.61	+0.12	0.32*	-0.10	0.62
Station 5	-.040*	-0.68	-0.02	0.85	0.65	0.95
Station 5-TI	0.20*	-0.35	+0.60	0.21*	-0.20	0.55
Station 8	0.05*	-0.35	+0.43	0.79	0.57	0.88
Station 13	0.28*	-0.12	+0.55	0.62	0.28	0.80
Station 15	0.12*	-0.30	+0.58	0.50	0.13	0.73

[a] Estimate of correlation coefficient.
[b] Correlation coefficient.
[c] Lower limit.
[d] Upper limit.
* Not significantly different from zero at the 0.05 level.

other factors such as flow and turbidity which obscure the relationship between uptake of nitrates and an increase in phytoplankton.

There was a significant positive correlation between chlorophyll a and total Kjeldahl nitrogen at Stations 5, 8, 13, and 15. The relationship between chlorophyll a and total Kjeldahl nitrogen was in part due to the digestion of phytoplankton in the total Kjeldahl analysis. However, other workers have reported an increase in both particulate and dissolved Kjeldahl nitrogen associated with an increase in the number of individual diatoms.[41] Wetzel[42] has shown that dissolved organic compounds can function directly as growth substances or indirectly by chelating or complexing micronutrients.

Phosphorous - Correlation coefficients for inorganic phosphate-phosphorous and chlorophyll a and for total phosphate-phosphorous and chlorophyll a are presented in Table XIV.

There are no significant correlations between inorganic phosphate-phosphorous and chlorophyll a. Significant correlations between total phosphate-phosphorous and chlorophyll a were observed at Stations 5, 8, and 13. Again these correlations are at least in part due to digestion of phytoplankton

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[41] J. D. H. Strickland, O. Holm-Hansen, R. W. Eppley, and J. J. Linn, "The Use of a Deep Tank in Plankton Ecology. I. Studies of the Growth and Composition of Phytoplankton Crops at Low Nutrient Levels," pp. 23-24.

[42] R. G. Wetzel, "Dissolved Organic Compounds and Their Utilization in Two Marl Lakes," pp. 298-303.

TABLE XIV

CORRELATION COEFFICIENTS WITH 95 PER CENT CONFIDENCE INTERVALS FOR CHLOROPHYLL A VERSUS INORGANIC PO4-P AND TOTAL PO4-P AT SEVEN STATIONS ON THE GUADALUPE RIVER BETWEEN FEBRUARY 22, 1969, AND JANUARY 17, 1970

	r^a for Inorganic Phosphate-Phosphorous and Chl *a*	95 per cent Confidence Intervals for ρ [b]		r for Total Phosphate-Phosphorous and Chl *a*	95 per cent Confidence Intervals for ρ	
		L.L.[c]	U.L.[d]		L.L.	U.L.
Station 3	-0.39*	-0.68	0.00	-0.09*	-0.09*	0.31
Station 4	-0.04*	-0.42	0.25	-0.16*	-0.52	0.22
Station 5	0.05*	-0.35	0.43	0.58	0.24	0.78
Station 5-TI	-0.22*	-0.55	0.20	-0.04*	-0.54	0.45
Station 8	0.38*	0.00	0.67	0.69	0.42	0.84
Station 13	-0.29*	-0.61	0.12	0.56	0.20	0.76
Station 15	-0.08*	-0.46	0.31	0.18*	-0.22	0.54

[a] Estimate of correlation coefficient.
[b] Correlation coefficient.
[c] Lower limit.
[d] Upper limit
* Not significantly different from zero at the 0.05 level.

in the total phosphate-phosphorous analysis. Because an increased phytoplankton standing crop did not appreciably decrease the dissolved inorganic phosphate-phosphorous, it must be assumed that there was a large surplus of phosphorous in the waters of the impoundments studied.

However, in at least one reservoir, inorganic nitrogen was reduced appreciably by increased standing crops of phytoplankton. Apparently, then, nitrogen was not present in as great a surplus as was phosphorous. Other indications of this condition were the low nitrogen-phosphorous ratios in the lakes and the net yearly retention of nitrogen by the impoundments. It is doubtful that nitrogen was the only factor limiting productivity. The combined effect of nitrogen concentrations, flow, and turbidity probably controls the productivity of the impoundments. If nitrogen is one factor controlling productivity, then large sources of nitrogen, such as Comal Springs, are very important to the productivity of the river.

CHAPTER V

SUMMARY

1. Results of monthly nitrogen and phosphorous analyses at 16 stations on the Guadalupe River from February 22, 1969, through January 17, 1970, indicate eutrophic conditions. During a period of low flow, Stations 1 and 2, immediately below New Braunfels and the New Braunfels sewage treatment plant, showed signs of organic pollution.

2. Comal Springs is the single most important source of nitrate-nitrogen to the stretch of the river studied. Analysis of nitrogen data from 1939 to the present indicates that the nitrate-nitrogen level of Comal Springs has increased markedly over that period. The two sewage outfalls located in the stretch studied were not important sources of nitrogen but were important sources of phosphorous.

3. Seasonal uptake of nitrogen and phosphorous compounds due to autotrophic assimilation occurred at all stations, but nitrogen uptake was of greater magnitude in the reservoirs. The range of nitrate-nitrogen over the year of study was from 0.20 to 1.20 mg/l at Station 3 and 0.20 to 1.40 mg/l at Station 5, while more riverine stations such as Stations 2 and 7 had ranges of 0.40 to 1.30 mg/l and 0.40 to 1.40 mg/l, respectively.

4. There was no significant accrual of nitrogen and phosphorous compounds over the stretch of the river studied. There was some accrual of inorganic phosphate-phosphorous below

sewage outfalls above Stations 2 and 8. Uptake of nitrogen and phosphorous by autotrophic organisms would explain the lack of build-up of nitrogen and phosphorous concentrations with distance downstream.

5. Nitrogen and phosphorous budgets for Lake Dunlap, Lake McQueeney, and Lake Gonzales demonstrate that these reservoirs act as nitrogen and phosphorous traps during the spring and summer months. There was a net yearly gain of nitrogen but not of phosphorous in the three impoundments.

6. Correlation coefficients indicate a negative relationship between nitrate-nitrogen and chlorophyll a and a positive relationship between total Kjeldahl nitrogen and chlorophyll a. There were no significant correlations between inorganic phosphate-phosphorous and chlorophyll a. Positive correlations between total organic phosphate-phosphorous and chlorophyll a were observed.

7. Nitrogen and phosphorous budgets, correlation between nitrogen and chlorophyll a, and low nitrogen-phosphorous ratios indicate that nitrogen is more important than phosphorous in the determination of primary productivity in the stretch of the river studied.

8. Analysis of data collected from Station 5-TI showed no diel pattern of uptake of nitrogen and phosphorous compounds by autotrophic organisms. Factors such as flow and insufficiently sensitive chemical analyses may have obscured diel uptake of nitrogen and phosphorous compounds.

APPENDIX

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

February 22, 1969

		*Nitrogen (mg/l)			*Phosphate-Phosphorous (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
0752	S	1.04	0.003	0.20	0.04	0.01	0.03
1200	S	1.10	0.007	0.23	0.05	0.02	0.03
1552	S	1.01	0.007	0.29	0.07	0.04	0.03
2000	S	1.01	0.006	0.34	0.06	0.04	0.02
2350	S	1.16	0.008	0.26	0.06	0.04	0.02
0345	S	1.21	0.002	0.18	0.04	0.02	0.02
				Station 2			
0845	S	1.07	0.011	0.50	0.08	0.05	0.03
1246	S	1.08	0.006	0.22	0.06	0.03	0.03
1627	S	1.11	0.005	0.27	0.10	0.07	0.03
2028	S	1.31	0.010	0.32	0.11	0.08	0.03
0024	S	1.03	0.012	0.42	0.09	0.07	0.02
0420	S	1.13	0.006	0.27	0.08	0.07	0.01
				Station 3			
0925	S	1.15	0.011	----	0.10	0.06	0.04
	B	1.18	0.013	----	0.13	0.07	0.06
1324	S	1.08	0.009	0.26	0.07	0.04	0.03
	B	1.08	0.011	0.32	0.12	0.05	0.07
1713	S	1.11	0.005	0.23	0.09	0.08	0.01
	B	1.13	0.006	0.39	0.11	0.08	0.03
2105	S	1.15	0.009	0.31	0.10	0.06	0.04
	B	1.10	0.005	0.39	0.19	0.07	0.12
0107	S	1.08	0.010	0.33	0.24	0.08	0.16
	B	1.20	0.004	0.27	0.11	0.08	0.03
0503	S	1.08	0.007	0.28	0.11	0.09	0.03

* Mean of two samples
** By Subtraction
S Surface Sample
B Bottom Sample

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

February 22, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 4			
1011	S	1.27	0.009	----	0.06	----	----
	B	1.20	0.006	0.41	0.06	0.02	0.04
1410	S	1.19	0.006	0.30	0.11	0.05	0.06
	B	1.26	0.006	0.52	0.23	0.05	0.18
1806	S	1.25	0.006	0.29	0.10	0.07	0.03
	B	1.28	0.006	0.49	----	0.03	----
2152	S	1.15	0.005	0.39	0.10	0.06	0.04
	B	1.19	0.005	0.40	0.13	0.07	0.06
0200	S	1.20	0.011	0.34	0.12	0.07	0.05
	B	1.17	0.009	0.39	0.09	0.08	0.01
0556	S	1.13	0.011	0.32	0.12	0.09	0.03
	B	1.18	0.010	0.40	0.09	0.07	0.02
				Station 5			
1035	S	1.11	0.006	0.32	0.12	0.01	0.11
	B	1.05	0.003	----	0.10	0.01	0.09
1425	S	1.27	0.016	0.35	0.09	0.04	0.05
	B	1.20	0.006	0.36	0.12	0.07	0.05
1825	S	1.32	0.011	0.40	0.12	0.08	0.06
	B	1.21	0.008	0.77	0.13	0.08	0.05
2230	S	1.28	0.011	0.50	0.12	0.07	0.05
	B	1.28	0.010	0.44	0.11	0.07	0.04
0230	S	1.39	0.012	0.39	0.12	0.07	0.04
	B	1.43	0.013	0.44	0.12	0.07	0.04
0635	S	1.28	0.013	0.36	0.11	0.07	0.04
	B	1.27	0.013	0.37	0.10	0.08	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

February 22, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 6			
1006	S	1.14	0.004	0.36	0.12	0.07	0.05
1353	S	1.12	0.005	0.36	0.08	0.06	0.02
1758	S	1.37	0.014	0.37	0.10	0.07	0.03
2220	S	1.32	0.012	0.47	0.10	0.07	0.03
0210	S	1.27	0.015	0.38	0.10	0.07	0.03
0610	S	1.44	0.012	0.28	0.11	0.08	0.03
				Station 7			
0930	S	1.54	0.008	0.33	0.15	0.06	0.09
1317	S	1.69	0.008	0.46	0.13	0.07	0.06
1725	S	1.56	0.008	0.45	0.12	0.06	0.06
2120	S	1.40	0.007	0.50	0.13	0.07	0.06
0130	S	1.50	0.009	0.58	0.12	0.06	0.06
0530	S	1.66	0.006	0.27	0.12	0.06	0.06
				Station 8			
0845	S	1.35	0.007	0.49	0.15	0.09	0.06
	B	1.25	0.010	0.36	0.23	0.09	0.14
1235	S	1.41	0.009	0.44	0.11	0.07	0.04
	B	1.40	0.009	0.55	0.21	0.10	0.11
1635	S	1.47	0.008	0.47	0.14	0.09	0.05
	B	1.46	0.009	0.50	0.26	0.09	0.17
2030	S	1.43	0.009	0.53	0.16	0.08	0.08
	B	1.49	0.009	----	0.18	0.08	0.10
0032	S	1.53	0.012	0.53	0.13	0.07	0.06
	B	1.54	0.013	----	----	0.09	----
0345	S	1.53	0.010	0.49	0.18	0.10	0.08
	B	1.47	0.010	0.51	0.15	0.09	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

February 22, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 9			
0800	S	1.30	0.013	0.40	0.16	0.08	0.08
1205	S	1.23	0.008	0.60	0.17	0.09	0.08
1605	S	1.25	0.007	0.46	0.15	0.08	0.07
2005	S	1.27	0.007	0.48	0.16	0.09	0.07
0005	S	1.40	0.012	0.53	0.15	0.08	0.07
0405	S	1.10	0.009	0.76	0.10	0.07	0.03
				Station 10 March 1, 1969			
0830	S	1.41	0.013	0.39	0.14	0.09	0.05
1305	S	1.70	0.014	0.38	0.10	0.09	0.01
1715	S	1.59	0.012	0.40	0.09	0.08	0.01
2058	S	1.28	0.011	----	0.16	0.10	0.06
0052	S	1.23	0.012	----	0.12	0.09	0.03
0445	S	1.53	0.006	0.34	0.16	0.08	0.08
				Station 11			
0930	S	1.27	0.012	0.35	0.17	0.08	0.09
1350	S	1.42	0.010	0.36	0.15	0.08	0.07
1755	S	1.38	0.011	0.30	0.15	0.08	0.07
2140	S	1.42	0.008	----	0.17	0.08	0.09
0140	S	1.32	0.007	----	0.15	0.08	0.07
0530	S	1.80	0.009	0.32	0.17	0.10	0.07

* Mean of two samples
S Surface Sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

March 1, 1969

Time	Sample Depth	*Nitrogen (mg/l) $NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	*Phosphate Phosphorus (mg/l) Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 12			
1100	S	1.61	0.011	0.38	----	0.01	----
1410	S	1.53	0.012	0.40	0.13	0.08	0.05
1815	S	1.49	0.014	0.47	0.13	0.07	0.06
2200	S	1.38	0.011	----	0.16	0.09	0.07
0215	S	1.31	0.009	0.40	0.21	0.08	0.13
0630	S	1.38	0.007	0.38	0.15	0.08	0.07
				Station 13			
1000	S	1.33	0.014	0.49	0.17	0.08	0.09
1330	S	1.50	0.015	0.39	0.13	0.08	0.05
1820	S	1.56	0.013	0.51	0.18	0.10	0.08
1915	S	1.44	0.012	0.44	0.20	0.08	0.12
0140	S	1.58	0.011	0.48	0.15	0.10	0.05
0525	S	1.40	0.010	0.52	0.14	0.08	0.06
				Station 14			
0920	S	1.52	0.013	0.39	0.16	0.07	0.09
1250	S	1.54	0.014	0.33	0.13	0.07	0.06
1700	S	1.68	0.016	0.38	0.12	0.07	0.05
2040	S	1.43	0.015	----	0.14	0.07	0.07
0040	S	1.36	0.012	0.48	0.14	0.08	0.06
0445	S	1.37	0.010	0.45	0.13	0.07	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

March 1, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 15			
0830	S	1.35	0.016	0.50	0.15	0.06	0.09
1205	S	1.41	0.013	0.45	0.13	0.07	0.06
1605	S	1.55	0.015	0.62	0.12	0.07	0.05
2000	S	1.42	0.013	----	0.14	0.07	0.07
2400	S	1.53	0.013	0.51	0.16	0.08	0.08
0345	S	1.34	0.019	0.52	0.10	0.07	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

March 29, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
1200	S	1.03	0.004	0.32	0.04	0.03	0.01
2330	S	1.12	0.006	0.40	0.04	0.03	0.01
				Station 2			
1220	S	1.07	0.006	0.29	0.06	0.04	0.02
0003	S	1.09	0.008	0.38	0.12	0.09	0.03
				Station 3			
1305	S	1.03	0.007	0.37	0.09	0.08	0.01
	B	1.02	0.008	0.61	0.10	0.07	0.03
0045	S	1.09	0.007	0.36	0.10	0.06	0.04
	B	1.11	0.009	0.39	0.10	0.07	0.03
				Station 4			
1358	S	1.04	0.007	0.30	0.10	0.07	0.03
	B	1.11	0.007	0.43	0.12	0.07	0.05
0135	S	1.12	0.008	0.32	0.09	0.06	0.03
	B	1.14	0.007	0.46	0.10	0.07	0.03
				Station 5			
1453	S	0.87	0.007	0.76	0.15	0.09	0.06
	B	0.86	0.008	0.46	0.10	0.06	0.04
0220	S	1.02	0.007	0.46	0.10	0.06	0.04
	B	1.07	0.007	0.45	0.08	0.05	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By substration

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

March 29, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 6			
1543	S	0.94	0.008	0.43	0.10	0.06	0.04
0252	S	1.11	0.007	0.45	0.10	0.06	0.04
				Station 7			
1130	S	1.04	0.009	0.48	0.10	0.05	0.05
2330	S	1.38	0.020	0.46	0.10	0.05	0.05
				Station 8			
1210	S	0.98	0.014	0.08	0.25	0.10	0.15
	B	0.98	0.013	0.60	0.12	0.06	0.06
2400	S	1.18	----	0.55	0.13	0.07	0.07
	B	1.17	0.013	0.52	0.13	0.06	0.07
				Station 9			
1310	S	0.98	0.015	0.72	0.15	0.06	0.09
0100	S	0.05	0.013	0.65	0.15	0.07	0.08
				Station 10			
1350	S	0.97	0.013	0.86	0.13	0.05	0.08
0145	S	1.23	0.012	0.69	0.16	0.06	0.10

* Mean of two samples
S Surface sample
B Bottom sample
** By súbtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

March 29, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 11			
1440	S	0.87	0.011	0.84	0.13	0.03	0.10
0235	S	0.97	0.008	0.88	0.09	0.02	0.07
				Station 12			
1430	S	1.12	0.010	1.14	0.11	0.05	0.06
	B	1.32	0.11	0.59	0.14	0.05	0.09
0215	S	1.01	0.009	----	0.14	0.04	0.10
	B	1.05	0.009	0.53	0.14	0.05	0.09
				Station 13			
1350	S	1.14	0.011	0.64	0.14	0.04	0.10
	B	1.17	0.010	0.45	----	----	----
0935	S	0.86	0.012	0.61	0.17	0.04	0.13
	B	1.13	0.012	0.63	0.14	0.04	0.10
				Station 14			
1250	S	1.15	0.010	0.69	0.12	0.04	0.08
0050	S	1.07	0.011	0.49	0.13	0.05	0.08
				Station 15			
1205	S	1.02	0.013	0.56	0.12	0.05	0.07
	B	1.25	0.012	0.65	0.12	0.04	0.08
2350	S	1.22	0.010	----	0.12	0.04	0.08
	B	1.28	0.010	----	0.14	0.04	0.10

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

April 19, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
1155	S	1.15	0.004	0.29	0.06	0.04	0.02
2330	S	1.15	0.003	0.35	0.04	0.01	0.03
				Station 2			
1210	S	1.14	0.006	0.32	0.09	0.06	0.02
2345	S	1.15	0.006	0.38	0.09	0.07	0.02
				Station 3			
1312	S	1.13	0.006	0.39	0.09	----	----
	B	1.05	0.007	0.43	0.10	0.08	0.02
0050	S	1.20	0.007	0.36	0.08	0.06	0.02
	B	1.15	0.008	0.54	0.12	0.06	0.06
				Station 4			
1400	S	1.19	0.009	0.42	0.11	0.06	0.05
	B	1.17	0.007	0.39	0.10	0.07	0.03
0145	S	1.20	0.007	0.48	0.11	0.07	0.04
	B	1.13	0.007	0.40	0.08	0.07	0.01
				Station 5			
1500	S	0.85	0.009	0.94	0.13	0.04	0.09
	B	1.73	0.009	0.54	0.10	0.03	0.07
0230	S	1.01	0.006	0.57	0.12	0.04	0.08
	B	1.10	0.006	0.44	0.10	0.05	0.05

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

April 19, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	Organic $PO_4 \cdot P$
				Station 6			
1540	S	0.95	0.009	0.47	0.07	0.04	0.03
0305	S	1.02	0.007	0.53	0.08	0.04	0.04
				Station 7			
1130	S	1.31	0.011	0.54	0.08	0.04	0.04
2330	S	1.52	0.008	0.46	0.09	0.04	0.05
				Station 8			
1200	S	1.28	0.017	0.86	0.09	0.08	0.01
	B	1.32	0.019	0.63	0.12	0.08	0.04
2345	S	1.24	0.013	0.56	0.09	0.05	0.04
	B	1.28	0.015	0.055	0.09	0.06	0.03
				Station 9			
1300	S	1.19	0.015	0.59	0.16	0.05	0.11
0030	S	1.22	0.005	0.60	0.10	0.09	0.01
				Station 10			
1330	S	1.24	0.014	0.55	0.16	0.06	0.10
0110	S	1.34	0.015	0.60	0.18	0.07	0.11

* Mean of two samples
S Surface sample
B Bottom sample
**By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

April 19, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 11			
1425	S	1.16	0.011	0.57	0.16	0.06	0.10
0200	S	1.23	0.009	0.60	0.11	0.06	0.05
				Station 12			
1400	S	1.32	0.015	0.71	0.09	0.08	0.01
	B	1.44	0.017	0.67	0.16	0.08	0.08
0200	S	1.36	0.014	0.59	0.07	0.06	0.01
	B	1.47	0.013	0.87	0.08	0.07	0.01
				Station 13			
1335	S	1.32	0.019	0.86	0.18	0.06	0.12
	B	1.25	0.015	0.82	0.14	0.04	0.10
0130	S	1.27	0.016	0.62	0.10	0.04	0.06
	B	1.30	0.015	0.77	0.14	0.06	0.08
				Station 14			
1245	S	1.26	0.014	0.61	0.14	0.06	0.08
0100	S	1.32	0.017	0.68	0.08	0.06	0.02
				Station 15			
1150	S	1.22	0.019	0.48	0.14	0.05	0.09
	B	1.22	0.014	0.62	0.07	0.06	0.01
2345	S	1.30	0.014	0.58	0.15	0.05	0.10
	B	1.35	0.017	0.71	0.08	0.06	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 10, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
0800	S	0.96	0.005	0.31	0.06	0.04	0.02
1205	S	1.04	0.003	0.27	0.02	<0.02	<0.02
1600	S	1.03	0.004	0.57	0.02	<0.02	<0.02
1950	S	0.90	0.003	0.32	0.02	<0.02	<0.02
2355	S	0.91	0.002	0.30	0.02	<0.02	<0.02
0405	S	1.00	0.002	0.21	0.02	----	----
				Station 2			
0845	S	1.01	0.005	0.47	0.06	0.04	0.02
1240	S	1.07	0.010	0.41	0.08	<0.02	0.07
1635	S	0.99	0.005	0.38	0.08	0.06	0.02
2030	S	0.86	0.004	0.34	0.07	0.04	0.04
0030	S	0.91	0.005	0.38	0.08	0.06	0.02
0435	S	1.05	0.003	0.19	0.08	0.04	0.04
				Station 3			
0935	S	1.03	0.008	0.43	0.09	0.07	0.02
	B	1.00	0.007	0.57	0.10	0.07	0.03
1325	S	1.05	0.006	0.40	0.08	0.05	0.03
	B	0.98	0.007	0.47	0.12	0.06	0.06
1720	S	0.94	0.009	0.29	0.11	0.06	0.05
	B	0.92	0.009	0.34	0.11	0.06	0.05
2120	S	1.02	0.008	0.28	0.11	0.05	0.06
	B	1.04	0.008	0.43	0.11	0.05	0.06
0120	S	0.95	0.006	0.46	0.07	0.06	0.02
	B	0.94	0.005	0.59	0.09	0.06	0.03
0515	S	0.97	0.006	0.28	0.08	0.05	0.03
	B	1.02	0.005	0.48	0.09	0.06	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 10, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 4			
1035	S	1.06	0.009	0.71	0.09	0.06	0.03
	B	1.04	0.010	0.61	0.11	0.07	0.04
1415	S	1.04	0.008	0.31	0.08	0.06	0.02
	B	1.03	0.010	0.47	0.10	0.06	0.04
1800	S	0.99	0.008	0.31	0.09	0.06	0.03
	B	0.99	0.009	0.47	0.11	0.07	0.04
2210	S	1.07	0.007	0.41	0.09	0.06	0.03
	B	1.07	0.006	0.40	0.12	0.06	0.06
0220	S	0.94	0.006	0.36	0.08	0.06	0.03
	B	0.92	0.006	0.40	0.12	0.06	0.06
0615	S	1.03	0.006	0.34	0.07	0.04	0.03
	B	1.03	0.006	0.33	0.09	0.04	0.05
				Station 5			
1005	S	0.96	0.014	0.35	0.08	0.04	0.04
	B	0.94	0.007	0.40	0.08	0.05	0.03
1415	S	0.90	0.009	0.56	0.10	0.04	0.06
	B	0.95	0.008	0.27	0.11	0.04	0.07
1820	S	0.84	0.008	0.43	0.10	0.05	0.05
	B	0.91	0.007	0.31	0.09	0.05	0.04
2225	S	1.02	0.007	0.32	0.09	0.04	0.05
	B	1.03	0.006	0.54	0.10	0.05	0.05
0230	S	0.91	0.006	0.43	0.08	0.04	0.04
	B	0.90	0.005	0.42	0.09	0.06	0.03
0630	S	0.94	0.005	0.32	0.09	0.06	0.03
	B	0.92	0.004	0.32	0.11	0.05	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 10, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 6			
0930	S	0.95	0.006	0.46	0.09	0.05	0.04
1350	S	0.92	0.008	0.47	0.08	0.04	0.04
1755	S	0.93	0.006	0.41	0.09	0.05	0.04
2200	S	0.91	0.007	0.39	0.10	0.05	0.05
0210	S	1.11	0.005	0.44	0.09	0.05	0.04
0615	S	0.99	0.005	0.41	0.09	0.04	0.05
				Station 7			
0900	S	1.16	0.008	0.54	0.09	0.03	0.06
1320	S	1.10	0.008	0.40	0.08	0.03	0.05
1725	S	1.05	0.008	0.49	0.08	0.02	0.06
2105	S	1.10	0.006	0.55	0.12	0.03	0.09
0120	S	0.91	0.005	0.37	0.09	0.03	0.09
0530	S	1.16	0.005	0.47	0.09	0.03	0.06
				Station 8			
0825	S	1.04	0.014	0.56	0.14	0.07	0.07
	B	1.03	0.014	0.52	0.12	0.06	0.06
1235	S	1.03	0.013	0.51	0.14	0.07	0.07
	B	0.97	0.014	0.49	0.15	0.06	0.09
1645	S	1.04	0.015	0.42	0.14	0.02	0.06
	B	1.08	0.016	0.54	0.16	0.08	0.08
2025	S	1.07	0.011	0.48	----	----	----
	B	1.05	0.009	0.52	0.11	0.04	0.07
0035	S	0.95	0.011	0.49	0.13	0.05	0.08
	B	0.91	0.009	0.46	0.12	0.05	0.07
0445	S	1.04	0.10	0.47	0.12	0.06	0.06
	B	1.04	0.009	0.46	0.10	0.07	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 10, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 9			
0750	S	1.12	0.017	0.54	0.17	0.08	0.09
1150	S	1.08	0.015	0.65	0.13	0.06	0.07
1545	S	0.96	0.013	0.53	0.14	0.06	0.08
1945	S	1.02	0.015	0.60	0.16	0.07	0.09
2350	S	0.95	0.013	0.50	0.15	0.07	0.08
0400	S	0.91	0.010	0.65	0.11	0.05	0.06
				Station 10 May 17, 1969			
0900	S	1.07	0.015	0.58	0.13	0.06	0.07
1325	S	0.79	0.010	0.54	0.10	0.07	0.03
1725	S	1.03	0.008	0.52	0.12	0.06	0.06
2100	S	1.09	0.009	0.43	0.11	0.06	0.05
0100	S	1.05	0.007	0.46	0.11	0.06	0.05
0520	S	1.08	0.006	----	0.10	0.06	0.04
				Station 11			
0950	S	1.05	0.011	----	0.16	0.05	0.11
1410	S	1.04	0.010	0.69	0.09	0.07	0.02
1815	S	1.12	0.008	0.74	0.14	0.06	0.08
2200	S	1.13	0.008	0.65	0.14	0.07	0.07
0145	S	1.07	0.007	0.61	0.13	0.07	0.06
0600	S	1.07	0.005	----	0.13	0.06	0.07

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 17, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 12			
1050	S	1.73	0.012	0.39	----	----	----
	B	1.67	0.012	0.61	0.17	0.06	0.11
1410	S	2.45	0.013	0.48	0.11	0.06	0.05
	B	2.56	0.011	0.88	----	----	----
1800	S	1.18	0.008	0.60	0.11	0.05	0.06
	B	1.14	0.011	0.73	0.16	0.06	0.10
2215	S	1.10	0.010	0.69	0.12	0.05	0.07
	B	1.10	0.010	----	0.16	0.06	0.10
0245	S	1.05	0.009	0.60	0.10	0.08	0.02
	B	1.03	0.009	0.69	0.13	0.06	0.07
0630	S	1.05	0.009	0.59	0.12	0.06	0.06
	B	1.08	0.007	0.64	0.13	0.06	0.07
				Station 13			
1015	S	1.07	0.013	0.52	0.12	0.06	0.06
	B	0.93	0.012	0.68	----	0.05	----
1340	S	1.05	0.014	0.69	----	----	----
	B	1.10	0.015	0.72	0.15	0.07	0.08
1730	S	1.81	0.014	0.72	0.12	0.05	0.07
	B	1.90	0.012	0.58	0.13	0.06	0.07
2130	S	1.67	0.013	0.64	0.12	0.04	0.08
	B	1.78	0.011	0.86	0.21	0.06	0.15
0200	S	1.12	0.012	0.61	0.12	0.05	0.07
	B	1.20	0.008	0.55	0.12	0.06	0.06
0600	S	1.04	0.011	0.61	0.11	0.05	0.06
	B	1.07	0.014	0.46	0.12	0.05	0.07

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

May 17, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 14			
0920	S	0.95	0.014	0.65	0.09	0.04	0.05
1310	S	0.97	0.013	0.60	0.10	0.06	0.04
1645	S	1.05	0.013	0.72	0.12	0.06	0.06
2040	S	1.23	0.011	0.62	0.12	0.06	0.06
0100	S	1.81	0.008	0.45	0.12	0.07	0.05
0500	S	1.93	0.012	0.54	0.11	0.06	0.05
				Station 15			
0815	S	1.07	0.017	0.67	0.13	0.08	0.05
	B	1.08	0.018	0.59	----	----	----
1210	S	1.07	0.015	0.055	0.12	0.08	0.04
	B	1.07	0.020	0.58	----	----	----
1600	S	0.96	0.015	0.79	0.12	0.04	0.08
	B	1.03	0.021	0.83	0.15	0.06	0.09
2000	S	0.96	0.015	0.70	0.14	0.06	0.08
	B	1.08	0.019	1.05	0.24	0.05	0.19
0005	S	1.03	0.014	0.60	0.13	0.07	0.06
	B	1.03	0.015	0.60	0.13	0.07	0.06
0355	S	1.07	0.012	0.50	0.11	0.07	0.04
	B	1.08	0.014	0.51	0.12	0.06	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

June 14, 1969

Time	Sample Depth	*Nitrogen (mg/l) $NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	*Phosphate Phosphorus (mg/l) Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
1135	S	1.19	0.009	0.42	0.08	0.06	0.02
2340	S	1.20	0.012	0.37	0.06	0.04	0.02
				Station 2			
1200	S	1.23	0.011	0.47	0.12	0.08	0.04
0020	S	1.18	0.015	0.37	0.10	0.08	0.02
				Station 3			
1300	S	0.53	0.009	0.58	0.07	0.03	0.04
	B	0.82	0.006	0.46	0.08	0.04	0.04
0110	S	0.50	0.009	0.56	0.05	0.02	0.03
	B	0.93	0.006	0.70	0.12	0.05	0.07
				Station 4			
1350	S	0.81	0.006	0.43	0.06	0.04	0.02
	B	0.76	0.006	0.70	0.06	0.04	0.02
0200	S	0.94	0.008	0.43	0.07	0.05	0.02
	B	0.93	0.007	0.42	0.07	0.04	0.02
				Station 5			
1510	S	0.33	0.005	0.67	0.09	0.02	0.07
	B	0.80	0.005	0.52	0.05	0.02	0.03
0255	S	0.52	0.005	0.49	0.06	0.02	0.04
	B	0.84	0.005	0.48	0.08	0.04	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

June 14, 1969

Time	Sample Depth	*Nitrogen (mg/l) $NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	*Phosphate Phosphorus (mg/l) Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 5-TI			
1450	S	0.04	0.004	0.49	0.04	0.02	0.02
0330	S	0.22	0.003	0.48	0.04	0.02	0.02
				Station 6			
1545	S	0.54	0.005	0.51	0.06	0.02	0.04
0345	S	0.76	0.005	0.53	0.04	<0.02	<0.02
				Station 7			
1135	S	0.96	0.004	0.34	0.05	0.03	0.02
2330	S	0.92	0.004	0.46	0.06	0.02	0.04
				Station 8			
1205	S	0.72	0.007	0.33	0.09	0.04	0.05
	B	0.84	0.006	0.62	0.08	0.03	0.05
2400	S	0.90	0.008	0.38	0.08	0.04	0.04
	B	0.90	0.008	0.30	0.06	0.04	0.02
				Station 9			
1255	S	0.83	0.008	0.48	0.09	0.03	0.06
0050	S	0.84	0.009	0.39	0.09	0.05	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

June 14, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 10			
1330	S	1.05	0.006	0.35	0.07	0.04	0.03
0130	S	1.15	0.007	0.40	0.10	0.05	0.05
				Station 11			
1415	S	0.94	0.004	0.37	0.09	0.04	0.05
0215	S	1.17	0.004	0.46	0.12	0.04	0.08
				Station 12			
1410	S	0.90	0.006	0.66	0.07	0.04	0.03
	B	0.96	0.006	0.58	0.08	0.04	0.04
0220	S	0.95	0.006	----	0.06	0.03	0.03
	B	0.95	0.006	0.41	0.08	0.04	0.04
				Station 13			
1350	S	0.93	0.006	0.71	0.06	0.04	0.02
	B	0.79	0.009	0.82	0.11	0.03	0.08
0145	S	0.77	0.008	0.56	0.07	0.02	0.05
	B	0.91	0.006	0.58	0.08	0.03	0.05
				Station 14			
1300	S	0.90	0.007	0.53	0.07	0.04	0.03
0100	S	0.98	0.008	0.49	0.08	0.03	0.05

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

June 14, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 15			
1200	S	0.73	0.007	0.47	0.07	0.02	0.05
	B	0.74	0.009	0.56	0.08	0.03	0.05
0010	S	0.74	0.008	0.50	0.08	0.04	0.04
	B	0.87	0.008	0.64	0.06	0.03	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

July 12, 1969

Time	Sample Depth	*Nitrogen (mg/l) $NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	*Phosphate Phosphorus (mg/l) Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 1			
1130	S	1.02	0.023	0.21	0.10	0.07	0.03
325	S	1.12	0.019	0.29	0.12	0.09	0.03
				Station 2			
1200	S	1.15	0.028	0.25	0.13	0.11	0.02
0010	S	1.20	0.30	0.34	0.16	0.13	0.03
				Station 3			
1300	S	0.42	0.015	0.60	0.08	0.02	0.06
	B	0.75	0.012	0.31	0.10	0.06	0.04
0100	S	0.51	0.019	0.50	0.07	0.03	0.04
	B	0.79	0.013	0.31	0.14	0.03	0.03
				Station 4			
1400	S	0.76	0.011	0.42	0.09	0.03	0.06
	B	0.70	0.010	0.43	0.10	0.04	0.06
0135	S	0.75	0.012	0.31	0.10	0.04	0.06
	B	0.72	0.012	0.33	0.09	0.04	0.05
				Station 5			
1530	S	0.25	0.009	0.61	0.07	0.02	0.05
	B	0.60	0.007	0.35	0.10	0.02	0.08
0230	S	0.45	0.009	0.37	0.06	0.02	0.04
	B	0.60	0.007	0.36	0.09	0.02	0.07

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

July 12, 1969

Time	Sample Depth	*Nitrogen (mg/l) $NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	*Phosphate Phosphorus (mg/l) Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 5-TI			
1500	S	0.04	0.006	0.50	0.06	0.02	0.04
0205	S	0.13	0.006	0.50	0.05	0.02	0.03
				Station 6			
1615	S	0.45	0.008	0.50	0.08	0.02	0.06
0300	S	0.57	0.007	0.39	0.06	0.02	0.04
				Station 7			
1135	S	0.84	0.007	0.25	0.09	0.04	0.05
2340	S	0.75	0.009	----	0.10	0.03	0.07
				Station 8			
1205	S	0.84	0.013	0.32	0.15	0.10	0.05
	B	0.87	0.014	0.35	0.13	0.09	0.04
0010	S	0.78	0.014	0.28	0.14	0.08	0.06
	B	0.75	0.012	0.43	0.15	0.09	0.06
				Station 9			
1300	S	0.79	0.012	0.20	0.14	0.09	0.05
0050	S	0.66	0.011	0.35	0.12	0.08	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

July 12, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 10			
1330	S	1.00	0.012	0.27	0.12	0.08	0.04
0140	S	1.00	0.11	0.42	0.14	0.09	0.05
				Station 11			
1415	S	0.98	0.005	0.21	0.12	0.07	0.05
0230	S	0.92	0.006	0.31	0.13	0.08	0.05
				Station 12			
1430	S	0.91	0.011	0.19	0.13	0.08	0.05
	B	0.95	0.013	0.39	0.10	0.07	0.03
0210	S	0.85	0.012	0.27	0.12	0.06	0.06
	B	0.85	0.013	0.36	0.18	0.07	0.11
				Station 13			
1400	S	0.90	0.013	0.43	0.12	0.06	0.06
	B	0.73	0.013	0.33	0.13	0.04	0.09
0140	S	0.77	0.015	----	0.11	0.06	0.05
	B	0.69	0.014	0.54	0.16	0.06	0.10
				Station 14			
1315	S	0.76	0.013	0.48	0.10	0.05	0.05
0040	S	0.70	0.013	0.44	0.11	0.05	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

July 12, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorus (mg/l)		
Time	Sample Depth	$NO_3 \cdot N$	$NO_2 \cdot N$	Total Kjeldahl·N	Total $PO_4 \cdot P$	Inorganic $PO_4 \cdot P$	**Total Organic $PO_4 \cdot P$
				Station 15			
1155	S	0.57	0.012	0.23	0.08	0.03	0.05
	B	0.58	0.011	0.53	0.10	0.04	0.06
2355	S	0.61	0.010	0.38	0.10	0.04	0.06
	B	0.58	0.012	0.76	0.11	0.04	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 2, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
0730	S	1.10	0.017	0.38	0.04	0.04	0.00
1200	S	0.96	0.006	0.35	<0.02	<0.02	<0.02
1645	S	1.00	0.008	0.27	<0.02	<0.02	<0.02
2045	S	0.96	0.008	0.32	0.07	0.02	0.02
0040	S	0.94	0.003	0.35	0.03	0.02	0.02
0420	S	1.01	0.003	0.34	0.02	0.02	0.02
				Station 2			
0820	S	1.15	0.026	0.56	0.13	0.13	0.02
1230	S	0.89	0.024	0.38	0.10	0.09	0.02
1730	S	1.07	0.022	0.43	0.12	0.10	0.02
2105	S	1.05	0.020	0.44	0.11	0.10	0.02
0105	S	1.09	0.016	0.41	0.13	0.12	0.02
0455	S	1.07	0.016	0.39	0.14	0.10	0.04
				Station 3			
0920	S	0.53	0.018	0.65	0.09	0.04	0.05
	B	0.44	0.027	0.70	0.15	0.12	0.03
1340	S	0.28	0.015	0.80	0.08	0.02	0.06
	B	0.67	0.015	0.80	0.13	0.11	0.02
1800	S	0.22	0.016	0.37	0.08	0.02	0.06
	B	0.18	0.016	----	0.24	0.14	0.10
2150	S	0.18	0.016	0.73	0.07	0.02	0.05
	B	0.62	0.016	0.66	0.13	0.10	0.03
0150	S	0.29	0.016	0.47	0.05	0.02	0.03
	B	0.65	0.016	0.61	0.16	0.10	0.06
0535	S	0.37	0.013	0.55	0.06	0.02	0.04
	B	0.47	0.017	0.59	0.15	0.13	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 2, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 4			
1020	S	0.74	0.013	0.60	0.12	0.06	0.06
	B	0.73	0.011	0.52	0.12	0.07	0.05
1440	S	0.64	0.013	0.56	0.10	0.04	0.06
	B	0.63	0.013	0.66	0.14	0.06	0.08
1910	S	0.52	0.014	0.57	0.12	0.03	0.09
	B	0.23	0.014	0.66	0.14	0.04	0.10
2235	S	0.52	0.013	0.58	0.13	0.06	0.07
	B	0.55	0.013	0.58	0.11	0.04	0.07
0235	S	0.55	0.011	0.61	0.11	0.06	0.05
	B	0.55	0.011	0.53	0.10	0.05	0.05
0620	S	0.55	0.010	0.55	0.11	----	----
	B	0.54	0.013	0.60	0.11	0.05	0.06
				Station 5			
1000	S	0.37	0.008	0.64	0.08	0.03	0.05
	B	0.61	0.005	0.49	0.12	0.06	0.06
1420	S	0.19	0.008	0.63	0.09	0.02	0.07
	B	0.51	0.007	0.50	0.10	0.04	0.06
1835	S	0.28	0.010	0.73	0.09	0.02	0.07
	B	0.41	0.006	0.65	0.09	0.03	0.06
2300	S	0.29	0.007	0.60	0.08	0.02	0.06
	B	0.47	0.005	0.54	0.08	0.04	0.04
0245	S	0.40	0.006	0.62	----	----	----
	B	0.51	0.004	0.47	0.13	0.05	0.08
0615	S	0.53	0.005	0.61	0.09	0.03	0.06
	B	0.59	0.003	0.58	0.10	0.04	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 2, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5-TI			
1115	S	0.06	0.003	0.59	0.05	0.02	0.03
	B	0.04	0.002	0.60	0.06	0.04	0.02
1525	S	0.02	0.002	0.67	0.05	0.02	0.03
	B	0.02	0.002	0.76	0.06	0.02	0.04
1935	S	0.02	0.004	0.58	0.05	0.03	0.02
	B	0.02	0.001	0.74	0.06	0.02	0.04
2325	S	0.02	0.003	0.68	0.05	0.02	0.03
	B	0.02	0.002	----	----	----	----
0320	S	0.22	0.002	0.60	0.03	<0.02	<0.02
0700	S	0.50	0.002	0.47	0.06	0.02	0.04
				Station 6			
0930	S	0.49	0.009	0.51	0.10	0.04	0.06
1355	S	0.38	0.006	0.55	0.08	0.04	0.04
1815	S	0.41	0.007	0.66	0.04	0.03	<0.02
2245	S	0.42	0.007	0.62	0.09	0.04	0.05
0217	S	0.41	0.005	0.52	0.09	0.04	0.05
0555	S	0.41	0.005	0.51	0.07	0.03	0.04
				Station 7			
0900	S	0.59	0.006	0.52	0.05	0.04	<0.02
1315	S	0.54	0.005	0.47	0.09	0.03	0.06
1735	S	0.60	0.004	0.49	0.06	0.02	0.04
2207	S	0.51	0.005	----	0.08	0.03	0.05
0150	S	0.51	0.003	0.54	0.09	0.02	0.07
0530	S	0.56	0.003	0.56	0.09	0.03	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 2, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 8			
0825	S	0.66	0.013	0.48	0.12	0.06	0.06
	B	0.65	0.011	0.50	0.14	0.10	0.04
1245	S	0.56	0.014	0.46	0.14	0.09	0.05
	B	0.61	0.015	0.53	0.15	0.08	0.07
1700	S	0.56	0.013	0.53	0.14	0.08	0.06
	B	0.53	0.013	0.53	0.13	0.09	0.04
2135	S	0.44	0.010	0.51	0.10	0.06	0.04
	B	0.55	0.010	0.52	0.13	0.08	0.05
0120	S	0.48	0.011	0.32	0.11	0.07	0.04
	B	0.53	0.009	0.72	0.14	0.08	0.06
0500	S	0.55	0.006	----	0.04	0.02	0.02
	B	0.51	0.008	0.69	0.14	0.07	0.08
				Station 9			
0745	S	0.75	0.013	0.55	0.13	0.11	0.02
1205	S	0.53	0.010	0.41	0.14	0.08	0.06
1630	S	0.55	0.009	0.46	0.13	0.08	0.05
2050	S	0.56	0.010	0.56	0.12	0.09	0.03
0045	S	0.55	0.010	0.53	0.14	0.08	0.06
0420	S	0.33	0.008	0.46	0.08	0.04	0.04
				Station 10 August 8, 1969			
0834	S	0.89	0.012	0.40	0.16	0.08	0.08
1205	S	0.53	0.010	0.41	0.14	0.08	0.06
1630	S	0.55	0.009	0.46	0.13	0.08	0.05
2050	S	0.56	0.010	0.56	0.12	0.09	0.03
0045	S	0.55	0.010	0.53	0.14	0.08	0.06
0420	S	0.34	0.008	0.46	0.08	0.04	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 8, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 11			
0915	S	0.67	0.006	0.41	0.11	0.06	0.05
1400	S	1.03	0.005	0.41	0.11	0.06	0.05
1815	S	1.15	0.006	0.36	0.06	0.05	<0.02
2155	S	0.90	0.005	0.35	0.07	0.04	0.03
0155	S	0.72	0.003	0.45	----	----	----
0500	S	0.73	0.002	0.39	0.15	0.05	0.10
				Station 12			
1010	S	0.72	0.010	0.45	0.08	0.04	0.04
	B	0.72	0.010	0.41	0.09	0.04	0.05
1340	S	0.67	0.010	0.40	0.08	0.04	0.04
	B	0.68	0.011	0.39	0.10	0.05	0.05
1730	S	0.71	0.007	0.40	0.09	0.04	0.05
	B	0.67	0.009	0.49	0.07	0.04	0.03
2220	S	0.73	0.008	0.49	0.08	0.04	0.04
	B	0.65	0.006	0.49	0.08	0.04	0.04
0145	S	0.80	0.008	0.40	0.08	0.04	0.04
	B	0.78	0.009	0.56	0.11	0.04	0.07
0500	S	0.87	0.006	0.38	0.06	0.04	0.02
	B	0.71	0.008	----	0.08	0.04	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 8, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 13			
0940	S	0.52	0.008	0.42	0.09	0.04	0.05
	B	0.57	0.009	0.45	0.12	0.04	0.08
1315	S	0.54	0.008	0.54	0.08	0.03	0.05
	B	0.41	0.003	0.51	0.09	0.03	0.06
1715	S	0.60	0.007	0.52	0.06	0.03	0.03
	B	0.58	0.006	0.48	0.08	0.03	0.05
2200	S	0.54	0.003	0.48	0.07	0.02	0.05
	B	0.72	0.006	0.47	0.09	0.04	0.05
0130	S	0.56	0.006	0.45	0.08	0.03	0.05
	B	0.67	0.006	0.51	0.10	0.04	0.06
0430	S	0.67	0.004	0.58	0.09	0.04	0.05
	B	0.54	0.004	0.51	0.07	0.02	0.05
				Station 14			
0900	S	0.60	0.008	0.39	0.08	0.04	0.04
1235	S	0.49	0.005	0.36	0.09	0.04	0.06
1630	S	0.55	0.005	0.43	0.06	0.04	0.02
2110	S	0.66	0.005	0.41	0.08	0.03	0.05
0045	S	0.60	0.006	0.47	0.10	0.04	0.06
0400	S	0.59	0.005	0.46	0.06	0.02	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

August 8, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 15			
0815	S	0.43	0.007	0.49	0.08	0.02	0.06
	B	0.61	0.006	0.50	0.07	0.02	0.05
1145	S	0.38	0.006	0.51	0.04	0.02	0.02
	B	0.37	0.005	0.59	0.06	0.02	0.04
1555	S	0.41	0.005	0.42	0.04	0.02	0.02
	B	0.41	0.004	0.40	0.05	0.02	0.03
2015	S	0.41	0.004	0.46	0.06	0.02	0.04
	B	0.39	-----	0.47	0.06	0.02	0.04
2340	S	0.41	0.006	0.41	0.06	0.02	0.04
	B	0.64	0.003	0.61	0.06	0.02	0.04
0330	S	0.64	0.003	0.61	0.06	0.02	0.04
	B	0.33	0.003	0.48	0.06	0.03	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

September 20, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
1140	S	1.07	0.003	0.25	0.05	0.04	0.01
2345	S	0.90	0.009	0.24	0.02	<0.02	<0.02
				Station 2			
1205	S	1.05	0.005	0.42	0.12	0.10	0.02
0005	S	1.18	0.004	0.40	0.10	0.09	<0.02
				Station 3			
1250	S	0.90	0.013	0.32	0.09	0.08	<0.02
	B	0.87	0.043	0.65	0.09	0.08	<0.02
0100	S	0.93	-----	0.45	0.09	0.07	0.02
	B	0.73	0.029	0.46	0.15	0.08	0.07
				Station 4			
1345	S	0.99	0.006	0.39	0.09	0.08	<0.02
	B	0.89	0.006	0.69	0.10	0.07	0.03
0140	S	0.91	0.006	0.40	0.09	0.06	0.03
	B	0.94	0.005	0.39	0.18	0.08	0.10
				Station 5			
1500	S	0.61	0.004	0.83	0.12	0.06	0.06
	B	0.65	0.002	0.44	0.09	0.04	0.05
0255	S	0.76	0.002	0.52	0.08	0.04	0.04
	B	0.62	0.005	0.62	0.11	0.05	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

September 20, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5-TI			
1440	S	0.04	0.005	0.54	0.05	0.02	0.03
	B	0.14	0.002	0.54	0.04	0.02	0.02
0230	S	0.16	0.002	0.55	0.05	<0.02	0.04
	B	0.23	0.005	0.46	0.10	0.02	0.08
				Station 6			
1550	S	0.62	0.004	0.67	0.10	0.04	0.06
2345	S	0.63	0.002	0.53	0.09	0.05	0.04
				Station 7			
1155	S	0.71	0.003	0.49	0.09	0.06	0.02
0020	S	0.87	0.002	0.68	0.09	0.04	0.05
				Station 8			
1230	S	0.75	0.010	0.59	0.12	0.09	0.03
	B	0.80	0.010	0.57	0.14	0.10	0.04
0050	S	0.72	0.007	0.56	0.12	0.08	0.04
	B	0.76	0.008	0.60	0.15	0.09	0.06
				Station 9			
1300	S	0.67	0.007	0.47	0.12	0.08	0.04
0130	S	0.59	0.007	0.52	0.09	0.06	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

September 20, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 10			
1345	S	0.78	0.006	0.50	0.11	0.08	0.03
0210	S	0.94	0.005	0.45	0.13	0.09	0.04
				Station 11			
1430	S	0.79	0.003	0.46	0.12	0.07	0.05
0255	S	0.80	0.003	0.63	----	----	----
				Station 12			
1400	S	1.12	0.014	0.55	0.09	0.08	<0.02
	B	1.11	0.016	0.65	0.12	0.08	0.04
0230	S	0.97	0.009	0.48	0.11	0.08	0.03
	B	1.04	0.008	0.91	0.13	0.08	0.05
				Station 13			
1330	S	0.63	0.007	0.64	0.09	0.04	0.05
	B	1.42	0.016	0.68	0.09	0.07	0.02
0145	S	1.30	0.013	0.59	0.09	0.06	0.03
	B	1.34	0.012	0.68	0.12	0.07	0.05
				Station 14			
1250	S	0.64	0.006	0.43	0.07	0.05	0.02
0055	S	0.80	0.003	0.49	0.09	0.05	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

September 20, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 15			
1150	S	0.47	0.004	0.46	0.06	0.04	0.02
	B	0.47	0.002	0.46	0.07	0.04	0.03
0010	S	0.63	0.004	0.46	0.06	0.03	0.03
	B	0.62	0.002	0.52	0.08	0.04	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

October 18, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
1155	S	0.41	0.005	0.47	0.03	<0.02	<0.02
2345	S	0.46	0.004	0.42	0.04	0.02	0.02
				Station 2			
1215	S	0.63	0.007	0.45	0.04	0.03	<0.02
0001	S	0.44	0.006	0.44	0.05	0.03	0.02
				Station 3			
1310	S	0.51	0.006	0.47	0.05	0.04	<0.02
	B	0.48	0.004	0.49	0.06	0.04	0.02
0045	S	0.40	0.008	0.38	0.06	0.04	0.02
	B	0.44	0.005	0.50	0.10	0.05	0.05
				Station 4			
1355	S	0.60	0.005	0.51	0.04	0.04	<0.02
	B	0.52	0.005	0.48	0.04	0.04	<0.02
0130	S	0.50	0.005	0.38	0.60	0.03	0.03
	B	0.49	0.005	0.41	0.06	0.04	0.02
				Station 5			
1450	S	0.51	0.005	0.42	0.05	0.03	0.02
	B	0.51	0.005	0.44	0.06	0.04	0.02
0220	S	0.46	0.005	0.40	0.06	0.05	<0.02
	B	0.50	0.006	0.52	0.05	0.03	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

October 18, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5-TI			
1425	S	0.30	0.007	0.55	0.04	0.02	0.02
	B	0.34	0.006	0.71	0.08	0.02	0.06
0205	S	0.29	0.007	0.49	0.05	0.02	0.03
	B	0.33	0.006	0.53	0.06	0.03	0.03
				Station 6			
1540	S	0.53	0.003	0.39	0.06	0.04	0.02
0250	S	0.51	0.005	0.46	0.06	0.05	<0.02
				Station 7			
1152	S	0.65	0.005	0.52	0.07	0.04	0.03
2345	S	0.53	0.003	0.43	0.08	0.05	0.03
				Station 8			
1230	S	0.58	0.004	0.42	0.07	0.05	0.02
	B	0.67	0.003	0.53	0.07	0.06	<0.02
0015	S	0.51	0.006	0.42	0.10	0.08	0.02
	B	0.49	0.006	0.46	0.10	0.05	0.05
				Station 9			
1315	S	0.63	0.006	0.46	0.10	0.06	0.04
0100	S	0.60	0.006	0.32	0.09	0.07	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

October 18, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 10			
1345	S	0.67	0.005	0.43	0.09	0.06	0.03
0140	S	0.64	0.003	0.37	0.10	0.05	0.05
				Station 11			
1430	S	0.79	0.003	0.49	0.10	0.04	0.06
0215	S	0.68	0.004	0.51	0.10	0.05	0.05
				Station 12			
1200	S	0.70	0.004	0.42	0.11	0.06	0.06
	B	0.80	0.004	0.65	0.09	0.05	0.04
0005	S	0.60	0.003	0.42	0.09	0.06	0.03
	B	0.68	0.003	0.43	0.10	0.07	0.03
				Station 13			
1220	S	0.67	0.004	0.50	0.08	0.07	$<$0.02
	B	0.65	0.003	0.39	0.10	0.05	0.05
0025	S	0.62	0.004	----	0.08	0.06	0.02
	B	0.63	0.003	0.52	0.08	0.07	0.02
				Station 14			
1325	S	0.59	0.004	0.40	0.10	0.05	0.05
0120	S	0.58	0.003	0.43	0.10	0.06	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

October 18, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 15			
1405	S	0.60	0.003	0.36	0.08	0.06	0.02
	B	0.69	0.003	0.48	0.09	0.05	0.04
0205	S	0.64	0.003	0.42	0.08	0.05	0.03
	B	0.60	0.002	0.43	0.09	0.06	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 8, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
0805	S	0.73	0.004	0.55	0.02	<0.02	<0.02
1250	S	0.68	0.006	0.53	----	----	----
1630	S	0.77	0.004	0.47	0.02	<0.02	<0.02
2045	S	0.61	0.010	0.48	0.04	0.02	0.02
0005	S	0.59	0.008	0.50	0.02	<0.02	<0.02
0340	S	0.58	0.007	0.55	0.02	<0.02	<0.02
				Station 2			
0845	S	0.72	0.007	0.54	0.04	0.02	0.02
1315	S	0.60	0.006	0.54	0.03	0.03	<0.02
1655	S	0.76	0.007	0.55	0.05	0.03	0.02
2105	S	0.59	0.008	0.49	0.04	0.02	0.02
0025	S	0.54	0.009	0.50	0.04	0.02	0.02
0350	S	0.65	0.008	0.55	0.04	0.02	0.02
				Station 3			
0945	S	0.95	0.003	0.53	----	----	----
	B	0.91	0.003	0.44	0.07	0.05	0.02
1400	S	0.67	-----	0.48	0.09	0.07	0.02
	B	0.90	0.002	0.56	0.06	0.06	<0.02
1730	S	0.69	0.004	0.52	0.06	0.05	<0.02
	B	0.80	0.004	0.70	0.06	0.04	0.02
2140	S	0.68	0.007	0.52	0.07	0.06	<0.02
	B	0.88	0.006	0.41	0.08	0.04	0.04
0100	S	0.57	0.004	0.58	0.08	0.06	0.02
	B	0.63	0.004	0.56	0.07	0.05	0.02
0420	S	0.70	0.004	0.62	0.08	0.06	0.02
	B	0.87	0.004	0.61	0.08	0.05	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 8, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 4			
1020	S	1.02	0.004	0.44	0.06	0.06	<0.02
	B	----	0.003	0.51	----	----	----
1445	S	0.72	0.003	0.53	----	----	----
	B	0.67	0.003	0.56	0.09	0.06	0.03
1805	S	0.75	-----	0.57	0.07	0.05	0.02
	B	0.76	0.003	0.48	0.07	0.05	0.02
2225	S	0.62	0.005	0.48	0.07	0.06	<0.02
	B	0.64	0.005	0.50	0.06	0.06	<0.02
0135	S	0.61	0.004	0.51	0.07	0.07	<0.02
	B	0.67	0.004	0.51	0.07	0.06	<0.02
0455	S	0.71	0.004	0.44	0.08	0.06	0.02
	B	0.66	0.004	0.57	0.07	0.06	<0.02
				Station 5			
1020	S	1.32	0.004	0.34	0.10	0.08	0.02
	B	1.01	0.003	0.51	0.11	0.08	0.03
1430	S	1.42	0.006	0.43	0.08	0.06	0.02
	B	1.40	0.002	0.51	0.10	0.05	0.05
1845	S	1.23	0.005	0.34	0.07	0.07	<0.02
	B	1.08	0.002	0.50	0.10	0.05	0.05
2230	S	1.21	0.005	0.39	0.07	0.06	<0.02
	B	0.71	0.004	0.41	0.09	0.06	0.03
0200	S	1.36	0.005	0.35	0.08	0.06	0.02
	B	0.70	0.004	0.45	0.08	0.06	0.02
0530	S	0.36	0.006	0.35	0.08	0.05	0.03
	B	1.02	0.003	0.54	0.12	0.06	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 8, 1969

		*Nitrogen (mg/l)			*Phosphate phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5-TI			
1110	S	0.25	0.003	0.76	0.02	<0.02	<0.02
	B	----	-----	----	----	----	----
1530	S	0.16	0.003	0.61	----	----	----
	B	0.31	0.002	0.84	0.07	0.02	0.05
1850	S	0.20	0.003	0.63	0.04	0.02	0.02
	B	0.05	-----	0.87	0.07	0.02	0.05
2305	S	0.18	0.004	0.60	0.03	<0.02	0.03
	B	0.02	0.004	0.80	0.06	<0.02	0.05
0220	S	0.19	0.004	0.68	0.04	<0.02	0.04
	B	0.19	0.004	0.85	0.04	<0.02	0.04
0535	S	0.28	0.004	0.56	0.03	<0.02	0.02
	B	0.15	0.003	0.61	0.04	<0.02	0.04
				Station 6			
0950	S	1.39	0.003	0.32	0.10	0.08	0.02
1400	S	1.24	0.003	0.39	0.09	0.07	0.02
1820	S	1.21	0.003	0.36	0.08	0.06	0.02
2210	S	1.17	0.005	0.45	0.07	0.05	0.02
0140	S	0.96	0.002	0.45	0.07	0.05	0.02
0510	S	1.12	0.004	0.45	0.07	0.05	0.02
				Station 7			
0915	S	1.21	0.002	0.39	0.11	0.08	0.03
1340	S	1.44	0.002	0.40	0.10	0.07	0.03
1755	S	1.40	0.002	0.37	0.12	0.08	0.04
2135	S	1.43	0.004	0.37	0.09	0.07	0.02
0115	S	1.41	0.004	0.40	0.10	0.08	0.02
0445	S	1.39	0.004	0.37	0.10	0.08	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 8, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 8			
0845	S	1.36	0.003	0.36	----	----	----
	B	1.36	0.003	0.57	0.14	0.09	0.05
1315	S	1.21	0.004	0.39	0.11	0.08	0.03
	B	1.34	0.003	0.43	0.14	0.12	0.02
1715	S	1.22	0.003	0.39	0.13	0.09	0.04
	B	1.19	0.003	0.47	0.12	0.09	0.03
2115	S	1.18	0.006	0.47	0.12	0.09	0.03
	B	1.31	0.006	0.40	0.15	0.09	0.06
0040	S	1.20	0.006	0.44	0.12	0.09	0.03
	B	1.22	0.006	0.40	0.12	0.09	0.03
0410	S	1.38	0.006	0.43	0.13	0.09	0.04
	B	1.31	0.006	0.47	0.13	0.10	0.03
				Station 9			
0810	S	1.15	0.003	0.44	0.11	0.08	0.03
1245	S	1.17	0.003	0.46	0.10	0.08	0.02
1650	S	1.15	0.003	0.54	0.10	0.08	0.02
2035	S	1.28	0.005	0.37	0.10	0.08	0.02
0020	S	1.28	0.005	0.37	0.10	0.08	0.02
0340	S	1.19	0.004	0.41	0.13	0.08	0.05
				Station 10 November 15, 1969			
0827	S	0.90	0.006	0.36	0.10	0.07	0.03
1320	S	0.81	0.06	0.43	0.12	0.07	0.05
1730	S	0.87	0.006	0.46	0.09	0.06	0.03
2045	S	0.69	0.007	0.39	0.10	0.06	0.04
0015	S	0.88	0.007	0.37	0.09	0.06	0.03
0430	S	0.82	0.006	0.37	0.10	0.07	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 15, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 11			
0910	S	0.78	0.003	0.32	0.12	0.08	0.04
1400	S	0.79	0.003	0.33	0.11	0.06	0.05
1800	S	0.58	0.004	0.35	0.10	0.06	0.04
2125	S	0.75	0.005	0.36	0.09	0.06	0.03
0055	S	0.93	0.006	0.38	0.08	0.06	0.02
0507	S	0.91	0.004	0.61	0.09	0.06	0.03
				Station 12			
1020	S	0.70	0.004	0.41	----	0.08	----
	B	0.77	0.004	0.47	0.11	0.06	0.05
1320	S	0.93	0.003	0.44	0.11	0.08	0.03
	B	0.78	0.002	0.46	0.12	0.08	0.04
1720	S	0.65	0.004	0.39	0.10	0.07	0.03
	B	0.77	0.004	0.37	0.10	0.07	0.03
2125	S	0.70	0.004	0.33	0.11	0.07	0.04
	B	0.72	0.003	0.45	0.12	0.06	0.06
0120	S	0.72	0.004	0.40	0.09	0.07	0.02
	B	0.81	0.004	0.42	0.10	0.07	0.03
0530	S	0.72	0.004	0.41	0.10	0.06	0.04
	B	----	0.010	0.45	0.10	0.06	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 15, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 13			
1000	S	0.84	0.003	0.42	0.11	0.08	0.03
	B	0.73	0.002	0.48	0.10	0.08	0.02
1300	S	0.78	0.003	0.56	0.12	0.08	0.04
	B	0.83	0.002	0.42	0.12	0.08	0.04
1705	S	0.65	0.004	0.42	0.12	0.07	0.05
	B	0.70	0.004	0.40	0.10	0.07	0.03
2105	S	0.65	0.003	0.33	0.10	0.07	0.03
	B	0.67	0.003	0.47	0.10	0.07	0.03
0100	S	0.76	0.004	0.41	0.09	0.07	0.02
	B	0.76	0.005	0.38	0.10	0.07	0.03
0510	S	0.87	0.004	0.36	0.09	0.08	<0.02
	B	0.68	0.004	0.34	0.11	0.08	0.03
				Station 14			
0850	S	0.74	0.003	0.41	0.13	0.09	0.04
1230	S	0.82	0.002	----	0.10	0.08	0.02
1630	S	0.68	0.003	0.41	0.12	0.08	0.03
2025	S	0.68	0.003	0.41	0.12	0.08	0.04
0025	S	0.73	0.004	0.43	0.10	0.07	0.03
0435	S	0.80	0.005	0.48	0.11	0.08	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

November 15, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 15			
0800	S	1.12	0.003	0.48	0.10	0.06	0.04
	B	1.14	0.004	0.40	0.12	0.09	0.03
1155	S	1.12	0.002	0.38	0.11	0.08	0.03
	B	0.73	0.010	0.42	0.10	0.08	0.02
1555	S	0.86	0.004	0.46	0.10	0.08	0.02
	B	1.03	0.005	0.29	0.12	0.08	0.04
1950	S	0.94	0.004	0.49	0.11	0.08	0.03
	B	0.98	0.004	0.40	0.10	0.07	0.03
2355	S	0.77	0.006	0.37	0.10	0.06	0.04
	B	0.75	0.005	0.43	0.10	0.08	0.02
0355	S	0.91	0.004	0.33	0.10	0.06	0.04
	B	0.94	0.007	0.46	0.10	0.08	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

December 13, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
1145	S	0.94	0.002	0.65	0.02	<0.02	<0.02
2350	S	0.85	0.002	0.32	0.02	<0.02	<0.02
				Station 2			
1214	S	0.89	0.004	0.38	0.04	0.03	<0.02
0015	S	0.98	0.003	0.33	0.06	0.04	0.02
				Station 3			
1250	S	0.92	0.003	0.89	0.06	0.04	0.02
	B	0.99	0.004	0.50	0.05	0.04	<0.02
0110	S	0.89	0.004	0.40	0.05	0.04	<0.02
	B	0.84	0.005	0.46	0.05	0.04	<0.02
				Station 4			
1400	S	1.05	0.002	0.59	0.06	0.04	0.02
	B	0.88	0.003	0.49	0.06	0.05	<0.02
0200	S	0.92	0.003	0.44	0.07	0.06	<0.02
	B	0.89	0.003	0.45	0.05	0.04	<0.02
				Station 5			
1520	S	0.75	0.003	0.37	0.06	0.04	0.02
	B	1.12	0.005	0.40	0.05	0.04	<0.02
0310	S	0.80	0.004	0.48	0.07	0.04	0.03
	B	0.82	0.004	0.51	0.06	0.04	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

December 13, 1969

		*Nitrogen (mg/l)			*Phosphate Phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5-II			
1455	S	0.43	0.002	0.42	0.05	0.02	0.04
	B	0.42	0.007	0.82	0.05	0.02	0.03
0245	S	0.32	0.007	0.75	0.04	0.02	0.03
	B	0.28	0.006	0.87	0.06	0.02	0.05
				Station 6			
1555	S	0.98	0.003	0.38	0.06	0.05	<0.02
0345	S	0.78	0.003	0.43	0.06	0.05	<0.02
				Station 7			
1150	S	1.31	0.004	0.50	0.06	0.04	0.02
0001	S	1.19	0.003	0.44	0.06	0.05	<0.02
				Station 8			
1230	S	1.13	0.007	0.43	0.10	0.07	0.03
	B	1.18	0.008	0.63	0.12	0.08	0.04
0032	S	0.93	0.007	0.49	0.08	0.07	<0.02
	B	1.04	0.016	-----	0.08	0.06	0.02
				Station 9			
1340	S	0.96	0.005	0.40	0.09	0.06	0.03
0130	S	1.06	0.006	0.49	0.08	0.06	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

December 13, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 10			
1415	S	1.16	0.006	0.52	0.09	0.06	0.03
0205	S	1.29	0.004	0.48	0.08	0.06	0.02
				Station 11			
1507	S	1.10	0.003	0.44	0.09	0.06	0.03
0300	S	1.41	0.004	0.44	0.09	0.05	0.04
				Station 12			
1445	S	1.18	0.005	0.65	0.10	0.07	0.03
	B	1.01	0.004	0.54	0.11	0.06	0.05
0210	S	1.23	0.004	0.48	0.09	0.06	0.03
	B	1.16	0.004	0.58	0.11	0.05	0.06
				Station 13			
1405	S	1.17	0.004	0.55	0.09	0.06	0.03
	B	1.02	0.004	0.49	0.10	0.06	0.04
0140	S	1.02	0.004	0.46	0.09	0.06	0.03
	B	1.03	0.004	0.53	0.09	0.07	0.02

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

December 13, 1969

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 14			
1315	S	1.07	0.004	0.49	0.11	0.06	0.05
0050	S	1.04	0.003	0.48	0.08	0.07	<0.02
				Station 15			
1215	S	1.14	-----	0.49	0.09	0.06	0.03
	B	1.29	0.004	0.57	0.11	0.06	0.05
0015	S	-----	0.004	0.57	0.09	0.05	0.04
	B	1.33	0.003	0.48	0.10	0.06	0.04

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

January 17, 1970

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 1			
1130	S	0.80	0.003	0.34	0.03	<0.02	0.02
2330	S	0.93	0.003	0.30	0.05	0.02	0.03
				Station 2			
1150	S	0.84	0.003	0.36	0.05	0.02	0.03
2345	S	0.94	0.003	0.52	0.05	0.02	0.03
				Station 3			
1250	S	0.80	0.004	0.44	0.07	0.04	0.03
	B	0.80	0.003	0.43	0.06	0.04	0.02
0030	S	0.89	0.006	0.53	0.08	0.04	0.04
	B	0.95	0.006	0.54	0.11	0.04	0.07
				Station 4			
1330	S	0.79	0.002	0.45	0.07	0.04	0.03
	B	0.79	0.004	0.43	0.07	0.04	0.03
0115	S	0.91	0.005	0.49	0.06	0.03	0.03
	B	0.95	0.006	0.34	0.07	0.04	0.03

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

January 17, 1970

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 5			
1415	S	0.79	0.003	0.52	0.06	0.04	0.02
	B	0.80	0.004	0.45	0.08	0.04	0.04
0205	S	0.91	0.003	0.58	0.11	0.04	0.07
	B	0.85	0.004	0.45	0.09	0.04	0.05
				Station 5-TI			
1400	S	0.69	0.005	0.56	0.07	0.03	0.04
	B	0.67	0.006	0.66	0.08	0.02	0.03
0245	S	0.79	0.006	0.54	0.06	0.04	0.03
				Station 6			
1515	S	0.80	0.003	0.53	0.07	0.05	0.02
0305	S	0.84	0.004	0.49	0.06	0.05	0.02
				Station 7			
1140	S	0.93	0.003	0.51	0.11	0.03	0.08
2350	S	1.03	0.005	0.45	0.08	0.03	0.05
				Station 8			
1220	S	0.93	0.004	0.53	0.11	0.06	0.05
	B	0.80	0.003	0.54	0.11	0.05	0.06
0013	S	0.94	0.006	0.47	0.12	0.07	0.05
	B	0.95	0.006	0.59	0.13	0.07	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

January 17, 1970

		*Nitrogen (mg/l)			*Phosphate phosphorous (mg/l)		
Time	Sample Depth	NO_3-N	NO_2-N	Total Kjeldahl-N	Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 9			
1300	S	0.30	0.004	0.45	0.10	0.05	0.05
0100	S	0.93	0.005	0.57	0.08	0.05	0.03
				Station 10			
1330	S	0.96	0.005	0.47	0.10	0.05	0.05
0135	S	0.98	0.004	0.50	0.11	0.05	0.06
				Station 11			
1420	S	1.14	0.003	0.50	0.11	0.06	0.05
0230	S	1.06	0.006	0.43	0.11	0.06	0.05
				Station 12			
1430	S	1.06	0.003	0.52	0.10	0.03	0.07
	B	0.95	0.003	0.48	0.11	0.06	0.05
0300	S	0.95	0.005	0.55	0.09	0.06	0.03
	B	1.07	0.004	0.52	0.10	0.05	0.05
				Station 13			
1355	S	0.95	0.004	0.47	0.09	0.04	0.05
	B	0.96	0.004	0.49	0.10	0.04	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** B_o subtraction

TABLE XV

NUTRIENT CONDITIONS FOR THE GUADALUPE RIVER, TEXAS

January 17, 1970

Time	Sample Depth	*Nitrogen (mg/l) NO_3-N	NO_2-N	Total Kjeldahl-N	*Phosphate Phosphorous (mg/l) Total PO_4-P	Inorganic PO_4-P	**Total Organic PO_4-P
				Station 14			
1255	S	1.07	0.005	0.47	0.09	0.04	0.05
0130	S	1.08	0.005	0.49	0.10	0.05	0.05
				Station 15			
1200	S	1.02	0.004	0.57	0.11	0.04	0.07
	B	0.98	0.006	0.69	0.10	0.06	0.04
0015	S	1.06	0.005	0.54	0.12	0.06	0.06
	B	1.06	0.005	0.54	0.12	0.06	0.06

* Mean of two samples
S Surface sample
B Bottom sample
** By subtraction

TABLE XVI - AMMONIA NITROGEN CONCENTRATIONS[a] IN MILLIGRAMS PER LITER FOR THE GUADALUPE RIVER, TEXAS FROM MAY 10, 1969 THROUGH JANUARY 17, 1970.

Stations	May 10	June 14	July 12	Aug 2	Sept 20	Oct 18	Nov 8	Dec 13	Jan 17
1	<0.05	-	<0.05	<0.05	-	0.19	0.16	<0.05	-
2	-	-	0.18	-	-	0.13	0.13	0.08	-
3	0.09	-	-	0.08	-	-	0.18	0.07	0.06
4	-	-	<0.05	-	-	0.10	0.11	0.06	-
5	-	<0.05	<0.05	<0.05	-	-	-	<0.05	-
5-TI	-	-	-	<0.05	-	<0.05	<0.05	0.06	-
6	-	-	<0.05	<0.05	-	-	0.08	-	<0.05
7	-	-	-	0.10	<0.05	-	<0.05	-	-
8	-	-	-	0.15	0.09	-	0.06	-	-
9	-	<0.05	-	0.06	<0.05	-	0.09	0.11	-
10	0.11	-	-	<0.05	<0.05	0.06	0.09	-	-
11	0.11	-	-	<0.05	-	-	0.09	-	<0.05
12	0.11	-	-	<0.05	-	-	0.06	-	-
13	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05
14	-	-	-	-	-	<0.05	<0.05	0.09	-
15	0.15	-	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05

[a] Mean of two samples

TABLE XVII - STATION LOCATIONS IN KILOMETERS FROM THE MOUTH OF THE GUADALUPE RIVER AND MEAN WATER DEPTHS IN METERS

Station Number	River Kilometers	Water Depth in Meters
1	449.5	2.5
2	445.3	3.3
3	437.9	7.6
4	431.1	4.1
5-TI	427.4	3.9
5	425.8	7.4
6	425.4	1.6
7	412.8	2.1
8	406.8	6.0
9	402.7	1.1
10	394.6	1.0
11	359.1	0.7
12	336.4	5.0
13	331.8	5.6
14	320.7	3.1
15	296.2	6.2

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