1975

An Application of "Storm" Mathematical Modeling for Evaluation of Nonpoint Source Water Pollution for a Nonurban Watershed

John T. Izzo
University of Central Florida

AN APPLICATION OF "STORM" MATHEMATICAL MODELING FOR EVALUATION OF NONPOINT SOURCE WATER POLLUTION FOR A NONURBAN WATERSHED

BY

JOHN T. IZZO
B.C.E., The City University of New York, 1966

RESEARCH REPORT

Submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Environmental Systems
Management in the Graduate Studies Program of
Florida Technological University

Orlando, Florida
1975

ACKNOWLEDGEMENTS

To Dr. Martin P. Wanielista for advice and assistance during the preparation of this Research Report and for his services as Chairman of the Committee on final examination.

To Dr. Waldron M. McLellon and Dr. Yousef A. Yousef for reviewing the report and serving on the Committee on final examination.

To my wife and parents for the many sacrifices they have made to enable me to receive my education.

ABSTRACT

AN APPLICATION OF "STORM" MATHEMATICAL MODELING FOR EVALUATION OF NONPOINT SOURCE POLLUTION

by

JOHN THOMAS IZZO

B.C.E., The City University of New York, 1966

Today, the engineer is faced with the task of predicting and evaluating the extent of the Nonpoint Sources that pollute our waterways.

A mathematical model may be an extremely useful tool in helping the engineer solve problems in the area of water resources.

During the course of this investigation, a literature survey related to the Econlockhatchee River Basin and to the "STORM" mathematical modeling technique for runoff evaluation has been conducted.

The latter part of this report deals with an application of the "STORM" mathematical model for predicting quantity and quality of surface runoff for the Econlockhatchee River Basin located in central Florida.

Martin P. Wanielista

Dr. Martin P. Wanielista, P.E.
Director, Research Report

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

CHAPTER I

INTRODUCTION

Most of us realize that without adequate supplies of clean water we cannot exist, but for years we have taken our natural waterways for granted by allowing pollutant discharges to enter our rivers, streams and lakes.

Governmental officials have now adopted more rigid standards to help control water pollution. For the most part these standards have been aimed at restricting point sources of pollution. The main reason for this is that we simply do not have enough information pertaining to nonpoint sources of pollution.

Models have and are being developed to help us to analyze the quantity and quality of stormwater runoff. One type of mathematical modeling technique that was recently developed is the Urban Storm Water Runoff Model ("STORM").

This model may be used to assist in the following types of analyses:

1. Preliminary sizing of storage and treatment facilities to meet desired criteria for the control of urban storm runoff.

2. Analyzing the impact of different land use management schemes on the quantity and quality of runoff and land surface erosion.

3. Predicting the quantity and quality of urban and nonurban runoff from subareas for use as input to an ecosystem model.

"STORM" is known as a planning model as opposed to the EPA Storm Water Management Model (SWMM) which is used primarily for design.

CHAPTER II

OBJECTIVES AND SCOPE

In the past few years public officials at the local, state and federal levels have been increasingly concerned with the nonpoint sources of water pollution. Urban and nonurban runoff are being carefully investigated to determine their contribution to the overall pollution of our surface waters.

This report is the result of applying a mathematical model for predicting stormwater runoff for a nonurban watershed located in central Florida.

The mathematical model that was employed for this research report is based on the "STORM" Program that was completed in January 1974. This Program was developed by Water Resources Engineers, Inc. (WRE) of Walnut Creek, California for the Hydrologic Engineering Center (HEC). Parts of the program had been previously developed by WRE for the Environmental Protection Agency and the City of San Francisco.

The watershed being investigated is the Econlockhatchee River basin which is located in Orange, Seminole and Osceola Counties, Florida.

CHAPTER III

LITERATURE REVIEW

Until recently governmental officials have been mainly concerned with water pollution problems from point sources. The Congress has legislated in the point source area for many years and has allocated funds to provide more and better treatment plants. It was not until 1972 that Congress began to recognize nonpoint water pollution. In the Federal Water Pollution Control Act Amendments of 1972[1], Congress decreed that specified nonpoint sources of pollution shall be characterized and plans formulated for improvement of pollution originating from them.

Water Pollution

Agee[2] has indicated that about a third of the pollutants entering the Nation's waterways originate from what we presently describe and define as nonpoint sources.

Although EPA defines[3] Water Pollution as: "A degradation of quality of water for a specified use," pollution, strictly speaking, is any departure from purity. Through the years, environmental pollution has come to mean a departure from a normal, rather than from a pure state.

Very rarely is water found in a completely pure state. Rainwater usually contains dissolved CO_2, O_2 and N_2 and dust or other particles that may be picked up from the atmosphere. Surface and well waters usually contain dissolved compounds of metals like Na, Mg, Ca and Fe. Stoker[4] has classified water pollutants into nine categories:

1. Oxygen-demanding wastes
2. Disease-causing agents
3. Plant nutrients
4. Synthetic organic compounds
5. Oil
6. Inorganic chemicals and mineral substances
7. Sediments
8. Radioactive materials
9. Heat

McKenzie[5] has defined pollution as "the process of contaminating air, water, and land with impurities to a level that is undesirable and results in a decrease in usefulness of environment for beneficial purposes."

Nonpoint sources of pollution have been described by Wanielista[6] as "land uses or locations at which pollutants are released to the natural environment at an uncontrolled rate." Once the source has been controlled the pollution is referred to as a point source type of pollution.

Nonpoint source pollution has been defined by EPA[7] as "A pollutant which enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances."

Humenik[8] has indicated the following parameters for evaluation of nonpoint source agricultural pollution:

1. Flow rate
2. pH
3. Temperature
4. Turbidity
5. Suspended sediment
6. Dissolved oxygen
7. BOD
8. P
9. N
10. MPN (coliform)
11. Specific conductance

Nonpoint source pollution problems may be caused by differed factors depending upon the region location.

Hill[9] has indicated that, in general, the major agricultural nonpoint source problems for the Southeast region of the country are:

1. Water erosion and sedimentation
2. Erosion, and sedimentation

3. Animal waste
4. Plant nutrients
5. Pesticides

Pollutant Transport and Management Techniques

There are three modes of transport of pollutants from sources to water:[10]

1. By runoff to surface water.
2. By infiltration and percolation to subsurface water.
3. By wind to surface water.

Management procedures are similar for all agricultural chemicals and basically involve good conservation techniques.

Humenik[11] has recommended a few specific management techniques:

1. Pretreatment alternatives
2. Application procedures
3. Loading and placement
4. Agronomic considerations
5. Contouring and terracing
6. Sediment basins
7. Water management structures
8. Grassland borders

STORM Modeling Program For Water Systems

Models are extremely useful tools in helping us to understand and manage various types of water systems. Due to their flexibility, models may be applied to many different aspects of a system. In the field of water resources management, model applications range from planning, policy development, allocation, and optimization techniques to the many aspects of operational interaction.

Models are particularly helpful when we do not have a clear understanding of what is occurring in a water system. Under these circumstances, mathematical models may help us to understand the various system parameters. Mathematical models may be formulated and modified to include practical experience along with engineering judgement.

The computer program STORM[12] was developed in 1973 by Water Resources Engineers, Inc. (WRE) of Walnut Creek, California while under contract with the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers. Parts of the program had been previously developed by WRE for the Environmental Protection Agency and the City of San Francisco. The input and output formats of the program were developed by HEC to conform to its standardized methods. The program has been modified to include computations for the quantity and quality of runoff from nonurban areas and for land surface erosion for urban and nonurban watersheds.

The STORM program is a method of analysis capable of estimating the quantity and quality of runoff from various watersheds. By using the program, land surface erosion, suspended and settleable solids, biochemical oxygen demand (BOD), total nitrogen (N), and orthophosphate (PO_4) may be computed.

The seven parameters that the STORM model considers are:

1. Precipitation and air temperature for rainfall/snowmelt
2. Runoff
3. Pollutant accumulation
4. Land surface erosion
5. Treatment rates
6. Storage
7. Overflows from the storage/treatment system

The STORM program concept recognizes not only the properties of duration and intensity, but also considers storm spacing and the capacity of the urban storm water system.

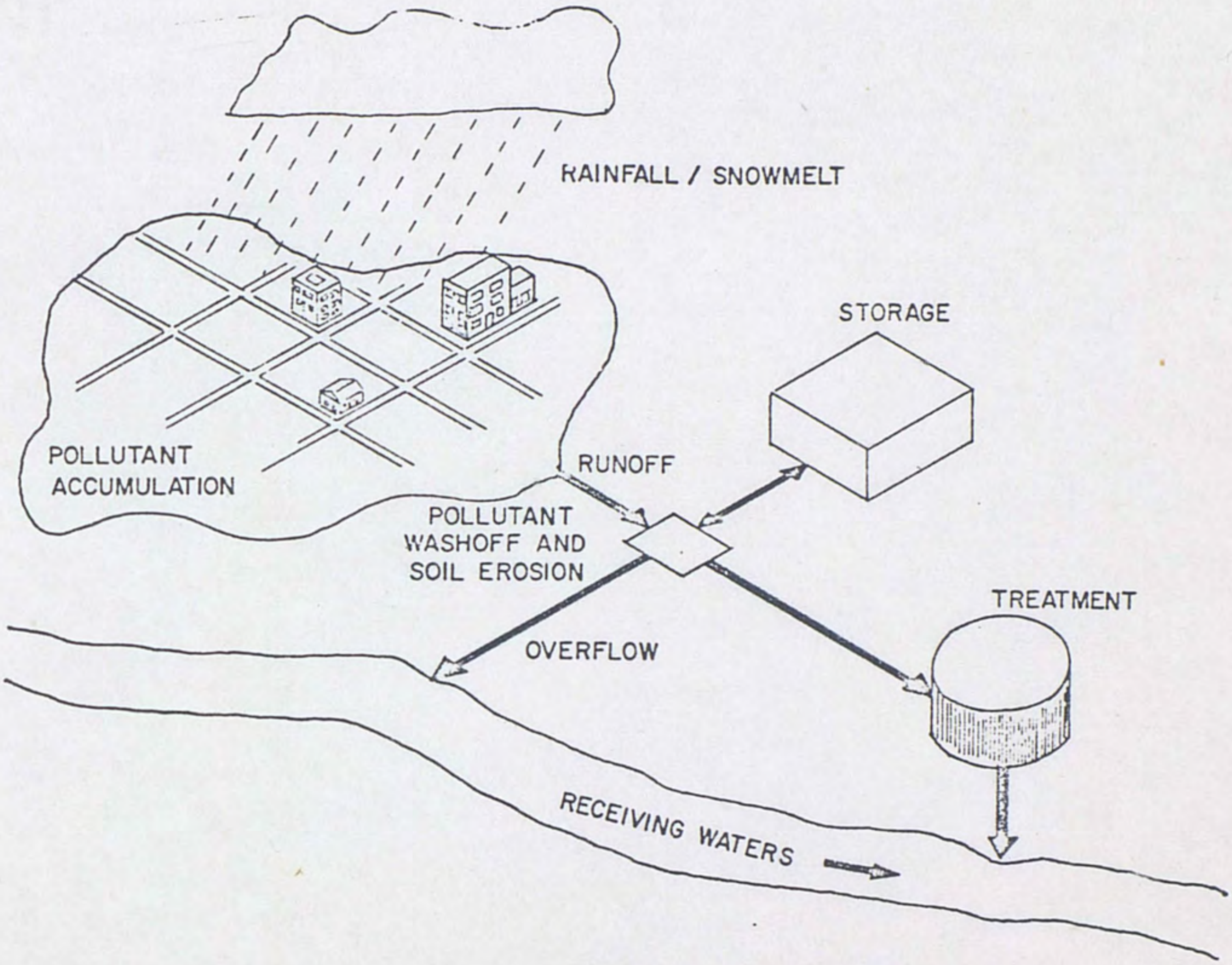
The interrelationship of the seven stormwater elements considered in estimating storm water runoff quality and quantity is shown pictorially in Figure 1. Rainfall washes dust and dirt and associated pollutants off the watershed to the treatment facilities where as much storm water runoff as possible is treated and released. The runoff exceeding the capacity of the treatment plant may be stored for later treatment. At some point the storage facilities may become inadequate to contain the runoff, the untreated excess is wasted through overflow directly into the receiving waters.

For a given rainfall/snowmelt record, the quantity, quality and number of overflows will vary as the treatment rate, storage capacity, and land use is changed. Land surface erosion is a function of land soil type, ground slope, rainfall/snowmelt energy, and erosion control practices. One typical investigation procedure would be to vary the treatment, storage, and land use and then note the resulting system response. Alternatives can then be selected based upon those that meet the overflow quantity and quality objectives.

The runoff from both urban and nonurban watersheds is computed in a similar manner except that for the nonurban case there is only one land use, "nonurban." Also, for the nonurban case, the runoff coefficient C_n, is an input variable rather than computed by a composite runoff equation.

Fig. 1

CONCEPTUALIZED VIEW OF URBAN SYSTEM USED IN STORM



SOURCE: U.S. Army Corps of Engineers, "Urban Storm Water Runoff 'STORM'," p. 4.

The urban runoff is computed as the following function of land use and rainfall/snowmelt losses.

$$r_u = C_u \, (P_u - f_u)$$

where

r_u = urban area runoff in inches per hour;

C_u = composite runoff coefficient dependent on urban land use;

P_u = rainfall/snowmelt in inches per hour over the urban area, and

f_u = available urban depression storage in inches per hour.

The runoff coefficient represents losses due to infiltration. It is computed from land use data.

The amount of depression storage at any point in time is a function of past rainfall/snowmelt and evaporation rates. The function is computed continuously by the following expression:

$$f_u = f_{ou} + N_D \, K_u, \; f_u \leq D_u$$

where

f_{ou} = available depression storage in inches, after previous rainfall;

N_D = number of dry days since previous rainfall;

K_u = recession factor, in inches/day, representing storage in inches;

D_u = maximum available depression storage in inches.

The nonurban runoff before diversion is:

$$r_n = C_n (P_n - f_n)$$

where

r_n = nonurban runoff before diversion;

C_n = composite runoff coefficient dependent on nonurban land use;

P_n = rainfall/snowmelt in inches per hour over the nonurban area, and

f_n = available nonurban depression storage in inches per hour.

The available nonurban depression storage in inches/hour is:

$$f_n = f_{on} + N_D K_n \text{ for } f_n \leq D_n$$

where

f_n = available nonurban depression storage in inches/hour;

f_{on} = available depression storage, in inches, after previous rainfall;

N_D = number of dry days since previous rainfall;

K_n = recession factor, in inches/day, representing the recovery (evaporation) of depression storage in inches; and

D_n = maximum available depression storage in inches.

The nonurban runoff after diversion is:

$R_n = r_n - W_n (r_n - DVN_{min})$ for $r_n \leq DVN_{max}$, and

$R_n = r_n - W_n (DVN_{max} - DVN_{min})$ for $r_n > DVN_{max}$

where

R_n = nonurban runoff after diversion;

r_n = nonurban runoff before diversion;

W_n = fraction of runoff between DVN_{max} and DVN_{min} diverted;

DVN_{min} = runoff at which diversion begins; and

DVN_{max} = runoff at which no additional diversion can occur.

The initial quality of pollutant p on the nonurban watershed at the beginning of a storm is computed as:

$$PN_p = PA_p \ A_n \ N_D + PN_{po}$$

where

PN_p = total pounds of pollutant p on the nonurban area, A_n, at the beginning of the storm;

PA_p = accumulation rate for pollutant p in pounds/day/acre;

A_n = nonurban area in acres;

N_D = number of days without runoff since the last storm; and

PN_{po} = total pounds of pollutant p remaining on the nonurban area at the end of the last storm.

The washoff of nonurban pollutants is a function of only the nonurban runoff rate and the amount of pollutants on the watershed.

The expression used to compute the rate at which pollutants are washed off the nonurban watershed is:

$$MN_p = PN_p \, (1 - e^{-E_n r_n \Delta t})/\Delta t$$

where

MN_p = pounds washoff of pollutant p during time Δ t (one hour);

E_n = nonurban washoff decay rate; and

r_n = rate of nonurban runoff in inches/hour.

No analysis of the availability of pollutants, as done in the urban case, is made for the nonurban pollutants.

Nonurban runoff is also subject to diversion losses and the pollutants are handled by using the equation:

$$MN_p' = MN_p \, (R_n/r_n)$$

where

MN_p' = pounds/hour of pollutant p after nonurban diversion and the variables are as previously defined.

Computation of Land Surface Erosion is made by using the universal soil-loss equation. This empirical equation was developed for cropland east of the Rocky Mountains.

The Soil Erosion Equation is:

Soil Erosion Rate = EI·K·(L·S)·C·P

where

Soil Erosion Rate = Soil Eroded from a plot in tons/acre/storm;

EI = Rainfall factor based on rainfall/snowmelt energy;

K = Soil erodibility factor based on soil properties;

L·S = Length-slope factor, a function of ground surface slope and length of that slope;

C = Cropping-management factor represents ground cover and includes the likelihood that a surface layer of coarse grained particles can develop if the soil is not worked; and

P = Erosion-control practice factor accounts for contouring, sediment basins, etc.

The soil erosion variables, except for EI, are coded into the computer program so that one need only to specify the soil type by its classification code and the program will calculate the erosion rate and total erosion.

The Econlockhatchee River Basin

A U.S. Geological Survey Publication[13] has supplied background data about the Econlockhatchee River:

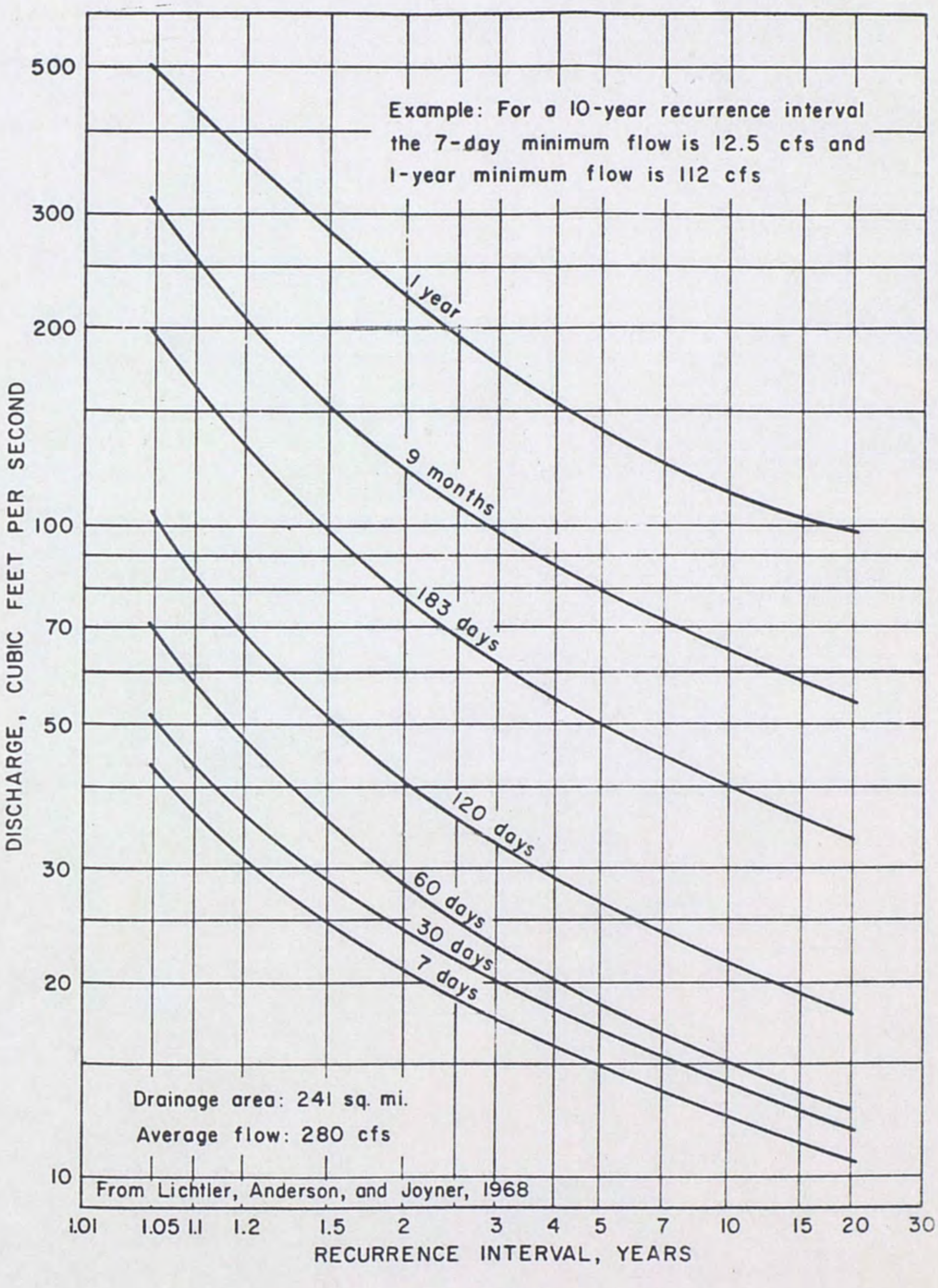
> The Econlockhatchee River drains 260 square miles of the western slope of the St. Johns River basin between Orlando and Bithlo. The headwaters are an elongated swamp from which drainage is slow and transpiration losses are high. Some of the topographically delineated drainage basin of its largest tributary, the Little Econlockhatchee River, are karst areas that contribute no runoff. The unit runoff is 1.16 cfs per square mile. The maximum recorded discharge at Chuluota is 11,000 cfs which is equivalent to 46 cfs per square mile. The recurrence interval of a flood of this magnitude exceeds 50 years. The channel of the Econlockhatchee River is well developed in its lower reach. In this reach the channel is incised into the water-table aquifer so that the river derives some base flow from the shallow aquifer during even the most severe droughts. Further, some low flow augmentation (11 cfs in 1963) is derived from effluent from the Orlando sewage plant. Figure 2 shows the frequency at which the minimum average flows for selected durations are likely to recur.
>
> Chemical quality of the water is generally within acceptable limits with moderate hardness but with fairly high color curing high flows.

The following additional information about the Econlockhatchee River was furnished by another U.S. Geological Survey Publication[14]:

> The Econlockhatchee River rises in the northern part of the Osceola Plain and flows northward in a coast-parallel course to a point some two miles east of Oviedo where it makes an abrupt right-angled turn to the east, separating Geneva Hill to the north from the Osceola Plain to the south. It continues this easterly lower course to confluence with the St. Johns River by flowing into the western side of Lake Harney.

Fig. 2

LOW-FLOW FREQUENCY CURVES FOR ECONLOCKHATCHEE RIVER NEAR CHULUOTA



SOURCE: U.S. Geological Survey, Water Resources of Northern Florida, Report of Investigation No. 54, (Orlando, Florida: Designers Press of Orlando, Inc., 1970), p. 24.

There would be little of note about this eastward turn of the Econlockhatchee River were it not for the fact that it leaves a broad, low, straight, flat floored valley to turn into a narrower steeper walled one which traverses much higher ground. The gentle northward slope of the valley floor of the upper, north-flowing part of the Econlockhatchee River Valley continues on the same northward slope to the shore of Lake Jessup, but the Econlockhatchee River turns abruptly out of it to traverse the narrow valley which separates Geneva Hill from the northern end of the Osceola Plain.

In attempting to explain this erratic and circuitous course of the lower Econlockhatchee River the process just described suggests itself. Possibly in Pamlico time, the Econlockhatchee debouched into a sound or estuary which flooded the St. Johns River Valley including the vicinity of the present Lake Jessup. The elevation of Pamlico sea-level is the same (30 feet) as the divide between the Econlockhatchee River and Lake Jessup at the point of tangency of the river's eastward bend. Thus it would seem probable that the mouth of the river was there in Pamlico time. During the Pamlico stand of the sea, insoluble sediments may have been deposited at the mouth of the river and after sea-level dropped below the Pamlico level, subterranean leakage on the east flank of the river opened a lower route to the east via the present lower Econlockhatchee Valley.

In support of the idea of a late origin for the lower east-flowing part of the Econlockhatchee River it seems significant that this is the only river which passes through the Caloosahatchee formation in a narrow cleft. All the other streams pass between remnants of the Caloosahatchee formation in valleys which form broad interruptions of the continuity of the Caloosahatchee outcrop zone. This suggests that the other valleys essentially acquired their present form before Pamlico inundation and sedimentation while the lower Econlockhatchee Valley was cut at a later time after withdrawal of the Pamlico sea.

Table 1 indicates name, number, location and type of discharge data collected by U.S. Geological Survey gaging stations located within the Econlockhatchee River drainage basin.

Precipitation and Evaporation

Rainfall in central Florida is quite varied both in annual amount and in seasonal distribution. In the summer rainy season, there is close to a 50-50 chance that some rain will fall on any given day. During the remainder of the year, the chances of rainfall are much less. Table 2 shows the Means and Extremes of Monthly Precipitation for Herndon Airport, Orlando based on a period of record of 30 years.

Table 3 provides data on the total evaporation in inches/month and inches/day for the North Central Florida region.

Basin Description and Land Use

The Econlockhatchee River drainage basin selected for study is located within Orange, Seminole and Osceola Counties in central Florida. The basin drains 260 square miles of the western slope of the St. Johns River basin between Orlando and Bithlo. Drainage is slow and evaporation and transpiration losses are high in the basin headwaters composed of an elongated swamp.

TABLE 1

USGS GAGING STATIONS LOCATED IN THE ECONLOCKHATCHEE RIVER BASIN

USGS Station No.	Name of Station	Location	Period of Record	Discharge Data Available
02233001-09E	Econlockhatchee River at Magnolia Ranch, Bithlo, Florida	Lat. 28° 25' 27", Long. 81° 07' 10" Orange County, on downstream side of bridge on Wewahotee Road, 250 ft. (76m) downstream of confluence of Disston Canal and 7 miles (11 km) south of Bithlo	1960 to current year	1964-67 one discharge measurement each year; Daily discharge from October 1972 to current year
02233500	Econlockhatchee River near Chuluota, Florida	Lat. 28° 40' 40", Long. 81° 06' 51" Seminole County, near right bank on downstream side of bridge on State Highway 13, 2.6 mi. (4.2 km) northeast of Chuluota and 10 miles (16 km) upstream from mouth	October 1935 to current year	Daily discharge from November 1935 to current year

TABLE 1-Continued

USGS Station No.	Name of Station	Location	Period of Record	Discharge Data Available
02233200	Little Econlockhatchee River near Union Park, Florida	Lat. 28° 31' 29", Long. 81° 14' 39" Orange County, near right bank on downstream side of bridge on Berry-Deese Road, 3,300 ft. (1,000 m), up-stream from a tributary, 3 mi. (5 km) south of Union Park, 8.5 miles (13.7 km) east of Orlando, and 13 miles (21 km) upstream from mouth	October 1959 to current year	Daily discharge from October 1959 to current year

SOURCE: U.S. Geological Survey, 1973 Water Resources Data For Florida, Part I, Surface Water Records, vol. I, Streams-Northern and Central Florida (Washington, D.C.: Government Printing Office, 1974), pp. 35-37.

TABLE 2

MEANS AND EXTREMES OF MONTHLY PRECIPITATION IN INCHES FOR THE ORLANDO AREA
(HERNDON AIRPORT)

Month	Record Mean	Maximum Monthly	Year	Minimum Monthly	Year	Max. in 24 hrs.	Year
Jan.	2.00	6.44	48	.15	50	3.35	64
Feb.	2.42	6.77	70	.10	44	4.88	70
Mar.	3.41	10.54	60	.16	56	5.03	60
Apr.	3.42	6.18	53	.28	67	2.79	53
May	3.57	8.58	57	.43	61	3.14	57
June	6.96	18.28	68	1.97	48	8.40	45
July	8.00	19.57	60	3.83	63	8.19	60
Aug.	6.94	15.19	53	3.20	60	5.29	49
Sept.	7.23	15.87	45	1.65	58	9.67	45
Oct.	3.96	14.51	50	.35	67	7.74	50
Nov.	1.57	6.39	63	.03	67	4.03	51
Dec.	1.89	4.66	69	Trace	44	3.61	69
Total	51.37	Max. 19.57	July 60	Min. Trace	Dec. 44	Max. 9.67	Sept. 45

SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Climates of The States: Climate of Florida (Washington, D.C.: Government Printing Office, 1972), p. 18.

TABLE 3

TOTAL EVAPORATION (INCHES/MONTH) FOR THE NORTH CENTRAL FLORIDA REGION (LISBON)

Year	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
65	2.79	3.40	4.48	6.43	8.24	6.42	6.43	6.08	5.32	4.14	3.00	2.23
66	2.35	3.06	5.14	6.43	6.04	6.44	5.92	5.89	5.43	4.47	3.71	2.46
67	2.91	3.35	4.91	7.64	7.89	5.60	6.15	6.09	4.99	4.53	3.78	2.83
68	2.71	3.04	4.98	6.73	7.13	5.64	6.46	5.82	5.23	4.61	3.21	2.86
69	2.65	3.29	4.16	6.58	6.96	7.39	6.33	5.34	4.69	4.11	2.64	3.17
70	2.38	3.13	4.45	6.00	7.12	6.36	6.29	5.78	5.94	4.59	3.23	3.19
71	2.92	3.71	5.15	6.27	7.73	6.80	6.49	5.81	4.82	4.62	3.17	2.78
72	2.67	2.92	5.11	6.19	6.11	7.27	7.23	5.50	5.96	4.20	2.74	2.58
73	2.30	3.23	4.93	6.46	7.55	6.54	6.39	6.04	4.47	4.53	3.69	2.90
74	3.22	4.09	5.50	6.64	7.04	6.36	5.93	5.42	4.44	4.49	3.35	2.57
Avg. (in/mo)	2.69	3.22	4.88	6.54	7.18	6.48	6.36	5.78	5.13	4.43	3.25	2.76
(in/ day)	.087	.118	.157	.218	.232	.216	.205	.186	.171	.143	.143	.089

SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Florida Climatological Data, Annual Summary 1965-1974, vol. 69-78; (Washington, D.C.: Government Printing Office, 1966-1975), vol. 69, p. 184; vol. 70, p. 163; vol. 71, p. 169; vol. 72, p. 163; vol. 73, p. 159; vol. 74, p. 171; vol. 75, p. 171; vol. 76, p. 165; vol. 77, p. 8; vol. 78, p. 8.

Figure 3 shows the basin boundary which is identified as Segment 20.1 GA.

The unit runoff for the drainage basin is 1.16 cfs per square mile.

The maximum recorded discharge at Chuluota is 11,000 cfs which is equivalent to 46 cfs per square mile.

For this investigation, a Sub-basin within the Econlockhatchee River basin was selected for sampling. One site selected was at Magnolia Ranch and was adjacent to an U.S. Geological Survey gaging station. The Sub-basin watershed is composed primarily of swamp, and woodland/meadow type terrain. The drainage area encompasses about 11% of Segment 20.1 GA. No point source effluents are contained within the Sub-basin.

The portion of Segment 20.1 GA drained by the Big Econ at Magnolia Ranch has the land use distributions shown in Table 4.

The Sub-basin drainage area is dominated by nearly level soils with a ground water table that normally fluctuates from 0 to 30 inches below the surface. The area contains sandy surface layers more than 40 inches thick.

Fig. 3

ECONLOCKHATCHEE RIVER BASIN (SEGMENT 20.1 GA)

SOURCE: Florida Department of Pollution Control, General Segment Delineation Map, (Florida Department of Pollution Control, Tallahassee, Florida, 1974).

TABLE 4

LAND USE WITHIN THE MAGNOLIA RANCH SUB-BASIN

Land Use	Area			Percent of Total Land Use
	Acres	Square Miles	Hectares	
Cultivated Land	2000	3.13	809	9.5
Pasture Land	7000	10.94	2833	33.3
Woodland/Swamps	12000	18.75	4856	57.2
Urban	0	0	0	0
Total	21000	32.82	8498	100.0

SOURCE: Florida Technological University, Environmental Systems Engineering Institute, Nonpoint Source Effects, Report for the Florida Department of Pollution Control, February 28, 1975, Orlando, Florida, p. V-21.

The predominant soils located within the Sub-basin drainage area are classified as:(15)

1. Leon Fine Sand
2. Immokalee Fine Sand
3. Pomello Fine Sand
4. St. Johns Fine Sand

CHAPTER IV

CHARACTERIZATION OF NONURBAN LAND RUNOFF

Sampling

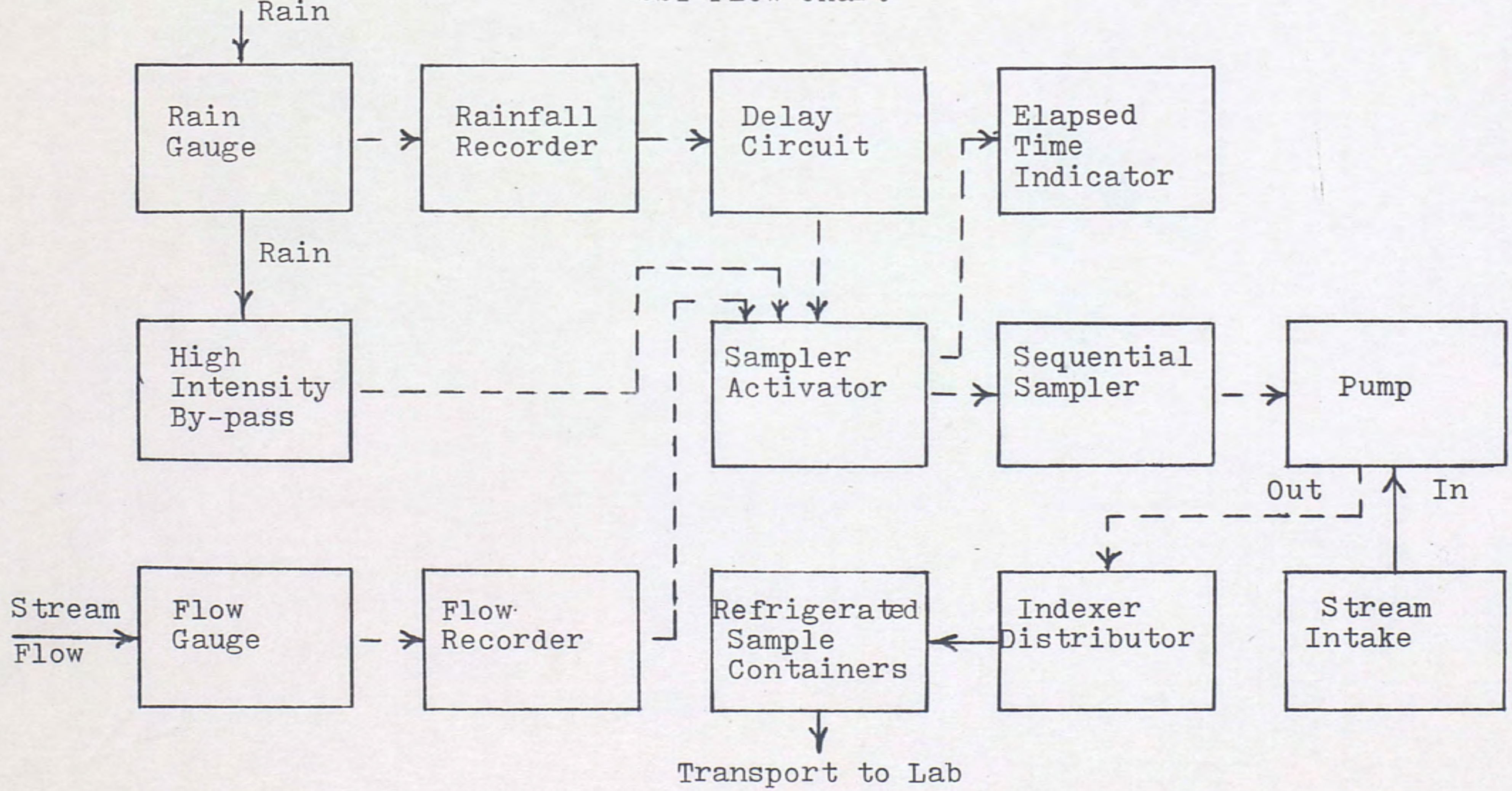
Water samples within the Econlockhatchee River basin were collected by using a Sequential Sampling Technology (SST) that was developed by Dr. Martin P. Wanielista, Associate Professor of Engineering and Ted Penland, an Undergraduate Student both of Florida Technological University.

Sequential sampling devices, rainfall intensity and quantity equipment, a refrigeration unit and other electronic components were assembled in an aluminum unit. The refrigeration unit operates on natural gas with a 30-day capacity. The temperature in the refrigerator is maintained at 3-6°C. These units are called SST's.

A schematic flow chart of an SST is shown in Figure 4. Calibration for flow rates ranging from a few milliliters to twenty-four liters can be programmed. The interval at which samples are taken can be varied from 15 minutes to 3 hours. In addition, the first sample can be delayed after rainfall in order to take the time of concentration into account. This delay time can be preset from zero to 6 hours in increments of 30 minutes.

Fig. 4

SST Flow Chart



_________Water from stream or rainfall

---------Electrical signal

The SST's were initially set up to obtain background samples at 30-minute intervals.

Later they were set to begin sampling after .01 inch of rainfall.

The samples collected by the SST's were periodically transported to the Florida Technological University Environmental Chemistry Laboratory where they were analyzed by Research Assistants for the following water quality parameters:

1. pH
2. Turbidity
3. Conductivity
4. Alkalinity
5. Hardness
6. Chemical Oxygen Demand
7. Total Solids
8. Suspended Solids
9. Dissolved Solids
10. Total Organic Carbon
11. Inorganic Carbon
12. Biochemical Oxygen Demand
13. Total Phosphorus
14. Orthophosphate
15. Nitrate Nitrogen

16. Total Kjeldahl Nitrogen
17. Total Bacterial Count
18. Total Coliform Count
19. Fecal Coliforms
20. Fecal Streptococci

Background Information

The U.S. Geological Survey conducts an extensive program to monitor our nation's waterways.

Water quality parameters that were obtained for the 1972-1973 Water Year by the U.S. Geological Survey at the Magnolia Ranch Sub-basin are shown in Table 5. Figures 5, 6, and 7 are hydrographs that show discharge conditions for the Econlockhatchee River at Magnolia Ranch during the time of sampling by the U.S. Geological Survey.

Water Quality Analysis

The parameters shown in Table 6 were obtained by Florida Technological University in conjunction with a research project on "Nonpoint Source Effects" that was performed for the Florida Department of Pollution Control.

TABLE 5

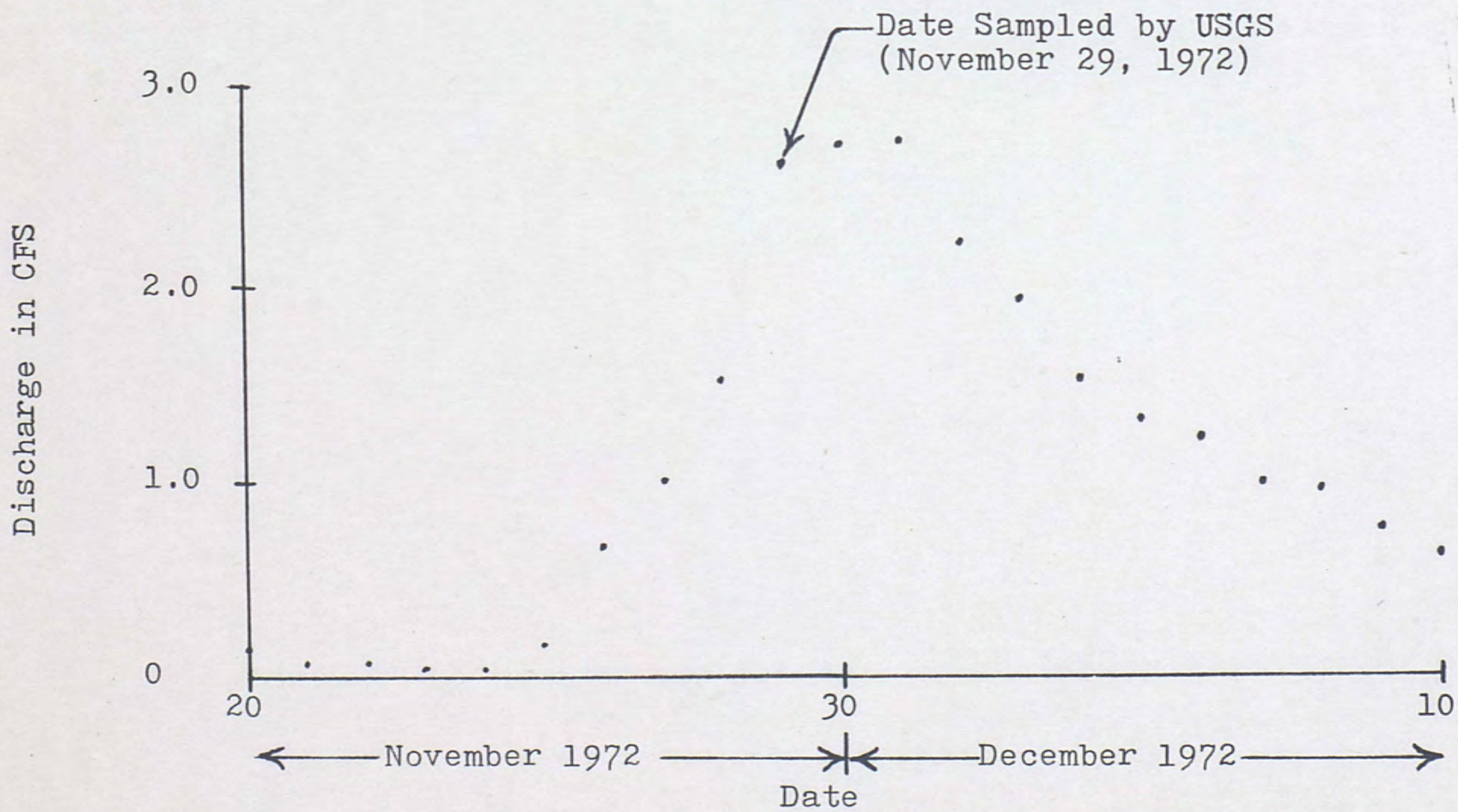
BACKGROUND INFORMATION: WATER QUALITY PARAMETERS AT MAGNOLIA RANCH, BITHLO

Parameter	Date Sampled		
	Nov. 29, 1972	Feb. 7, 1973	Sept. 26, 1973
Suspended Solids	-	-	-
Dissolved Solids (Residue) mg/l	141	97	100
BOD mg/l	0.6	0.0	1.0
Total N mg/l	1.07	.96	2.27
Ortho P (PO_4) mg/l	.04	.01	.04

SOURCE: U.S. Geological Survey, Water Resources Data for Florida, Part II - Water Quality Records (Washington, D.C.: Government Printing Office, 1974), pp. 213, 343 and 564.

Fig. 5

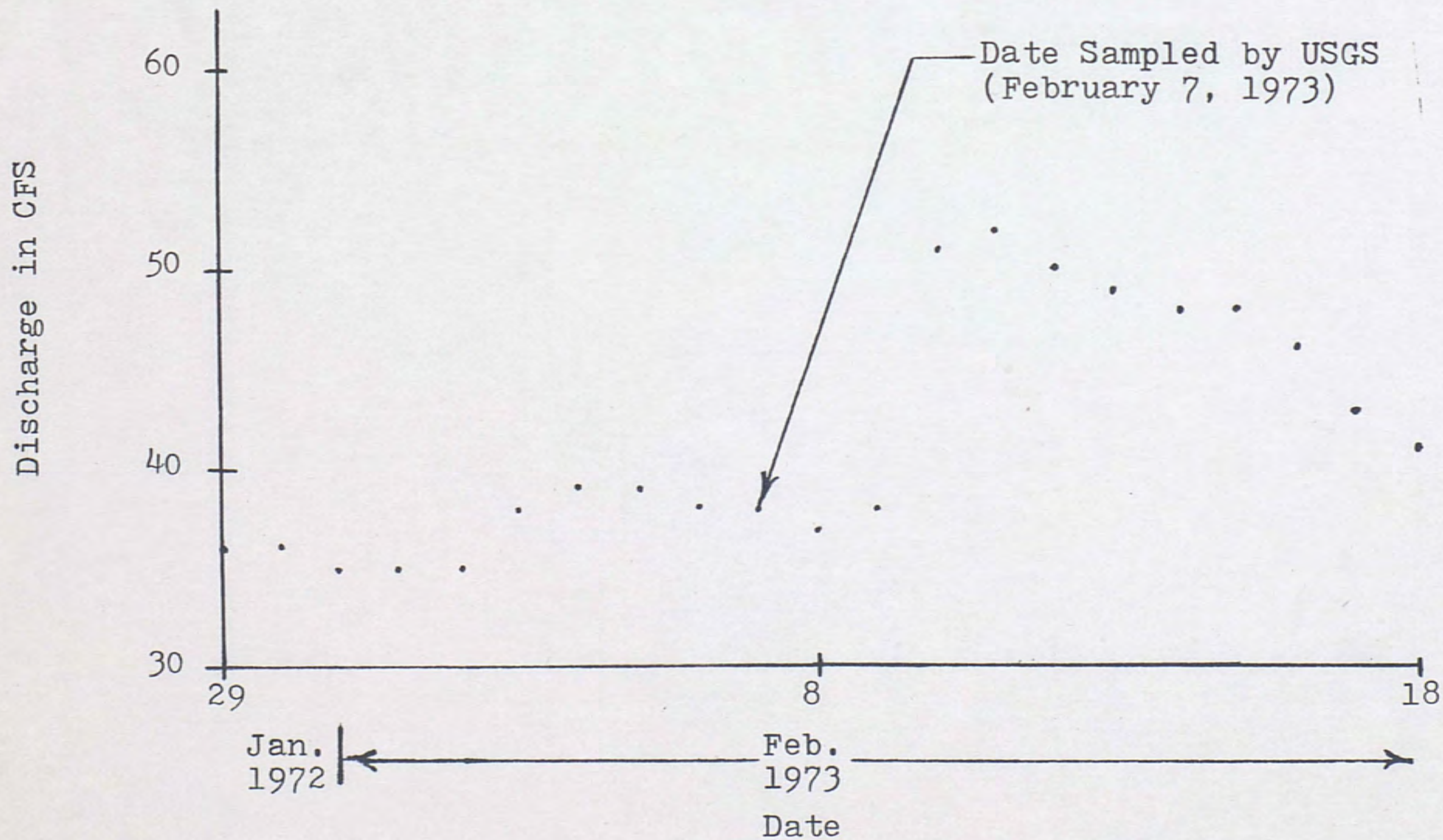
HYDROGRAPH SHOWING DISCHARGE CONDITION AT MAGNOLIA RANCH AT THE TIME OF SAMPLING BY USGS (NOV. 29, 1972)



SOURCE: U.S. Geological Survey, Water Resources Data for Florida, Part I, Surface Water Records, Vol. 1 Streams - Northern & Central Florida (Washington, D.C.: Government Printing Office, 1974), p. 35.

Fig. 6

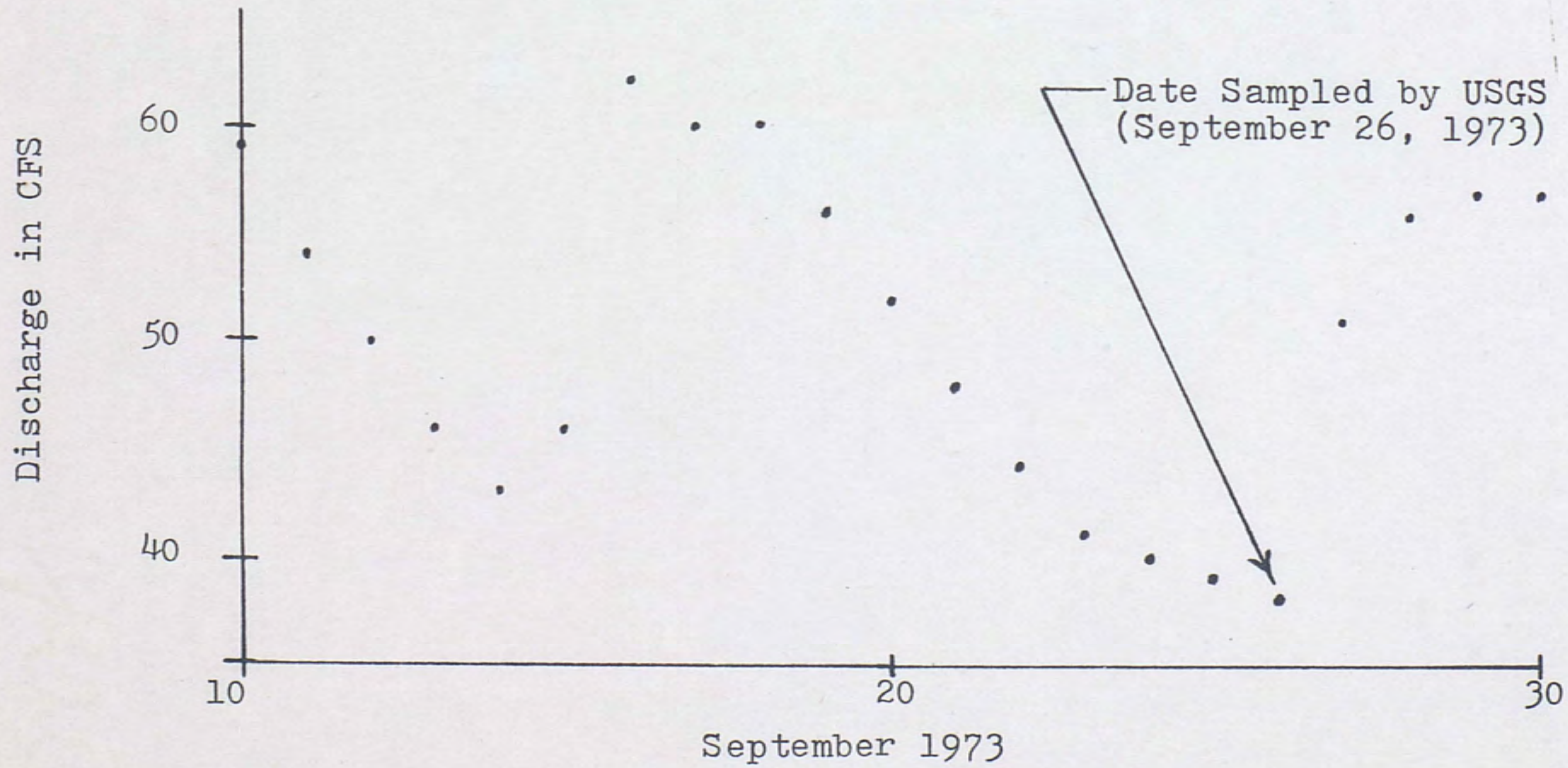
HYDROGRAPH SHOWING DISCHARGE CONDITION AT MAGNOLIA RANCH AT THE TIME OF SAMPLING BY USGS (Feb. 7, 1973)



SOURCE: U.S. Geological Survey, <u>Water Resources Data for Florida</u>, <u>Part I</u>, <u>Surface Water Records</u>, <u>Vol. 1 Streams - Northern & Central Florida</u> (Washington, D.C.: Government Printing Office, 1974), p. 35.

Fig. 7

HYDROGRAPH SHOWING DISCHARGE CONDITION AT MAGNOLIA RANCH AT THE TIME OF SAMPLING BY USGS (Sept. 26, 1973)



SOURCE: U.S. Geological Survey, <u>Water Resources Data for Florida</u>, <u>Part I, Surface Water Records</u>, <u>Vol. 1 Streams - Northern & Central Florida</u> (Washington, D.C.: Government Printing Office, 1974), p. 35.

TABLE 6

WATER QUALITY PARAMETERS FOR MAGNOLIA RANCH SUB-BASIN DURING THE SAMPLING PERIOD FROM MAY 21, 1975 TO JULY 29, 1975

Parameter and Unit	Range of Measured Values
pH, pH Units	4.70 - 5.7
Turbidity, JTU	.5 - 42.0
Conductivity, u mhos	114 - 187
Alkalinity, mg/l as $CaCO_3$	5.6 - 16.7
Hardness, mg/l as $CaCO_3$	24 - 62
Chemical Oxygen Demand, mg/l	70.4 - 88.0
Total Dissolved Solids, mg/l	134 - 220
Suspended Solids, mg/l	3.0 - 28.0
Total Organic Carbon, mg/l	55.3 - 61.6
Inorganic Carbon, mg/l	1.1 - 2.5
Biochemical Oxygen Demand, mg/l	6.8 - 8.4
Total Phosphorus, mg/l	.09 - .44
Orthophosphate, mg/l	.04 - .35
Nitrate Nitrogen, mg/l	.02 - .16
Total Kjeldahl Nitrogen, mg/l	.30 - .72
Total Bacterial Count, Count per ml	5.5×10^6 - 2.0×10^7
Total Coliform Count, Count per 100 ml	300 - 700
Fecal Coliforms, Count per 100 ml	330 - 7,000
Fecal Streptococci, Count per 100 ml	175 - 100,000

SOURCE: Dr. Yousef A. Yousef, Associate Professor of Engineering, Florida Technological University, August, 1975.

CHAPTER V

SENSITIVITY ANALYSIS USING "STORM"

Method of Attack

Several runs were made using the "STORM" model. Parameters such as pollutant loading rate and the percent urbanization within the watershed were varied to determine their effect on the concentration of pollutants to receiving waters. A summary of the input criteria to the "STORM" model is shown in Appendix II.

Appendix III shows the actual input and output format of the model.

Pollutant Loading Rates

Table 7 shows a comparison between the average pollutant loading rates recommended by Florida Technological University and those recommended by the "STORM" program. It can be seen from this table that a few values vary substantially. One possible reason for this is that the values recommended by Florida Technological University were obtained by using data that pertained mainly to the Florida environment. It is believed that the values given by "STORM" were meant to represent a national average of pollutant loading rates.

TABLE 7

COMPARISON OF POLLUTANT LOADING RATES

Land Use	Average Loading Rates in lb./acre/day						
	Florida Techological University*				"STORM"**		
	BOD	Sus. Solids	N	PO_4	BOD	N	PO_4
Urban	.1833	4.1548	.0208	.0049	-	-	-
Pasture	.0269	2.0530	.0130	.0007	3.1	.5	.35
Cultivated	.0440	10.2648	.0635	.0026	.02	.23	.07
Woodland	.0122	.2395	.0076	.00024	.01	.002	.00002
Open Space & Rural	-	-	-	-	.03	.007	.003

SOURCE: *Florida Technological University, Environmental Systems Engineering Institute, Nonpoint Source Effects, Report for the Florida Department of Pollution Control, February 28, 1975, Orlando, Florida, pp. II-6 to II-9.

**U.S. Army Corps of Engineers, "Urban Storm Water Runoff 'STORM'," p. 101.

Table 8 is representative of the Urban Pollutant Loading Rates recommended by "STORM" and is classified according to Urban Land Use.

The values given by FTU for urban pollutant loadings were not subdivided according to land use.

Table 9 shows how a weighted average value for pollutant loading rates was calculated for the Magnolia Ranch Sub-basin. The FTU nonurban loading rates were used since it was felt that they would be more applicable to Florida loadings.

Pollutant loadings in the basic model were varied from 50 to 200 percent of the calculated average loading rate while holding the land use constant.

Table 10 shows the different values of the nonurban loading rates that were used for the "STORM" model.

A parametric study was performed in order to verify that pollutant loading rates are directly proportional to the concentration of pollutants to receiving waters.

Table 11 shows the actual model output in terms of concentration of pollutants to receiving waters for the various percentages of average loading rates.

Figures 8 through 12 illustrate graphically how the concentration of pollutants to receiving waters (output) varies with pollutant loading rates (input) for the existing nonurban land use.

TABLE 8

URBAN POLLUTANT LOADING RATES RECOMMENDED BY "STORM"

Land Use	Sweeping Interval-Days	Daily Rate of Accum. of Dust & Dirt (DD) lbs/day/100 ft. of gutter	Lbs. Pollutant/100 Lbs. DD				
			SUS	SET	BOD	N	PO_4
Single Family Res.	90.0	.7	11.1	1.1	.500	.048	.005
Mult. Family Res.	90.0	2.3	8.0	.8	.360	.061	.005
Commercial	90.0	3.3	17.0	1.7	.770	.041	.007
Industrial	90.0	4.6	6.7	.7	.300	.043	.003
Open or Park	90.0	1.5	11.1	1.1	.500	.048	.005

SOURCE: U.S. Army Corps of Engineers, "Urban Storm Water Runoff 'STORM'," p. 100.

TABLE 9

POLLUTANT LOADING RATES FOR MAGNOLIA RANCH SUB-BASIN

		Loading Rates* (lb/acre/day)				Weighted Value (lb/acre/day)			
Land Use	% of Total Land Use	BOD	N	PO_4	Sus. Solids	BOD	N	PO_4	Sus. Solids
Cultivated	9.5	.0440	.0635	.0026	10.2648	.00418	.00603	.00025	.97516
Pasture	33.3	.0269	.0130	.0007	2.0530	.00896	.00433	.00023	.68365
Woodland/ Swamp	57.2	.0122	.0076	.000244	.2395	.00698	.00435	.00014	.13700
Urban	0	.1833	.0208	.0049	4.1548	0	0	0	0
Weighted Value for Total Sub-basin (lb/acre/day) =						.02012	.01471	.00062	1.79581

*SOURCE: Florida Technological University, Environmental Systems Engineering Institute, Nonpoint Source Effects, Report for the Florida Department of Pollution Control, February 28, 1975, Orlando, Florida, pp. II-6-II-9.

TABLE 10

NONURBAN POLLUTANT LOADING RATES USED IN "STORM" (FIXED LAND USE)

Run	% of Average Loading	Nonurban Loading Rate Lb/Acre/Day				
		Suss. Solids	Settl. Solids	BOD	N	PO_4
1	50	.8979	.5000	.01006	.00735	.00031
2	75	1.3468	.7500	.01509	.01103	.00046
3	100	1.7958	1.0000	.02012	.01471	.00062
4	150	2.6937	1.5000	.03018	.02206	.00093
5	200	3.5916	2.0000	.04024	.02942	.00124

TABLE 11

EFFECT OF LOADING RATES ON CONCENTRATION OF POLLUTANTS TO RECEIVING WATER (FIXED LAND USE)*

Run	% of Average Loading	Concentration of Pollutants In Overflow To Receiving Water (mg/l) Predicted by "STORM"				
		Sus. Solids	Settl. Solids	BOD	N	PO_4
1	50	113.05	62.95	1.27	0.93	0.04
2	75	169.57	94.43	1.90	1.39	0.06
3	100	226.11	125.91	2.53	1.85	0.08
4	150	339.16	188.86	3.80	2.78	0.12
5	200	452.22	251.82	5.07	3.70	0.16

*Predicted by "STORM"

Fig. 8

SUSPENDED SOLIDS LOADING RATE VS. CONCENTRATION
OF SUSPENDED SOLIDS TO RECEIVING WATERS
(FIXED LAND USE)*

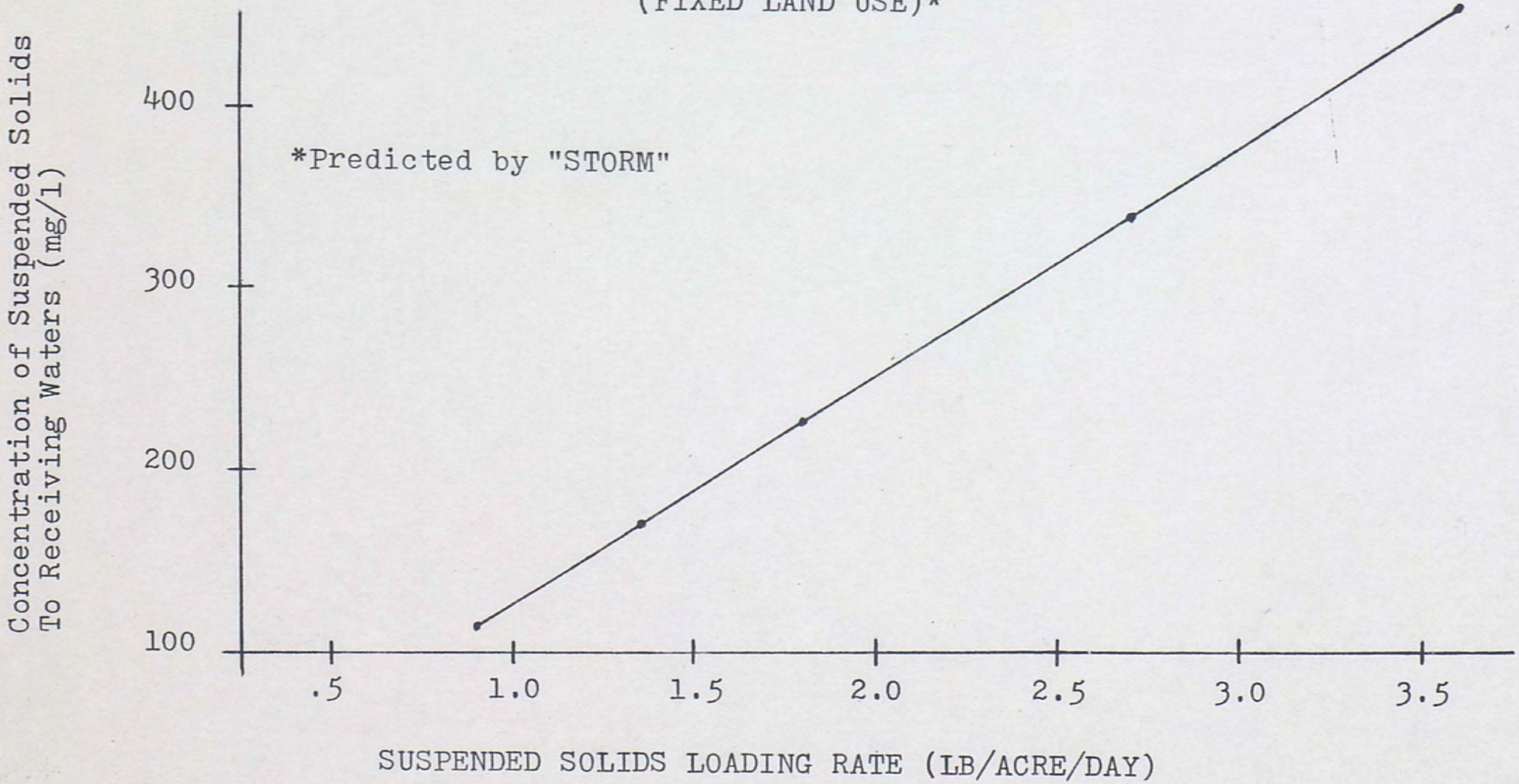


Fig. 9

SETTLEABLE SOLIDS LOADING RATE VS. CONCENTRATION OF SETTLEABLE SOLIDS TO RECEIVING WATERS (FIXED LAND USE)*

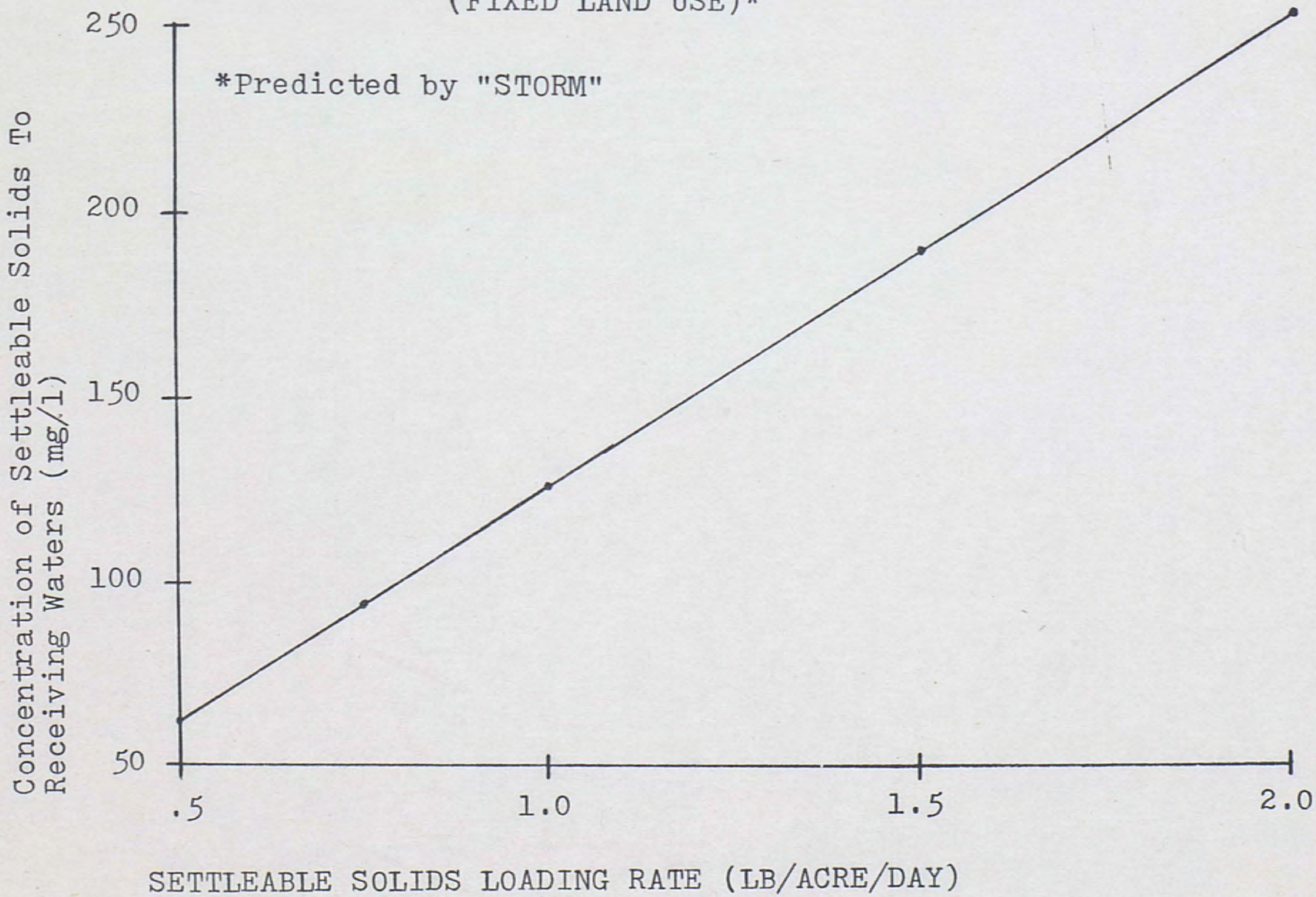


Fig. 10

BOD LOADING RATE VS. CONCENTRATION OF BOD TO RECEIVING WATERS (FIXED LAND USE)*

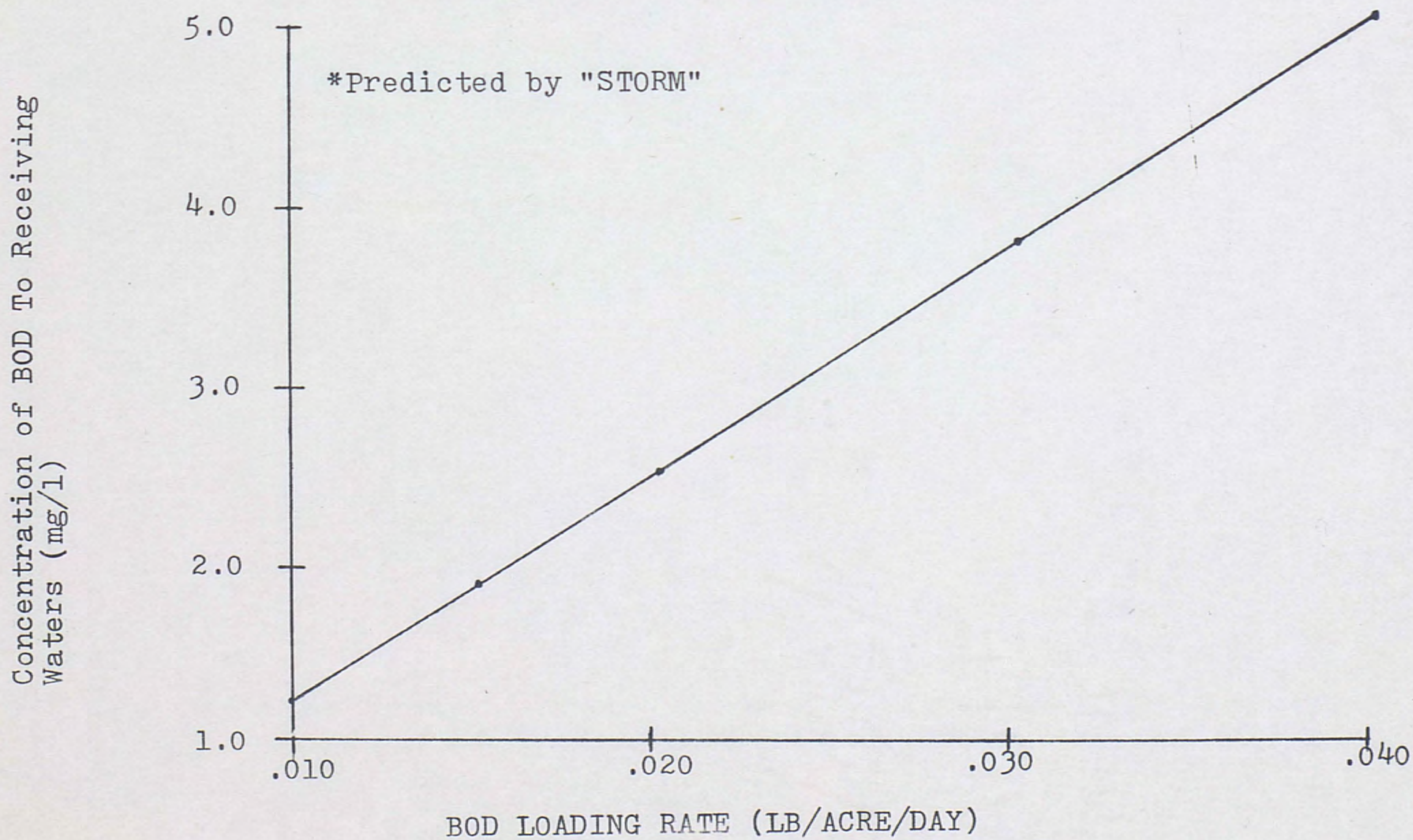


Fig. 11

TOTAL NITROGEN LOADING RATE VS. CONCENTRATION OF TOTAL NITROGEN TO RECEIVING WATERS (FIXED LAND USE)*

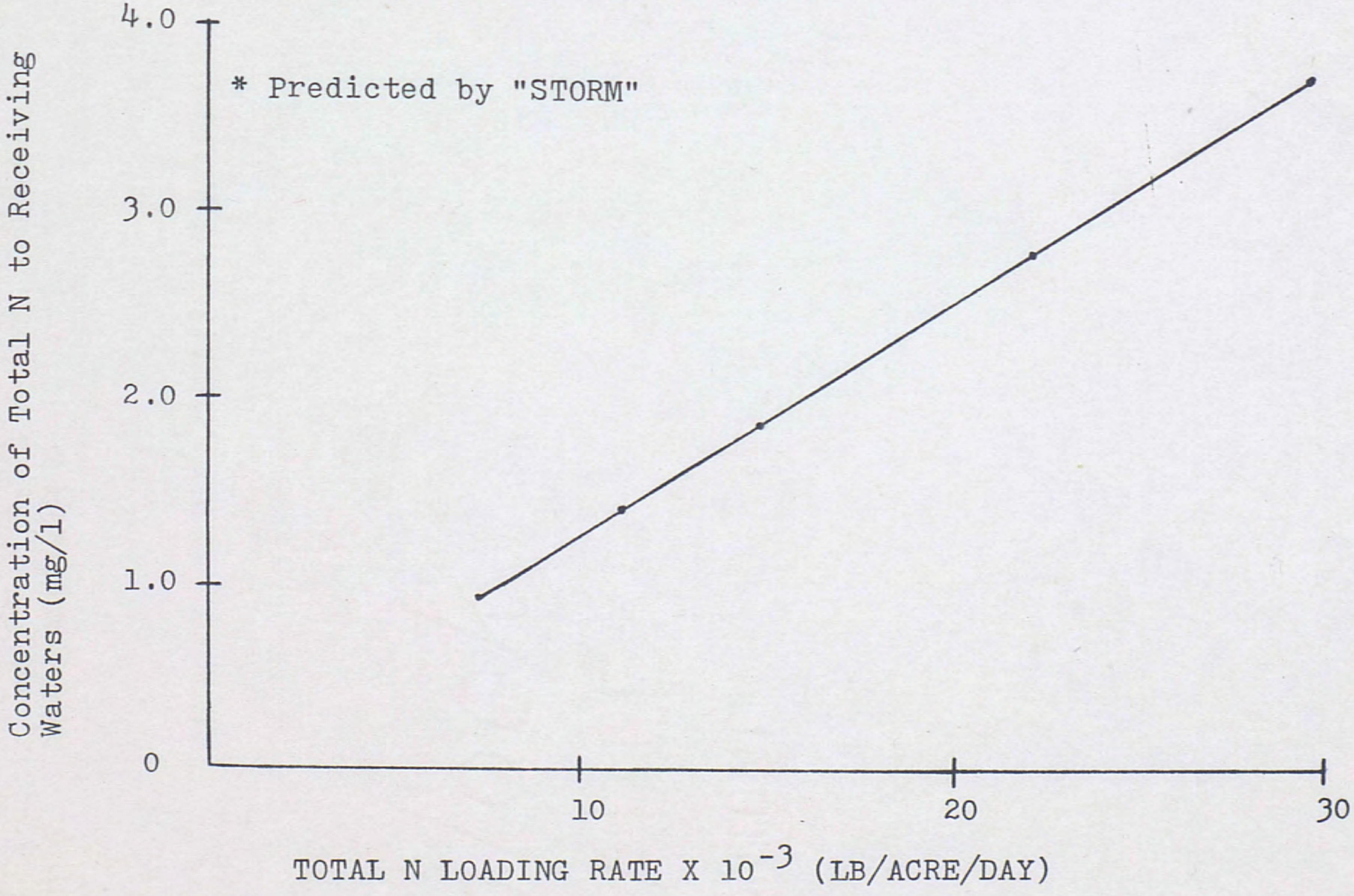
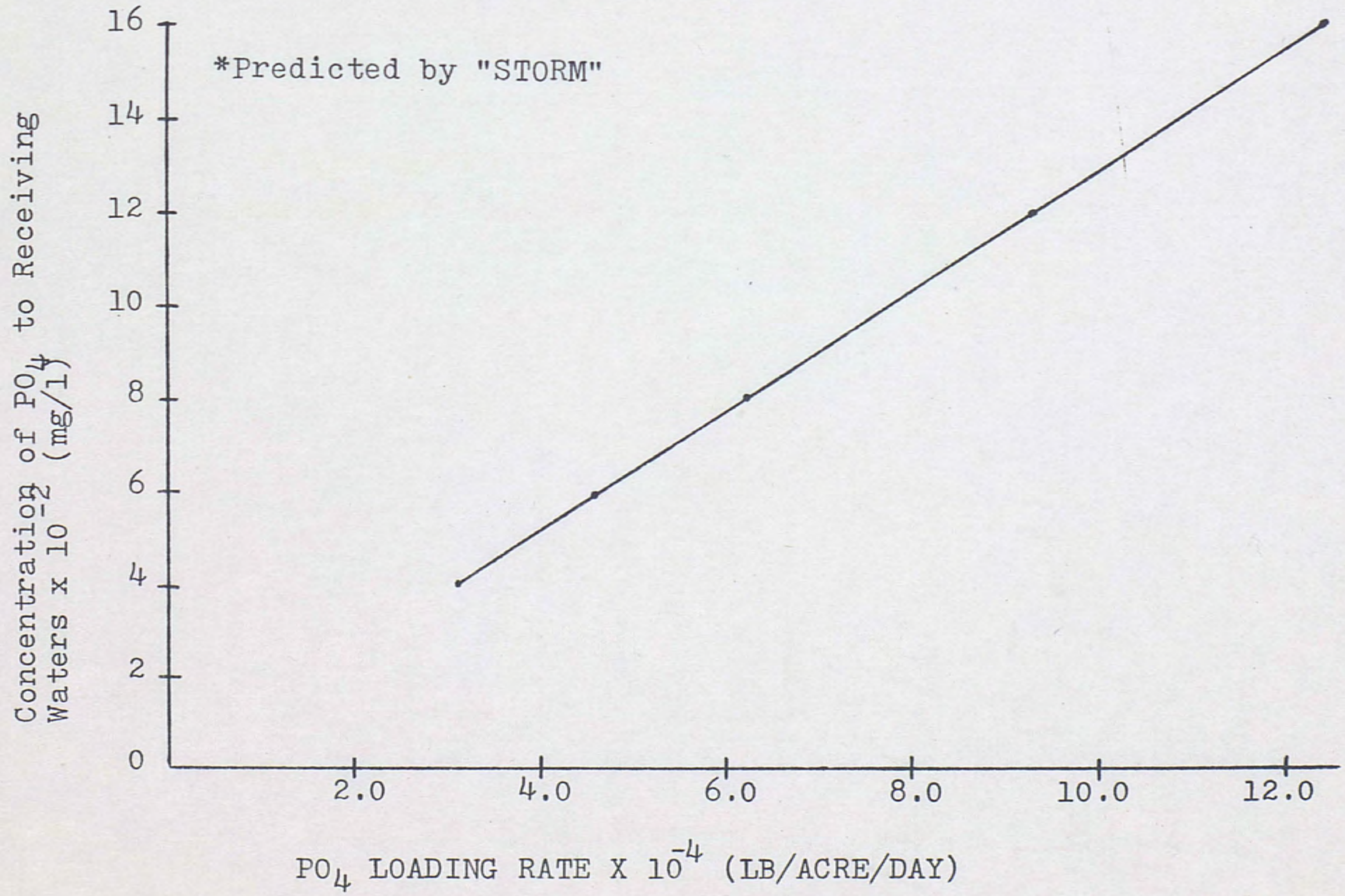


Fig. 12

PO_4 LOADING RATE VS. CONCENTRATION OF PO_4 TO RECEIVING WATERS (FIXED LAND USE)*



Effect of Urbanization

The "STORM" model has been used to predict the effect of urbanization upon both the concentration of pollutants to receiving waters and the total pounds/year of pollutant washoff.

The Magnolia Ranch Sub-basin is presently a nonurban watershed (zero percent urban). The effect of urbanization was simulated by increasing the urban (single family residential) acreage in the model while decreasing the nonurban acreage proportionately. The urbanization values used in the model were 0, 25, 50, 75 and 100 percent. Single family urbanization (20% single family and 80% open space) was assumed since it was felt that this is the most likely type of potential development for the watershed.

Table 12 illustrates the effect of urbanization (input) on the quality of pollutant runoff (output).

Figures 13 through 17 show graphically the data presented in Table 12.

These figures illustrate that as urbanization is increased, the pollutant runoff concentration decreased when the "STORM" urban loading rates were used with the FTU nonurban loading rates. Engineering judgement would indicate that this situation would be highly unlikely. Upon examination of the loading rates, it can be seen that the "STORM" urban loading rates are much lower than the FTU nonurban loadings. Thus, as the percent urbanization was increased in the model, the loadings were, in effect, being decreased. This points out one of the pitfalls in using data from two different sources which actually contradict one another (in general, the urban loadings should be higher than the nonurban).

The FTU urban loadings were then input in the model in conjunction with the FTU nonurban loadings. It can be seen from Figures 13 through 17 that as urbanization increased, the concentration of pollutants to receiving waters also increased. These results are more reasonable and appropriate for this type of development.

Table 14 shows the effect of urbanization (input) upon the total pounds/year of pollutant washoff (output) for both the FTU and "STORM" urban loading rates.

Figures 18 through 22 are graphical illustrations of the data presented in Table 14.

TABLE 12

EFFECT OF PERCENT URBANIZATION ON CONCENTRATION OF POLLUTANTS TO RECEIVING WATER (FIXED POLLUTANT LOADING RATE) PREDICTED BY "STORM"

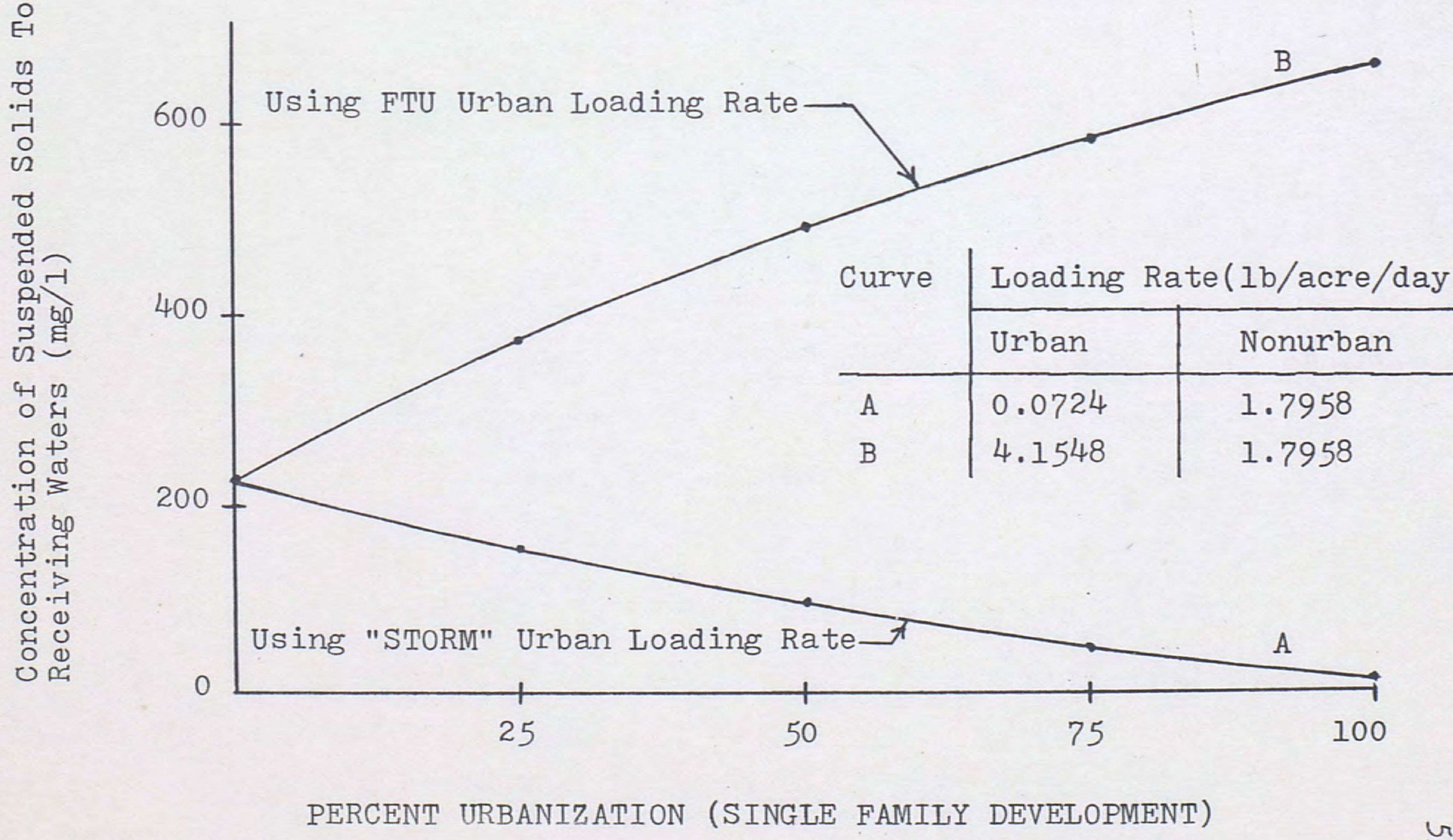
Percent Urban	Concentration of Pollutants In Overflow To Receiving Water (mg/l)									
	Using "STORM" Urban Loadings*					Using FTU Urban Loadings*				
	Sus.	Settl.	BOD	N	PO_4	Sus.	Settl.	BOD	N	PO_4
0	226.11	125.91	2.53	1.85	0.08	226.11	125.91	2.53	1.85	0.08
25	152.94	83.34	2.25	1.44	0.07	375.01	208.49	11.65	2.35	0.32
50	95.64	50.00	2.04	1.12	0.07	491.61	273.16	18.78	2.74	0.50
75	49.55	23.19	1.86	0.86	0.07	585.39	325.17	24.52	3.06	0.66
100	11.68	1.16	1.72	0.65	0.06	662.44	367.91	29.24	3.32	0.78

*FTU Nonurban Loadings were used with these Urban Loadings.

NOTE: The Urban FTU Settl. solid loading rate was assumed at .55 X Suspended solid loading rate.

Fig. 13

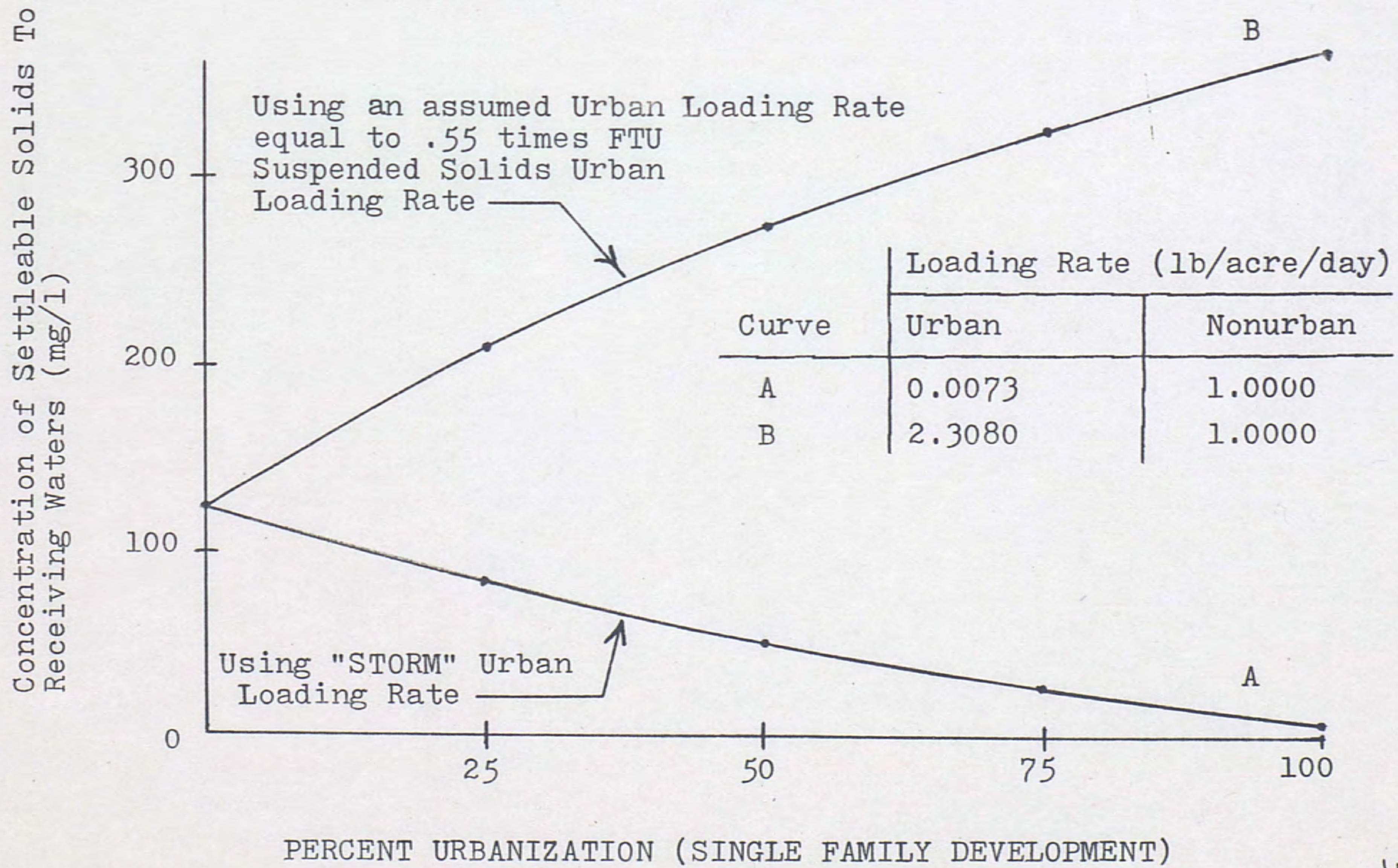
PERCENT URBANIZATION VS. CONCENTRATION OF SUSPENDED SOLIDS TO RECEIVING WATERS (FIXED POLLUTANT LOADING) PREDICTED BY "STORM"



Curve	Loading Rate(lb/acre/day)	
	Urban	Nonurban
A	0.0724	1.7958
B	4.1548	1.7958

Fig. 14

PERCENT URBANIZATION VS. CONCENTRATION OF SETTLEABLE SOLIDS TO RECEIVING WATERS (FIXED POLLUTANT LOADING) PREDICTED BY "STORM"



Curve	Loading Rate (lb/acre/day) Urban	Nonurban
A	0.0073	1.0000
B	2.3080	1.0000

Fig. 15

PERCENT URBANIZATION VS. CONCENTRATION OF BOD TO RECEIVING WATERS (FIXED POLLUTANT LOADING) PREDICTED BY "STORM"

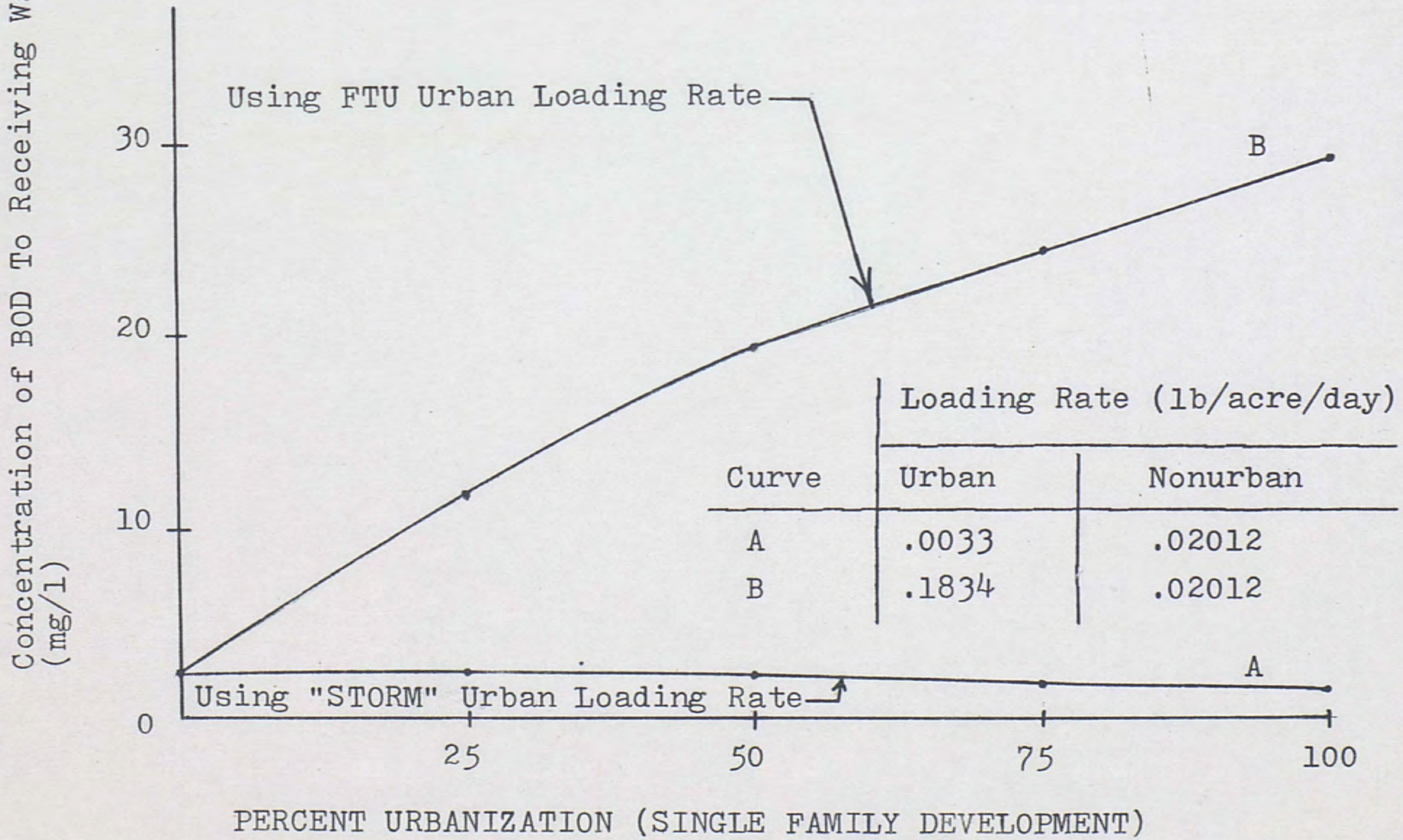
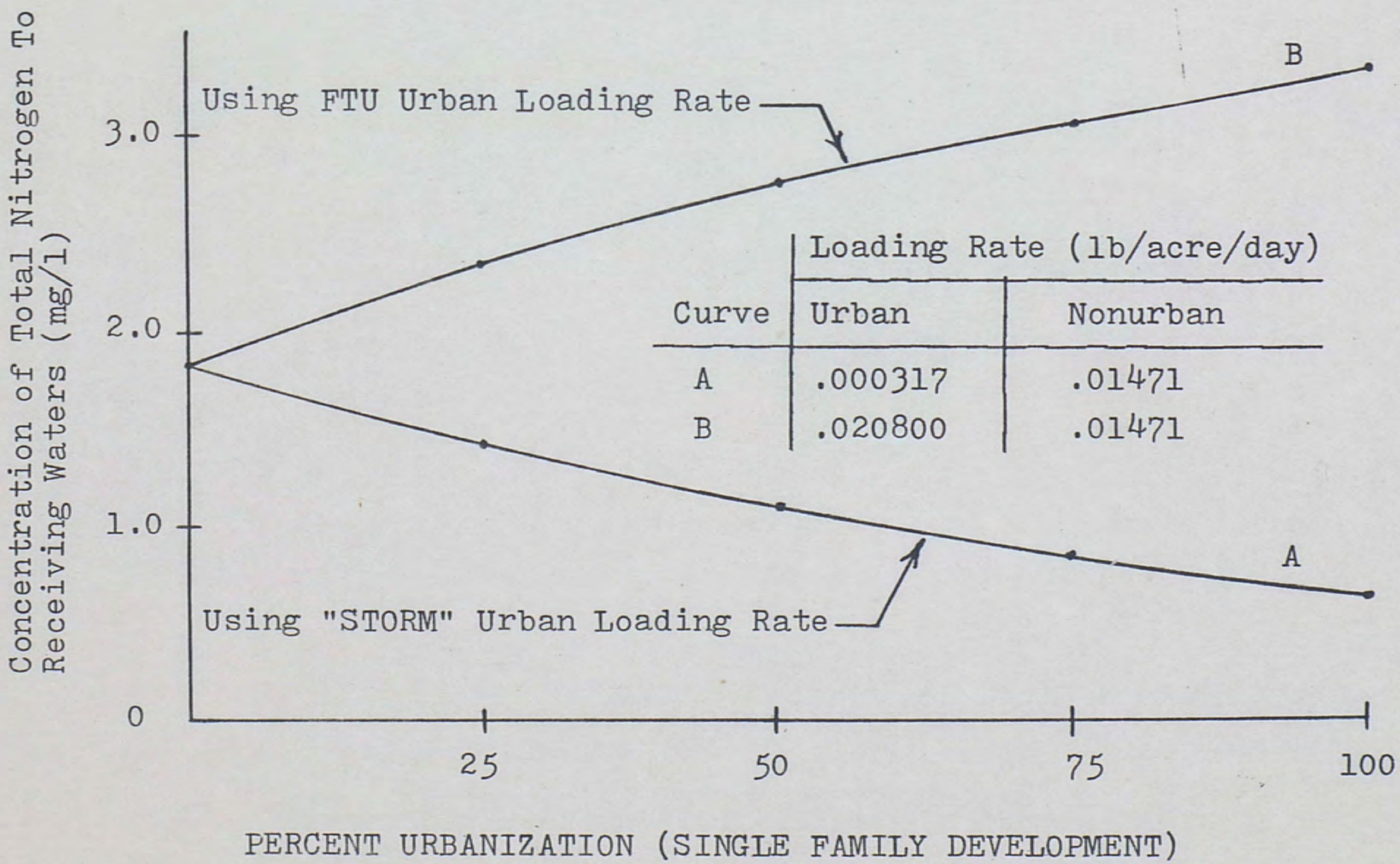


Fig. 16

PERCENT URBANIZATION VS. CONCENTRATION OF TOTAL NITROGEN TO RECEIVING WATERS (FIXED POLLUTANT LOADING) PREDICTED BY "STORM"



Curve	Loading Rate (lb/acre/day)	
	Urban	Nonurban
A	.000317	.01471
B	.020800	.01471

Fig. 17

PERCENT URBANIZATION VS. CONCENTRATION OF PO_4 TO RECEIVING WATERS (FIXED POLLUTANT LOADING) PREDICTED BY "STORM"

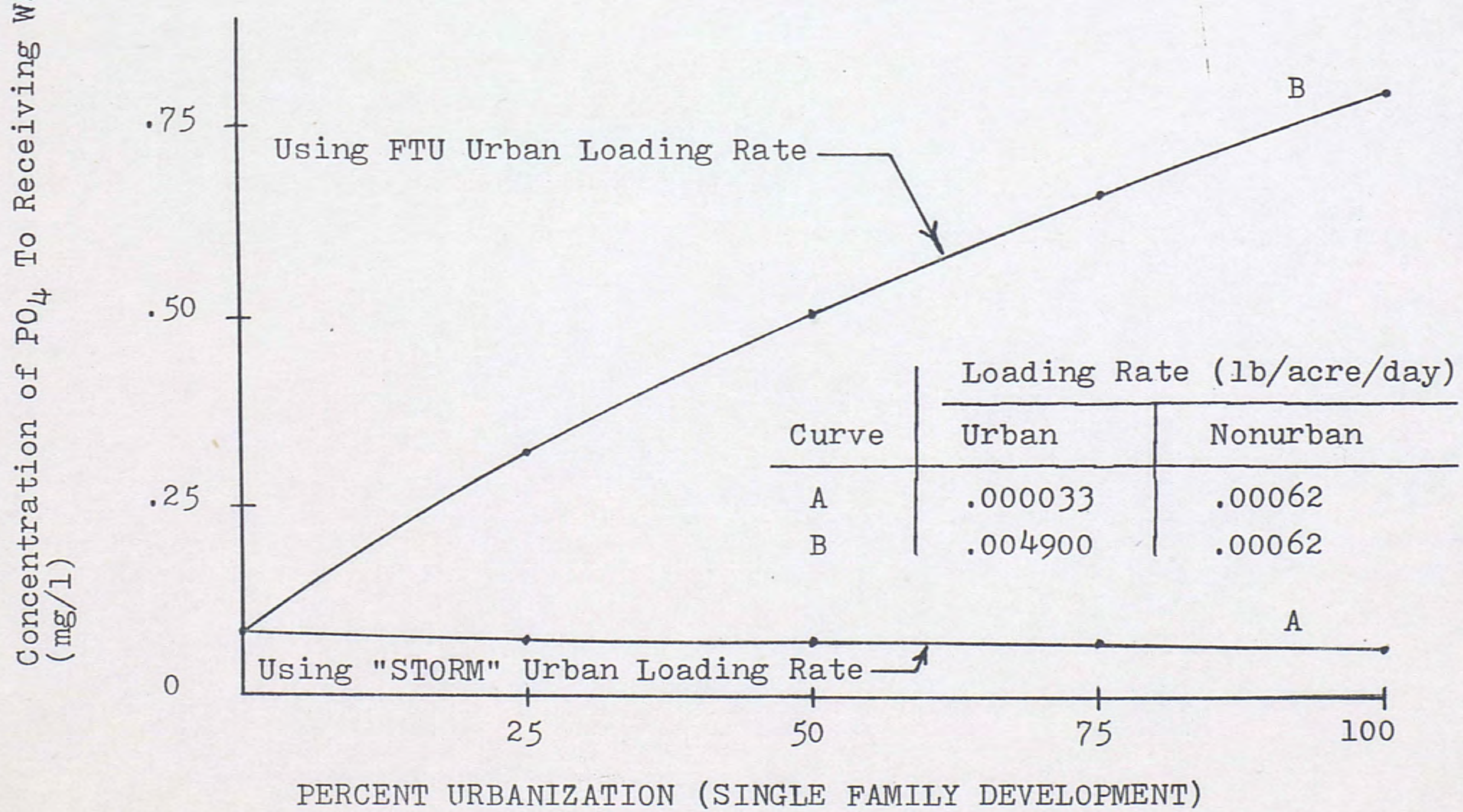


TABLE 13

CALCULATIONS FOR URBAN "STORM" LOADINGS
(FOR ASSUMED GUTTER LENGTHS)

Land Use	Assumed Gutter Length Ft/Acre	DD Rate* Lb./day/100 ft. of gutter	Pollutant Loading, lbs/acre/day				
			Sus.	Settl.	BOD	NIT	PO_4
Single Family Residential	300	.7	.2331	.0231	.0105	.001008	.000105
Open or Park	20	1.5	.0333	.0033	.0015	.000144	.000015
Weighted For: 20% Single Family 80% Open or Park			.0724	.0073	.0033	.000317	.000033

Pollutant loading (lbs/acre/day)=

$$\frac{\text{DD rate (lbs/day/100 ft. of gutter)* X Pollutant loading in lbs. of pol./100 lbs. DD* X Gutter Length (Ft./Acre)}}{100\ \frac{\text{lb.}}{\text{100 lb.}} \quad \text{X} \quad 100\ \frac{\text{ft.}}{\text{100 ft.}}}$$

*Figures obtained from Table 8

TABLE 14

EFFECT OF PERCENT URBANIZATION ON TOTAL POUNDS/YEAR OF POLLUTANT WASHOFF (FIXED LAND USE) PREDICTED BY "STORM"

Percent Urban	Total Pounds/Year of Pollutant Washoff									
	Using "STORM" Urban Loadings*					Using FTU Urban Loadings*				
	Sus. X 10^6	Settl. X 10^6	BOD X 10^3	N X 10^3	PO_4 X 10^3	Sus. X 10^6	Settl. X 10^6	BOD X 10^3	N X 10^3	PO_4 X 10^3
0	6.72	3.74	75.25	55.01	2.31	6.72	3.74	75.25	55.01	2.31
25	5.17	2.82	76.25	48.72	2.47	12.68	7.05	393.87	79.52	10.73
50	3.63	1.90	77.26	42.41	2.64	18.65	10.36	712.51	104.04	19.15
75	2.08	.97	78.27	36.13	2.81	24.61	13.67	1,031.13	128.57	27.57
100	.54	.53	79.27	29.82	2.99	30.58	16.98	1,349.75	153.08	35.98

*FTU Nonurban Loadings were used with these Urban Loadings.

NOTE: The Urban FTU Settl. solid loading rate was assumed at .55 X Suspended solid loading rate.

Fig. 18

PERCENT URBANIZATION VS. TOTAL POUNDS/YEAR OF
SUSPENDED SOLIDS WASHOFF (FIXED LAND USE)
PREDICTED BY "STORM"

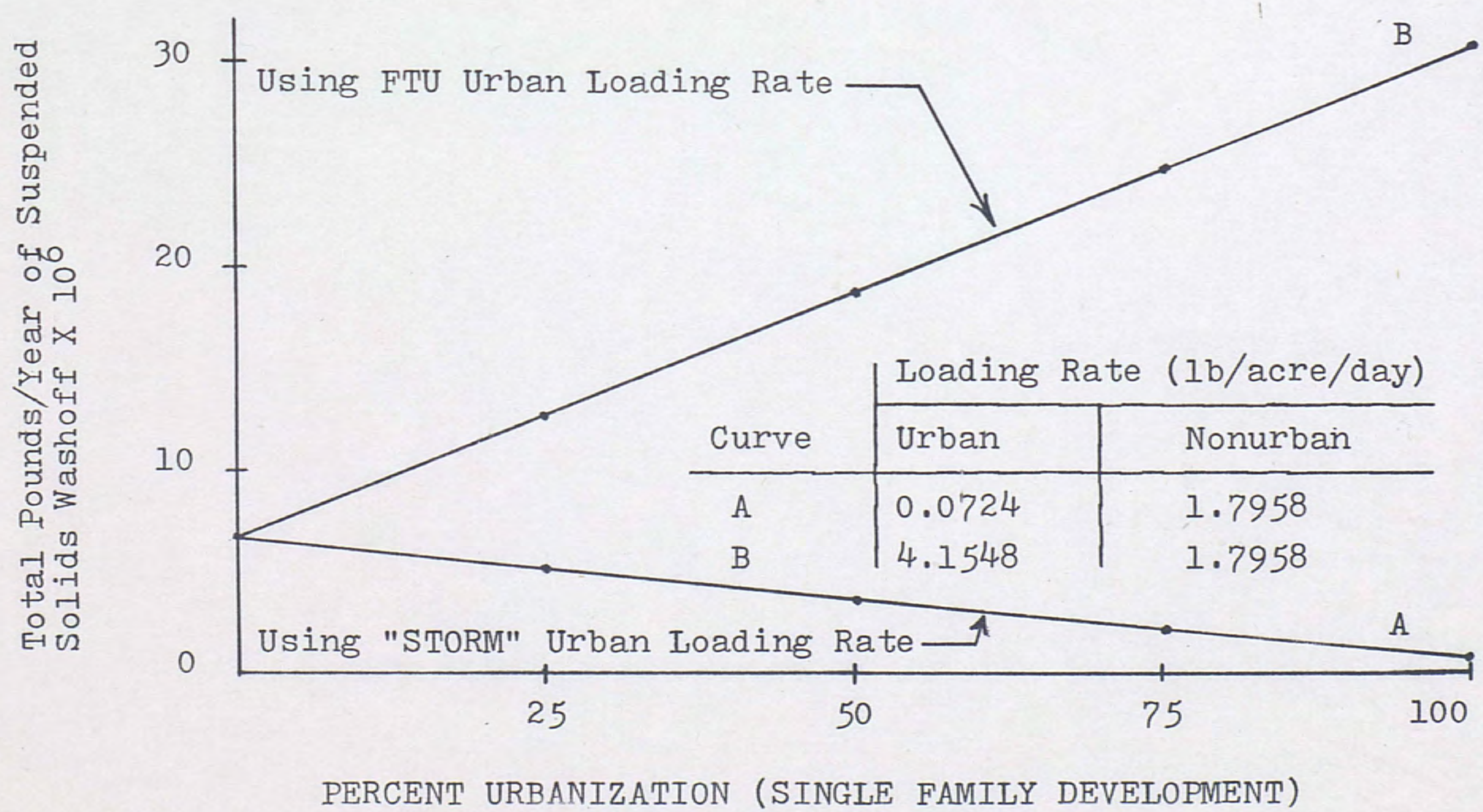


Fig. 19

PERCENT URBANIZATION VS. TOTAL POUNDS/YEAR OF SETTLEABLE SOLIDS WASHOFF (FIXED LAND USE) PREDICTED BY "STORM"

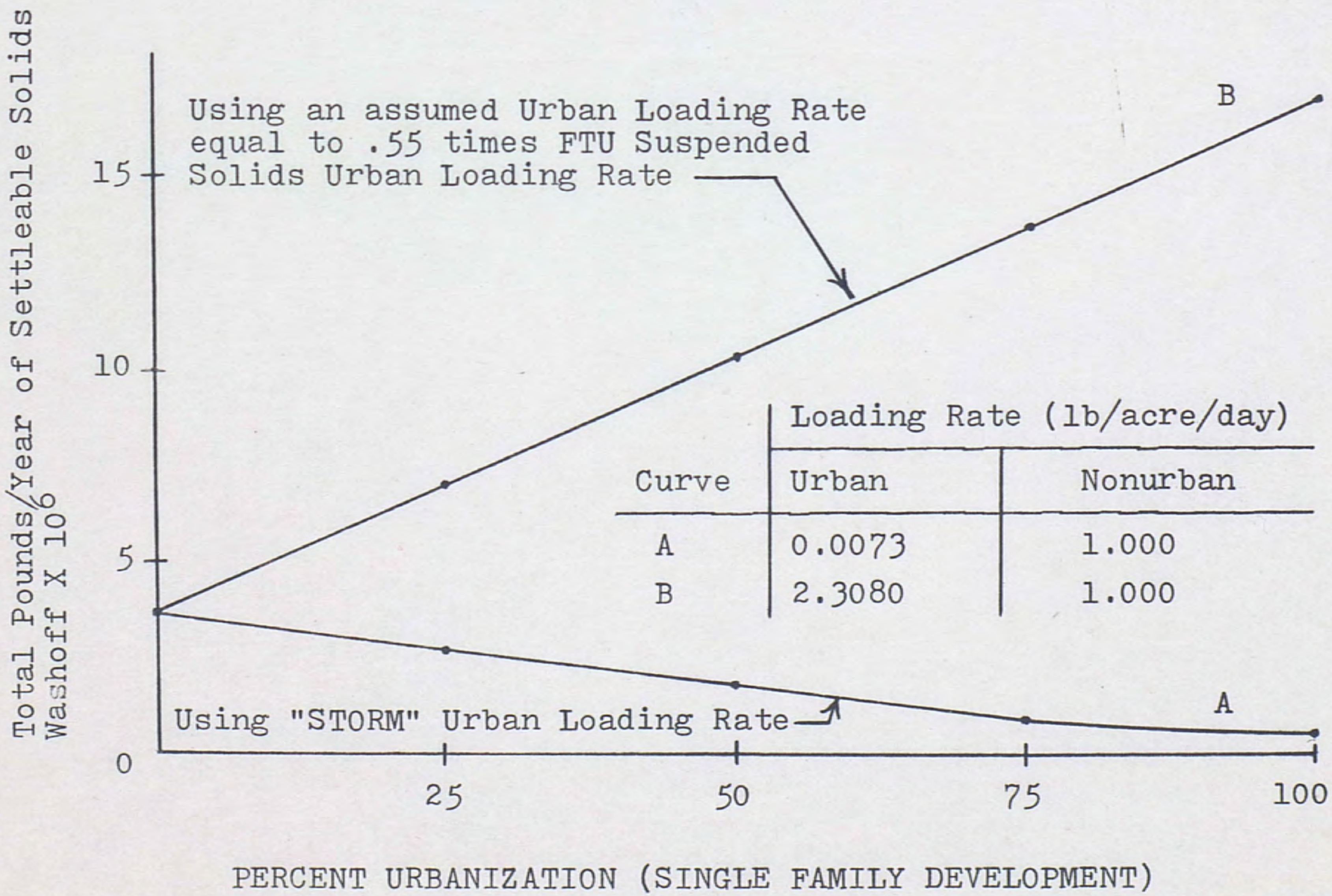


Fig. 20

PERCENT URBANIZATION VS. TOTAL POUNDS/YEAR OF BOD WASHOFF (FIXED LAND USE) PREDICED BY "STORM"

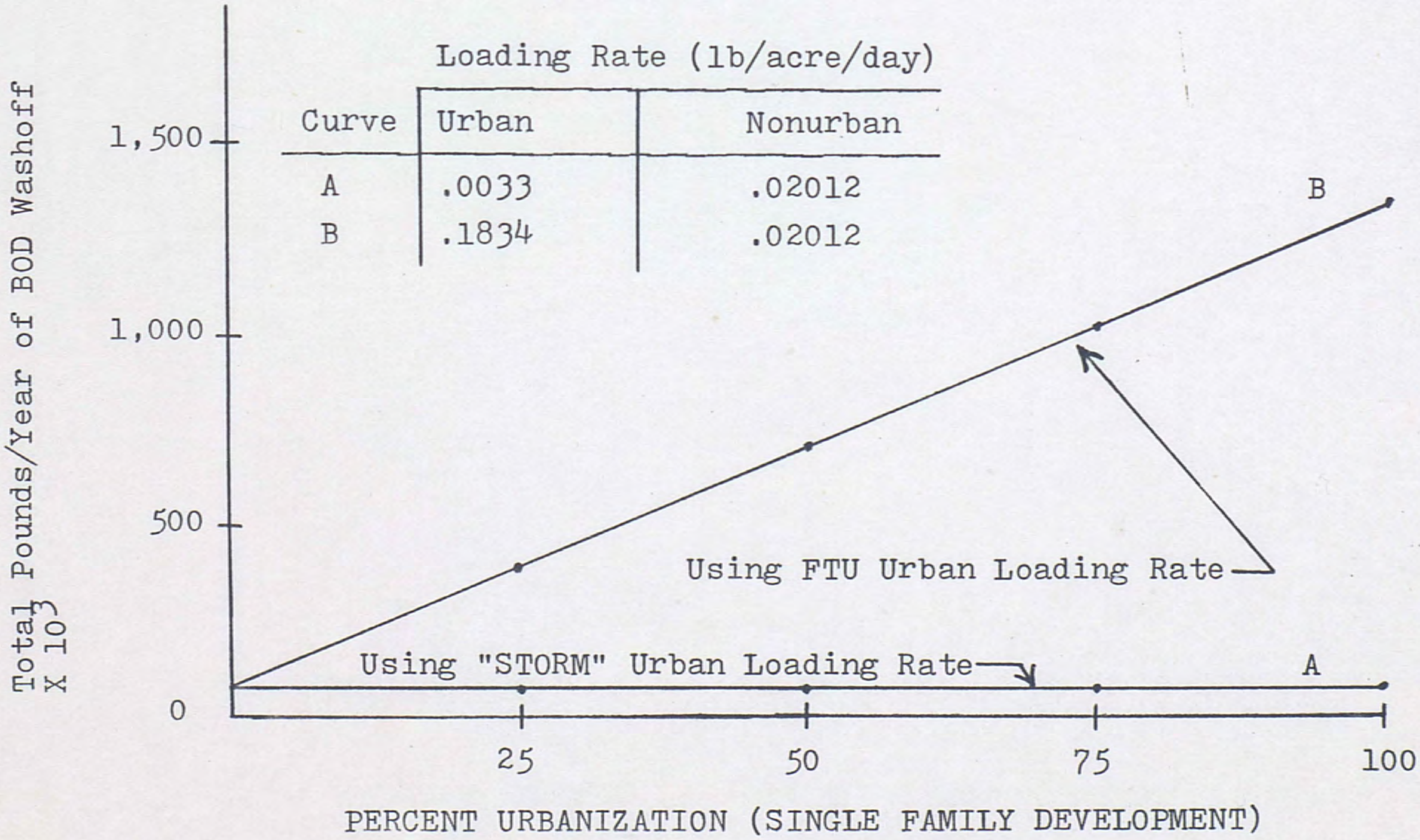


Fig. 21

PERCENT URBANIZATION VS. TOTAL POUNDS/YEAR OF TOTAL NITROGEN WASHOFF (FIXED LAND USE) PREDICTED BY "STORM"

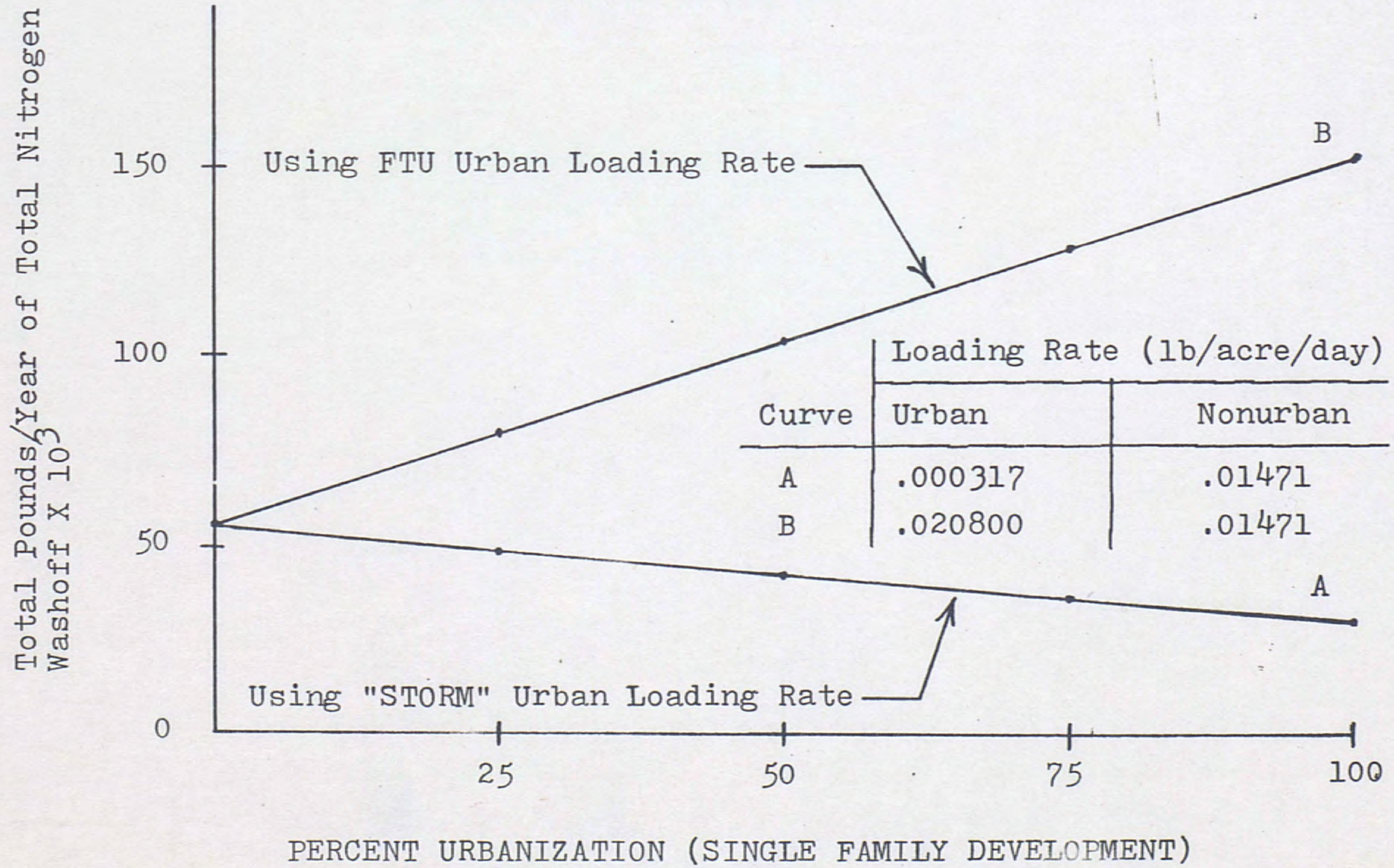
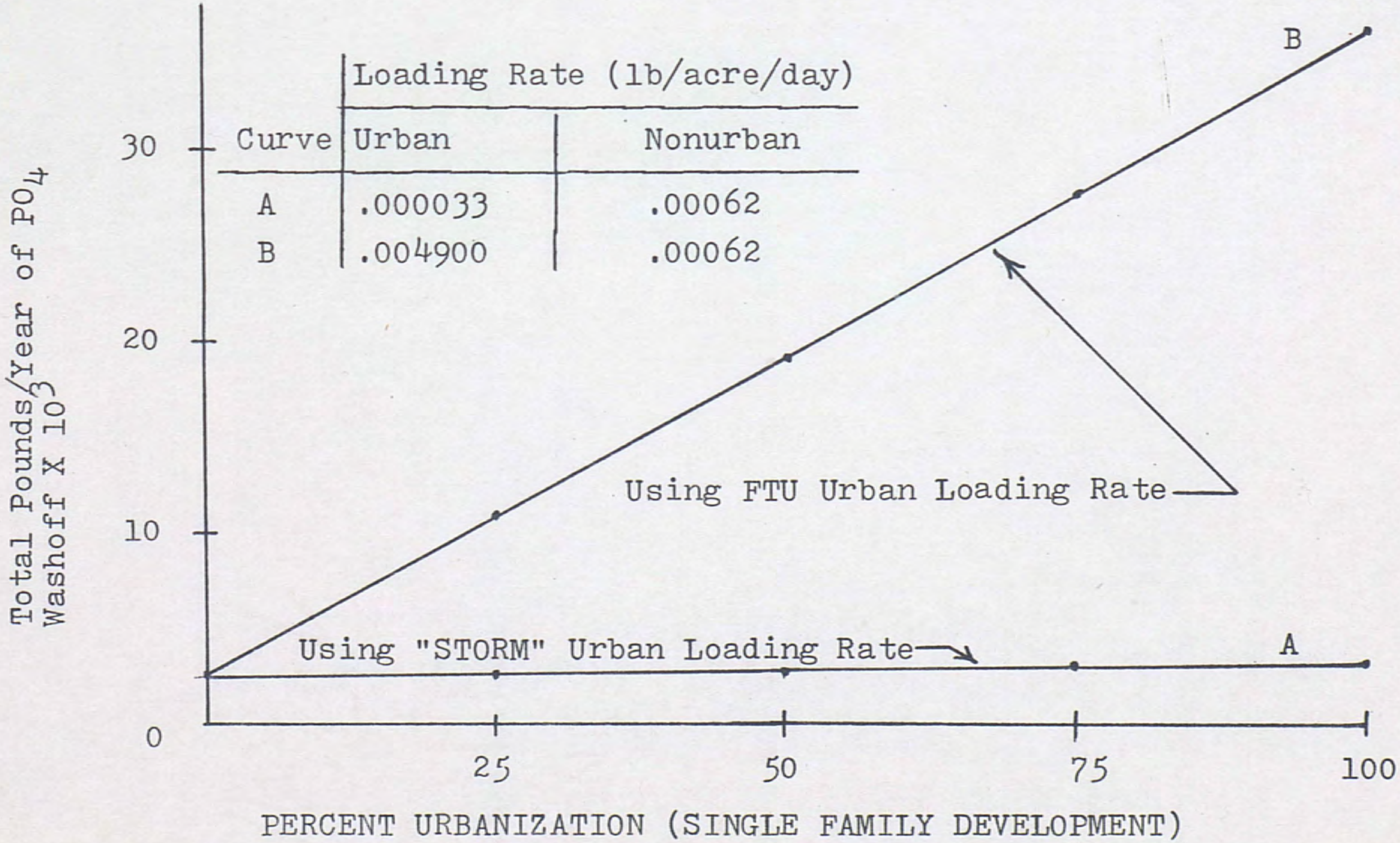


Fig. 22

PERCENT URBANIZATION VS. TOTAL POUNDS/YEAR OF PO_4 WASHOFF (FIXED LAND USE) PREDICTED BY "STORM"



Curve	Loading Rate (lb/acre/day) Urban	Nonurban
A	.000033	.00062
B	.004900	.00062

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The Corps of Engineers' Urban Storm Water Runoff Model "STORM" was used to determine the effect of various parameters upon the quality of pollutant runoff.

A sensitivity analysis was performed varying the parameters of pollutant loading rate and percent urbanization for the Magnolia Ranch Sub-basin.

Results obtained were presented in the previous chapter. The model calculated the average annual concentration of five pollutants to the receiving waters. As expected, the model predicted that for a given land use, the pollutant runoff concentration is directly proportional to the pollutant loading rate.

In order to determine what effect urbanization would have on the quality of pollutant runoff, the percentage urbanization of the watershed was varied from 0 to 100 percent. This was done by increasing the urban acreage while decreasing the nonurban acreage proportionately. When the results were examined and plotted, it was noted that the model predicted a higher concentration of pollutant runoff as urbanization increased when consistent input loading rates were used (FTU urban and FTU nonurban pollutant loading rates). The unexpected results that were obtained when the urban and nonurban loadings were taken from two different sources clearly illustrates the dangers in using "cookbook" values for input parameters to the "STORM" model. Input parameters shculd be obtained by a local study of the watershed being investigated so that the input values to the model are truly applicable to the site.

A sensitivity analysis to determine the effect of urbanization upon the total pounds/year of pollutant washoff was also investigated.

The results indicate that the pounds/year of pollutant washoff increased for increasing urbanization. These results are reasonable and in line with good engineering judgement.

Ratliff[16] has indicated that he and his colleagues throughout the State of Florida are finding increasing evidence that many air, water and noise parameters are site specific.

Conclusions

1. In order to properly apply the "STORM" model, it is essential that the pollutant loading rates used in the model be truly representative of the watershed under investigation. It must be kept in mind that pollutant loadings may vary dramatically from one locality to another and are largely dependent on land use and rainfall characteristics.

2. An accurate determination of land area for each land use must be made when using the "STORM" model.

3. Both the quality and quantity of pollutant runoff should be evaluated when attempting to determine the effects of urbanization upon a watershed.

4. Personal observation has shown that precipitation, especially in Florida, can be quite localized.

5. Urban pollutant loadings in the "STORM" model are directly proportional to gutter length for all urban land uses.

6. The "STORM" model if properly applied, may be a valuable tool to aid one in comparing the effects that potential development may have upon the pollutant runoff quality and quantity of a specific area. This

model could provide Planners and Engineers with a basis of comparison in order to determine which areas could best be developed without destroying our natural environment.

Recommendations

1. Obtain pollutant loading rates that are applicable to the watershed under investigation.

2. If no reliable pollutant loading rates are available for the watershed, a local sampling and testing program should be established in order to produce this data.

3. Default values should not be used in the model since it is highly unlikely that they apply to more than a few situations.

4. Keep in mind that the model predictions are to be used as a guide, and are only as reliable as the input data or garbage in, garbage out (GIGO).

APPENDIXES

APPENDIX I

Calculation of expected pollutant loading on the Magnolia Ranch sub-basin of the Econlockhatchee River watershed. Average annual rainfall = 52 inches.

1. BOD_5 Loading

   a. Urban Acreage = 0

   b. Pasture = 7,000 acres

   loading rate = 11 Kg/ha/yr

   $\therefore$ (7,000 acres)(.405 $\frac{ha}{acre}$)(11 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

   = 68,763 lb./yr.

   c. Cultivated Land = 2,000 acres

   loading rate = 18 Kg/ha/yr

   $\therefore$ (2,000 acres)(.405 $\frac{ha}{acre}$)(18 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

   = 32,149 lb./yr.

   d. Woodland/Swamps = 12,000 acres

   loading rate = 5 Kg/ha/yr

   $\therefore$ (12,000 acres)(.405 $\frac{ha}{acre}$)(5 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

   = 53,582 lb./yr.

   Total BOD_5 loading

   = 68,763 + 32,149 + 53,582 = 154,494 lb./yr.

2. Suspended Solids

a. Urban Acreage = 0

b. Pasture = 7,000 acres

loading rate = 840 Kg/ha/yr

$\therefore$ (7,000 acres)(.405 $\frac{ha}{acre}$)(840 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

= 5,250,987 lb./yr.

c. Cultivated Land = 2,000 acres

loading rate = 4,200 Kg/ha/yr

$\therefore$ (2,000 acres)(.405 $\frac{ha}{acre}$)(4,200 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

= 7,501,410 lb./yr.

d. Woodland/Swamps = 12,000 acres

loading rate = 98 Kg/ha/yr

$\therefore$ (12,000 acres)(.405 $\frac{ha}{acre}$)(98 Kg/ha/yr)2.205 $\frac{lb}{Kg}$)

= 1,050,197 lb./yr.

Total Suspended Solids loading

= 5,250,987 + 7,501,410 + 1,050,197 = 13,802,594 lb./yr.

3. Phosphorus

a. Urban Acreage = 0

b. Pasture = 7,000 acres

loading rate = .30 Kg/ha/yr

$\therefore$ (7,000 acres)(.405 $\frac{ha}{acre}$)(.30 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

= 1875 lb./yr.

c. Cultivated Land = 2,000 acres

loading rate = 1.05 Kg/ha/yr

$\therefore$ (2,000 acres)(.405 $\frac{ha}{acre}$)(1.05 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

= 1,875 lb./yr.

d. Woodland/Swamps = 12,000 acres

loading rate = .10 Kg/ha/yr

$\therefore$ (12,000 acres)(.405 $\frac{ha}{acre}$)(.10 Kg/ha/yr)(2.205 $\frac{lb}{Kg}$)

= 1,072 lb./yr.

Total Phosphorus loading

= 1,875 + 1,875 + 1,072 = 4,822 lb./yr.

4. Total Nitrogen

a. Urban Acreage = 0

b. Pasture = 7,000 acres

loading rate = 5.3 Kg/ha/yr

$\therefore$ (7,000 acres)(.405 $\frac{\text{ha}}{\text{acre}}$)(5.3 Kg/ha/yr)(2.205 $\frac{\text{lb}}{\text{Kg}}$)

= 33,131 lb./yr.

c. Cultivated Land = 2,000 acres

loading rate = 26.0 Kg/ha/yr

$\therefore$ (2,000 acres)(.405 $\frac{\text{ha}}{\text{acre}}$)(26.0 Kg/ha/yr)(2.205 $\frac{\text{lb}}{\text{Kg}}$)

= 46,437 lb./yr.

d. Woodland/Swamps = 12,000 acres

loading rate = 3.1 Kg/ha/yr

$\therefore$ (12,000 acres)(.405 $\frac{\text{ha}}{\text{acre}}$)(3.1 Kg/ha/yr)(2.205 $\frac{\text{lb}}{\text{Kg}}$)

= 33,221 lb./yr.

Total Nitrogen loading

= 33,131 + 46,437 + 33,221 = 112,789 lb./yr.

APPENDIX II

Input Criteria to the "STORM" Model

A1 Card (Title Card)

This card inputs the name or title of the program--"STORM".

A2 Card (Title Card)

Inputs the job title information--"Rainfall Runoff Analysis for a nonurban area, no treatment/no storage."

A3 Card (Title Card)

Also inputs job title information: "Magnolia Ranch Sub-basin of the Econlockhatchee River Watershed."

B1 Card (Job Specification Card)

Inputs the following:

1. One watershed is to be analyzed
2. No snowmelt computations are desired
3. Nonurban watershed computations will be made
4. Land surface erosion computations will be made
5. Water quality computations will be made
6. Detailed analysis (pollutograph) of selected events is desired.

<u>B2 Card</u> (Climatic Data)

Inputs the following:

1. The length, in days, of average summer (period of no rain). A value of 10 days was selected based on past rainfall records from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.
2. The number of initial hours of overflow for which separate quantity and quality reporting is desired. A default value of 3 was used for this entry.
3. The number of years of rainfall represented on rainfall record. A default value equal to the computed value was used for this entry.
4. The date (year, month, day) of the end of rainfall for the last major precipitation preceding the first rainfall record. A default value of 6 days was used for this entry.
5. The hour of last major precipitation preceding the rainfall record. A default value equal to midnight was used for this entry.

C1 Card (Precipitation Data)

Inputs the following:

1. Title of precipitation record: "Herndon Airport, Orlando," and "Magnolia Ranch Rain Gage."
2. Precipitation data is to be supplied on C2 cards. This notation is made by inputting a 5 in field 5 of this card.

C2 Cards (Precipitation Record)

These cards input precipitation data by year, month and day. Hourly rainfall is entered in hundredths of an inch per hour specified in 24 hourly intervals.

Hourly rainfall at Herndon Airport, Orlando, for the period from October 1972 through September 1973 (the 1972-1973 Water Year) was obtained from the National Oceanic and Atmospheric Administration, Environmental Data Service.

An hourly rainfall record at Magnolia Ranch for the period from July 8, 1975 through July 29, 1975 was obtained from Florida Technological University's Environmental Engineering Institute.

D Cards (Snowmelt Parameters)

No D cards will be used since no snowmelt parameters are required for the subject watershed.

<u>E1 Card</u> (Urban Watershed Data)

Inputs the following:

1. Title of the watershed--Econ Basin.
2. The number of urban land use groups modelled. A value of 2 was used for this entry based on anticipated development of single family and open land uses.
3. Exponent for dust and dirt washoff. A default value of 4.6 was used.
4. Street sweeping efficiency. A default value of 0.70 was used.

<u>E2 Card</u> (Urban Watershed Data)

Inputs the following:

1. Total Urban Area.

   Theoretically, this value should be zero at this time since the watershed is totally non-urban. Since the model did not function correctly when a zero was input, a value of .1 acres was used for the urban area.

   In subsequent runs, the urban area was increased to determine the effect that urbanization would have on the quality of pollutant runoff. Values for the area were varied to simulate 0, 25, 50, 75 and 100% urbanization.

2. Runoff coefficient for pervious areas. A default value of .15 was used.
3. Runoff coefficient for impervious areas. A default value of .90 was used.
4. Factor by which KRAIN, rainfall array, is multiplied to obtain average rainfall over urban area. A default value of 1.0 was used.
5. No hydrographs are to be input on the G cards.
6. Minimum flow (cfs) above which flow from the urban area is diverted. A default value equal to no diversions was used.

E3 Cards (Initial Loss Rate and Recovery Data)

Input the following:

1. Depression storage, average over total urban watershed, in inches. A value of .3 inches was used.
2. Potential evaporation rate in inches/day (for recovery of depression storage) for each month of the year. This data was obtained by taking a 10-year average of monthly evaporation rates for Lisbon, Florida. Although Lisbon is about 50 miles from the Sub-basin being investigated, this is the nearest station for which detailed

evaporation records are available. The evaporation rate data was supplied by the National Oceanic and Atmospheric Administration, Environmental Data Service.

F1 Cards (Land Use Data)

Input the following:

1. Land use descriptions: Single family dwellings, Open or park area.
2. Percent of urban watershed area in this land group.

   A value of 20 percent was used for the single family dwellings, and 80 percent for the open land use. These values were used since the development in the watershed area is expected to be very light and thinly spread.
3. Percent imperviousness of this land group.

   A value of 30 percent imperviousness was used for the "single" land use and 10 percent imperviousness was used for the "open" land use.
4. Length of street gutters in feet per acre.

   Three hundred feet was used for the "single" land use and twenty feet for the "open" land use. These values were obtained from one of the sample problems in the Urban Storm Water Runoff "STORM" Report (Exhibit #2, p. 61).

5. Number of days between street sweeping in each land use group.

   A value of 30 days was used for the "single" land use and 100 for the "open" land use. These values were also obtained from the sample problem cited above.

F2 Cards (Urban Pollutant Accumulation and Contents)

Input the following:

1. Daily rate of accumulation of dust and dirt in pounds per 100 feet of gutter. Default values of .7 for the "single" land use and 1.5 for the "open" land use was used.
2. Pounds of suspended solids per 100 pounds of dust and dirt. A default of 11.1 was used for both the "single" and "open" land use.
3. Pounds of settleable solids, per 100 pounds of dust and dirt. A default value of 1.1 was used for both the "single" and "open" land use.

4. Pounds of BOD per 100 pounds of dust and dirt. A default value of .500 was used for both the "single" and "open" land use.
5. Pounds of Nitrogen per 100 pounds of dust and dirt. A default value of .048 was used for both the "single" and "open" land use.
6. Pounds of Orthophosphate (PO_4) per 100 pounds of dust and dirt. A default value of .005 was used for both the "single" and "open" land use.

H1 Card (Nonurban Watershed Data)

Inputs the following:

1. Area of the nonurban watershed in acres.

   A value of 21,000 acres for the Magnolia Ranch Sub-basin was obtained from the "Nonpoint Source Effects" Report by Florida Technological University, College of Engineering, dated February 28, 1975 (p. V-21).

   The nonurban area has the following land use distribution:

Cultivated Land	2,000 acres
Pasture Land	7,000 acres
Woodland/Swamps	12,000 acres
Urban	0 acres
Total	21,000 acres

2. Runoff coefficient for nonurban area. A nonurban runoff coefficient of .20 was used. This value was calculated by using a weighted average for the different land use areas over the Sub-basin.

TABLE 15

DETERMINATION OF RUNOFF COEFFICIENT FOR THE MAGNOLIA RANCH SUB-BASIN

Land Use	% of Total Land Use	Runoff Coefficient*		Weighted Value
		Range	Average	
Cultivated	9.5	.15-.40	.275	.0261
Pasture	33.3	.15-.40	.275	.0916
Woodland/Swamp	57.2	.05-.25	.15	.0858
Urban	0		0	
Weighted Runoff Coefficient				.2035

*SOURCE: Florida Department of Transportation, Drainage Manual 2nd Ed., Tallahassee, Florida, 1967, p. 6-3.

3. Factor by which KRAIN, rainfall array, is multiplied to obtain average rainfall/snowmelt over nonurban area.

   A value of 1.0 was used for this entry.

4. No hydrographs are to be input on K cards.

5. Minimum flow (cfs) above which flow from the nonurban area is to be diverted. A value of 74 cfs was used which was the maximum discharge for the 1972-1973 Water Year. This data was taken from a U.S. Geological Survey publication, 1973 Water Resources Data for Florida, Part I, Surface Water Records, Vol. I Streams-Northern and Central Florida, p. 35.
6. Maximum flow (cfs) from nonurban area, above which no additional flow can be diverted. A value of 75 cfs was used in order to minimize the effect of diversion.
7. Fraction of available flow that is actually diverted. A value of 0 was input for this parameter.
8. Exponent for pollutant washoff from nonurban area. A default value of 4.6 was used.

H2 Cards (Nonurban Watershed Data)

Input the following:

1. Depression storage, in inches, over nonurban area. A value of .5 inches was used for this entry. This nonurban depression storage for the Sub-basin was found by trial.

Using data compiled by the U.S. Geological Survey, the total discharge of the Econlockhatchee River at the Magnolia Ranch Gaging Station for the Water Year from October 1972 to September 1973 was computed.

The total discharge for the Water Year was 5,486.61 cubic feet per second which is equal to 1.08825×10^4 acre-ft./year.

This discharge when spread over the 21,000 acre Sub-basin is equivalent to a runoff of 6.2186 inches/year.

The "STORM" model was calibrated by varying the nonurban depression storage factor in order to obtain different values of the total runoff over the watershed.

Run	Nonurban Depression Storage (inches)	Total Runoff Computed by "STORM" inches/year
1	.4	6.87
2	.5	6.24
3	.6	5.68
4	.8	4.74

As can be seen from the preceding data, a nonurban depression storage of .5 inches, resulted in a computed runoff that was very close to the actual yearly runoff that was calculated from discharge data.

Based on the above, an input value for nonurban depression storage of .5 inches was used in the model.

2. Potential evaporation rate in inches/day (for recovery of nonurban depression storage) for each month of the year. This data is the same as the potential evaporation data that was input on the E3 cards for the urban area.

J Card (Pollutant Accumulation on Nonurban Area)

Inputs the following:

Pollutant accumulation rate for Suspended Solids, Settleable Solids, BOD, Total Nitrogen and PO_4 in lbs/acre/day.

Table 7 in Chapter VII showed how the weighted values (according to land use) of pollutant loading rates were obtained.

Pollutant	Loading Rate(lb/acre/day)
Suspended Solids	1.7958
Settleable Solids	1.0 (Estimated)
BOD	.02012
Total N	.01471
PO_4	.00062

In subsequent runs the pollutant loadings were varied to 50, 75, 100, 150 and 200 percent of average pollutant loading at fixed land use.

* Cards (Comment Cards for Land Surface Erosion)

Input the following:

1. "Soil Series Identification Reference - Orange County Soil Survey."
2. "U.S. Department of Agriculture Series 1957, No. 5, Issued September 1966."
3. "Major Soil Types."
4. "LF Leon Fine Sand"
   "IA Immokalee Fine Sand"
   "PC Pomello Fine Sand"
   "SA St. Johns Fine Sand"

P Card (Soil Series Identification)

Inputs the following:

"Soil Series Identification by slope and soil type."

P1 Card (Job Parameters)

Inputs the following:

1. Maximum number of depths in the soil Column. A value of 1 was used due to insufficient data.
2. Maximum number of soil parameters for each depth entry. A value of 1 was used due to insufficient data.
3. Maximum number of characters in the soil classification code. A default value of 3 was used.
4. Maximum number of characters in the slope group. A default value of 1 was used.
5. The weight of the natural ground slope to the minimum value of the soil group. A default value of .5 was used.
6. Ratio of maximum hourly intensity to the maximum thirty minute intensity. A default value of .8 was used.

P2 Card (Ground Slope Data)

Inputs the following:

Soil Conservation Service (SCS) designated slopes that describe ground surface slope. All of the soil series identification codes can be divided into two slope groups.

P4 Card (Soil Properties)

Inputs the following:

1. The first two digits of the code assigned by SCS to identify soil series. Each of the following soil types was input on a separate P4 Card: IA, LF, PC, and SA.
2. For each soil type, a slope group must be entered. A value of 1 was used since all soils in the Sub-basin belong to slope group 1.
3. The depth below the ground surface in inches for which soil properties have been identified. A value of 12 inches was used due to insufficient data.
4. Soil-erodibility factor (K) in the universal soil-loss equation.

Soil Type	K*
IA	.15
LF	.20
PC	.17
SA	.20

*SOURCE: U.S. Department of Agriculture, Soil Conservation Service, Environmental Planning Handbook (Gainesville, Florida, 1974) pp. 3.29-3.43.

Q Card (Sediment Trap Data)

Inputs the trap efficiency desired for the sediment detention reservoirs. Since the program would not function without this card, a value of .00001 was used.

R Card (Erosion Potential Model by Land Use)

The R card data describes potential development by land use as it will impact on sediment erosion potential.

Inputs the following:

1. The type of land use and the soil series identification for the land used.

   Input values for land use are: Single, Open, and Nonurban. For each land use, one or more major soil types were entered.

2. Percent of area in this land use category that has the soil and slope properties to be defined on this R card. A value of 20 percent was used for all R cards. The four major soils that are found in the Sub-basin have similar soil-erodibility factors (K).

3. The length of lot in the direction of the ground slope expressed in feet. A value of 150 was used. The sample problem in the "STORM" Program used values of 150 feet for the "open" and "nonurban" land uses and 100 feet for the "single" land use.

4. The soil-erodibility factor (K) for the universal soil-loss equation. Its value needs to be determined by soils experts. Values entered were in accordance with those from the P4 card.

5. The sediment delivery ratio is a factor that accounts for deposition in the basin between the erosion plot being analyzed and the basin outflow point. A default value of 1 for unimpervious areas was used.

<u>T Cards</u> (Treatment Rate and Storage Capacity Alternative)

A zero was entered since no treatment or storage capacity was to be investigated.

APPENDIX III

"STORM" INPUT LISTING AND SELECTED OUTPUT

```
A1        TEST 1                              STORM                        L2520
A2   RAINFALL RUNOFF ANALYSIS FOR A NONURBAN AREA NO TREATMENT / NO STORAGE
A3       ECONLOCKHATCHEE RIVER BASIN IN CENTRAL FLORIDA                EXHIBIT ONE
B1        1       0       1       1       1       1
B2       10
C1 HERNDON AIRPORT - ORLANDO            5                             1
C 721001                                  25 12
C 721002                                                 24 88  4  3
C 721011                         20                                6
C 721015                                                          2
C 721020                4 11  2
C 721028                            3 29  1
C 721106                                  12  3  1  1        1     5    42     3
C 721107  4  1  7        7                             15
C 721113                                            12  8
C 721114             32 33  2
C 721119                                             2 10 15
C 721125                   3  3  5  1              1     9 14 12  2     3 82  9
C 721126     8                             5
C 721128                                                  4  1  4  1  2  2
C 721129                                                                     3
C 721130  7 10                                         3  1
C 721205                                      13
C 721215                            5  1  4
C 721216              4  3
C 721221                                               2  3  7     1  1 98 15 11
C 721222  5  9  1
C 721225              6
C 730110                            2     2  3           1  1  5  4 14 23 24  8
C 730111  6  6  4  4  5  4                                            3 20 19 15
C 730112 20 10 15  2  1  2  1  2  1  1        1  8  4
C 730122                               11 10  8  3
C 730123                      10  7 18 32 44 18  2  3  1  1
C 730124     2
C 730126                                                                1  5 10
C 730127  1
C 730128                                     22 20  5  4  1  2
C 730202                                                 30 11  4  1  4  1 11  1
C 730209                                                        6 60 53 17 26
C 730210  3
C 730215              8  4        4
C 730218                   1  4  4  2  3  2           1  2           1  4  1
C 730219        4
C 730308                                                          1
C 730309                               18 21  2
C 730317                34  1  1
C 730320                                                             3  8  2  1
```

```
C 730321  1
C 730325
                                               12  2  5 10 16 10 29113 48  1  9
C 730329
                                             3  7  3  6 15 15  8  8
C730401
                                       2 35  1 11
C 730404
                                    5  5  2  2  4  1
C 730407
C 730408 63  1                                                             1 79
C 730426
                                                  26  1       33 10
C 730508
                                                               6
C 730509  3  7                4              2 39 33  1
C 730513
                                                                   10
C 730516
                                             2  1
C 730518
                                                           26  2
C 730524
                                                                         19  1
C 730525
                                      53 36  1  2
C 730530
                                   55113  1          29 14  9  1  4
C 730601
                                                                   12
C 730602
                                                3
C 730603
                                               17  3
C 730607
                                                                       2
C 730608  1 16       10  1
                                                     39
C 730611
                                                               7107 36
C 730613
                                                              11 3
C 730614
                                               19             91 2
C 730618
                                                               1
C 730619
                                         42  3           2
C 730621
                                    2                       2  1
C 730622
                                          1  4  1     2  1     1
C 730623
                                                          30 57  7  5  1
C 730630
                                                   6   76 26   9 3
C 730704
                                                    103 12 2   4 4  1
C 730706
                                                     20
C 730707
                                                           1
C 730708
                                                   5  6
C 730709
                                            10  5  3     1
C 730712
                                                             24 70 12
C 730714
                                                          90 22 12  4  1
C 730718
                                                 54   1
C 730719
                                               16  2         15  4
```

C 730722											24	8	3					12						
C 730724												1												
C 730725																		2	3					
C 730728															20									
C 730729											11													
C 730730																7	8	9	1					
C 730731															4	1	1	2	1					
C 730801														95	9	4	3	1						
C 730802													42	5	2									
C 730803																	68							
C 730804																10	31							
C 730805											11													
C 730810																		38						
C 730811																					27	1		
C 730816																				1	1	1		
C 730817														10		84	6							
C 730819														5										
C 730821																						7	48	6
C 730822	3																							
C 730823							30				45													
C 730827													11	7										
C 730830																		1	14	2				
C 730831			1	1			6							40	45	9	2							
C 730901											3	1	17			9	11	4	3					
C 730902													12		3		61	20						
C 730903													8											
C 730904											2													
C 730907																70								
C 730908															1						9	1		
C 730909																			45					
C 730912														15			21							
C 730913																			93					
C 730915																35								
C 730923											16			14	1	4								
C 730924													40	3										
C 730925																		10						
C 730926															5		11	592	471	50	9	6		5
C 730927							2	89	4	14	1	9	1	2	1	4			1	1				
C?																								

```
E1 ECON BASIN          2
E2   0.1     .15     .90      1.0      0


E3    .3     .09     .12      .16      .22      .23      .22      .21      .19      .17
E3   .14     .11     .09
F1SINGLE      20      30      300       30
F2    .7    11.1     1.1     .500     .048     .005
F1OPEN        80      10       20      100
F2   1.5    11.1     1.1     .500     .048     .005
H121000.     .20     1.0        0      74.      75.        0
H2    .5     .09     .12      .16      .22      .23      .22      .21      .19      .17
H2   .14     .11     .09
J11.7958     1.0  .02012   .01471   .00062
*       SOIL SERIES IDENTIFICATION REFERENCE - ORANGE COUNTY SOIL SURVEY
* U.S. DEPARTMENT OF AGRICULTURE SERIES 1957, NO. 5 . ISSUED SEPT 1960
*   MAJOR SOIL TYPES
* LF LEON FINE SAND
* IA IMMOKALEE FINE SAND
* PC POMELLO FINE SAND
* SA ST. JOHNS FINE SAND
P SOIL SERIES IDENTIFICATION BY SLOPE AND SOIL TYPE
P1 DATA PAR                1        1        3        1       .5       .8
P2 SLOPE GROUP             1        0        4       12       25       40       65       80
P2 SLOPE GROUP             2        0        2        4        7
P4 SOIL TYPE   IA          1       12      .15
P4 SOIL TYPE   LF          1       12      .20
P4 SOIL TYPE   PC          1       12      .17
P4 SOIL TYPE   SA          1       12      .20
Q                     .00001
R SINGLE       LF         20      150                                  .20      .1
R   OPEN       LF         20      150                                  .20      .1
R NONURB       IA         20      150                                  .15      .1
R NONURB       LF         20      150                                  .20      .1
R NONURB       PC         20      150                                  .17      .1
R NONURB       SA         20      150                                  .20      .1
END
T1      0
T2      0        0        0        0        0        0        0
T3      0        0
```

TEST 1 STORM L2520

RAINFALL RUNOFF ANALYSIS FOR A NONURBAN AREA NO TREATMENT / NO STORAGE

ECONLOCKHATCHEE RIVER BASIN IN CENTRAL FLORIDA EXHIBIT ONE

NWSHD	ISNO	NONURB	ISED	IQUAL	IEVNT
1	0	1	1	1	1

NSUMR	LEXT	LINE	LDATE	LHR
10	3	0	-6	0

TITLE OF RAIN GAGE

HERNDON AIRPORT - ORLANDO

IN	IFILE	ISTART	IEND	IR
5	0	0	999999	1

HOURLY RAINFALL, IN HUNDRETHS OF AN INCH

YEAR	MO	DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1972	10	1	0	0	0	0	0	0	0	0	0	0	0	25	12	0	0	0
1972	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	10	11	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
1972	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	10	20	0	0	0	0	0	4	11	2	0	0	0	0	0	0	0	0
1972	10	28	0	0	0	0	0	0	0	0	0	3	29	1	0	0	0	0
1972	11	6	0	0	0	0	0	0	0	0	0	0	0	12	3	1	1	0
1972	11	7	4	1	7	0	0	7	0	0	0	0	0	0	0	0	0	0
1972	11	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	8
1972	11	14	0	0	0	0	32	33	2	0	0	0	0	0	0	0	0	0
1972	11	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10
1972	11	25	0	0	0	0	0	0	3	3	5	1	0	0	0	0	1	0
1972	11	26	0	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0
1972	11	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	11	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

URBAN WATERSHED DATA

AREA
0.10

INPUT DATA DESCRIBING LAND USE AND POLLUTANTS

LNDUSE	PRCNT	DD	POUNDS POLLUTANT PER 100LB DD SUSP	SETL	BOD	N	PO4
SINGLE	20.0	0.70	11.100	1.100	0.500	0.048	0.005
OPEN	80.0	1.50	11.100	1.100	0.500	0.048	0.005

LAND USE	PRCNT OF LND AREA	PRCNT IMPERV	GUTTERS FT/AC	SWEEPING INTRVL, DYS
SINGLE	20.0	30.0	300.0	30
OPEN	80.0	10.0	20.0	100

NON URBAN WATERSHED DATA

AREAN	CN	RFN	IQN	DVN	DVNMX	WN	EXPTN
21000.0	0.20	1.00	0	74.0	75.0	0.0	4.60

DEPRESSION STORAGE %INCHES<
0.500

DAILY EVAPORATION RATES FOR EACH MONTH, JAN-DEC IN INCHES/DAY
0.09 0.12 0.16 0.22 0.23 0.22 0.21 0.19 0.17 0.14 0.11 0.09

	SUSP	SETL	BOD	N	PO4
POLLUTANT ACCUMULATION RATES %LBS/ACRE/DAY<	1.80	1.00	0.02	0.01	0.00
%LBS/DAY<	37711.8	21000.0	422.5	308.9	13.0

AVERAGE ANNUAL STATISTICS FOR 1 YEARS OF RECORD

FOR THE PERIOD BEGINNING 721001 AND ENDING 730927

NUMBER OF EVENTS # 53.0

NUMBER OF OVERFLOWS # 53.0

	INCHES
TOTAL PRECIPITATION ON WATERSHED	58.80
TOTAL RUNOFF FROM WATERSHED	6.24
OVERFLOW TO RECEIVING WATER	6.24
INITIAL OVERFLOW TO RECIEVING WATER	5.64

	SUSP	SETL	BOD	N	PO4
TOTAL POUNDS WASHOFF FROM WATERSHED	6715683	3739660	75246	55012	2311
TOTAL POUNDS OVERFLOW TO RECEIVING WATER	6715198	3739383	75236	55006	2318
CONCENTRATION OF POLLUTANTS IN OVERFLOW %MG/L<	226.11	125.91	2.53	1.85	0.08

FOOTNOTES

[1]John Quarles, "Federal Water Pollution Control Act," Public Law 92-500, Section 208, Federal Register, Vol. 39, No. 93, (May 13, 1974), pp. 17202-17206.

[2]James L. Agee, "The National Water Quality Strategy and the Role of Agriculture," Proceedings of the Workshop on Agricultural Nonpoint Source Water Pollution Control (Washington, D.C.: September 16, 1974), p. 4.

[3]U.S., Environmental Protection Agency, Office of Air and Water Programs, Processes, Procedures, and Methods To Control Pollution Resulting From Silvicultural Activities (Washington, D.C.: Government Printing Office, 1973), p. 91.

[4]H. Stephen Stoker and Spencer L. Seager, Environmental Chemistry: Air and Water Pollution (Glenview, Illinois: Scott, Foresman and Company, 1972), p. 91.

[5]Garry D. McKenzie and Russell O. Utgard, Man and His Physical Environment (Minneapolis, Minn.: Burgess Publishing Co., 1972), p. 335.

[6]Martin P. Wanielista, "Program Goals of Storm Water Management Workshop," Proceedings: Stormwater Management Workshop (Gainesville, Florida, February 26-27, 1975), p. 2.

[7]U.S., Environmental Protection Agency, Processes, Procedures, and Methods To Control Pollution Resulting From Silvicultural Activities (Washington, D.C.: Government Printing Office, 1973), p. 91.

[8]Frank J. Humenik, "Animal Wastes As A Nonpoint Source," Proceedings of the Workshop on Agricultural Nonpoint Source Water Pollution Control (Washington, D.C.: September 16, 1974), p. 115.

[9]David Hill, "Region IV Nonpoint Source Problem Assessment," Proceedings of the Workshop on Agricultural Nonpoint Source Water Pollution Control (Washington, D.C.: September 16, 1974), p. 169.

[10]U.S., Environmental Protection Agency, Office of Air and Water Programs, Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants (Washington, D.C.: Government Printing Office, 1973), p. 37.

[11]Humenik, "Animal Wastes As A Nonpoint Source," Proceedings of the Workshop on Agricultural Nonpoint Source Water Pollution Control (Washington, D.C.: September 16, 1974), p. 116.

[12]U.S., Army, Corps of Engineers, "Urban Storm Water Runoff 'STORM'," (unpublished computer program 723-S8-L2520, Hydrologic Engineering Center, Davis, California, January 1975), pp. 1-32.

[13]U.S., Geological Survey, Water Resources of Northeast Florida, by L.J. Snell and Warren Anderson, Report of Investigation No. 54 (Orlando, Florida: Designers Press of Orlando, Inc., 1970), p. 41.

[14]U.S., Geological Survey, The Geomorphology of The Florida Peninsula, by William A. White, Bulletin No. 51 (Orlando, Florida: Designers Press of Orlando, Inc., 1970), pp. 108-109.

[15]U.S., Department of Agriculture, Soil Conservation Service, Soil Survey-Orange County, Florida (Washington, D.C., Government Printing Office, 1960), p. 64.

[16]Interview with James Ronald Ratliff, District Environmental Coordinator, Florida Department of Transportation, Orlando, Florida, 13 August 1975.

BIBLIOGRAPHY

Agee, J.L. "The National Water Quality Strategy and The Role of Agriculture," Proceedings of The Workshop on Agricultural Nonpoint Source Water Pollution Control. Washington, D.C., September 16, 1974.

Hill, D. "Region IV Nonpoint Source Problem Assessment," Proceedings of The Workshop on Agricultural Nonpoint Source Water Pollution Control. Washington, D.C., September 16, 1974.

Humenik, F.J. "Animal Wastes As A Nonpoint Source," Proceedings of The Workshop On Agricultural Nonpoint Source Water Pollution Control. Washington, D.C., September 16, 1974.

McKenzie, G.D., and Utgard, R.O. Man And His Physical Environment. Minneapolis, Minn.: Burgess Publishing Co., 1972.

Ratliff, J.R. Florida Department of Transportation, Orlando, Florida. Interview, 13 August 1972.

Quarles, John. "Federal Water Pollution Control Act." Public Law 92-500, Section 208, Federal Register, Vol. 39, No. 93, (May 13, 1974), pp. 17202-17206.

Stoker, S.H., and Seager, S.L. Environmental Chemistry: Air and Water Pollution. Glenview, Illinois: Scott, Foresman and Company, 1972.

U.S. Army Corps of Engineers. "Urban Storm Water Runoff 'STORM'." Unpublished computer program 723-S8-L2520, Hydrologic Engineering Center, Davis, California, January 1975.

U.S. Department of Agriculture. Soil Conservation Service. Soil Survey-Orange County, Florida. Washington, D.C., Government Printing Office, 1960, p. 64.

U.S. Environmental Protection Agency. Office of Air and Water Programs. Methods For Identifying and Evaluating The Nature and Extent of Nonpoint Sources of Pollutants. Washington, D.C.: Government Printing Office, 1973.

U.S. Environmental Protection Agency. Office of Air and Water Programs. Processes, Procedures, and Methods To Control Pollution Resulting From Silvicultural Activities. Washington, D.C.: Government Printing Office, 1973.

U.S. Geological Survey. The Geomorphology of The Florida Peninsula, by William A. White. Geological Bulletin No. 51. Orlando, Florida: Designers Press of Orlando, Inc., 1970.

U.S. Geological Survey. Water Resources of Northeast Florida, by L.J. Snell and Warren Anderson. Report of Investigation No. 54. Orlando, Florida: Designers Press of Orlando, Inc., 1970.

Wanielista, M.P. "Program Goals," Proceedings: Storm-Water Management Workshop. Gainesville, Florida, February 26-27, 1975.