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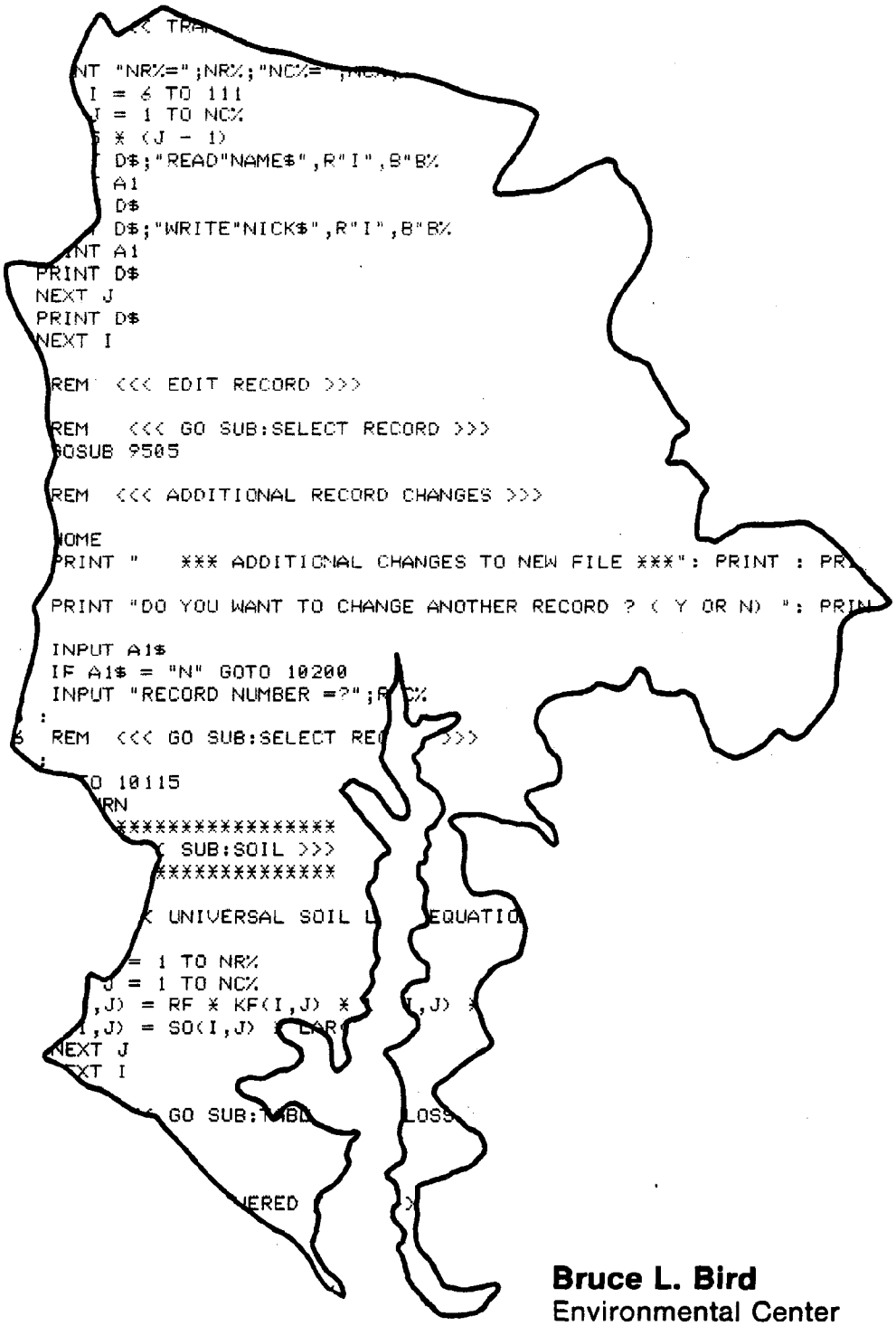
CHURCH CREEK WATERSHED

An illustration of the application of microcomputers for estimating the effects of land use changes on nutrient and pollutant loading.



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EXECUTIVE SUMMARY

Land use planners must channel demands for land use within a watershed so that a proper balance can be maintained between an individual's right to develop his land versus society's obligation to preserve the environment for future generations. This report discusses one approach that land planners may wish to use to help them achieve a reasonable distribution of land use.

A computer program, WATER SCREEN, has been written for the Apple II microcomputer. This program can be used by land use planners to estimate the amounts of sediment, nitrogen, phosphorous, BOD, lead, and zinc that are produced by various land use patterns within a watershed. Both a modified universal soil loss equation and a loading factor method are used in the program to estimate nutrient and pollutant loadings.

The 1200 acre Church Creek watershed was analyzed with the WATER SCREEN program. A comparison of the Modified Universal Soil Loss Equation approach to the loading factor method for forest and agricultural land use did not give good agreement on estimated loadings. This is attributed to the simplified method of relating nutrient and pollutant loadings to sediment loadings used with the Modified Universal Soil Loss Equation approach.

The loading factor method was used to arrive at estimated loadings from the Church Creek watershed for the following development patterns: all forest predevelopment, 1974 land utilization, 1981 land utilization, and a hypothetical development pattern for study purposes based on the present general development plan map (GDP). Between 1974 and 1981 there

has been a small decrease in sediment loading from the watershed due to a change in farming practices from conventional to minimum tillage. Total nitrogen and total phosphorous loadings have remained unchanged, while biochemical oxygen demand (BOD), lead, and zinc have increased 25% because of increased commercial and high density residential land use.

By taking the ratio of loadings produced by the 1981 land utilization pattern to the loadings produced assuming the watershed was originally covered with forest, it was estimated that by 1981 yearly sediment loadings had increased by a factor of 10, total nitrogen by 2, total phosphorous by 7, BOD by 4.5, lead by 60, and zinc by 40. If the watershed were to develop without any controls as hypothesized then all of these loading ratios would double. These estimates are probably conservative because they do not account for nutrient and pollutant loadings that occur during road and building construction. A rough estimate of the lead loading produced by vehicle traffic within the Church Creek watershed indicates that this may be a significant source of pollution within the watershed.

At the present time scientific knowledge does not allow a definitive statement as to the effect of the estimated loadings on the water quality of Church Creek. However, a method is suggested for using pollutant loading ratios based on the model results and correlated with desired estuarine health as a guideline for planning land use within a watershed.

It is suggested that additional monitoring of single use sub-watersheds be undertaken by appropriate agencies. Also the effect of best management practices on impervious areas needs further study. Local jurisdictions should consider use of WATER SCREEN for the evaluation of watersheds under heavy development pressure. The contribution of vehicle traffic to nutrient and pollutant loadings in small watersheds should be investigated.

I. INTRODUCTION

To understand the sources of excess nutrients and pollutants that enter a stream or tidal tributary it is necessary to look at all inputs: point source, non-point source, and atmospheric. Unfortunately, a thorough environmental analysis requires extensive spatial and temporal monitoring in order to adequately characterize inputs, dynamics, and sinks of the primary nutrients and pollutants. Add to this the variety and number of physical, chemical, and biological variables involved and one can then appreciate the difficulty that water quality managers face when, with limited funds and personnel, they are charged with the responsibility of protecting the water quality of a stream or tidal tributary.

Land use planners must channel demands for land use within a watershed so that a proper balance can be maintained between an individual's right to develop his land versus society's obligation to preserve the environment for future generations. This report discusses one approach that land planners may wish to use to help them achieve a reasonable distribution of land use.

The objectives of this work were the following:

1. Develop a computer program, WATER SCREEN, suitable for use with a microcomputer, that utilizes currently available algorithms for the calculation of sediment, nutrient, and pollutant loadings as a function of land use.
2. Illustrate the use of this computer program by application to the Church Creek watershed for 1974 and 1981 land use patterns. Compare these results with those obtained

assuming the watershed was all forest and with hypothetical land use for the watershed based on the 1978 General Development Plan.

In addition, some approximate calculations are given for estimating the flushing time of Church Creek. The question of how much nutrient and pollutant loading Church Creek can absorb without degradation in water quality is also discussed.

This report is divided into five sections. The first section is a discussion of the range of computer models available that deal with pollutant loadings and where the program WATER SCREEN fits within this framework. The second section discusses the algorithms used in WATER SCREEN. The third section illustrates the application of WATER SCREEN to the Church Creek watershed. The land use patterns for the watershed are presented and the parameter values chosen for use in WATER SCREEN are listed. The loadings are given for sediment, total nitrogen, total phosphorous, BOD, lead, and zinc for the four land use patterns: all forest, 1974 land use, 1981 land use, and hypothetical land use based on the General Development Plan (GDP). The fourth section discusses calculations of flushing time and the impact of nutrient and pollutant loadings on Church Creek. The final section gives a summary of the findings for the Church Creek watershed and suggestions for further work. Technical details for using WATER SCREEN are given in Appendix A, while a complete listing of WATER SCREEN is given in Appendix B.

II. WATERSHED COMPUTER MODELS

Because of the high cost of carrying out sufficient spatial and temporal sampling to adequately characterize even a small watershed, other alternatives have been sought. A great deal of effort has been devoted to the development of detailed computer models that can be used to simulate the water, nutrient, and pollutant transport within a watershed. These detailed models include processes with short time scales so that the hydrology can follow effects of a single storm event or follow variations in daily rainfall. The models then relate sediment, nutrient, and pollutant transport to the hydrologic simulation.[1-7]

The mathematical equations used in these detailed models to describe the individual processes occurring within the natural system contain numerical coefficients that must be determined by comparing the model calculations with at least three years of watershed data. Once these coefficients are determined two additional years of data are needed to verify that the predictions of the model agree with measured values.[8] Thus a minimum of five years of watershed data is needed to develop a detailed model that would be considered reliable.

The development of a detailed model is expensive. Most models that are now available have been developed primarily with federal support.[1] These detailed models also need computers that are large enough to handle the computational and memory requirements. This requires access to a main frame computer and personnel with the required technical background to run the model.

Because most local agencies do not have the resources required for proper application of the detailed models, a further simplification

has been made. Watersheds with sufficient data to calibrate and verify a model are used to generate average loading factors for nutrients and pollutants and for different land uses.[9-11] A loading factor gives the average amount of pollutant produced by a given land use in terms of pounds per acre per year. If the watershed from which the loading factors are derived is similar to the watershed of local interest, then an estimate of nutrient and pollutant loadings can be made once the land use patterns of the local watershed are determined. This is one of the approaches used in WATER SCREEN.

An alternative method for estimating nutrient and pollutant loadings is based on the Modified Universal Soil Loss Equation (MUSLE). The USLE was developed by soil scientists to estimate soil loss from agricultural fields. It was later modified by the addition of a sediment delivery factor so that the amount of soil that reaches a natural water body can be estimated. Nutrient and pollutant loadings can be related to the amount of delivered sediment.[12-14] This approach is also used in WATER SCREEN to allow comparison with the loading factor method for forest and agricultural land use.

The modeling methods discussed here avoid the high cost of adequate spatial and temporal sampling of a large number of physical, chemical, and biological variables. As a result all of these methods produce <u>estimates</u> of pollutant loadings. In addition, the simplified approaches work with spatially and temporally <u>averaged</u> quantities. Hence one can not expect these less costly approaches to predict the exact value of any one particular measurement. However, they can give some insight into what effect land use changes will have and perhaps

indicate areas of concern that should be investigated in greater detail.

Some may be tempted to argue that instead of spending time and money on estimates of pollutant loadings produced in a watershed one could better utilize resources by measuring a few selected variables. We suggest that because of the spatial and temporal distributions of the system the results of a few measurements can produce as much, if not more, uncertainty in average values as that obtained from calculated estimates. There is no simple solution. Perhaps the use of simplified model estimates to indicate selected measurements that should be taken is the most realistic approach for water quality managers with funding and personnel limitations.

III. WATER SCREEN

The computer program WATER SCREEN uses input parameters provided by the operator to calculate nutrient and pollutant loadings from a watershed. In the following sections personnel requirements, computer hardware, program logic, and loading equations for this program are described. Details for running the program are given in Appendix A and the program is listed in Appendix B.

Personnel Requirements

A person with minimum computer experience can run WATER SCREEN. A person who has run some commercially available programs on a microcomputer should have no difficulty. A knowledge of BASIC is not required; however, some acquaintance with BASIC on the level of Apple II User's Guide, by Poole, would allow the operator to take full advantage of the logical structure and data file generating capabilities of the program. The user need not be an expert in hydrology or ecology, but he/she should become familiar with the material covered in references 9 and 12.

Machine Requirements

WATER SCREEN has been written and run on an Apple II microcomputer system with 48K of memory. The system consists of a single disk drive and a NEC PC-8023A printer connected to the Apple II using the Orange Micro Grappler interface. As written, for six subwatersheds, the program without REMARK statements occupies 29K of memory. It is estimated that a watershed with up to 20 subwatersheds could be run before one would run out of memory on a 48K machine. If more subwatersheds were needed, the watershed could be separated into smaller sections and then

each section evaluated using the program. While the program is written in Applesoft BASIC it could readily be modified for use on other machines using the appropriate translations. The printer commands are listed in separate subroutines and can be easily modified for other printers if needed. Modifications of the file commands used to store input data on disk would require the most effort.

Program Logic

WATER SCREEN can easily be modified to accommodate changes that may be proposed to the algorithms now used or to incorporate new algorithms. The program consists of three major sections: (1) data file creating, reading, and editing; (2) calculation of pollutant and nutrient loading using the modified universal soil loss equation (MUSLE) and algorithms described by Zison et al[12] for nitrogen, phosphorous and organic matter; (3) calculation of nutrient and pollutant loading using loading factors developed by the Northern Virginia Planning District Commission (NVPDC) in their extensive study of the Occoquan River Basin.[9]

The data file part of the program asks the user to input factors for the MUSLE and for soil and rainfall information needed to calculate nitrogen, phosphorous, and organic loadings. Loading factors for various categories of land use must also be input to the program. Much of this information is requested by subwatershed so that variations within the watershed can be accommodated.

For the Church Creek watershed with six subwatersheds it takes about twenty minutes to input all the required data. The program stores this data on a disk file where it can later be recalled and edited if

desired. The run time of the program depends upon the number of subwatersheds selected and the speed of the printer. The printout of the results from the Church Creek watershed takes about twenty minutes using an eighty characters per second printer. Subtotals and totals are printed by subwatershed, land use, and pollutant type.

The file editing feature makes it possible to quickly see the sensitivity of the calculation to changes in the value of a parameter, such as slope or loading factor, by running the program, using the editing feature to change the desired parameter, and then rerunning the program.

Algorithms Used in WATER SCREEN

A. Modified Universal Soil Loss Equation

Agricultural and soil scientists have been concerned for decades with the problem of controlling soil loss from farm land. The universal soil loss equation was developed to estimate soil loss from a field and to predict the effects of crop rotation, management practices, etc.[15]

The USLE has the form:

$$Y(S)_E = A \cdot R \cdot K \cdot L \cdot S \cdot C \cdot P$$

where

$Y(S)_E$ = soil loss due to surface erosion (tons/year)

A = area of field (acres)

R = rainfall factor, indicates the erosion potential of average annual rainfall (R unit)

K = soil-erodibility factor (tons/acre/R unit)

L = slope-length factor (dimensionless ratio)

S = slope-steepness factor (dimensionless ratio)

C = cover factor (dimensionless ratio)

P = erosion control practices factor (dimensionless ratio)

The U. S. Department of Agriculture has carried out extensive experimental studies on fields located throughout the United States. From these studies accepted values for the factors in the USLE have been tabulated. Local values are obtainable from handbooks published by the Soil Conservation Service.[16] As has been pointed out by various authors, the USLE only predicts the soil lost from a field. It does not estimate the actual amount of soil that is delivered to a stream channel. In order to estimate this an additional factor, the sediment delivery ratio, is needed.[17]

To estimate the amount of soil delivered to a stream the modified universal soil loss equation (MUSLE) is used. The MUSLE has the form:

$$Y(S)_D = Y(S)_E \, S_D$$

where

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$Y(S)_E$ = soil lost from field (tons/year)

S_D = sediment delivery ratio (dimensionless ratio)

The sediment delivery ratio is probably the most difficult factor in the MUSLE to estimate with any degree of reliability. Its value in different watersheds has been obtained by observing the silting rate of dams. Obtained this way it accounts not only for field losses but also all other erosion processes, such as stream channel erosion, which are not accounted for by the USLE.

It is generally accepted that the soil lost from an individual field can be reliably estimated using appropriate local values for the factors in the USLE. However, it is quite another matter to

reliably estimate the sediment loading from a watershed composed of many fields with varying slopes, ground cover, distance from stream channel, etc. For example, it is not clear how to handle fields with concave slopes. Soil lost from one part of a field may redeposit in another part of the same field or in another part of the watershed.[18]

The MUSLE has been applied primarily to agricultural and forest land although some work has been done to extend it to residential land use. In this report the MUSLE will only be applied to forest and agricultural land use.

B. Nitrogen Loading Function

Zison et al.[12] point out that the movement of nitrogen compounds within an ecosystem is complex and still not thoroughly understood. For an estimate of the amount of total nitrogen produced by runoff and erosion, excluding leaching losses, they suggest the following expression:

$$Y(NA) = f_N \, Y(NT)_E + Y(N)_{Pr}$$

where

$Y(NA)$ = total available nitrogen (lbs/year)

f_N = ratio of available to total nitrogen in sediment (dimensionless)

$Y(NT)_E$ = total nitrogen loading from erosion (lbs/year)

$Y(N)_{Pr}$ = stream nitrogen loading from precipitation (lbs/year)

$Y(NT)_E$ is found from the expression:

$$Y(NT)_E = 20\ Y(S)_D\ C_S(NT)\ r_N$$

where

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$C_S(NT)$ = total nitrogen concentration in soil (g/100g)

r_N = nitrogen enrichment ratio

The factor of 20 takes into account the units used in this equation.

$Y(N)_{Pr}$ is found from the expression:

$$Y(N)_{Pr} = A\ \frac{Q(OR)}{Q(Pr)}\ N_{Pr}\ b$$

where

A = area (acres)

Q(OR) = overland flow from precipitation (in/year)

Q(Pr) = total amount of precipitation (in/year)

N_{Pr} = nitrogen loading in precipitation (lb/acre/year)

b = attenuation factor

Zison et al.[12] discuss the methods of evaluation of the parameters in the nitrogen loading function.

C. Phosphorous Loading Function

A great deal of confusion still exists about the proper terms for describing the various physical and chemical states of phosphorous. There is also some disagreement about the effectiveness of chemical extraction procedures to selectively remove a particular phosphate

form from soils.[19] Because of these uncertainties the values of the parameters used in the loading function for phosphorous are only rough approximations. Zison et al.[12] suggest that based on the soil erosion transport mechanism the loading function for phosphorous should have the form:

$$Y(PA) = 20 \cdot f_P \cdot Y(S)_D \cdot C_S(PT) \cdot r_P$$

where

$Y(PA)$ = loading of available phosphorous (lbs/year)

f_P = ratio of available phosphorous to total phosphorous (dimensionless)

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$C_S(PT)$ = total phosphorous concentration in soil (g/100g)

r_P = phosphorous enrichment ratio

Zison et al.[12] discuss the methods for determining the parameters in the phosphorous loading function.

D. Organic Matter Loading Function

Zison et al.[12] also suggest a loading function for organic matter of the form:

$$Y(OM)_E = 20 \cdot C_S(OM) \cdot Y(S)_D \cdot r_{OM}$$

where

$Y(OM)_E$ = organic loading (lbs/year)

$C_S(OM)$ = organic matter concentration in soil (g/100g)

$Y(S)_D$ = soil delivered to stream channel (tons/year)

r_{OM} = enrichment ratio for organic matter in eroded soil

Procedures for determining the values of the parameters in the organic loading function are given by Zison et al.[12]

E. Loading Factors

During the last seven years field and detailed modeling studies of non-point pollution from small watersheds with one predominant land use have been funded by the Water Resources Planning Board, Washington Council of Governments, and by the Environmental Protection Agency Chesapeake Bay Program. The modeling studies were carried out by the Northern Virginia Planning District Commission (NVPDC). The earlier watershed studies on the Occoquan River Basin were done by personnel from the Civil Engineering Department, Virginia Polytechnic Institute. Later watershed measurements were done in the Ware River Basin (southeastern Virginia), Pequea Creek Basin (Lancaster, Pennsylvania), Patuxent River Basin (western shore of Chesapeake Bay), and Chester River Basin (eastern shore of Chesapeake Bay). These measurements were done by groups from Virginia Institute of Marine Science, U. S. Geological Survey, and State of Maryland, respectively.[20-23]

As a result of this work non-point pollution loading factors have been generated which can be used to estimate loadings produced in a watershed by using the equation:

$$Y(X) = \sum_{i=1}^{N} F_i(X)\, A_i$$

where

$Y(X)$ = loading of pollutant X (lbs/year)

$F_i(X)$ = loading factor for pollutant X and land use i (lbs/acre/year)

A_i = area of land use i (acres)

In this report we have used the loading factors given in reference 9. A recalibration of these factors has recently been reported.[11]

IV. CHURCH CREEK WATERSHED

Introduction

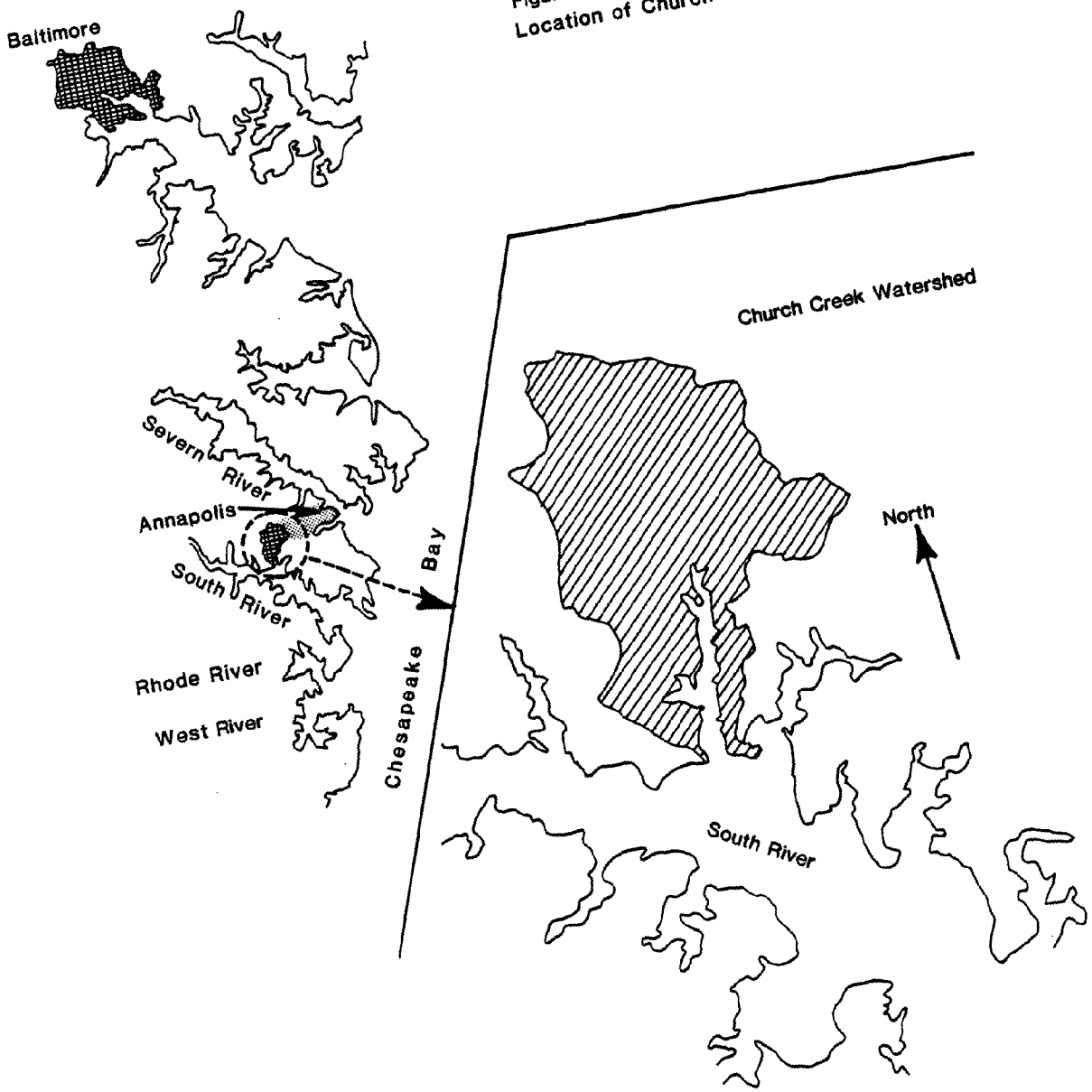
A small watershed was selected to demonstrate the application of the WATER SCREEN program. In this section we describe the Church Creek watershed, land use patterns of this watershed in 1974, 1981, and a hypothetical development pattern based on the General Development Plan (GDP), and the choice of input parameters for WATER SCREEN. We then compare the results of the modified universal soil loss equation (MUSLE) method with the loading factor approach for forest and agricultural land use, and discuss the estimated loadings for all forest, 1974, 1981, and GDP land use patterns.

Description

Church Creek is located just south of Annapolis, Maryland. It is a mile-long tidal tributary of South River, which is a subestuary of the Chesapeake Bay. (See Figure 1.) The watershed has an area of 1200 acres. The soil type within the watershed is predominately Monmouth loamy sand with some Collington fine sandy loam.[25] Typical land slopes are in the 0 to 10% range with the higher slopes on land close to the shores of the creek.

For purposes of analysis the watershed was divided into six sub-watersheds based on water drainage patterns. These sub-watersheds are indicated in Figure 2. The land use patterns that existed in 1974 and 1981 are shown in Figures 4 and 5, using the color code shown in Figure 3. A hypothetical land use pattern based under the present General Development Plan is shown in Figure 6. It should be emphasized that this

Figure 1
Location of Church Creek Watershed



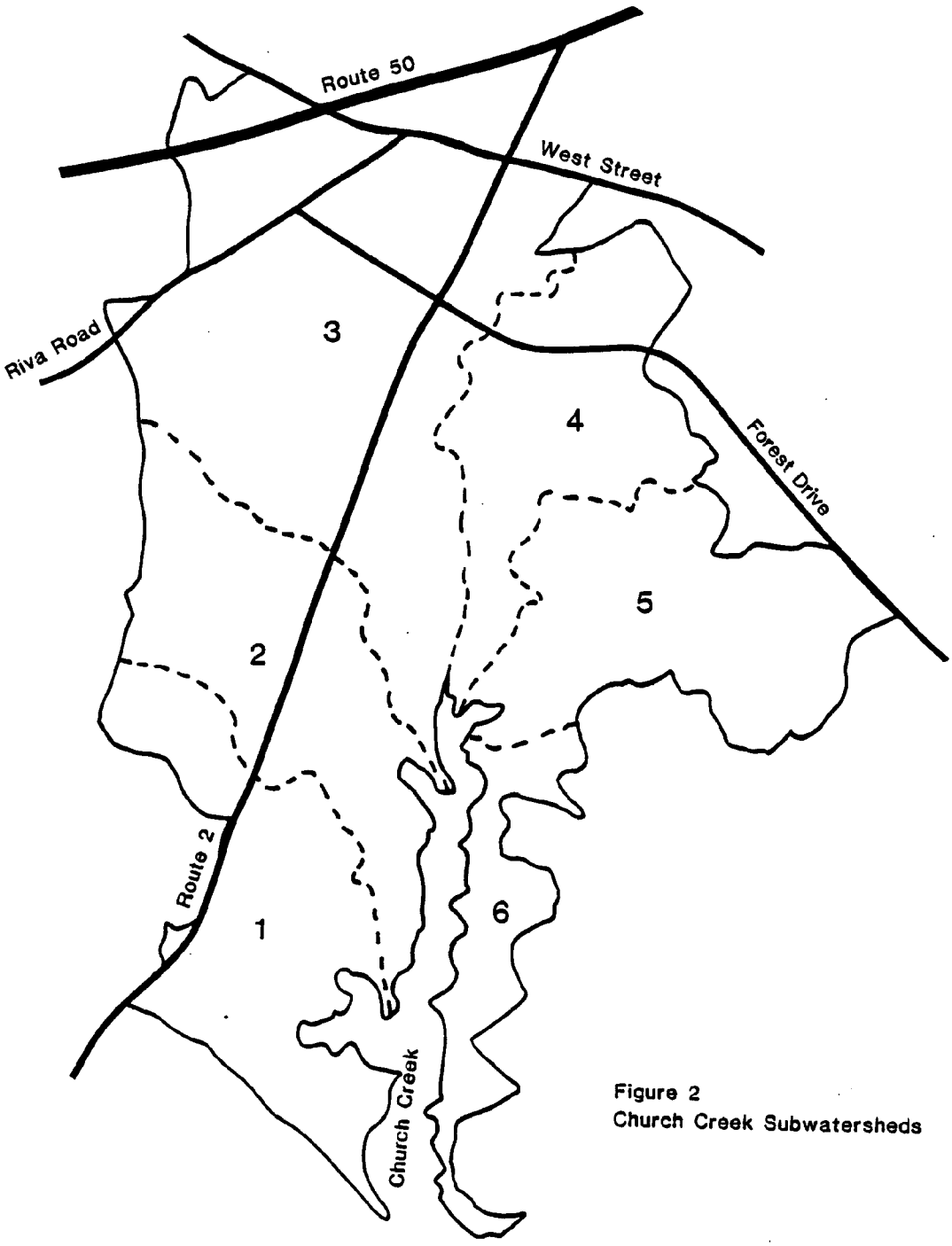


Figure 2
Church Creek Subwatersheds

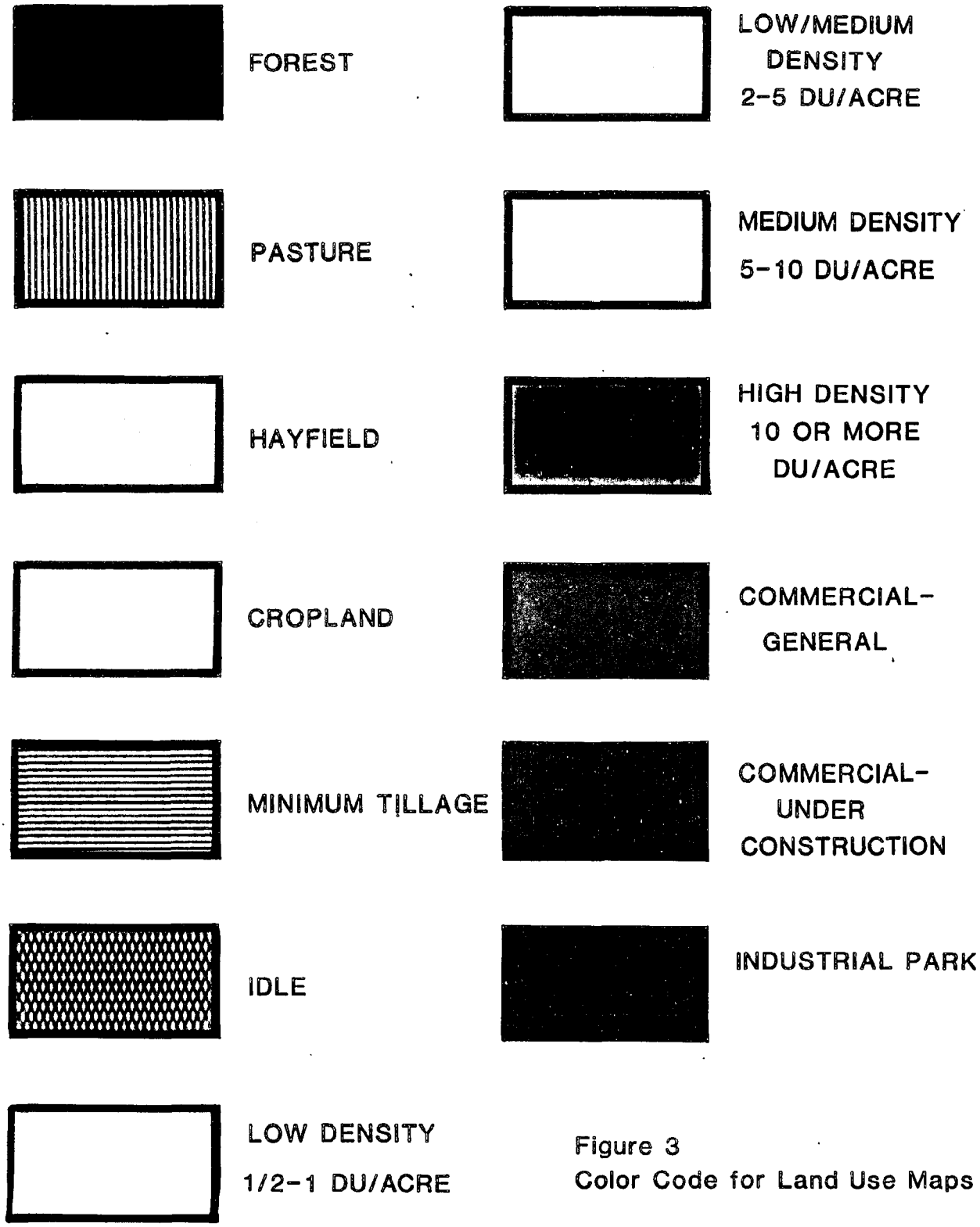


Figure 3
Color Code for Land Use Maps

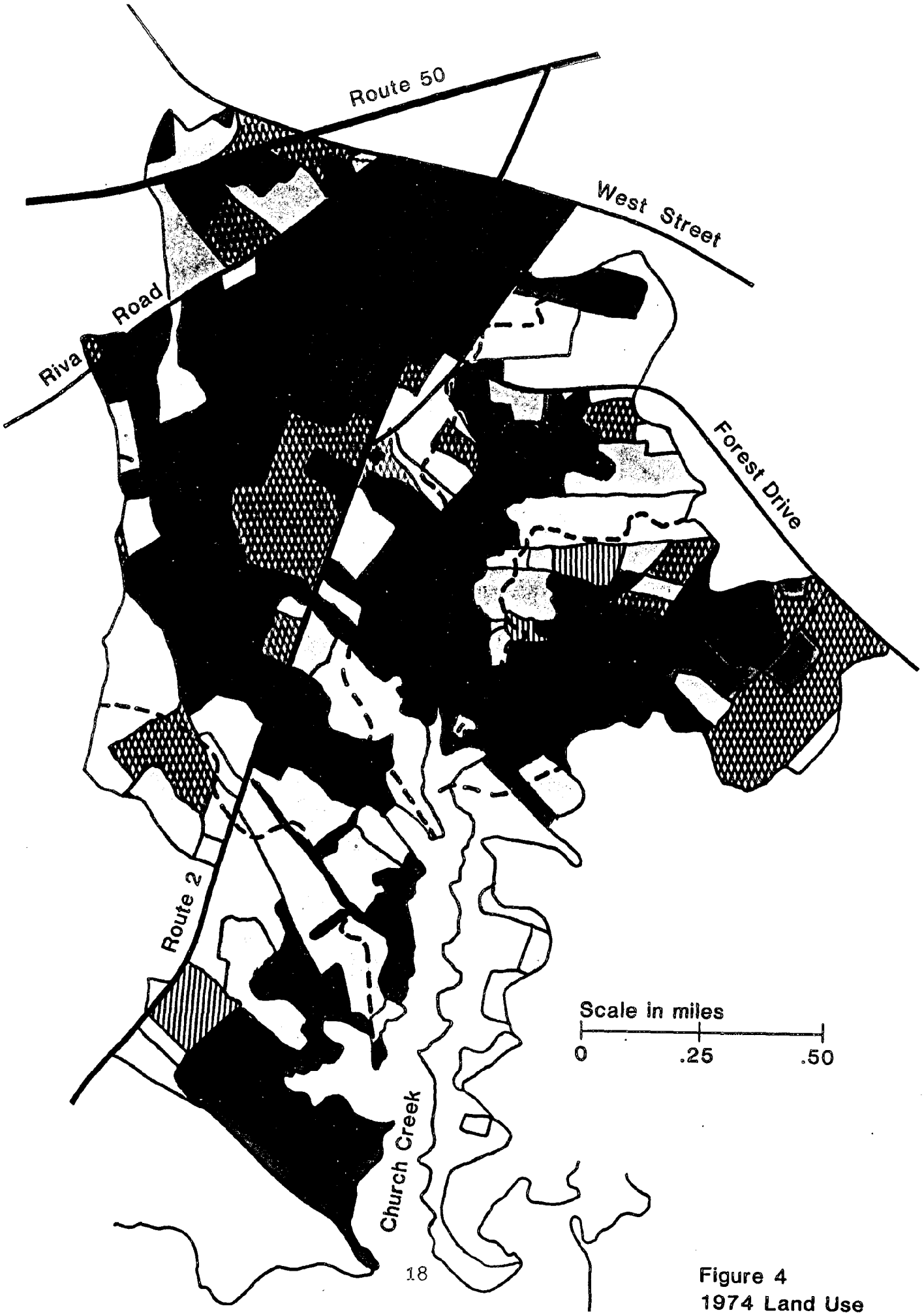


Figure 4
1974 Land Use

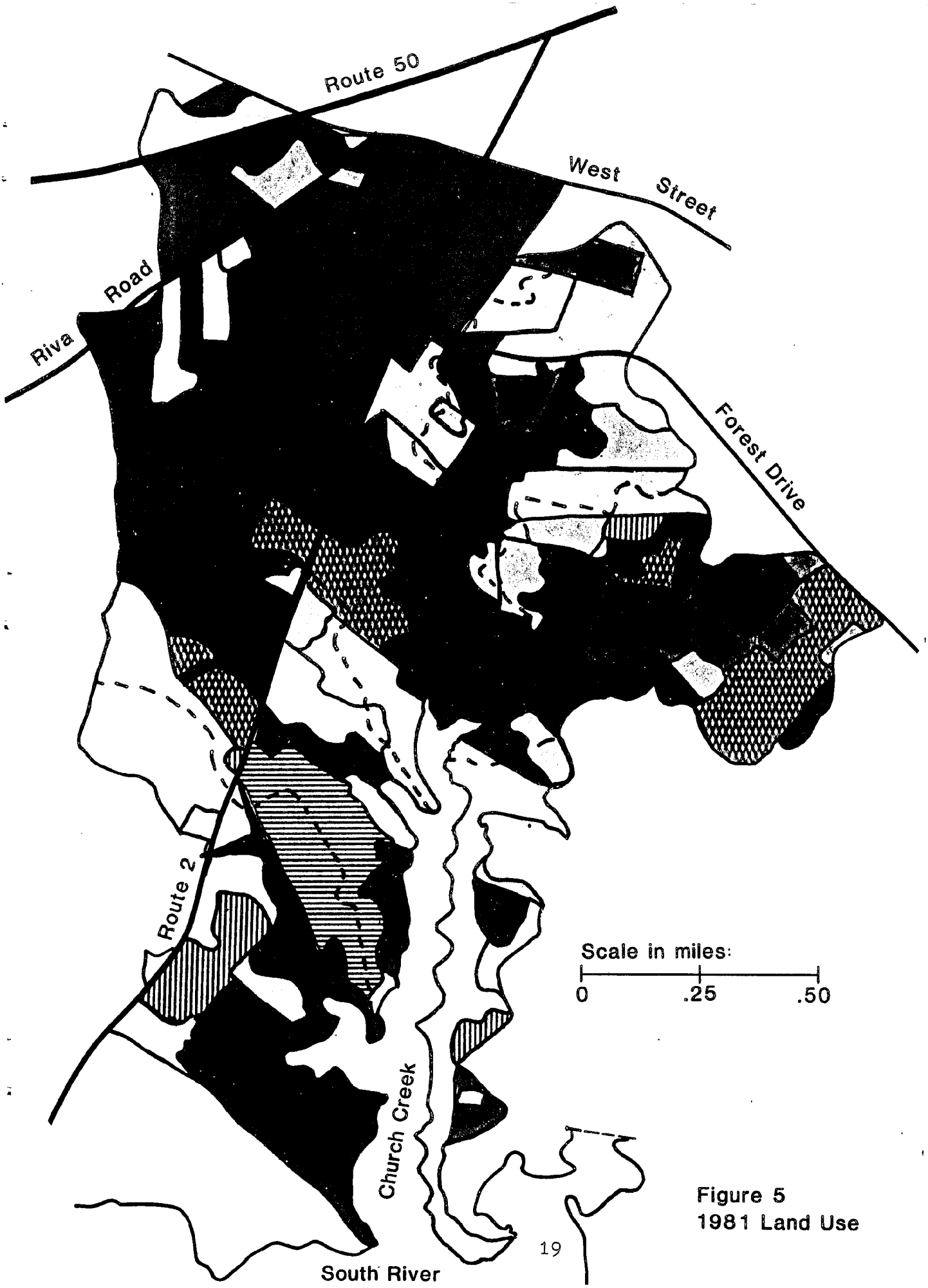


Figure 5
1981 Land Use

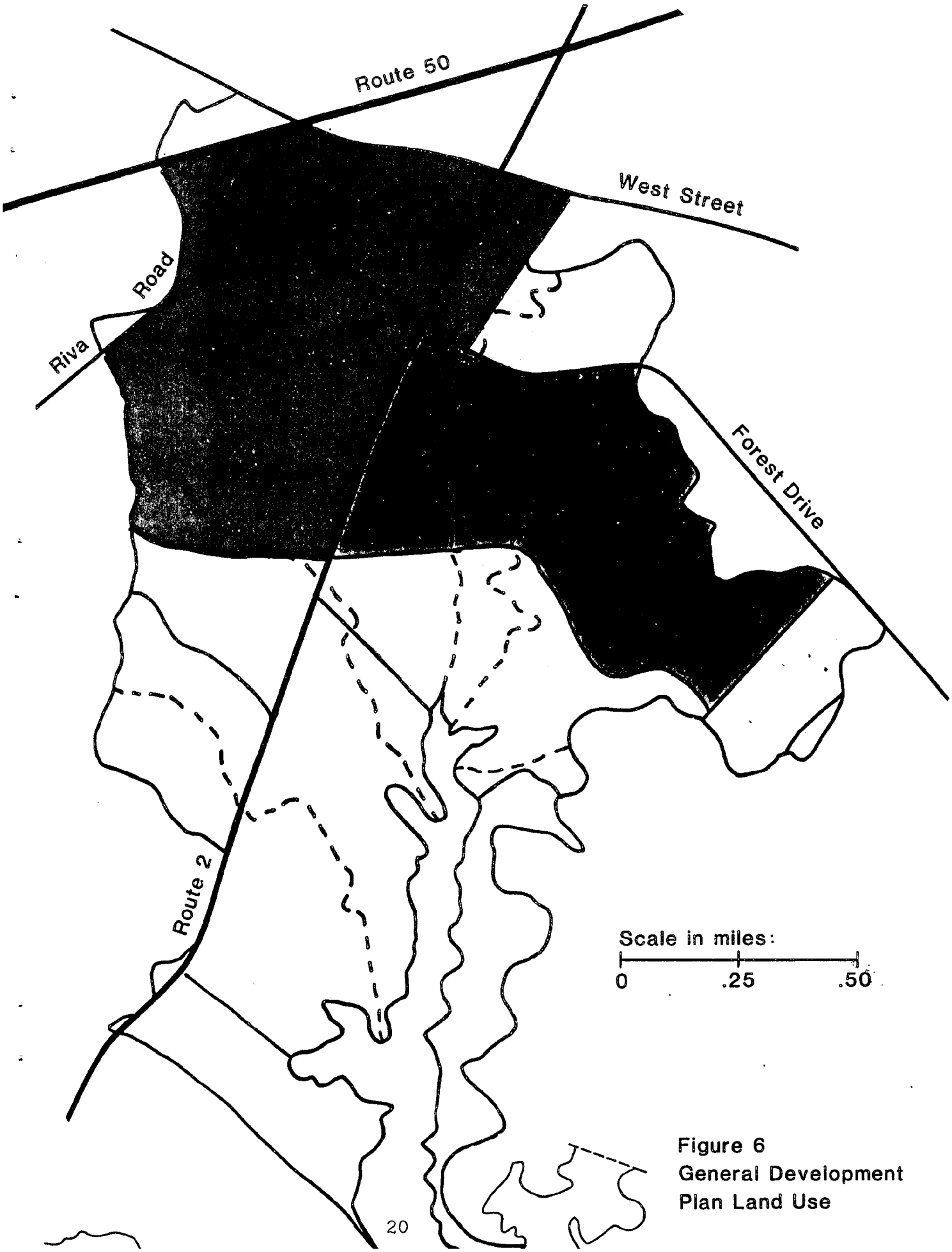


Figure 6
General Development
Plan Land Use

projected land use is not possible because of existing development patterns and regulatory controls. It is presented as an extreme to which present land use can be compared. Tabulated values for 1974, 1981, and GDP land use areas are given in Tables 1, 2 and 3. The land use classifications used in this report are forest, pasture, hayfield, conventional tillage crop, minimum tillage crop, idle, low density residential (½ - 1 dwelling unit [DU] per acre), low/medium density (2 - 5 DU/acre), medium density (5 - 10 DU/acre), and high density (greater than 10 DU/acre). In these tables the numbers in parentheses are the percentages of subwatershed area for that particular land use.

Commercial areas are located primarily in subwatersheds 3 and 4. These are shopping centers or office buildings. There is no heavy industrial land use within the watershed. Agricultural land lies primarily in subwatersheds 1, 2 and 6. Comparison of 1974 with 1981 land use indicates an increase of commercial land by 25% and a decrease in conventional tillage land by 88%, largely due to changes in farming practice, from conventional to minimum tillage.

These land use maps are based on analysis of aerial photographs on file at Anne Arundel County Office of Planning and Zoning for 1970, 1977, and 1980. Using County maps for 1970 and 1977, changes within this time period were noted. Dates of development were determined through tax maps, development files in the Office of Planning and Zoning, and through interviews with long-time residents. This process provided the necessary information to create a land use map for 1974 at a scale of 1:4800.

SW	Forest	Pasture	Hayfield	Conventional Crop	Minimum Tillage	Idle
1	75.1*(38.5)**	11. (5.6)	14.8 (7.6)	43.8 (22.5)	-	13.8 (7.1)
2	73.1 (40.2)	-	14.8 (8.1)	31.1 (17.1)	-	5.2 (2.9)
3	152.2 (39.1)	9.2(2.4)	17.8 (4.6)	-	-	46.3 (11.9)
4	48.0 (29.9)	1.7 (1.0)	12.5 (7.8)	4.0 (2.5)		7.4 (4.6)
5	71.2 (37.8)	6.6 (3.5)	10.5 (5.6)	10.2 (5.4)		45.4 (24.1)
6	1.8 (2.2)	-	5.9 (7.4)	11.2 (14.0)	-	-
TOTAL	421.4 (35.3)	28.5 (2.4)	76.3 (6.4)	100.3 (8.4)	-	118.1 (9.9)

	Residential Density				Commercial	TOTAL
	Low	Low/ Medium	Medium	High		
1	34.4 (17.6)	2.2 (1.1)	-	-	-	195.1 (16.3)
2	40.5 (22.2)	11.7 (6.4)	-	-	5.5 (3.0)	181.9 (15.2)
3	11.6 (3.0)	31.3 (8.0)	7.8 (2.0)	1.4 (.4)	111.4 (28.6)	389.0 (32.5)
4	11.7 (7.3)	22.2 (13.8)	36.7(22.8)	14.2 (8.8)	2.2 (1.4)	160.6 (13.4)
5	5.8 (3.1)	9.4 (5.0)	-	28.9 (15.4)	-	188.0 (15.7)
6	61.1 (76.4)	-	-	-	-	80.0 (6.7)
TOTAL	165.1 (13.8)	76.8 (6.4)	44.5 (3.7)	44.5 (3.7)	119.1 (10.0)	1195.0

* Acres

** Percentage

Table 1 1974 LAND USE

SW	Forest	Pasture	Hayfield	Conventional Crop	Minimum Tillage	Idle
1	81.7*(40.6)**	16.8 (8.3)	2.6 (1.3)	5.9 (2.9)	21.3 (10.6)	-
2	74.4 (38.2)	.9 (.5)	3.8 (1.9)	2.3 (1.2)	30.9 (15.8)	14.3 (7.3)
3	147.9 (38.5)	-	18.1 (4.7)	1.3 (.3)	-	30.0 (7.8)
4	54.5 (34.3)	11.3 (7.1)	-	3.6 (2.3)	-	-
5	84.6 (44.2)	2.9 (1.5)	9.6 (5.0)	8.8 (4.6)	-	40.4 (21.1)
6	14.2 (18.2)	2.6 (3.3)	13.2 (16.9)	-	-	-
TOTAL	457.3 (37.8)	34.5 (2.8)	47.3 (3.9	21.9 (1.8)	52.2 (4.3)	84.7 (7.0)

	Low	Low/ Medium	Medium	High	Commercial	TOTAL
	Residential Density					
1	72.9 (36.2)	-	-	-	-	201.2 (16.6)
2	48.2 (24.8)	8.0 (4.1)	-	-	11.8 (6.1)	194.6 (16.1)
3	4.9 (1.3)	41.3 (10.7)	1.5 (.4)	5.7 (1.5)	133.7 (34.8)	384.4 (31.8)
4	1.6 (1.0)	37.8 (23.7)	30.6(19.2)	16.1 (10.1)	3.6 (2.3)	159.1 (13.1)
5	2.8 (1.5)	9.6 (5.0)	-	32.6 (17.0)	-	191.3 (15.8)
6	47.9 (61.5)	-	-	-	-	77.9 (6.4)
TOTAL	178.3 (14.7)	96.7 (8.0)	32.1 (2.6)	54.4 (4.5)	149.1 (12.3)	1209.0

* Acres

** Percentage

Table 2 1981 LAND USE

	Low	Low/ Medium	Medium	High	Commercial	TOTAL
	Residential Density					
1	73.3*(36.2)**	129.4 (63.8)	-	-	-	202.7 (16.5)
2	-	126.2 (62.7)	56.7 (28.2)***	-	18.5 (9.2)	201.4 (16.4)
3	14.5 (3.7)	20.4 (5.2)	35.2 (9.0)	48.6(12.5)	271.3(69.6)	390.0 (31.8)
4	-	46.8 (29.1)	20.7 (12.8)	93.5(58.1)	-	161.0 (13.1)
5	-	3.3 (1.7)	96.9 (50.5)	91.7(47.8)	-	191.9 (15.6)
6	72.0 (88.7)	-	9.2 (11.3)	-	-	81.2 (6.6)
TOTAL	159.8 (13.0)	326.1 (26.6)	218.7 (17.8)	233.8(19.0)	289.8(23.6)	1228.0

* Acres
** Percentage
*** See comment on page 66

Table 3 GDP LAND USE

Land use maps for 1981, based on 1980 aerial photos, have been generated by the Office of Planning and Zoning for the Annapolis Neck Sector Plan. This information was further refined by field checking for types of farm practices as well as percent imperviousness of developed areas. New maps were drafted by us using the land use categories needed for input to the WATER SCREEN program.

Maps prepared for the Anne Arundel County General Development Plan were enlarged to 1:4800 scale to determine how this land use might affect the creek. The GDP provides policy direction; it does not show what will physically happen to the watershed. For the purpose of this study it was hypothesized that development would occur without normal regulatory controls and without regard to existing development.

Input Parameters for WATER SCREEN

Input parameters for the Church Creek watershed used in WATER SCREEN are listed in Table 4.

Soil maps indicate most of the watershed is composed of loamy sand, but in subwatershed 4 there is some fine sandy loam; the soil erodibility factor K was adjusted to account for this.[25]

The length-slope factor (LS) was obtained from the 1:4800 contour maps by "eyeball" estimates of average lengths to a stream channel and typical changes in elevation. The difficulty in determining these average values is illustrated in Figure 6'.

For the irregularly shaped land use area shown in Figure 6'(a) it is not clear how to arrive at an average value of length because

Function	Parameter	Sub-Watershed	Land Use	Parameter Value	Source
MUSLE	R	All	All	200	Reference 12
	K	1	All	.43	" "
		2	"	.43	
		3	"	.43	
		4	"	.35	
		5	"	.43	
		6	"	.43	
"	LS		See Table 5		1/4800 scale maps
					Reference 12
"	C	All	Forest	.003	Reference 16
			Pasture	.013	
			Hayfield	.009	
			Idle	.012	
			Conventional Crop	.319	
			Minimum Tillage Crop	.185	
"	P	All	Non-cropland	1.0	Reference 16
			Cropland	.75	
"	S_D	1	All	.5	1/4800 scale maps
		2	"	.54	Reference 12
		3	"	.48	
		4	"	.54	
		5	"	.54	
		6	"	.56	

TABLE 4 PARAMETER VALUES FOR CHURCH CREEK WATERSHED

Year	Sub-Watershed	Forest	Pasture	Hayfield	Conventional Crop	Minimum Tillage	Idle
1974	1	1.2	.45	.53	.55	-	.25
	2	.45	-	.55	.35	-	.38
	3	.33	.3	.26	-	-	.26
	4	1.1	1.0	.28	.7	-	.33
	5	1.7	.9	.75	.4	-	.28
	6	1.0	-	1.2	.8	-	-
1981	1	2.5	.15	.4	1.1	2.0	-
	2	.5	.4	.75	.3	1.4	.31
	3	.6	-	.55	.4	-	.4
	4	1.9	.8	1.6	.7	-	-
	5	1.3	.4	.9	.4	-	.3
	6	3.0	1.3	1.7	-	-	-

TABLE 5 LS PARAMETER VALUES FOR CHURCH CREEK WATERSHED

of the greater distance the soil must travel from the upper branch of this land use area as compared to soil eroded in the lower branch. In addition, part of this field may have a variation in elevation as shown in Figure 6'(b). Furthermore, there may be more than one location having the same land use within a particular subwatershed, as illustrated in Figure 6'(c).

An attempt was made to deal with these averaging problems by choosing a location that appeared to represent an average distance to stream channel and average elevation for each land use. In the case of multiple areas within a given subwatershed with the same land use, an "average" of the "averages" was used.

It is recognized that this is not a satisfactory procedure. First of all, it depends upon individual choices and therefore is not reproducible. Even for the same individual the subjective nature of the process can result in large uncertainties. For example, the values for the LS factor shown in Table 5 were done a week apart for 1974 and 1981 land use. Inspection of this table indicates that the LS factors for land use having little change between the two years may vary as much as a factor of two in the tabulated values. Secondly, it is not clear what an appropriate weighting procedure should be when the average value of the LS factor for separate land use areas of variable size, elevation, and distance from stream channel is desired.

The question of the proper averaging procedure for a collection of differing or spatially separated fields is a fundamental problem in the MUSLE approach.[18] The original USLE was meant to be applied to a single field. It is likely that a reproducible averaging procedure could be

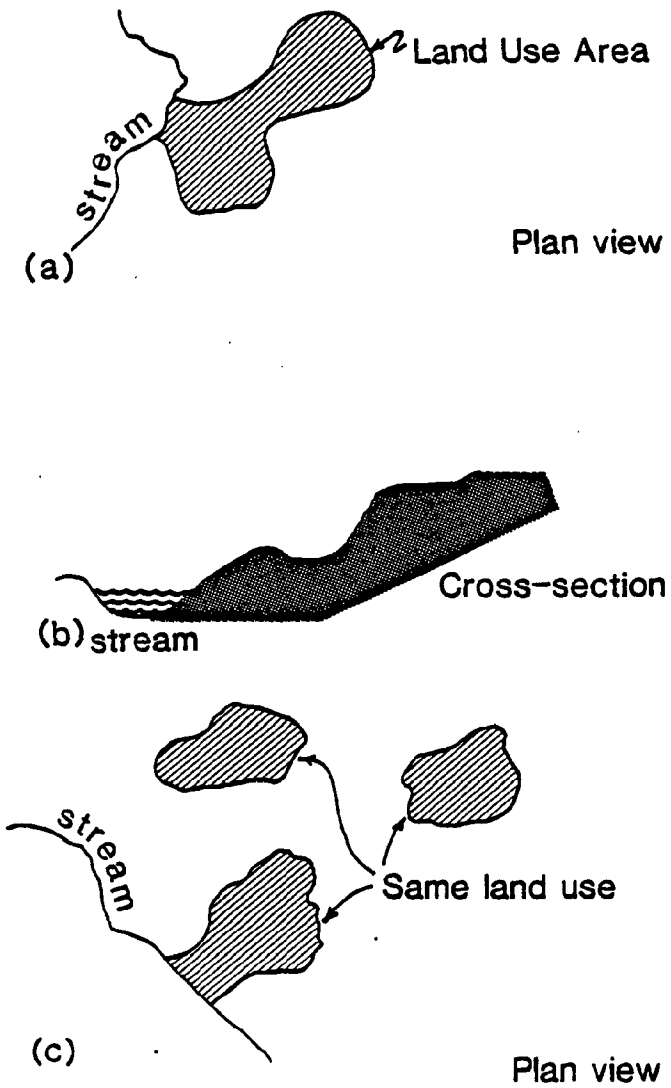


Figure 6'. Problems in estimating average (LS) factor.

developed based on superimposing a square grid on the watershed contour map and assigning values for the various factors based on well defined procedures. A weighting scheme could be used in conjunction with the grid values to arrive at average values.[2, 26-31] Questions then arise as to the minimum grid size necessary, and as to the relative merits of different weighting schemes. Answers to these questions will require further studies of single and multiple use watersheds.

The values chosen for the cover factor C were based on assumptions as to the degree of canopy cover and ground cover. The cover factor for forest requires an estimate of the amount and type of forest litter. Values of C for conventional crop and minimum tillage crop assume a two year crop rotation as follows: first year corn, second year soybeans.

The agricultural practices factor has a value of 1.0 if no special practices are assumed. A value of .75 for cropland assumes that planting was done across the slope.

Sediment delivery ratio (S_D) values were found using a graph of S_D versus the reciprocal of the drainage density (Figure III-10, Zison et al.)[12] Drainage density is defined as the ratio of total channel-segment lengths to the watershed area. The reciprocal of the drainage density approximates the average distance a soil particle would have to travel from the point of erosion to the stream channel.

Loading factors in reference 9 are tabulated on the basis of soil type and percent imperviousness of the land surface. The values listed in Table 6 selected for Church Creek are for sandy loam soils and an average value for the range of percent imperviousness that is listed.

Pollutant	Land Use: Forest	Pasture	Hayfield	Conventional Crop	Minimum Tillage	Idle
Sediment	20	20	20	1580	900	20
Nitrogen	2.4	4.3	2.6	12.5	8.7	2.6
Phosphorous	.1	.3	.1	2.3	1.1	.1
BOD	6	13	6	29	19	6
Lead	.01	.01	.01	.02	.02	.01
Zinc	.01	.02	.01	.1	.1	.01

Pollutant	Land Use: Low Density	Low/Medium Density	Medium Density	High Density	Commercial
Sediment	120	240	420	560	480
Nitrogen	5.1	7.1	9.7	12.5	13.2
Phosphorous	.5	.8	1.1	1.7	1.6
BOD	13	18	25	36	163
Lead	.12	.29	.59	.97	2.58
Zinc	.11	.23	.38	.55	2.06

TABLE 6 LOADING FACTORS (LBS/ACRE/YEAR) SELECTED FOR CHURCH CREEK WATERSHED[9]

Some of the loading factors listed in Table 6 have been revised based on recent recalibration measurements.[11] The effect of these revisions on our estimates for the Church Creek watershed will be discussed in a later section.

Comparison of MUSLE method with Loading Factor Approach

Loading estimates from both the MUSLE and loading factor methods are shown for sediment, total nitrogen, and total phosphorous in Figures 7, 8 and 9, respectively. These results are only for forest and agricultural land use within the watershed. As can be seen, the MUSLE method estimates a much larger amount of sediment, by a factor of 10 to 20, than that estimated from the loading factor method. However, estimates for total nitrogen and total phosphorous are just the opposite; the MUSLE estimates are a factor of 4 to 15 times lower than those given by the loading factor approach. Only in the case of minimum tillage crop are the estimates of comparable size. Both the nitrogen and phosphorous loading functions used with the MUSLE approach relate the amount of nutrient to the amount of sediment; therefore one would expect the sediment, nitrogen, and phosphorous estimates to all be high or low, but they are not.

Possible reasons for the discrepancy between the two methods are:

1. Nitrogen and phosphorous loading functions that were used are not correct or not appropriate for this watershed.
2. The loading factors used are not appropriate for this watershed.

The transport of nitrogen and phosphorous have been intensively studied because of their importance in the eutrophication of natural

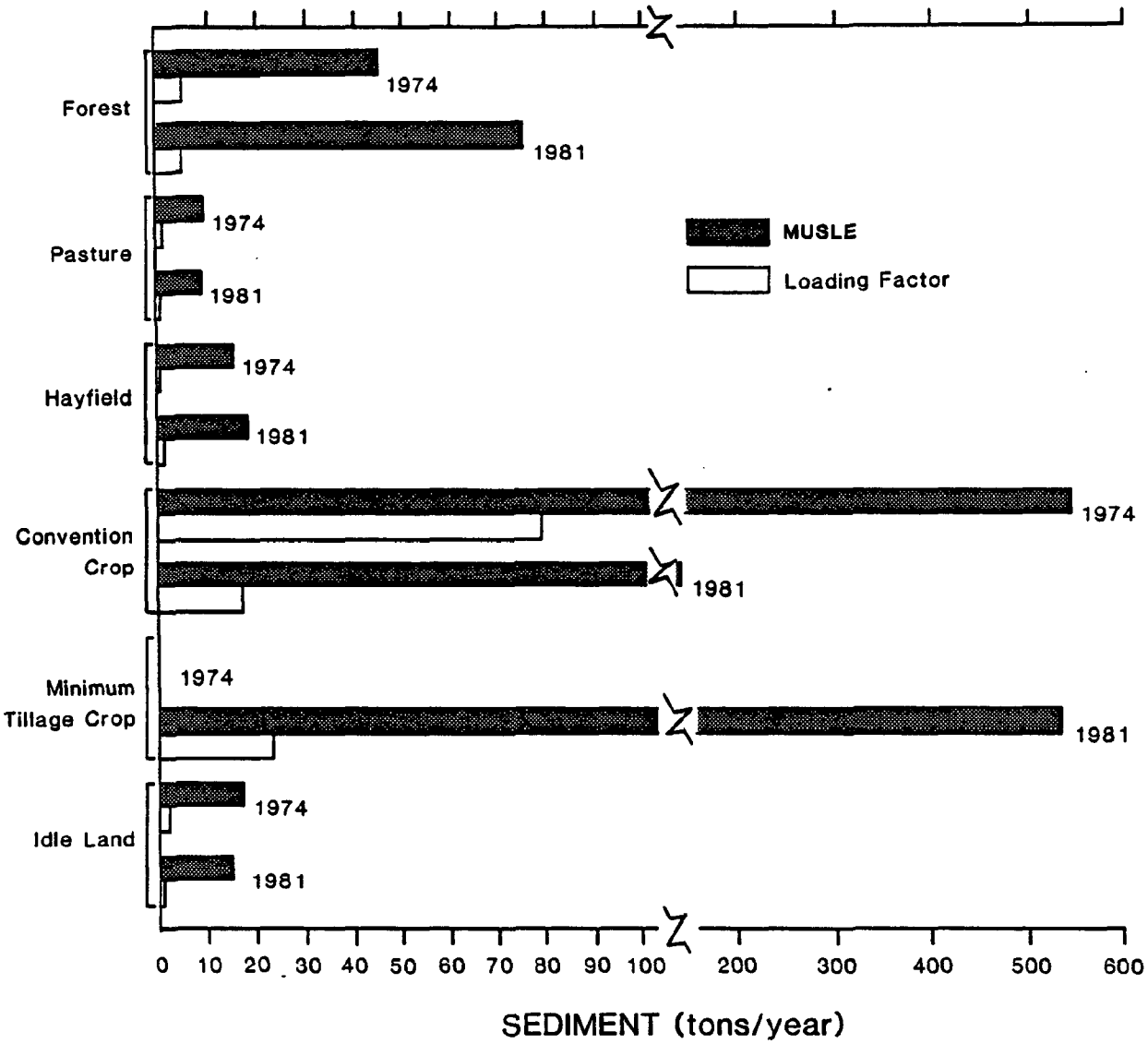


Figure 7.
Comparison of MUSLE and loading factor estimates-sediment

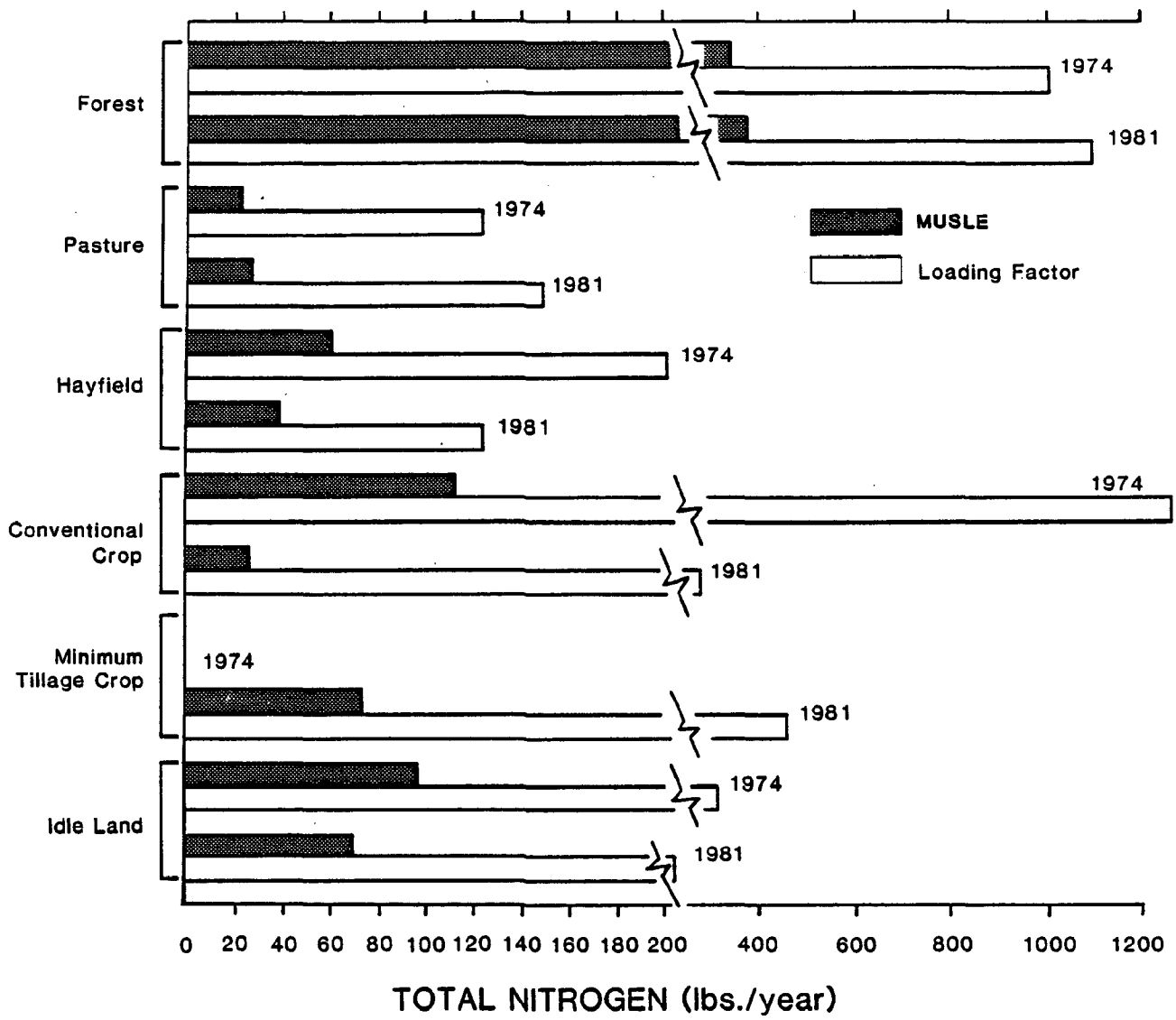


Figure 8 .
Comparison of MUSLE and loading factor estimates -Total nitrogen

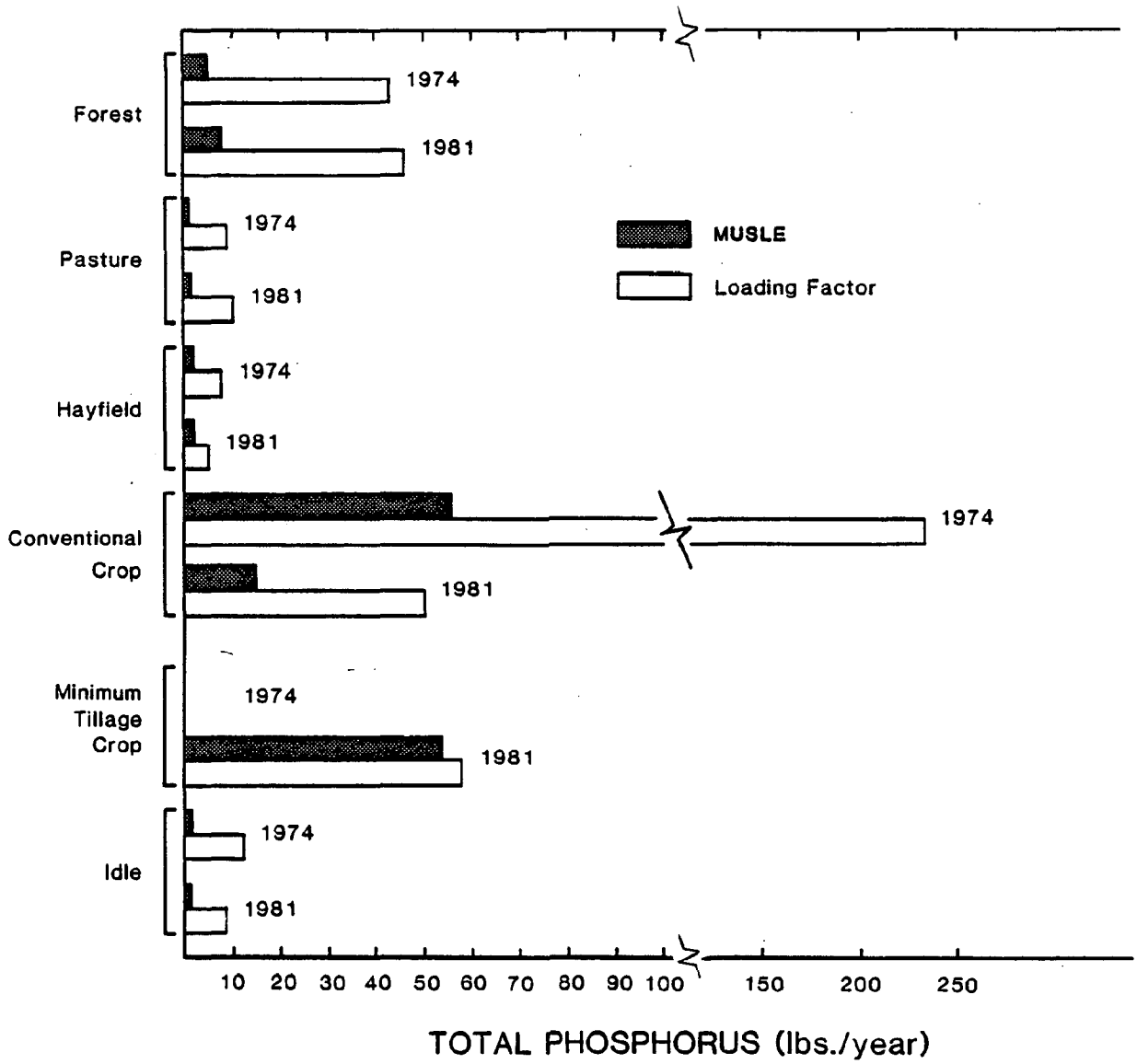


Figure 9.
Comparison of MUSLE and loading factor estimates–Total phosphorus

waters.[19,32,33] They are part of an extremely complex process with some of the details still not well understood. It is therefore not unlikely that the simplified method of estimating nitrogen and phosphorous loadings by means of loading functions is not correct.

Recent work in the Chesapeake Bay Program found that the loading factors developed for the Occoquan River basin in Northern Virginia were comparable to values found in small watersheds located in the Pequea Creek region near Lancaster, Pennsylvania.[24] Work with other watersheds within the Chesapeake Bay watershed also indicated comparable loading factors. This suggests that these loading factors are appropriate for use with the Church Creek watershed provided there are no unique characteristics of the Church Creek watershed which distinguish it from the watersheds on which the loading factors are based.

The Smithsonian Institution's Chesapeake Bay Center for Environmental Studies is located on the Rhode River, which is the nearest subestuary of the Chesapeake Bay south of the South River. (See Figure 1.) Center workers have carried out an extensive study of the Rhode River watershed. Some of the measured values they obtained for nitrogen, phosphorous, and sediment loading factors are given in Table 7. Comparing their measured values with those chosen for the Church Creek watershed (Table 6), the nitrogen and phosphorous values for forest are in reasonable agreement; for pasture/hayfield they disagree by a factor of 3 to 15; and for cultivated land they differ by factors of 2 to 4. It is more difficult to compare the sediment loading result because of the mixed land use within the Rhode River subwatersheds. Basins 101, 103 and 105 have similar land use patterns, so that the values ranging from

Land Use	Nitrogen	Phosphorous
Cultivated	3.3*	1.2*
Pasture/Hay	11.6	3.4
Forest	1.3	.18

Basin		1974	1975	1976
101	Forest, old fields, pasture	67*	456	286
102	Forest, pasture, row crops	40	136	113
103	Forest, old fields, pasture			220
105	Forest, old fields, pasture		254	178
108	Forest, pasture, row crops, hayfields	71	426	327

*(lbs/acre/year)

TABLE 7 MEASURED LOADINGS FROM RHODE RIVER SUBWATERSHEDS.[34,35]

67 to 456 lbs/acre/year should be comparable to the loading factor listed in Table 6 of 20 lbs/acre/year, but they are not. The lower measured value was obtained in a year having less rainfall, so that part of the difference may be reduced if measured values for several years were to be averaged.

A recent study of five small subwatersheds in the Patuxent River Basin arrived at average measured loading factors.[23] For forest they found an average loading factor for total suspended solids of 141 lbs/acre/year with a standard error of 89 lbs/acre/year and a range of measured values from 6 to 2074 lbs/acre/year. These results along with the variation in sediment discharge from year to year (shown in Table 7) provide good examples of the necessity for loading factors to be based on several years of measurements. The data collected by the VPI group on small watersheds in the Occoquan River Basin illustrates the possible range of measured values.[22] For example, the range of measured values for total nitrogen from a forested area overlaps the range of measured values produced by minimum tillage-corn land use. Nevertheless, there is a significant difference between the median values for these two land uses.

As the previous discussion has indicated, selected loading factors for nearby watersheds differ from the Northern Virginia Planning District Commission (NVPDC) values to some extent. However, the variability of measured loading factors from year to year indicates that a statistical average of several years of data should be used to obtain a reasonable average value for loading factors. We therefore have selected the NVPDC loading factors (Table 6) as the best available values.

While writing this report we received the recently revised loading factors from NVPDC based on additional measurements.[11] There were no changes in the nitrogen, phosphorous, and BOD loading factors. A 33% reduction in the zinc loading factor for single family residential (0.5-6.0 DU/acre) and townhouse garden apartments (6.0-20.0 DU/acre) was recommended. For lead a 50% reduction was recommended for single family residential and a 33% reduction for townhouse garden apartments. Based on a better sampling technique for suspended solids they recommend a 33% reduction in the sediment loading factor for all residential land use categories.

Part of the reduction in the lead loading factor may be due to the increased use of no-lead gasoline so that the original lead loading factor may be more appropriate for the 1974 and 1981 land use patterns. In any case, the revised loading factors do not significantly affect the nutrient and pollutant loading estimates in this report which are based on the earlier loading factors from NVPDC.

Nutrient and Pollutant Discharge to Church Creek

The loading factor method was used to estimate nutrient and pollutant loadings for four different land use patterns:

1. The appropriate loading factor for forest land use was multiplied by the total land area (1200 acres) to give an estimate for each pollutant of the total loadings if the whole watershed were completely forested. This is called the "all forest" land use pattern and serves as an index of minimum loadings from the watershed.

2. 1974 land use.

3. 1981 land use.

4. Hypothesized development based on the current General Development Plan (GDP). This serves as an index of the maximum loading from the watershed.

Figures 10 through 15 show the loadings for sediment, total nitrogen, total phosphorous, biological oxygen demand (BOD), lead, and zinc for each of the eleven categories of land use. In general, no significant change in loadings between 1974 and 1981 was noted except in two categories. The change from conventional to minimum tillage practices on some of the farmland reduced the sediment, total nitrogen, and total phosphorous from this land use by a significant amount. On the other hand, increase in commercial land use increased BOD, lead, and zinc loadings by 25%.

Comparing the loadings for all four land use patterns indicates that high density residential and commercial land use can contribute significant loadings for all the pollutants studied. For example, in 1981 sediment from commercial land was almost as much as from cropland. One of the more surprising results is the large amount of BOD loading produced by commercial land. In 1981 the BOD loading from commercial land use in the watershed was a factor of three larger than would have been produced if all the land were still forested, even though commercial land in 1981 made up only 12% of the entire watershed. Loadings of zinc and lead are also disproportionally higher for commercial land as compared to other land uses within the watershed.

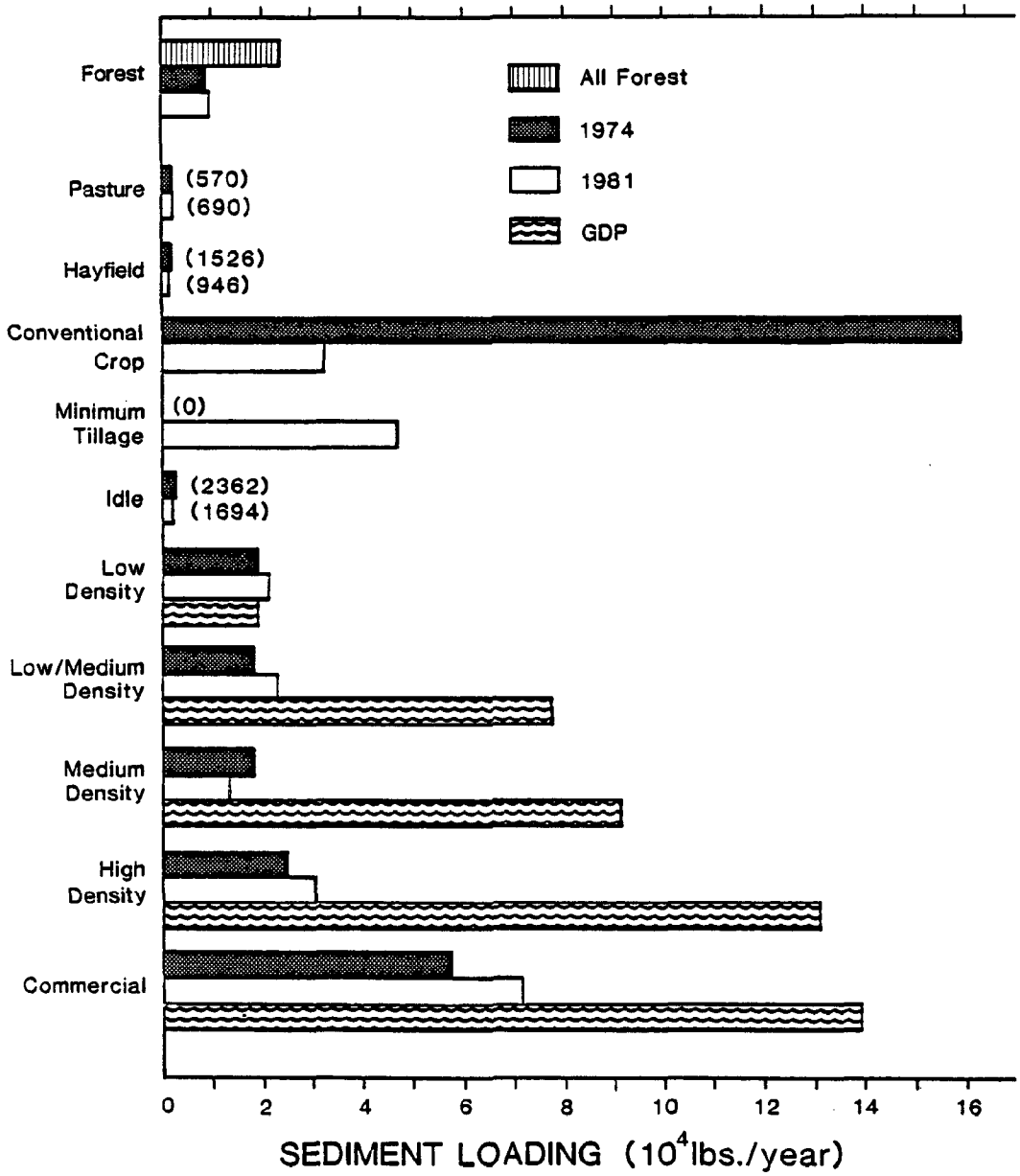


Figure 10.
Total Sediment Loading by Land Use

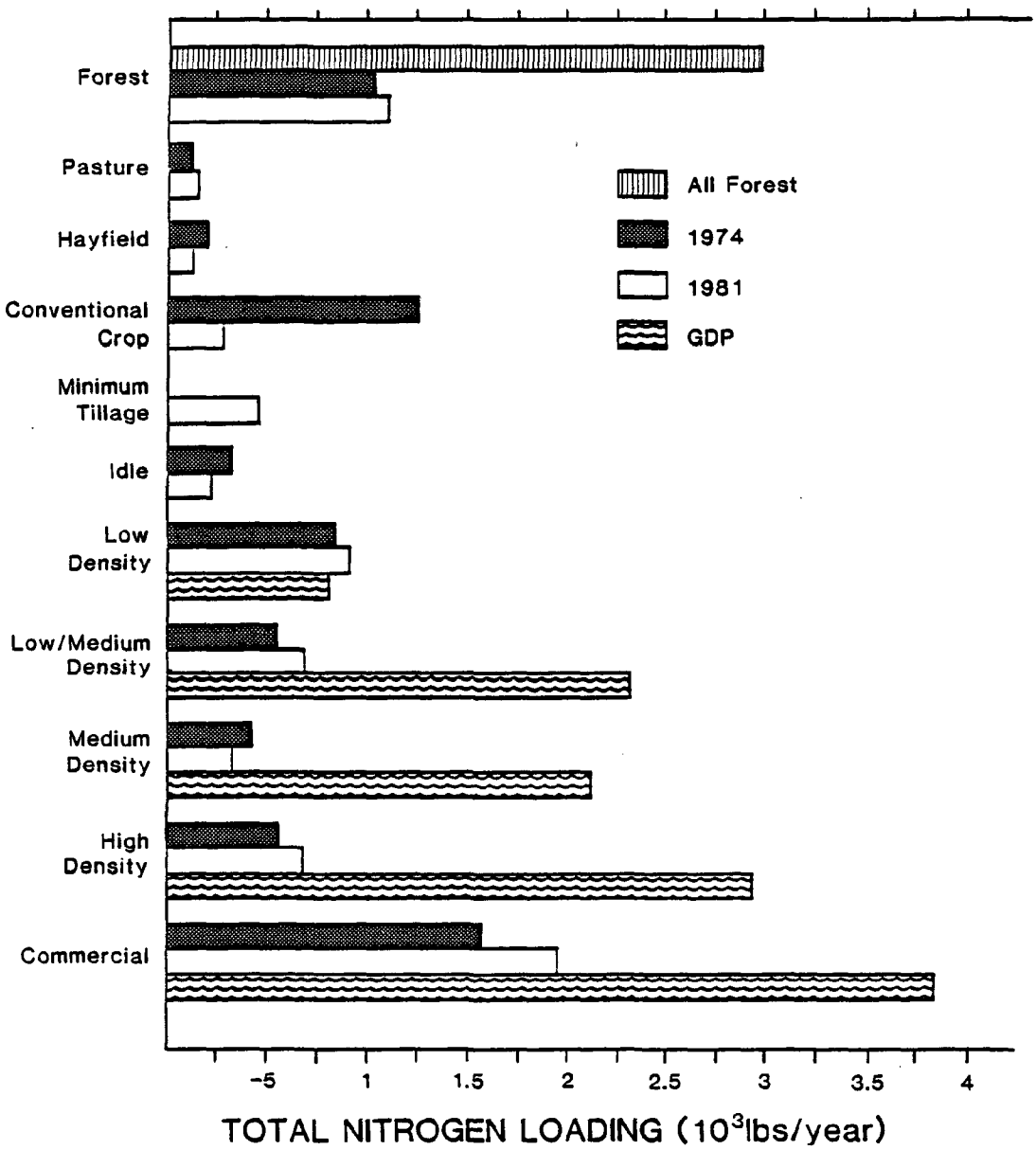


Figure 11.
Total Nitrogen Loading by Land Use

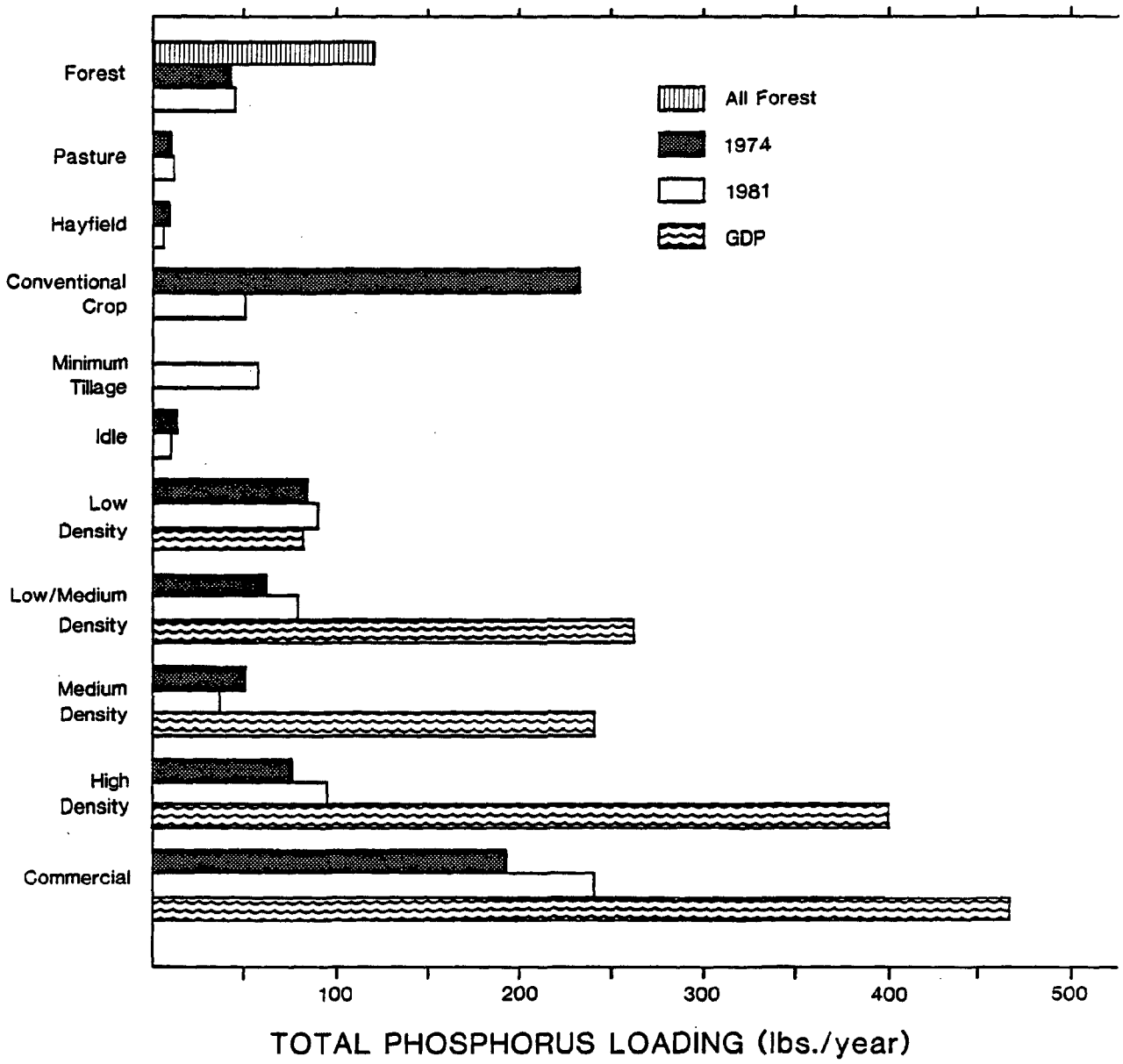


Figure 12
Total Phosphorous Loading by Land Use

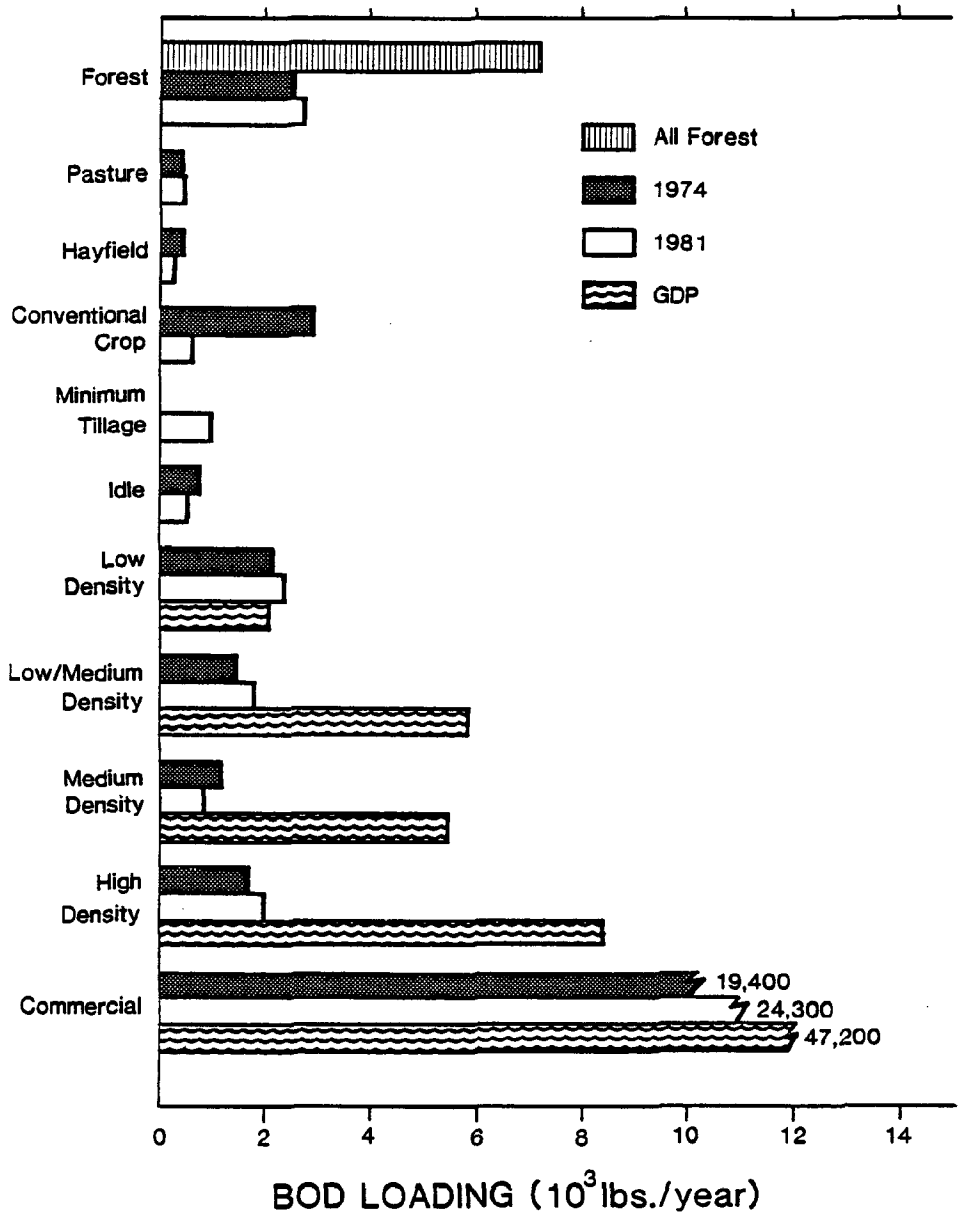


Figure 13.
BOD Loading by Land Use

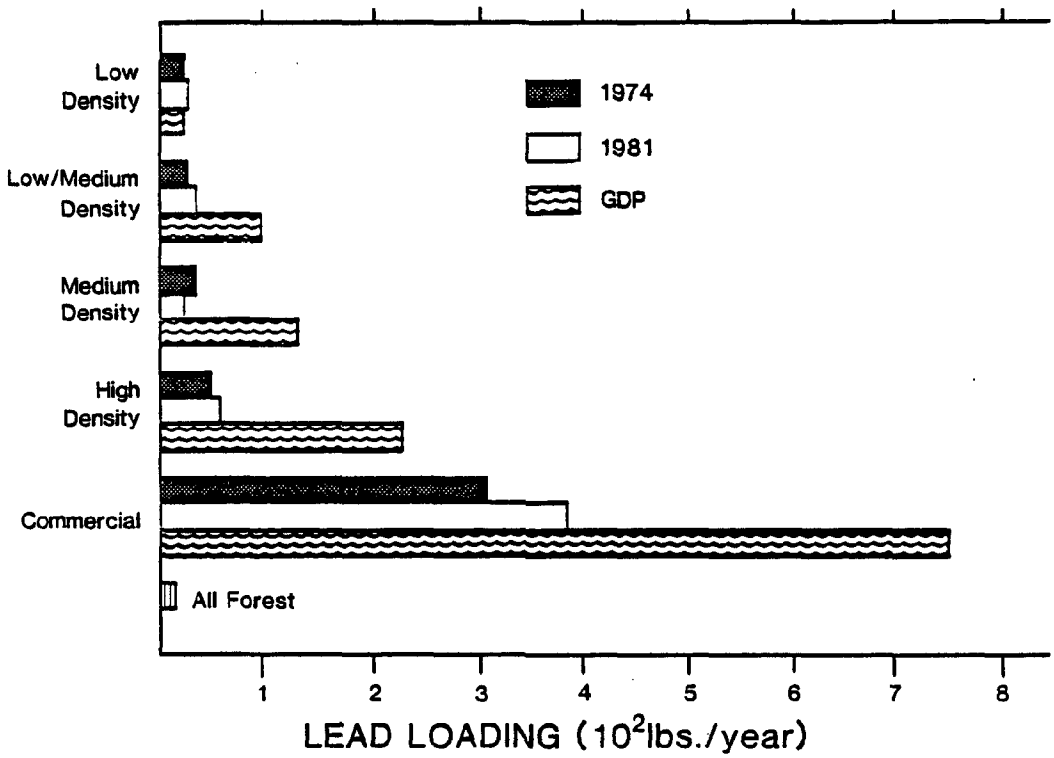


Figure 14.
Lead Loading by Land Use

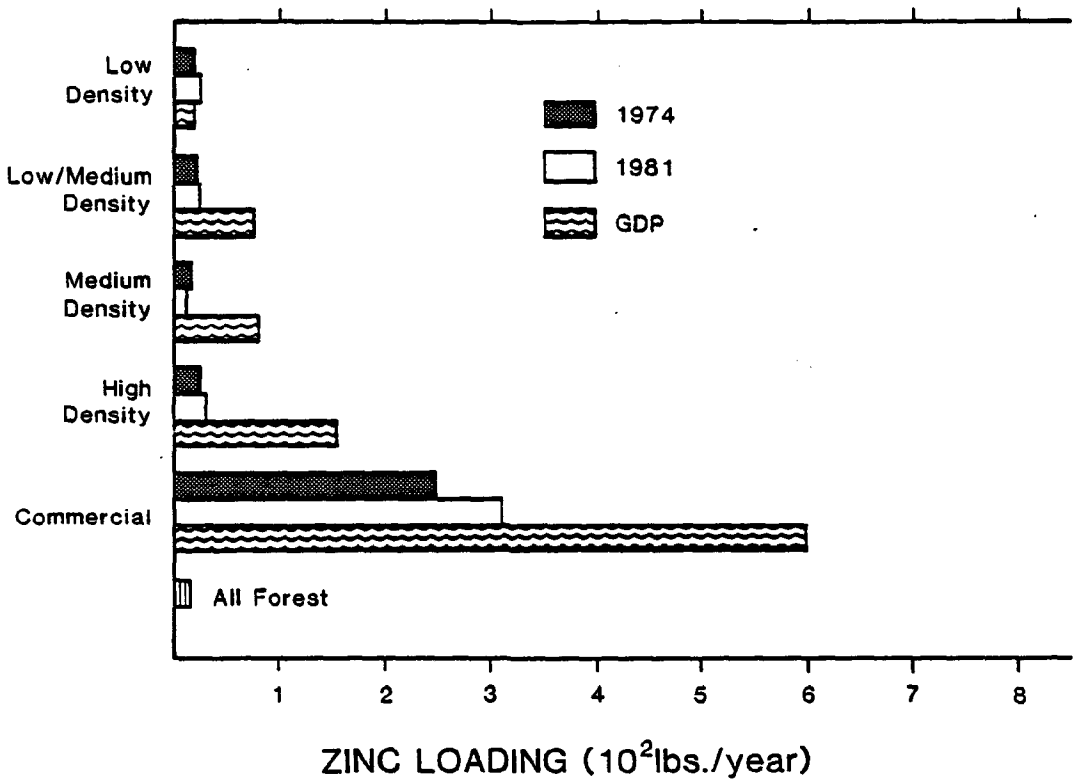


Figure 15.
Zinc Loading by Land Use

Figures 16 through 18 illustrate the estimated pollutant loadings by subwatershed. As can be seen, subwatershed 3 produces more of the loadings than the other subwatersheds. Some of this is accounted for by the larger area of subwatershed 3, but of more importance is the larger fraction of commercial land use in this watershed.

Figure 19 summarizes the estimated total pollutant loading by pollutant type for the four different development patterns considered. Between 1974 and 1981 there has been a small decrease in sediment and total phosphorous, total nitrogen has remained unchanged, and BOD, lead, and zinc have increased by about 25%. If one uses the "all forest" values for normalization, then by 1981 yearly sediment loading had increased by a factor of 10, total nitrogen by 2, total phosphorous by 7, BOD by 4.5, lead by 60, and zinc by 40. If the hypothetical land use patterns based on the GDP were to occur, then sediment would increase by a factor of 18, total nitrogen by 4, total phosphorous by 12, BOD by 9, lead by 100, and zinc by 75.

One source of lead that has not been accounted for in these estimates is the lead contained in stormwater runoff from the heavily traveled highways that are in the Church Creek watershed. A 1981 traffic survey found that the average daily traffic on Route 2, Forest Drive, West Street, and Riva Road was in the range from 14,000 to 32,000 vehicles/day.[36]

A 1972 study of lead input into a watershed in Illinois assumes 2.5 g of lead per gallon of gasoline, and in urban areas 50% of the consumed lead is emitted from the exhaust system of the automobile.[37] For the Church Creek watershed we make the additional assumptions:

1. Within the watershed there are 5 miles of roads with an average traffic volume of 23,000 automobiles/day.

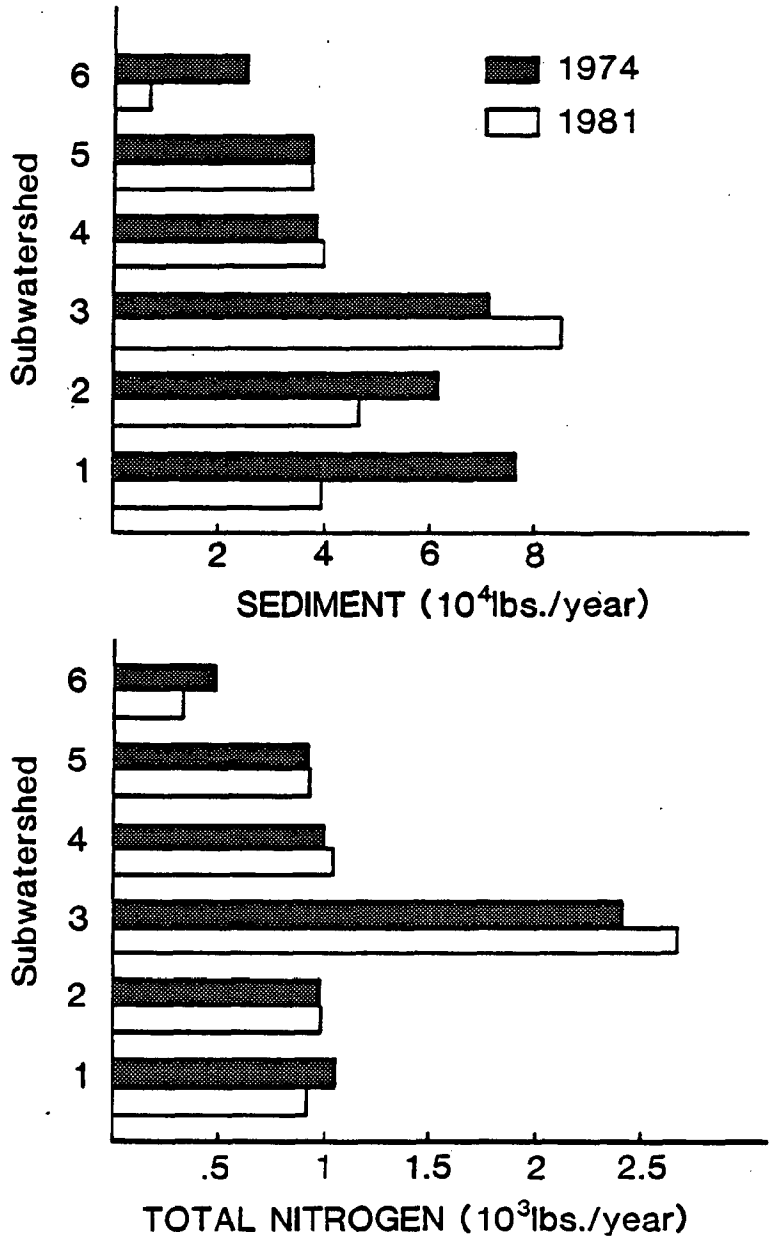


Figure 16.
Pollutant Loading by Subwatershed (Sediment and Nitrogen)

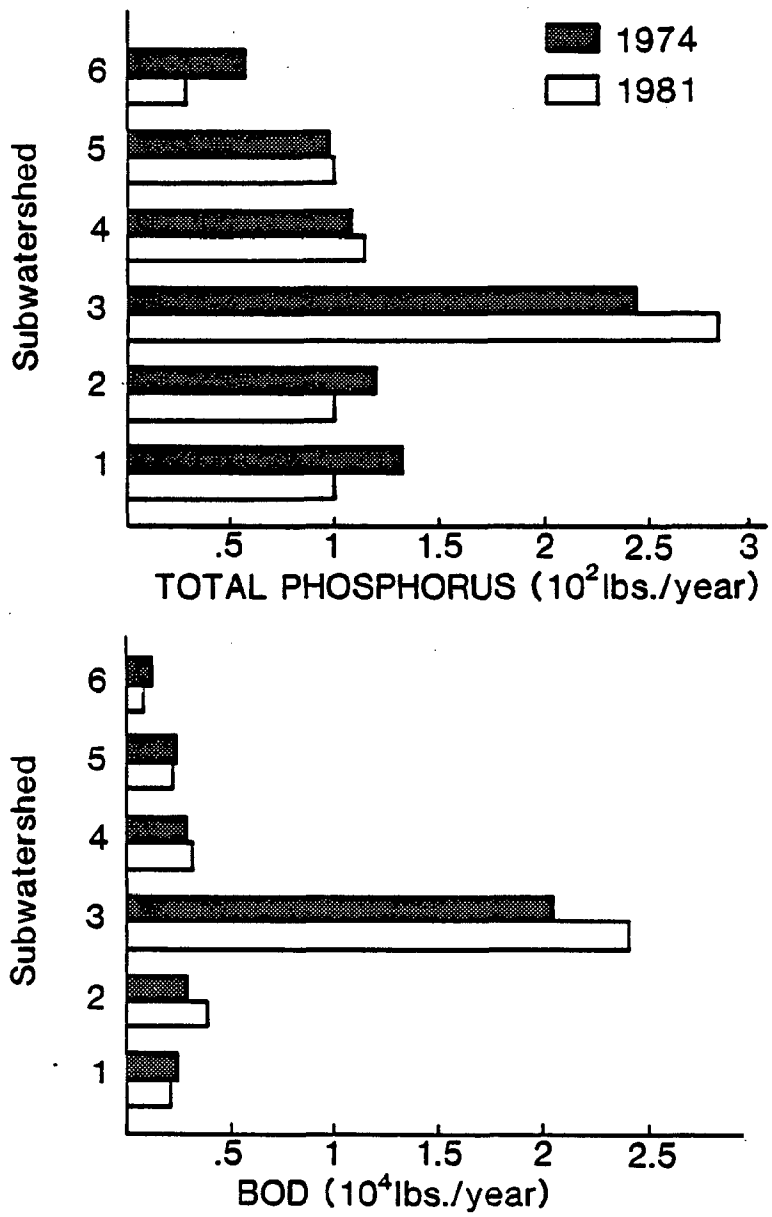


Figure 17.
Pollutant Loading by Subwatershed (Phosphorous and BOD)

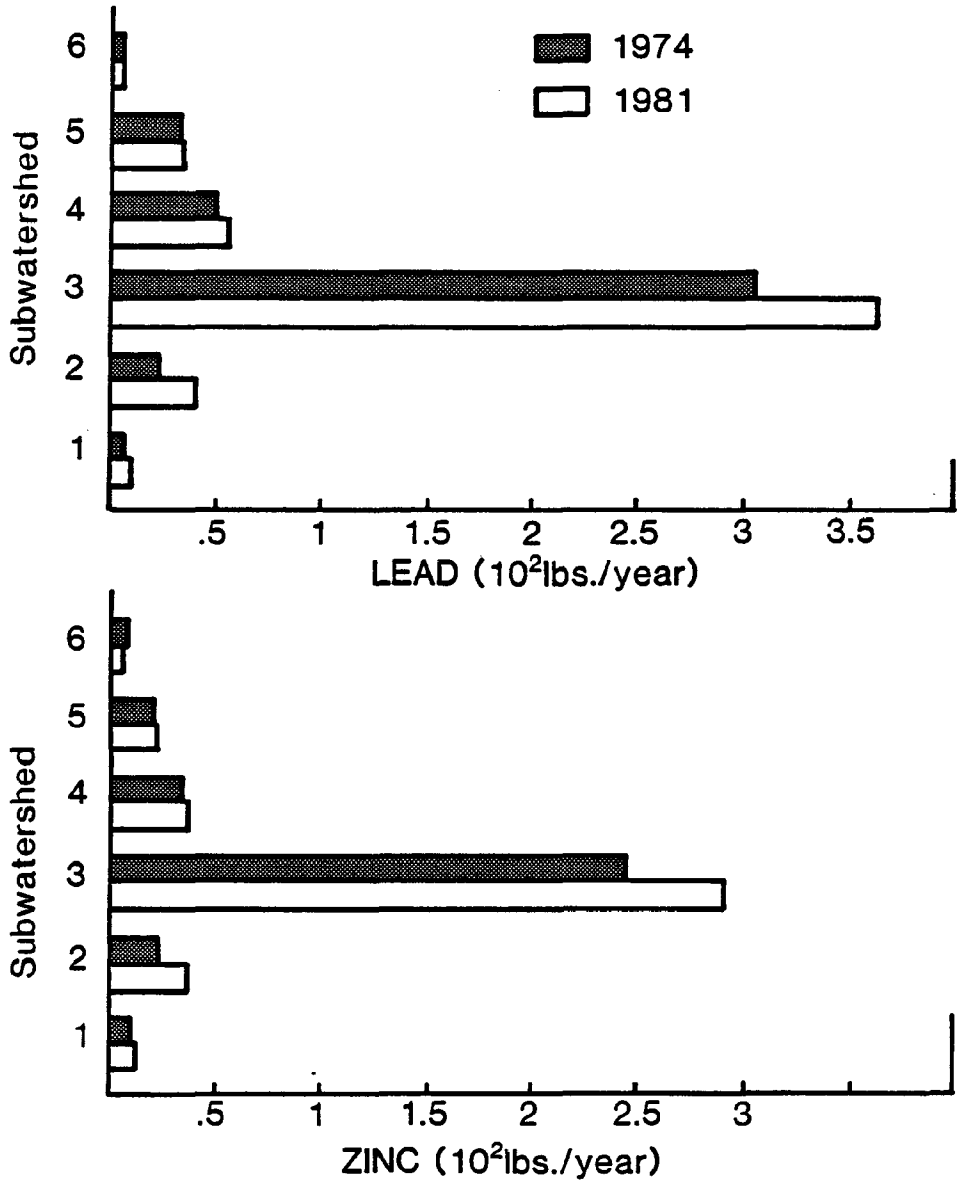


Figure 18.
Pollutant Loading by Subwatershed (Lead and Zinc)

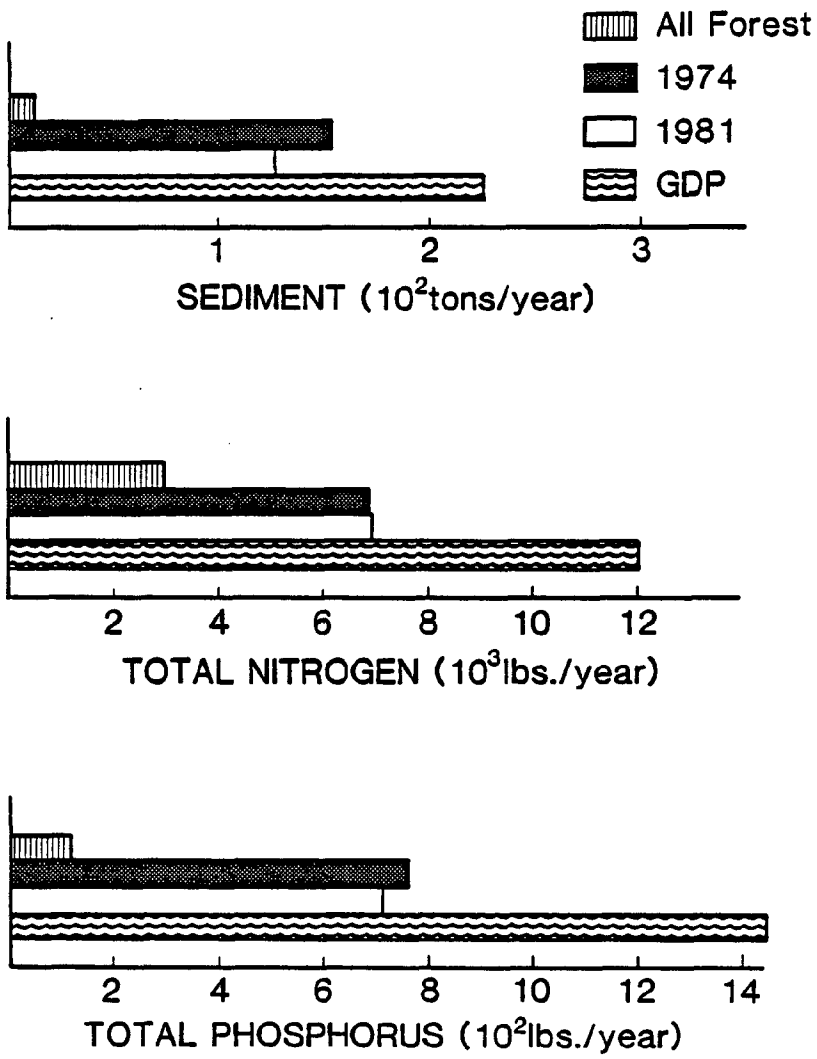


Figure 19.
Total Pollutant Loading from Church Creek Watershed (Sediment, Nitrogen, Phosphorous)

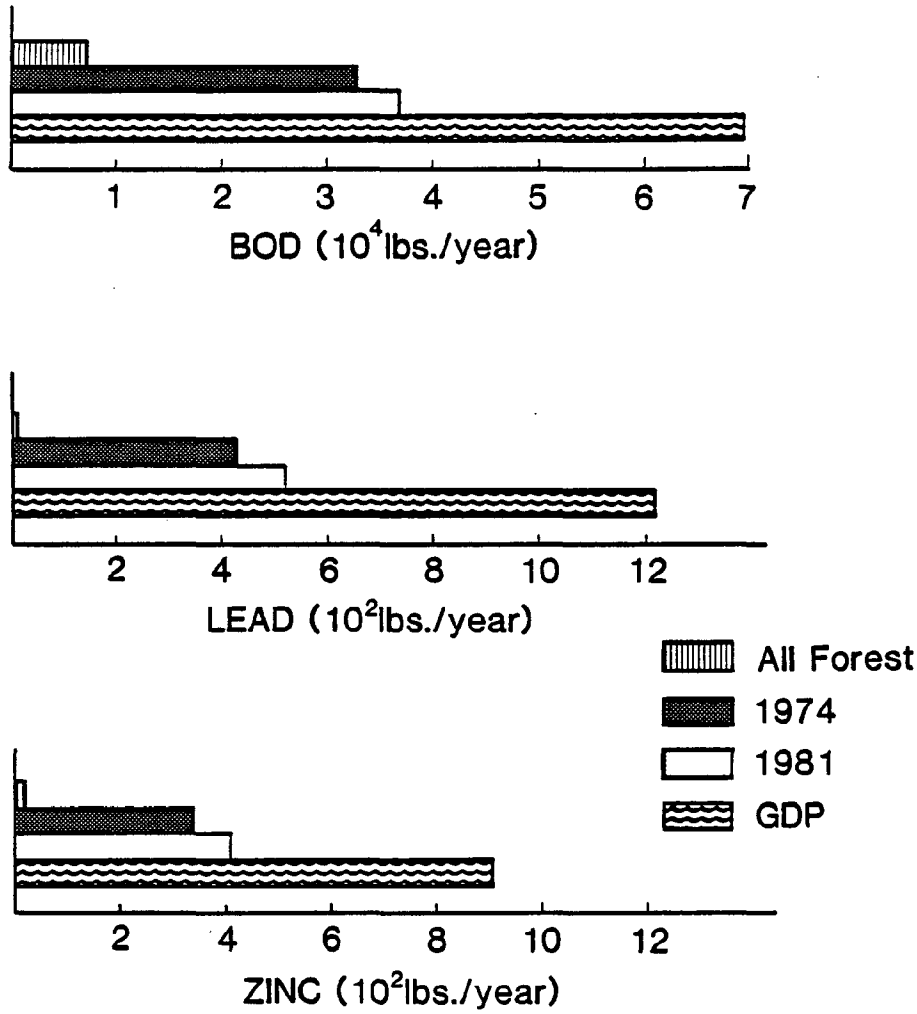


Figure 20.
Total Pollutant Loading from
Church Creek Watershed (BOD,Lead, Zinc)

2. Each car gets 20 miles/gallon.

The estimated yearly production of lead from automobiles L_A is then given by

$$L_A = \left(\frac{5\ \text{mi}}{20\ \text{mi/gal}}\right)\left(2.5\ \text{g}\ \frac{\text{lead}}{\text{gal}}\right)\left(.5\right)\left(2.2 \times 10^{-3}\ \frac{\text{lbs}}{\text{g}}\right)\left(23{,}000\ \frac{\text{cars}}{\text{day}}\right)\left(365\ \frac{\text{days}}{\text{yr}}\right)$$

$$L_A = 5{,}000\ \text{lbs lead/year}$$

According to the Illinois study a large fraction of the lead accumulates in the surface soil near the highways. Stormwater runoff from the highways will transfer some of this lead to Church Creek. If we compare the admittedly rough estimate of yearly lead loadings from traffic (5,000 lbs) with the total lead loading estimate from the watershed (450 lbs), it suggests that vehicle traffic may be a major source of lead within the Church Creek watershed. Similar arguments may hold true for zinc because the major source of the zinc loading is thought to be the wear of automobile tires. At the least, the contributions of vehicle traffic to heavy metal pollution in the Church Creek watershed should be further investigated.

Another process that is not accounted for in these calculations is the disturbance and exposure of soil at construction sites or new road construction. At present there are no good procedures for estimating the nutrient and pollutant discharges from construction sites. The reason for this is the uniqueness of each construction site in terms of land disturbance, sediment control practices, intensity and duration of storms that occurred while bare soil was exposed, etc. Because construction activity has been neglected in our model the estimated loadings are probably conservative.

V. IMPACT OF NUTRIENT AND POLLUTANT LOADINGS ON CHURCH CREEK

In the previous section we have obtained estimates of yearly nutrient and pollutant loadings from the Church Creek watershed. In this section we discuss the following questions:

1. What happens to these nutrients and pollutants once they enter Church Creek?
2. What impact do these nutrients and pollutants have on the water quality of Church Creek?

The first question cannot be answered without a thorough physical, chemical, and biological study of Church Creek. Even if this were available, many of the chemical and biological interactions that control the transport of nutrients and pollutants within an estuary are still not completely understood. This is particularly true of the water-sediment interface at the bottom of the creek.[38]

The second question is not answerable at the present time. There is insufficient scientific knowledge to predict the amount of a particular nutrient or pollutant that will cause a decline in the water quality of an estuary.[39] There is not even a consensus among scientists as to the proper choice of variables required to define the water quality of an estuary.[40-42]

What then can land use planners or water quality managers do to get some perspective of the effects of nutrient and pollutant loadings on an estuary such as Church Creek? The best that can be done with limited resources is to use some of the simplified methods that have been developed to estimate water circulation, biochemical transport, and water quality within an estuary.

Detailed computer models have been developed in an attempt to simulate the physical, chemical, and biological processes occurring in an estuary.[43-45] Because of the complexity of the problem, most of the work has been done using one or two dimensional models--that is, these models only account for processes that vary in one or two directions while assuming all variables are constant in the other directions. A one dimensional model, for example, assumes that the estuary has a uniform cross section.

The topography of Church Creek is shown in the bathymetry map, Figure 21. This map is part of a hydrographic survey map, number 5329, done by the U. S. Coast and Geodetic Survey in 1933. The soundings shown are in feet at mean low water. This is the latest survey done on Church Creek. Undoubtedly tidal action and silting have changed some of the indicated depths, but for purposes of rough estimates it will suffice. Cross sections of the creek and the distribution of water at mean low tide within the creek are shown in Figure 22. About 78% of the water is contained between the mouth and a point approximately half way up the creek. A longitudinal profile taken along the center of the channel is shown in Figure 23.

Because of varying cross sections of Church Creek, estimates of water circulation and pollutant concentration based on a one dimensional model would likely be misleading. However, rough estimates can be made of the flushing time of the creek. The flushing time is time required to replace the water in the creek with water from other sources, either fresh water inflow from the watershed or tidal water from the South River.

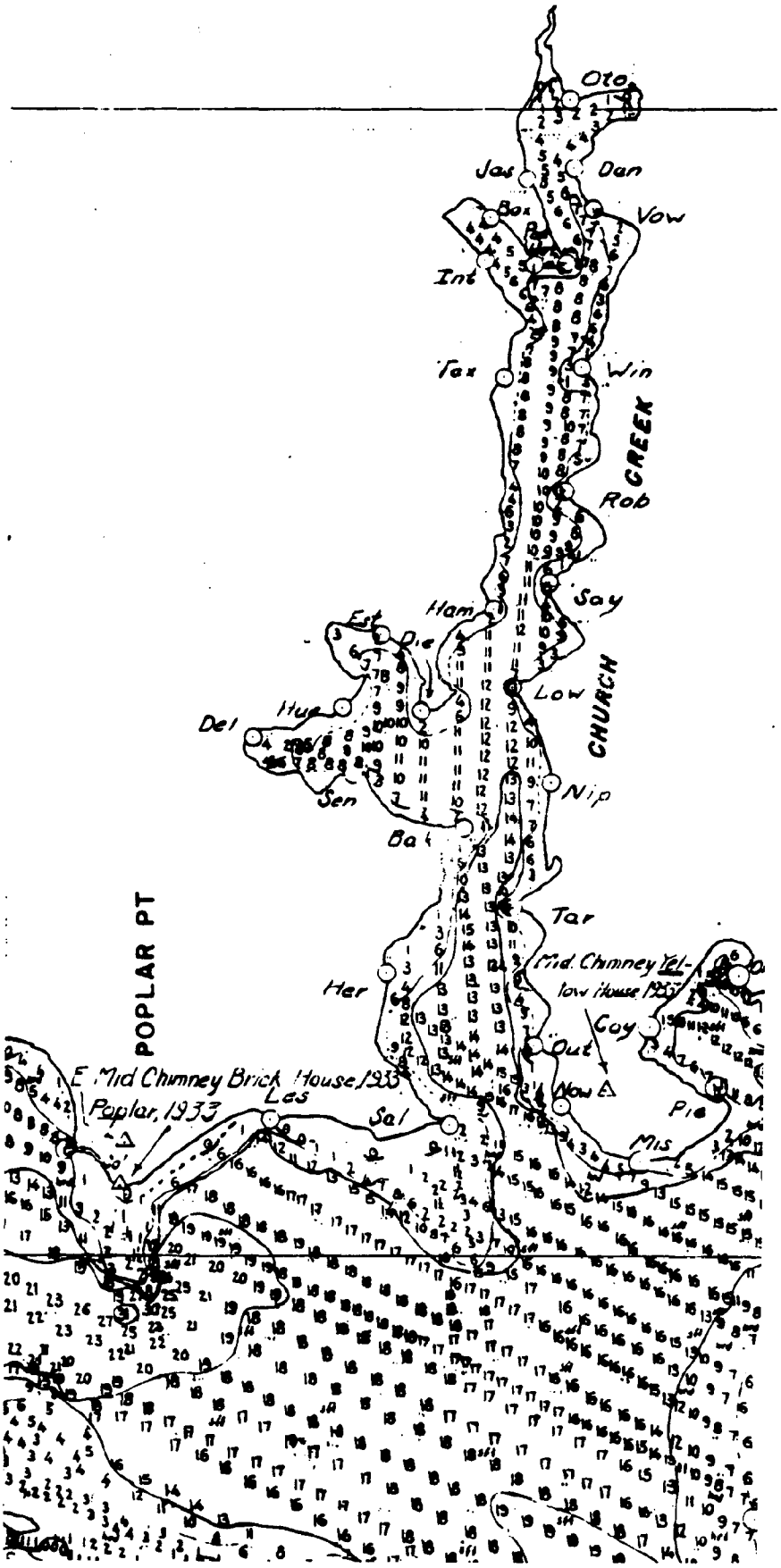


Figure 21. Church Creek Bathymetry

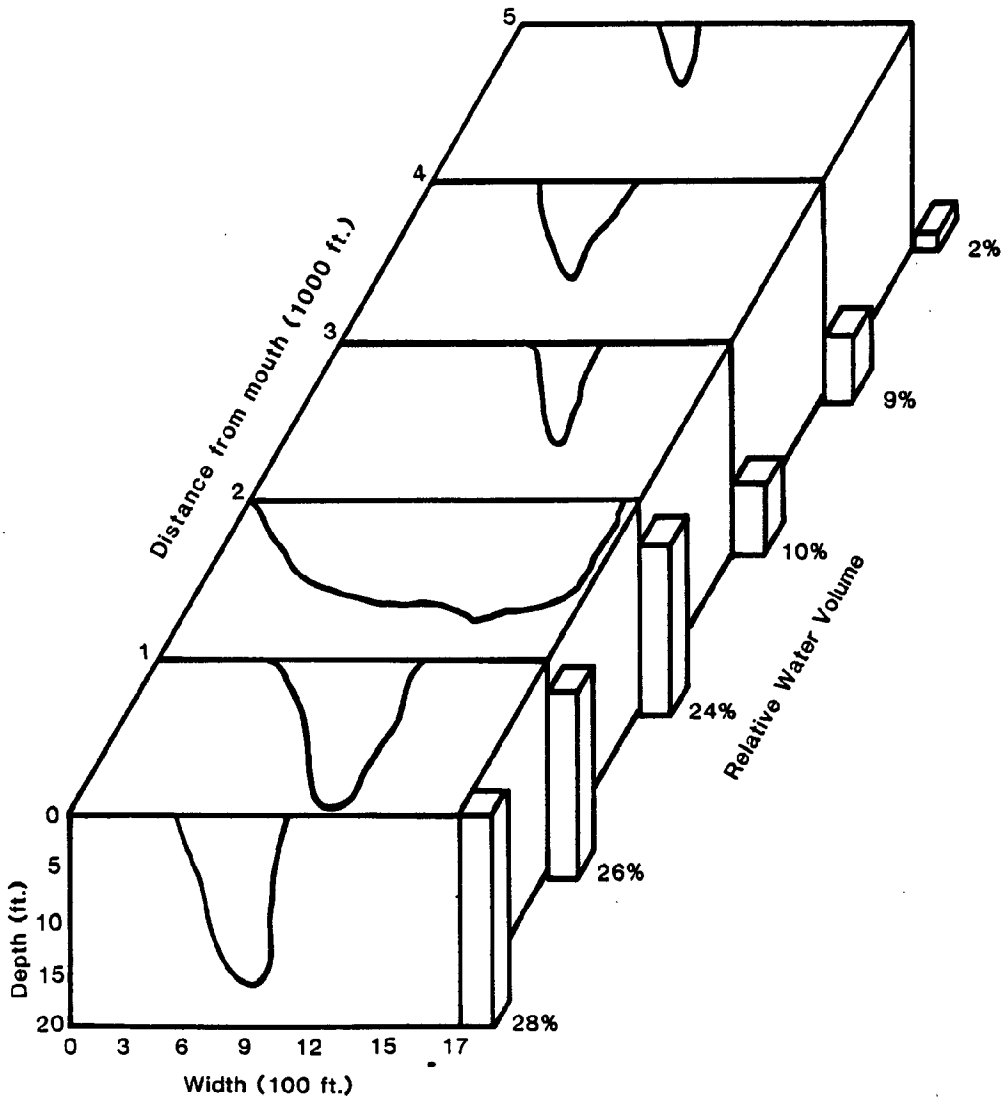


Figure 22 Church Creek in Cross Section

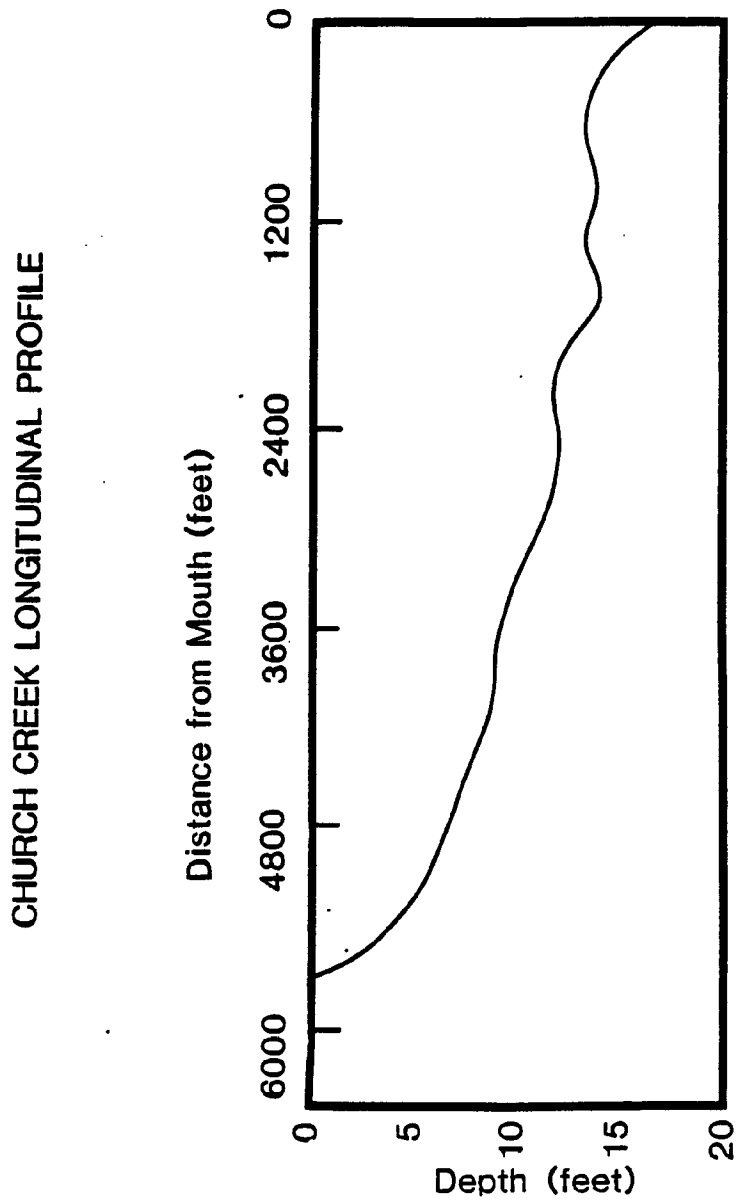


Figure 23. Church Creek Longitudinal Profile

A rough estimate of the flushing time is given by the expression[46,12]

$$T_F = \frac{V + P}{P}$$

where

T_F = flushing time (tidal cycles)

V = volume of water in the estuary at mean low tide (ft^3)

P = intertidal volume (ft^3)

The intertidal volume was calculated by multiplying the average tidal height, which for the South River is .89 feet,[47] by the surface area of the creek as shown on the bathymetric map (Figure 21). This gave an intertidal volume of 2.8×10^6 ft^3.

The volume of water in the estuary at mean low tide was found by drawing a series of transverse cross sections of the creek. A planimeter was used to find the areas of these cross-sections and then the average area of two adjacent cross sections was multiplied by the average depth between the cross sections. The total volume of water found in this way is 24.7×10^6 ft^3. The estimated flushing time obtained by this method is 8.7 tidal cycles, or taking a tidal cycle equal to 12.4 hours results in a flushing time estimate of 4.5 days.

Another method for estimating flushing times as described by Zison et al.[12] is the modified tidal prism method. In this approach the estuary is segmented so that each segment length represents the excursion distance a particle can travel during one tidal cycle. The first segment, located at the head of the creek, must therefore have an intertidal volume that is completely supplied by fresh water flow from the watershed.

Let P_i represent the intertidal volume of segment i. The first intertidal volume P_o can be estimated by combining the average fresh water flow from subwatersheds 3, 4 and 5. The average yearly rainfall is 48 inches/year,[48] so that on the average 6.8×10^{-2} inches of rain falls on the watershed per tidal cycle. If we assume that 50% of this rain water reaches the estuary, then the average flow rate from subwatersheds 3, 4 and 5 is 9×10^4 ft^3/tidal cycle. Thus P_o is equal to 9×10^4 ft^3.

Let V_i represent the low tide volume of the segment i. The low tide volume V_o can be found because it lies under the intertidal volume P_o which occupies a volume $P_o = d\ W_o\ L_o$, where d is height of tide, W_o is the width of the segment, and L_o is the length of the segment. From the survey map W_o = 360 feet and d is the height of tide, .89 feet. Therefore L_o = 282 feet. Once the length L_o of the initial segment is known the volume V_o is found by

$$V_o = W_o\ L_o\ d_{av} = (360)(282)(3) = 304{,}000\ ft^3$$

where d_{av} is the average water depth of this segment. An exchange ratio r_o can now be calculated

$$r_o = \frac{P_o}{P_o + V_o} = \frac{9 \times 10^4}{9 \times 10^4 + 30 \times 10^4} = .231/\text{tidal cycle}$$

From this the flushing time for this segment is

$$T_{F_o} = \frac{1}{r_o} = 4.3 \text{ tidal cycles}$$

Now for the next segment the low tide volume is found using the expression $V_1 = P_o + V_o$. Once V_1 is known then the length of this

segment L_1 can be calculated, from which the intertidal volume P_1, the exchange ratio r_1, and segment flushing time T_{F_1} can be calculated. The procedure is repeated for as many segments as are needed to reach the mouth of the creek. The flushing time for the creek is then the sum of the flushing times of each segment.

The results of this modified tidal prism method for Church Creek give a flushing time of 50 days for the water to travel 3,300 feet from the head of the creek. This long flushing time is primarily due to the low average fresh water input to the creek. If an extended storm were to deliver a significant amount of water over a few days, then the flushing time would be greatly reduced. This calculation does point out that during extended dry periods tidal action is not very effective in flushing the upper half of the creek.

The circulation of water within an estuary is not only due to fresh water input and tides. Wind stresses and density variations due to salinity gradients can be important factors in determining the amount and location of mixing in estuaries.[45] The hydrologic map (Figure 21) and the creek cross sections (Figure 22) show a broadening of Church Creek at a distance of 2000 feet from the mouth. This large surface area makes it likely that wind driven circulation is important in this part of the creek.

The estimated flushing times indicate that it is possible for nutrients and pollutants that are introduced from the watershed to spend a significant time within Church Creek. The concentration of these nutrients and pollutants depends upon a series of complex,

interrelated physical, chemical and biological processes. For example, it has been found that the amount and type of organic compounds in the water determine the fraction of lead that is transferred from sediment particles to the water.[49]

The impact of nutrient enrichment on an estuary and corresponding management implications are discussed in an excellent collection of review articles edited by Neilson and Cronin.[50] The overall sense of these reviews is that while a great deal has been learned about nutrient cycling within an estuary, much still remains to be discovered.

With the present state of knowledge of estuarine ecology, what method can planners use to establish reasonable patterns of land use within a watershed? We suggest that the ratios R_i, where

$$R_i = \frac{\text{total loading of pollutant i from watershed (lbs/year)}}{\text{total loading of pollutant i for completely forested watershed (lbs/year)}}$$

be used as the index of the state of the watershed. If there is a correlation between the "health" of an estuary and these pollutant ratios, then maximum ratio values could be assigned based on comparison of several watersheds within a county. For this purpose the "health" of an estuary could be based on fairly broad criteria, such as water clarity, odor production, dissolved oxygen history, etc. Adjustments to the maximum ratios may be needed to account for factors such as flushing time and quality of benthic material.

These maximum ratio values could be used as guidelines in the establishment of general development plans for a watershed. Admittedly the establishment of maximum loading ratios is not a trivial task and

is well beyond the scope of work reported here. We offer it as a suggestion that we believe is reasonable and within the resources of local government agencies. Planning guidelines based on watershed characteristics will focus the attention of both planners and citizens on the ecological unit that often determines the health of an estuary--its watershed.

VI. DISCUSSION AND RECOMMENDATIONS

Loading estimates for the Church Creek watershed illustrate three important influences of land use on the water quality of an estuary. First, the importance of agricultural practices is shown by the reduction in sediment loading because of the change from conventional crop to minimum tillage farming. Second, the large amount of biological oxygen demand (BOD) from commercial and high density residential land use, when coupled with excess nitrogen and phosphorous input, is likely to lower the dissolved oxygen concentration in the estuary during the summer months. Excess nitrogen and phosphorous promote algae growth which when it dies sinks to the bottom and becomes another source of BOD. This BOD along with the BOD load from the watershed is likely to increase the length of time during which the dissolved oxygen level is below 5 parts per million, the level usually regarded as necessary to sustain fish and other important aquatic organisms. Third, commercial areas are important sources of heavy metals, such as lead and zinc.

As a result of the work reported here we offer the following recommendations:

1. State and federal agencies should be encouraged to support the monitoring of single use subwatersheds in the Chesapeake Bay region over long time periods (5 year minimum) by qualified agencies, such as the Smithsonian's Chesapeake Bay Center for Environmental Studies or the Baltimore Regional Planning Council's monitoring division. The goal of this work would be to produce a larger data base from which improved loading factor values would be obtained.

Additional long term monitoring data are also needed to evaluate best management practices (holding ponds, pervious surfaces, etc.) applied to commercial land use. This will provide loading factors that allow local jurisdictions to evaluate the relative impact of different scenarios of best management practices.

2. WATER SCREEN be used by local jurisdictions to evaluate watersheds that are under heavy development pressure. Comparison of the loading estimates of different watersheds will help to establish management priorities and provide a criterion for the allocation of funds and planning efforts.

3. The contribution of vehicle traffic to nutrient and pollutant loadings in small watersheds, such as Church Creek, should be investigated. Development of loading factors based on daily traffic volume would be useful.

4. The need for implementing pollution control measures for highly impervious land uses, such as Commercial Development, has been indicated in this study. Stormwater management techniques which reduce the pollutant load carried in runoff should be mandated for these sites. The large BOD loading should particularly be addressed with best management practices that would remove these pollutants. The effectiveness of street sweeping and other general housekeeping measures for reduction of the available pollutants should be explored for areas of high imperviousness.

5. This study has estimated that a large amount of pollution may be transported to Church Creek in stormwater runoff from existing highly impervious areas. The possibility of adding pollution control measures to existing storm drainage systems or the installation of a regional facility to reduce these pollutant loads should be considered by decision makers. The Department of Natural Resources is funding a flooding study of the Church Creek watershed. Stormwater management techniques which may be evaluated during this study should have pollution reduction capabilities.

*** A reviewer has pointed out that the medium density land use (56.7 acres) in subwatershed 2 listed in Table 3 is not correct. The GDP map indicates this area as high density land use. A recalculation of the total GDP pollutant loadings using the correct land use assignment increases the estimates shown in Figures 19 and 20 by only 1 to 2%. This correction does not change any of the conclusions in this report.

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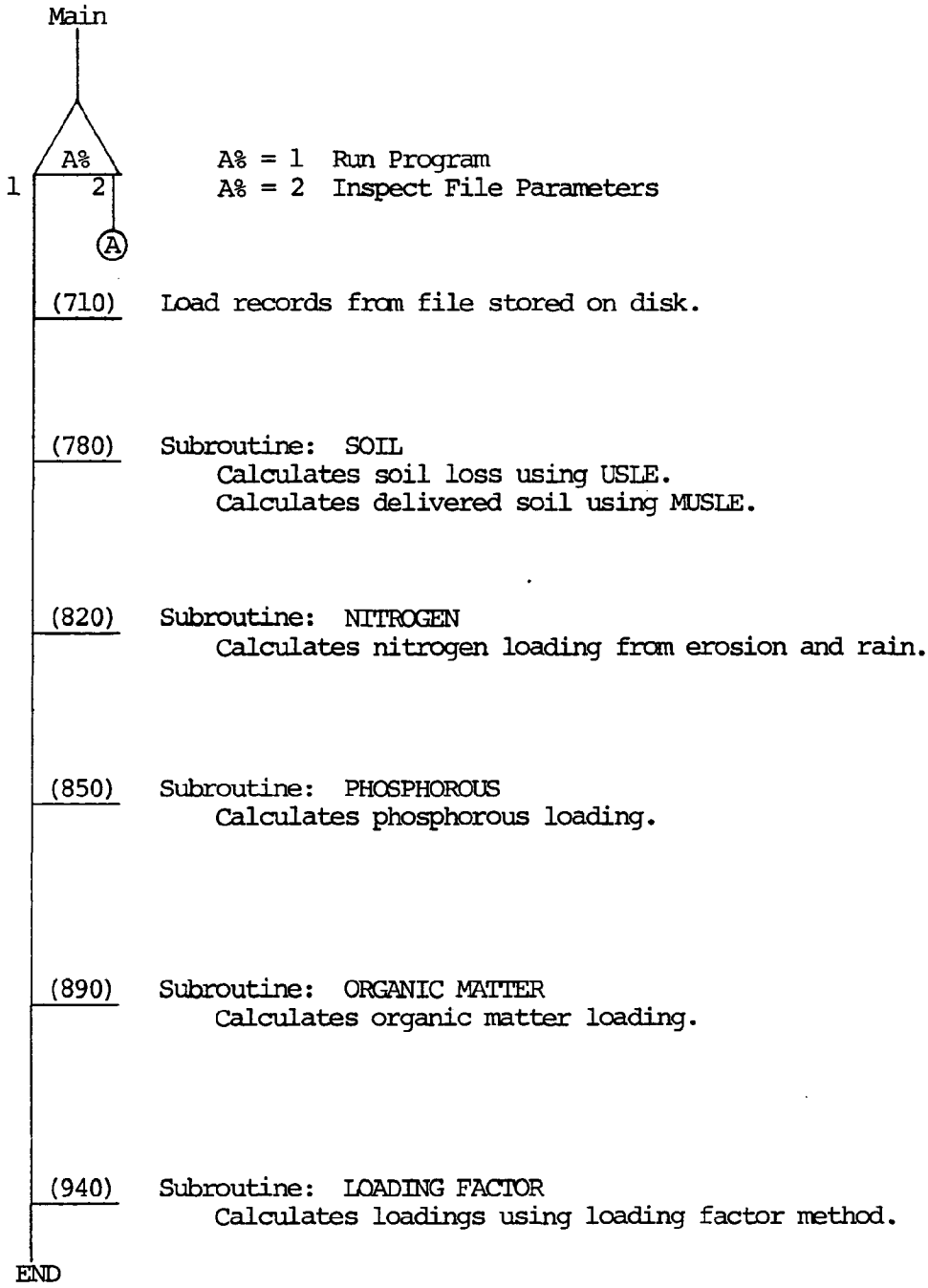
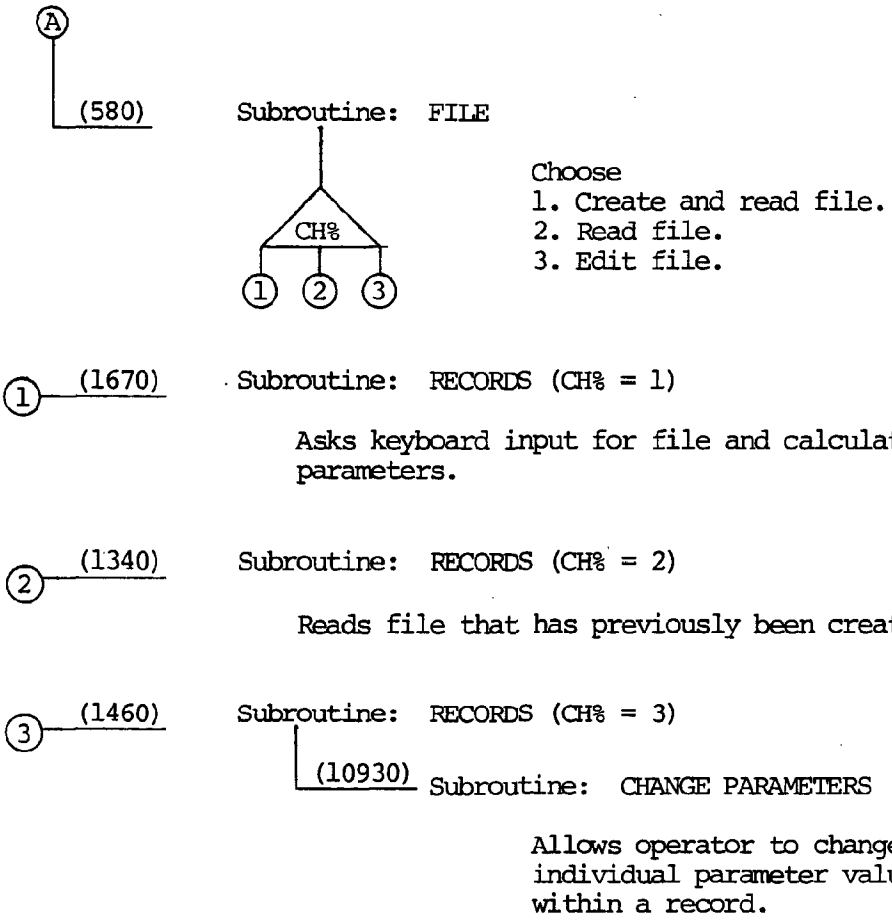
APPENDIX A

A logic diagram for the major subsections of WATER SCREEN is shown below. (The numbers in parentheses are program line numbers.)





Line 430 contains the variable NSUB% and NTYPE%. NSUB% is the number of subwatersheds and NTYPE% is the number of land uses. To change the number of subwatersheds just change the value of NSUB%. If more than 7 subwatersheds are needed, then some of the variables will have to have their dimensions changed in lines 310 through 350. Note that in the program NR% = NSUB% and NC% = NTYPE%.

Because of the logic used in the program it is quite easy to add or delete subroutines that use different methods of calculating nutrient and pollutant loadings and to add or delete the corresponding records that contain the parameters used in the calculation. Commercially available utility programs, such as Apple Doc, are very helpful in this process.

APPENDIX B

```
]LIST

100  PRINT "*********************************"
110  PRINT "*                               *"
120  PRINT "*                               *"
130  PRINT "*        WATER SCREEN           *"
132  PRINT "*                               *"
134  PRINT "*   (FILE,USLE,LOADING FACTOR)  *"
136  PRINT "*                               *"
140  PRINT "*                               *"
150  PRINT "*        VERSION 2.0            *"
160  PRINT "*                               *"
170  PRINT "*              BY               *"
180  PRINT "*                               *"
190  PRINT "*         BRUCE BIRD            *"
200  PRINT "*                               *"
210  PRINT "*********************************"
220  REM
230  REM
240  REM
250  REM  ******************
260  REM  *      MAIN      *
270  REM  ******************
280  REM
290  REM
300  REM
310  DIM AR(7,11),REC$(20),N0%(20),SW$(15),LAR(7,11),UV(7,7),DIR%(20)
320  DIM A$(10),KF(7,7),LF(7,7),SF(7,7),CF(7,7),PF(7,7),SD(7,7),HF(6,1
1),LF$(6)
330  DIM IN$(20),RS%(30),RG%(30),F1%(30)
340  DIM SL(7,7),DD(7,7),SQ(7),DQ(7),LL(7),LD(7),NLE(7),NWS(7),LU(7),N
QR(7),LW(7),NPR(7)
350  DIM NTL(7),NST(7),PL(7),PW(7),ML(7),MW(7),OL(7),OW(7),PM(7,11),PI
(7,11),OM(5),PC(5),PA(11)
355  REM  READ FIELD LENGTHS FOR EACH RECORD GROUP
356  DATA  40,8,2,8,40,8,8,8,8,8,8,8,8,8,8
357  FOR I = 0 TO 14: READ F1%(I): NEXT I
360  REM   SW$(I) USED WITH INPUT FOR USLE PARAMETERS
370 SW$(1) = "FOREST"
380 SW$(2) = "PASTURE":SW$(3) = "HAYFIELD":SW$(4) = "CONVENTIONAL CROP
":SW$(5) = "MINIMUM TILLAGE CROP":SW$(6) = "IDLE"
390 SW$(7) = "LOW DENSITY RESIDENTIAL":SW$(8) = "LOW/MED DENSITY RESID
ENTIAL":SW$(9) = "MEDIUM DENSITY RESIDENTIAL":SW$(10) = "HIGH DENSITY
RESIDENTIAL":SW$(11) = "COMMERCIAL"
400  REM
410 LF$(1) = "SEDIMENT":LF$(2) = "TOTAL NITROGEN":LF$(3) = "TOTAL PHOS
PHOROUS"
420 LF$(4) = "BOD":LF$(5) = "LEAD ":LF$(6) = "ZINC"
425  REM    NSUB% = NO. OF SUBWATERSHEDS, NTYPE% = NO. OF LAND USES
430 NSUB% = 6:NTYPE% = 11:TG% = 15:RL% = 40
440 D$ =  CHR$ (4):I$ =  CHR$ (9)
450  REM
460  REM    <<< CHOOSE OPTIONS >>>
470  REM
480  HOME
490  PRINT "*** OPTIONS ***": PRINT : PRINT
500  PRINT "CHOOSE:": PRINT
```

```
510  PRINT "    1 RUN PROGRAM ": PRINT
520  PRINT "    2 INSPECT PARAMETERS": PRINT
530  INPUT "OPTION NUMBER = ?";A%: PRINT : PRINT
532  INPUT "DO YOU WANT PRINTED COPY OF INPUT DATA FILE?(Y OR N)";A$
534 PC% = 1
536  IF A$ = "Y" THEN PC% = 2
540  ON A% GOTO 620,580
550  REM
560  REM  <<< GO SUB:FILE >>>
570  REM
580  GOSUB 1050
590  PRINT D$;"PR#0"
600  GOTO 730
610  REM  START PROGRAM
620  HOME
630  PRINT "    *** INPUT ***": PRINT : PRINT
640  INPUT "FILE NAME = ?";NAME$
650  REM
660  REM     TRANSFER FILE TO VARIABLES
670  REM     GOSUB:RECORDS
680  REM      OPT%=2 : READ AND LOAD ONLY
690  REM
700 OPT% = 2:ID$ = NAME$
710  GOSUB 1670
720  PRINT D$;"CLOSE"
730  INPUT "DO YOU WANT TO RUN THE PROGRAM ?  ( Y OR N)";A$
740  IF A$ = "N" GOTO 950
741  REM
742  REM      GOSUB: PRINTER CODE 1
743  REM
744  GOSUB 12955
750  REM
760  REM     GOSUB: SOIL
770  REM
780  GOSUB 20070
790  REM
800  REM  GOSUB: NITROGEN
810  REM
820  GOSUB 21040
830  REM
840  REM     GOSUB: PHOSPHOROUS
850  REM
860  GOSUB 24270
870  REM
880  REM     GOSUB: ORGANIC MATTER
890  REM
900  GOSUB 24980
910  REM
915  IF NO%(1) = 2 GOTO 950: REM  MUSLE ONLY OPTION
920  REM     GOSUB: LOADING FACTORS
930  REM
940  GOSUB 25634
945  REM
947  REM     GOSUB: PRINTER CODE 2
950  GOSUB 12965
958  PRINT D$;"PR#0"
960  END
970  REM
980  REM
990  REM  **********************
```

```
1000  REM        SUBROUTINE FILE
1010  REM  ***********************
1020  REM
1030  REM
1040  REM
1050  HOME
1060  REM
1070  REM  <<< OPTIONS >>>
1080  REM
1090  HOME
1100  PRINT "    *** OPTIONS ***": PRINT : PRINT
1110  PRINT "CHOOSE:": PRINT
1120  PRINT "    1 CREATE AND READFILE": PRINT
1130  PRINT "    2 READ FILE ": PRINT
1140  PRINT "    3 EDIT FILE ": PRINT
1150  INPUT "OPTION NUMBER =?";CH%
1160  ON CH% GOTO 1220,1340,1460
1170  REM
1180  REM  <<< CREATE AND READ FILE>>>
1190  REM
1200  REM  <<< INPUT FILE NAME >>>
1210  REM
1220  HOME
1230  PRINT "    *** INPUT ***": PRINT : PRINT
1240  INPUT "FILE NAME =?";NAME$
1250  REM
1260  REM  <<< GO SUB: RECORDS >>>
1270  REM
1280 ID$ = NAME$:OPT% = CH%
1290  GOSUB 1670
1300  GOTO 1580
1310  REM
1320  REM  <<< READ FILE>>>
1330  REM
1340  HOME
1350  PRINT "    *** READ FILE *** ": PRINT : PRINT
1360  INPUT "FILE NAME = ?";NAME$
1370  REM
1380  REM  <<< GOSUB:RECORDS>>>
1390  REM
1400 ID$ = NAME$:OPT% = CH%
1410  GOSUB 1670
1420  GOTO 1580
1430  REM
1440  REM   <<< EDIT RECORD GROUP >>>
1450  REM
1460  HOME : PRINT "*** EDIT FILE ***": PRINT : PRINT
1470  INPUT "FILE NAME = ?";ID$
1480  PRINT D$;"OPEN"ID$",L40"
1490  REM
1500  REM    <<< READ FILE PARAMETERS >>>
1510  REM
1520  REM    <<< GOSUB: RG2 >>>
1530  GOSUB 3220
1540  REM
1550  REM    <<< GOSUB: CHANGE PARAMETERS >>>
1560  REM
1570  GOSUB 10930
1580  PRINT D$;"CLOSE"
1590  RETURN
```

```
1600  REM
1610  REM  ********************
1620  REM      SUBROUTINE RECORDS
1630  REM  ********************
1640  REM
1650  REM
1660  REM
1670  PRINT D$;"OPEN"ID$",L40"
1690 ID$ = NAME$:PT% = OPT%
1700  REM
1710  REM    GOSUB: RG0    (FILE INFORMATION)
1720  REM
1730  GOSUB 2440
1740  REM
1750  REM    GOSUB: RG1    (FILE NUMBERS)
1760  REM
1770  GOSUB 2970
1780  REM
1790  REM    GOSUB: RG2    (CALCULATION OPTIONS)
1800  REM
1810  GOSUB 3560
1820  REM    GOSUB: RG3    (LAND USE AREAS)
1830  GOSUB 4350
1840  REM
1850  REM    GOSUB: RG4    (RAINFALL FACTOR)
1860  REM
1870  GOSUB 5040
1880  REM
1890  REM    GOSUB: RG5    (ERODIBILITY FACTOR)
1900  REM
1910  GOSUB 5400
1920  REM
1930  REM    GOSUB: RG6    (LENGTH FACTOR)
1940  REM
1950  GOSUB 6020
1960  REM
1970  REM    GOSUB: RG7    (SLOPE FACTOR)
1980  REM
1990  GOSUB 6660
2000  REM
2010  REM    GOSUB: RG8    (COVER FACTOR)
2020  REM
2030  GOSUB 7070
2040  REM
2050  REM    GOSUB: RG9    (PRACTICES FACTOR)
2060  REM
2070  GOSUB 7530
2080  REM
2090  REM    GOSUB: RG10   (SEDIMENT DELIVERY RATIO)
2100  REM
2110  GOSUB 7950
2120  REM
2130  REM    GOSUB: RG11   (NITROGEN)
2140  GOSUB 8380
2150  REM
2160  REM    GOSUB: RG12   (PHOSPHOROUS)
2170  REM
2180  GOSUB 9000
2190  REM
2200  REM    GOSUB: RG13   (ORGANIC MATTER)
```

```
2210  REM
2220  GOSUB 9520
2230  REM
2240  REM    GOSUB: RG14   (LOADING FACTOR)
2250  REM
2260  GOSUB 10020
2270  REM
2280  REM
2290  REM    <<< GO SUB: RG1 >>>
2300  REM
2310  REM  STORE FINAL FILE PARAMETERS IN RG1
2320  GOSUB 3060
2330  RETURN
2340  REM
2350  REM
2360  REM   ******************************
2370  REM   INDIVIDUAL RECORD SUBROUTINES
2380  REM   ******************************
2390  REM
2400  REM
2410  REM     **************
2420  REM    *   SUB:RG0  *
2430  REM     **************
2440 RI% = 0:RS%(0) = RI%
2450  ON PT% GOTO 2490,2740,2490
2460  REM
2470  REM   <<< INPUT FOR RECORD GROUP 0  >>>
2480  REM
2490  HOME
2500 IN$(0) = "WATER SCREEN (FILE*USLE*LF) VER 2.0"
2510 IN$(1) = "RECORD LENGTH= 40 "
2520  PRINT "   *** PROGRAM AND FILE INFORMATION ***": PRINT : PRINT
2530  PRINT "RECORD GROUP NUMBER 0 ": PRINT
2540  INPUT "RIVER NAME=?";IN$(2): PRINT
2550  INPUT "YOUR NAME =?";IN$(3): PRINT
2560  INPUT "FILE NAME =?";IN$(4): PRINT
2570  INPUT "FILE DESCRIPTION =?";IN$(5): PRINT
2580 ID$ = IN$(4)
2590  REM
2600  REM   <<< WRITE RECORD GROUP 0 >>>
2610  REM
2620 RS%(0) = RI%: REM  RS% IS THE STARTING RECORD NO. FOR THE I TH GR
OUP.
2630  FOR I = 0 TO 5
2640 R% = I
2650  PRINT D$;"WRITE"ID$",R"R%
2660  PRINT IN$(I)
2670  NEXT I
2680  PRINT D$
2690 RG%(0) = R% - RI%
2700 RI% = R%
2710  REM
2720  REM   <<< READ RECORD GROUP 0 >>>
2730  REM
2740  FOR I = 0 TO 5
2750 R% = I
2760  PRINT D$;"READ"ID$",R"R%
2770  INPUT IN$(I)
2780  NEXT I
2790  PRINT D$
```

```
2800  REM
2810  REM    <<< OUTPUT FOR RECORDGROUP 0 >>>
2820  REM
2830  ON PC% GOTO 2850,2832
2832  GOSUB 12955: REM  PRINTER CODE 1
2840  REM
2850  PRINT : PRINT : PRINT "*** RECORD GROUP 0 ***": PRINT : PRINT
2860  PRINT "INFORMATION FOR FILENAME ";ID$: PRINT
2870  FOR I = 0 TO 5
2880  PRINT IN$(I)
2890  NEXT I
2895  GOSUB 12965: REM  PRINTER CODE 2
2900  RETURN
2910  REM    ****************
2920  REM    *   SUB:RG1    *
2930  REM    ****************
2940  REM
2950  REM    RECORD GROUP 1 CONTAINS THE STARTING RECORD NUMBER (RS%(I
)) AND NUMBER OF RECORDS FOR EACH GROUP RECORD (RG%(I))
2960  REM
2970 FL% = F1%(1)
2975  ON PT% GOTO 2980,3220,3050
2980  FOR I = 2 TO TG%
2990 RS%(I) = 0:RG%(I) = 0
3000  NEXT I
3010 RG%(1) = 4: REM  THIS MUST BE CHANGED IF NO. OF RECORDS IN RG1 CH
ANGES.
3020  REM
3030  REM    <<< WRITE RG1 >>>
3040  REM
3050 RS%(1) = RI% + 1
3060 R% = RS%(1)
3070 K = 1
3080  FOR I = 0 TO TG%
3090 B% = FL% * (K - 1)
3100  PRINT D$;"WRITE"ID$",R"R%",B"B%
3110  PRINT RS%(I): PRINT RG%(I)
3120 K = K + 1
3130  IF K > RL% / FL% THEN R% = R% + 1
3140  IF K > RL% / FL% THEN K = K - RL% / FL%
3150  NEXT I
3160  PRINT D$
3170 RG%(1) = R% - RI%
3180 RI% = R%
3190  REM
3200  REM  <<< READ RG1 >>>
3210  REM
3220 RS%(1) = 6:R% = RS%(1):FL% = F1%(1)
3230 K = 1
3240  FOR I = 0 TO TG%
3250 B% = FL% * (K - 1)
3260  PRINT D$;"READ"ID$",R"R%",B"B%
3270  INPUT RS%(I): INPUT RG%(I)
3280 K = K + 1
3290  IF K > RL% / FL% THEN R% = R% + 1
3300  IF K > RL% / FL% THEN K = K - RL% / FL%
3310  NEXT I
3320  PRINT D$
3330  REM
3340  REM   <<< OUTPUT RG1 >>>
```

```
3350  REM
3352  ON PC% GOTO 3360,3354
3354  GOSUB 12955: REM  PRINTER CODE 1
3360  PRINT : PRINT : PRINT "*** RECORD GROUP 1 ***": PRINT : PRINT
3370  PRINT "RECORD GROUP NUMBER, STARTING RECORD NUMBER, NUMBER OF RE
CORDS IN GROUP": PRINT
3390  FOR I = 0 TO TG% STEP 3
3400  FOR J = 0 TO 2
3410 K = 1 + (J * 20)
3415  IF PC% = 1 THEN K = 1 + (J * 10)
3420 L = I + J
3430  IF L > TG% GOTO 3480
3435  ON PC% GOTO 3444,3440
3440  POKE 36,K + 7: PRINT L;: POKE 36,K + 12: PRINT RS%(L);: POKE 36,
K + 17: PRINT RG%(L);
3443  GOTO 3450
3444  PRINT  TAB( K);L; TAB( K + 3);RS%(L); TAB( K + 6);RG%(L);
3450  NEXT J
3460  PRINT
3470  NEXT I
3480  PRINT
3485  GOSUB 12965: REM  PRINTER CODE 2
3490  RETURN
3500  REM   ****************
3510  REM    *    SUB: RG2  *
3520  REM   ****************
3530  REM
3540  REM    RECORD GROUP 2 CONTAINS THE SELECTED CALCULATION OPTION N
UMBERS
3550  REM
3560 FL% = F1%(2)
3565  ON PT% GOTO 3590,4090,3590
3570  REM    <<< INPUT: RG2 >>>
3580  REM
3590  PRINT
3600  PRINT "*** CALCULATION OPTIONS ***": PRINT
3610  PRINT "     1 ALL OPTIONS": PRINT
3620  PRINT "     2 MUSLE ONLY ": PRINT
3630  PRINT "     3 LOADING FACTORS ONLY ": PRINT : PRINT
3870  INPUT "OPTION NUMBER =?";NO%(1): PRINT
3880 TC% = 1
3890  REM
3900  REM    <<< WRITE RG2  >>>
3910  REM
3920 RS%(2) = RI% + 1: REM  RS%(I) IS THE STARTING RECORD NUMBER FOR T
HE I TH GROUP
3930 R% = RS%(2)
3940 K = 1
3950  FOR I = 0 TO TC% - 1
3960 B% = FL% * (K - 1)
3970  PRINT D$;"WRITE"ID$",R"R%",B"B%
3980  PRINT NO%(I)
3990 K = K + 1
4000  IF K > RL% / FL% THEN R% = R% + 1
4010  IF K > RL% / FL% THEN K = K - RL% / FL%
4020  NEXT I
4030  PRINT D$
4040 RG%(2) = R% - RI%: REM   RG%(I) = NO. OF RECORDS IN THE I TH GROU
P
4050 RI% = R%: REM  RI% = RECORD INDEX NUMBER
```

```
4060  REM
4070  REM    <<< READ RG2  >>>
4080  REM
4090 R% = RS%(2):TC% = 5
4100 K = 1
4110  FOR I = 0 TO TC% - 1
4120 B% = FL% * (K - 1)
4130  PRINT D$;"READ"ID$",R"R%",B"B%
4140  INPUT NO%(I)
4150 K = K + 1
4160  IF K > RL% / FL% THEN R% = R% + 1
4170  IF K > RL% / FL% THEN K = K - RL% / FL%
4180  NEXT I
4190  PRINT D$
4200  REM
4210  REM    <<< OUTPUT RG2  >>>
4220  REM
4222  ON PC% GOTO 4230,4224
4224  GOSUB 12955: REM  PRINTER CODE 1
4230  PRINT : PRINT : PRINT "*** RECORD GROUP 2 ***": PRINT : PRINT
4240  PRINT "CALCULATION OPTIONS": PRINT
4260  PRINT NO%(1)
4280  PRINT
4282  GOSUB 12965: REM  PRINTER CODE 2
4290  RETURN
4300  REM  ***************
4310  REM   *  SUB: RG3   *
4320  REM  ***************
4330  REM
4340  REM   RG3 CONTAINS THE LANDUSE AREAS OF THE SUB-WATERSHEDS
4350 NR% = NSUB%:NC% = NTYPE%:UN$ = "ACRES":TITLE$ = "LAND USE AREAS"
4360 NU% = NC%:FL% = F1%(3)
4370  ON PT% GOTO 4440,4720,4440
4380  REM
4390  REM   <<< INPUT RG3 >>>
4400  REM
4410  REM
4420  REM  <<<GOSUB:INPUT TO ARRAY>>>
4430  REM
4440  GOSUB 10240
4450  FOR I = 1 TO NR%
4460  FOR J = 1 TO NC%
4470 LAR(I,J) = AR(I,J)
4480  NEXT J
4490  NEXT I
4500  REM   <<< WRITE: RG3 >>>
4510  REM
4520  IF PT% = 3 THEN RI% = RS%(3) - 1
4530 RS%(3) = RI% + 1
4540 R% = RS%(3)
4550 K = 1
4560  FOR L = 1 TO NR%
4570  FOR J = 1 TO NC%
4580 B% = FL% * (K - 1)
4590  PRINT D$;"WRITE"ID$",R"R%",B"B%
4600  PRINT LAR(L,J)
4610 K = K + 1
4620  IF K > RL% / FL% THEN R% = R% + 1
4630  IF K > RL% / FL% THEN K = K - RL% / FL%
4640  NEXT J
```

```
4650  PRINT D$
4660  NEXT L
4670 RG%(3) = R% - RI%
4680 RI% = R%
4690  REM
4700  REM   <<< READ: RG3 >>>
4710  REM
4720 R% = RS%(3):K = 1
4730  FOR L = 1 TO NR%
4740  FOR J = 1 TO NC%
4750 B% = FL% * (K - 1)
4760  PRINT D$;"READ"ID$",R"R%",B"B%
4770  INPUT LAR(L,J)
4780 K = K + 1
4790  IF K > RL% / FL% THEN R% = R% + 1
4800  IF K > RL% / FL% THEN K = K - RL% / FL%
4810  NEXT J
4820  PRINT D$
4830  NEXT L
4840  REM
4850  REM   <<< OUTPUT: RG3 >>>
4860  REM
4862  IF PC% = 2 THEN  GOSUB 12955
4870  HOME
4880  PRINT : PRINT : PRINT "***RECORD GROUP 3 *** ": PRINT : PRINT
4890  HOME
4900  PRINT "LAND USE AREAS": PRINT
4901  ON PC% GOTO 4902,4914
4902  FOR L = 1 TO NR%: PRINT "SW ";L
4903 K1 = 1
4904  FOR J = 1 TO NC%
4905  PRINT  TAB( K1);LAR(L,J);
4906 K1 = K1 + 6
4907  IF K1 < 40 GOTO 4910
4908  PRINT
4909 K1 = 1
4910  NEXT J
4911  PRINT
4912  NEXT L
4913  GOTO 4980
4914  FOR L = 1 TO NR%
4920  PRINT : PRINT "SW: ";L
4940  POKE 36,7: PRINT LAR(L,1);: POKE 36,13: PRINT LAR(L,2);: POKE 36
,19: PRINT LAR(L,3);: POKE 36,25: PRINT LAR(L,4);: POKE 36,31: PRINT L
AR(L,5);
4942  POKE 36,37: PRINT LAR(L,6);: POKE 36,43: PRINT LAR(L,7);: POKE 3
6,49: PRINT LAR(L,8);: POKE 36,55: PRINT LAR(L,9);
4944  POKE 36,61: PRINT LAR(L,10);: POKE 36,67: PRINT LAR(L,11);
4960  PRINT
4970  NEXT L
4975  GOSUB 12965: REM  PRINTER CODE 2
4980  RETURN
4990  REM  ********************
5000  REM     <<< SUB: RG4 >>>
5010  REM  ********************
5020  REM
5030  REM  RG4 CONTAINS THE RAINFALL FACTOR R
5040  ON PT% GOTO 5080,5240,5080
5050  REM
5060  REM    <<< INPUT: RG4 >>>
```

```
5070  REM
5080  HOME
5090  PRINT "   *** RAINFALL FACTOR ***": PRINT : PRINT
5100  INPUT "RAINFALL FACTOR=?";RF
5110  REM
5120  REM    <<< WRITE:RG4 >>>
5130  REM
5140 RS%(4) = RI% + 1:R% = RS%(4)
5150 B% = 0
5160  PRINT D$;"WRITE"ID$",R"R%",B"B%
5170  PRINT RF
5180  PRINT D$
5190 RG%(4) = R% - RI%
5200 RI% = R%
5210  REM
5220  REM    <<< READ:RG4 >>>
5230  REM
5240 R% = RS%(4)
5250 B% = 0
5260  PRINT D$;"READ"ID$",R"R%",B"B%
5270  INPUT RF
5280  PRINT D$
5290  REM
5300  REM    <<< OUTPUT:RG4>>>
5310  REM
5312  ON PC% GOTO 5320,5314
5314  GOSUB 12955: REM  PRINTER CODE 1
5320  PRINT : PRINT : PRINT "*** RECORD GROUP 4 ***": PRINT : PRINT
5330  PRINT "RAINFALL FACTOR = ";RF: PRINT
5335  GOSUB 12965: REM  PRINTER CODE 2
5340  RETURN
5350  REM  ******************
5360  REM    <<< SUB:RG5 >>>
5370  REM  ******************
5380  REM
5390  REM  RG5 CONTAINS ERODIBILITY FACTORS FOR FOREST AND AGRICULTURA
L LAND USE
5400 NR% = NSUB%:NC% = NTYPE%:UN$ = "TONS/ACRE/R UNIT ":TITLE$ = "SOIL
 ERODIBILITY FACTOR":NU% = 6:FL% = F1%(5)
5410  ON PT% GOTO 5450,5710,5720
5420  REM
5430  REM    <<< INPUT: RG5 >>>
5440  REM
5450  GOSUB 10240
5460  FOR I = 1 TO NR%
5470  FOR J = 1 TO NU%
5480 KF(I,J) = AR(I,J)
5490  NEXT J
5500  NEXT I
5510  REM    <<< WRITE: RG5 >>>
5520  REM
5530 RS%(5) = RI% + 1:R% = RS%(5)
5540 K = 1:NF% = RL% / FL%
5550  FOR I = 1 TO NR%
5560  FOR J = 1 TO NU%
5570 B% = FL% * (K - 1)
5580  PRINT D$;"WRITE"ID$",R"R%",B"B%
5590  PRINT KF(I,J)
5600 K = K + 1
5610  IF K > NF% THEN R% = R% + 1
```

```
5620  IF K > NF% THEN K = K - NF%
5630  NEXT J
5640  PRINT D$
5650  NEXT I
5660 RG%(5) = R% - RI%
5670 RI% = R%
5680  REM
5690  REM    <<<  READ:RG5 >>>
5700  REM
5710 R% = RS%(5):K = 1:NF% = RL% / FL%
5720  FOR I = 1 TO NR%
5730  FOR J = 1 TO NU%
5740 B% = FL% * (K - 1)
5750  PRINT D$;"READ"ID$",R"R%",B"B%
5760  INPUT KF(I,J)
5770 K = K + 1
5780  IF K > NF% THEN R% = R% + 1
5790  IF K > NF% THEN K = K - NF%
5800  NEXT J
5810  PRINT D$
5820  NEXT I
5830  REM
5840  REM    <<< OUTPUT: RG5 >>>
5850  REM
5852  ON PC% GOTO 5860,5854
5854  GOSUB 12955: REM  PRINTER CODE 1
5860  PRINT : PRINT : PRINT "*** RECORD GROUP 5 ***": PRINT : PRINT
5870  PRINT "ERODIBILITY FACTOR": PRINT
5880  PRINT
5890  FOR I = 1 TO NR%
5900  PRINT "SW ";I;"    ";
5910  FOR J = 1 TO NU%
5920  PRINT KF(I,J);"  ";
5930  NEXT J
5940  PRINT
5950  NEXT I
5955  GOSUB 12965: REM  PRINTER CODE 2
5960  RETURN
5970  REM  ****************
5980  REM    <<< SUB:RG6 >>>
5990  REM  ****************
6000  REM  RG6 CONTAINS LENGTH FACTORS FOR FOREST AND AGRICULTURAL LAN
D USES
6010  REM
6020 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE ":TITLE$ = " LENGTH FACTOR "

6030 NU% = 6:NF% = RL% / FL%
6040  ON PT% GOTO 6080,6350,6080
6050  REM
6060  REM    <<< INPUT: RG6 >>>
6070  REM
6080  GOSUB 10240
6090  FOR I = 1 TO NR%
6100  FOR J = 1 TO NU%
6110 LF(I,J) = AR(I,J)
6120  NEXT J
6130  NEXT I
6140  REM
6150  REM    <<< WRITE: RG6 >>>
6160  REM
```

```
6170 RS%(6) = RI% + 1:R% = RS%(6)
6180 K = 1
6190  FOR I = 1 TO NR%
6200  FOR J = 1 TO NU%
6210 B% = FL% * (K - 1)
6220  PRINT D$;"WRITE"ID$",R"R%",B"B%
6230  PRINT LF(I,J)
6240 K = K + 1
6250  IF K > NF% THEN R% = R% + 1
6260  IF K > NF% THEN K = K - NF%
6270  NEXT J
6280  PRINT D$
6290  NEXT I
6300 RG%(6) = R% - RI%
6310 RI% = R%
6320  REM
6330  REM    <<<READ: RG6 >>>
6340  REM
6350 R% = RS%(6):K = 1
6360  FOR I = 1 TO NR%
6370  FOR J = 1 TO NU%
6380 B% = FL% * (K - 1)
6390  PRINT D$;"READ"ID$",R"R%",B"B%
6400  INPUT LF(I,J)
6410 K = K + 1
6420  IF K > NF% THEN R% = R% + 1
6430  IF K > NF% THEN K = K - NF%
6440  NEXT J
6450  PRINT D$
6460  NEXT I
6470  REM
6480  REM    <<< OUTPUT: RG6 >>>
6490  REM
6492  ON PC% GOTO 6500,6494
6494  GOSUB 12955: REM  PRINTER CODE 1
6500  PRINT : PRINT : PRINT "*** RECORD GROUP 6 ***": PRINT : PRINT
6510  PRINT "LENGTH FACTOR": PRINT
6520  FOR I = 1 TO NR%
6530  PRINT "SW ";I;"     ";
6540  FOR J = 1 TO NU%
6550  PRINT LF(I,J);"   ";
6560  NEXT J
6570  PRINT
6580  NEXT I
6590  PRINT
6595  GOSUB 12965: REM  PRINTER CODE 2
6600  RETURN
6610  REM  ****************
6620  REM    <<< SUB: RG7 >>>
6630  REM  ****************
6640  REM  RG7 CONTAINS SLOPE FACTORS FOR FOREST AND AGRICULTURAL LAND
 USE
6650  REM
6660 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "SLOPE FACTOR"
6670 NU% = 6:FL% = F1%(7):NF% = RL% / FL%
6680  ON PT% GOTO 6720,6890,6890
6690  REM
6700  REM    <<< INPUT: RG7 >>>
6710  REM
6720  GOSUB 10240
```

```
6730  FOR I = 1 TO NR%
6740  FOR J = 1 TO NU%
6750 SF(I,J) = AR(I,J)
6760  NEXT J
6770  NEXT I
6780  REM    <<< WRITE: RG7 >>>
6790  REM
6800 RS%(7) = RI% + 1
6810 R% = RS%(7)
6820 K = 1
6830  GOSUB 10400
6840 RG%(7) = R% - RI%
6850 RI% = R%
6860  REM
6870  REM    <<< READ: RG7 >>>
6880  REM
6890 R% = RS%(7):K = 1
6900  GOSUB 10610
6910  FOR I = 1 TO NR%
6920  FOR J = 1 TO NU%
6930 SF(I,J) = AR(I,J)
6940  NEXT J
6950  NEXT I
6960  REM
6970  REM    <<< OUTPUT:RG7 >>>
6980  REM
6990 G% = 7:TITLE$ = "SLOPE FACTOR":NU% = 6
7000  GOSUB 10770
7010  RETURN
7020  REM  ****************
7030  REM    <<< SUB: RG8 >>>
7040  REM  ****************
7050  REM   RG8 CONTAINS COVER FACTOR FOR FOREST AND AGRICULTURAL LAND
 USE
7060  REM
7070 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "COVER FACTOR "
7080 NU% = 6:FL% = F1%(8):NF% = RL% / FL%
7090  ON PT% GOTO 7130,7320,7130
7100  REM
7110  REM    <<< INPUT: RG8 >>>
7120  REM
7130  GOSUB 10240
7140  FOR I = 1 TO NR%
7150  FOR J = 1 TO NU%
7160 CF(I,J) = AR(I,J)
7170  NEXT J
7180  NEXT I
7190  REM
7200  REM    <<< WRITE: RG8 >>>
7210  REM
7220 RS%(8) = RI% + 1
7230 R% = RS%(8)
7240 K = 1
7260  GOSUB 10400
7270 RG%(8) = R% - RI%
7280 RI% = R%
7290  REM
7300  REM    <<< READ: RG8 >>>
7310  REM
7320 R% = RS%(8):K = 1
```

```
7330 K = 1:NU% = 6:NF% = RL% / FL%
7340  GOSUB 10610
7350  FOR I = 1 TO NR%
7360  FOR J = 1 TO NU%
7370 CF(I,J) = AR(I,J)
7380  NEXT J
7390  NEXT I
7400 MF% = 1
7410  REM
7420  REM    <<< OUTPUT: RG8 >>>
7430  REM
7440 G% = 8:TITLE$ = "COVER FACTOR":NU% = 6
7450  GOSUB 10770
7460  RETURN
7470  REM  ****************
7480  REM    <<< SUB: RG9 >>>
7490  REM  ****************
7500  REM
7510  REM  RG9 CONTAINS PRACTICES FACTOR FOR FOREST AND AGRICULTURAL L
AND USE
7520  REM
7530 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "PRACTICES FACTOR
"
7540 NU% = 6:FL% = F1%(9):NF% = RL% / FL%
7550  ON PT% GOTO 7590,7770,7590
7560  REM
7570  REM    <<< INPUT: RG9 >>>
7580  REM
7590  GOSUB 10240
7600  FOR I = 1 TO NR%
7610  FOR J = 1 TO NU%
7620 PF(I,J) = AR(I,J)
7630  NEXT J
7640  NEXT I
7650  REM
7660  REM    <<< WRITE: RG9 >>>
7670  REM
7680 RS%(9) = RI% + 1
7690 R% = RS%(9)
7700 K = 1
7710  GOSUB 10400
7720 RG%(9) = R% - RI%
7730 RI% = R%
7740  REM
7750  REM   <<< READ:R82-R96 >>>
7760  REM
7770 R% = RS%(9):K = 1
7780  GOSUB 10610
7790  FOR I = 1 TO NR%
7800  FOR J = 1 TO NU%
7810 PF(I,J) = AR(I,J)
7820  NEXT J
7830  NEXT I
7840  REM
7850  REM    <<< OUTPUT: RG9 >>>
7860  REM
7870 G% = 9:TITLE$ = "PRACTICES FACTOR":NU% = 6
7880  GOSUB 10770
7890  RETURN
7900  REM  ********************
```

```
7910  REM    <<< SUB: RG10 >>>
7920  REM  ********************
7930  REM  RG10 CONTAINS SEDIMENT DELIVERY RATIOS FOR FOREST AND AGRIC
ULTURAL LAND USE
7940  REM
7950 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "SEDIMENT DELIVERY
 RATIO"
7960 NU% = 6:FL% = F1%(10):NF% = RL% / FL%
7970  ON PT% GOTO 8010,8170,8010
7980  REM
7990  REM    <<< INPUT: RG10 >>>
8000  REM
8010  GOSUB 10240
8020  FOR I = 1 TO NR%
8030  FOR J = 1 TO NU%
8040 SD(I,J) = AR(I,J)
8050  NEXT J
8060  NEXT I
8070  REM
8080  REM    <<< WRITE: RG10 >>>
8090  REM
8100 RS%(10) = RI% + 1
8110 R% = RS%(10)
8120 K = 1
8130  GOSUB 10400
8140 RG%(10) = R% - RI%
8150 RI% = R%
8160  REM
8170  REM  <<< READ: RG10 >>>
8180  REM
8190 R% = RS%(10):K = 1
8200  GOSUB 10610
8210  FOR I = 1 TO NR%
8220  FOR J = 1 TO NU%
8230 SD(I,J) = AR(I,J)
8240  NEXT J
8250  NEXT I
8260  REM
8270  REM    <<< OUTPUT: RG10 >>>
8280  REM
8290 G% = 10:TITLE$ = "SEDIMENT DELIVERY RATIO"
8300  GOSUB 10770
8310  RETURN
8320  REM  ********************
8330  REM    <<< SUB: RG11 >>>
8340  REM  ********************
8350  REM
8360  REM  RG11 CONTAINS CONSTANTS FOR NITROGEN CALCULATION
8370  REM
8380 FL% = F1%(11):NF% = RL% / FL%
8390  ON PT% GOTO 8420,8710,8420
8400  REM
8410  REM    <<< INPUT: RG11 >>>
8420  HOME
8430  PRINT "*** NITROGEN PARAMETERS ***": PRINT : PRINT
8440  INPUT "TOTAL NITROGEN CONCENTRATION IN SOIL (G/100 G) = ?";RC(1)

8450  INPUT "ENRICHMENT RATIO = ?";RC(2)
8460  INPUT "OVERLAND FLOW FROM RAIN (IN/YEAR) = ?";RC(3)
8470  INPUT "NITROGEN LOAD IN RAIN (LB/ACRE/YEAR) = ?";RC(4)
```

```
8480  INPUT "TOTAL RAIN = ?";RC(5)
8490  INPUT "(AVAILABLE/TOTAL) NITROGEN IN SEDIMENT = ?";RC(6)
8500 RC(7) = 0
8510  REM
8520  REM    <<< WRITE: RG11 >>>
8530  REM
8540 RS%(11) = RI% + 1
8550 R% = RS%(11):K = 1
8560 K = 1:NF% = RL% / FL%:NU% = 6
8570  FOR J = 1 TO NU%
8580 B% = FL% * (K - 1)
8590  PRINT D$;"WRITE"ID$",R"R%",B"B%
8600  PRINT RC(J)
8610 K = K + 1
8620  IF K > NF% THEN R% = R% + 1
8630  IF K > NF% THEN K = K - NF%
8640  NEXT J
8650  PRINT D$
8660 RG%(11) = R% - RI%
8670 RI% = R%
8680  REM
8690  REM    <<< READ: RG11 >>>
8700  REM
8710 R% = RS%(11):K = 1
8720  FOR J = 1 TO NU%
8730 B% = FL% * (K - 1)
8740  PRINT D$;"READ"ID$",R"R%",B"B%
8750  INPUT RC(J)
8760 K = K + 1
8770  IF K > NF% THEN R% = R% + 1
8780  IF K > NF% THEN K = K - NF%
8790  NEXT J
8800 CNT = RC(1):RN = RC(2):OLF = RC(3):N1 = RC(4):RAIN = RC(5):F1 = R
C(6)
8810  PRINT D$
8820  REM
8830  REM    <<< OUTPUT: RG11 >>>
8840  REM
8842  ON PC% GOTO 8850,8846
8846  GOSUB 12955: REM  PRINTER CODE 1
8850  PRINT : PRINT : PRINT "*** RECORD GROUP 11 ***": PRINT : PRINT
8860  PRINT "    NITROGEN PARAMETERS": PRINT
8870  PRINT "TOTAL NITROGEN CONCENTRATION IN SOIL =";CNT;"  (G/100 G)"

8880  PRINT "ENRICHMENT RATIO =";RN
8890  PRINT "OVERLAND FLOW FROM RAIN =";OLF;"(IN/YEAR)2
8900  PRINT "NITROGEN LOAD IN RAIN =";N1;"  (LB/ACRE/YEAR)"
8910  PRINT "TOTAL RAIN = ";RAIN;"  (IN/YEAR)"
8920  PRINT "(AVAILABLE/TOTAL) NITROGEN IN SEDIMENT =";F1
8925  GOSUB 12965: REM  PRINTER CODE 2
8930  RETURN
8940  REM  **********************
8950  REM     <<<  SUB: RG12 >>>
8960  REM  **********************
8970  REM
8980  REM  RG12 CONTAINS CONTENTS FOR PHOSPHOROUS CALCULATIONS
8990  REM
9000 FL% = F1%(12):NF% = RL% / FL%
9010  ON PT% GOTO 9020,9260,9020
9020  HOME
```

```
9030  PRINT "*** PHOSPHOROUS PARAMETERS ***": PRINT : PRINT
9040  INPUT "TOTAL PHOSPHOROUS CONCENTRATION IN SOIL (G/100G) =?";PC(1
): PRINT
9050  INPUT "PHOSPHOROUS ENRICHMENT RATIO = ?";PC(2): PRINT
9060  INPUT " (AVAILABLE/TOTAL) PHOSPHOROUS IN SOIL = ?";PC(3): PRINT

9070  REM
9080  REM    <<< WRITE: RG12 >>>
9090  REM
9100 RS%(12) = RI% + 1
9110 R% = RS%(12):K = 1
9120  FOR J = 1 TO 3
9130 B% = FL% * (K - 1)
9140  PRINT D$;"WRITE"ID$",R"R%",B"B%
9150  PRINT PC(J)
9160 K = K + 1
9170  IF K > NF% THEN R% = R% + 1
9180  IF K > NF% THEN K = K - NF%
9190  NEXT J
9200  PRINT D$
9210 RG%(12) = R% - RI%
9220 RI% = R%
9230  REM
9240  REM    <<< READ: RG12 >>>
9250  REM
9260 R% = RS%(12):K = 1
9270  FOR J = 1 TO 3
9280 B% = FL% * (K - 1)
9290  PRINT D$;"READ"ID$",R"R%",B"B%
9300  INPUT PC(J)
9310 K = K + 1
9320  IF K > NF% THEN R% = R% + 1
9330  IF K > NF% THEN K = K - NF%
9340  NEXT J
9350  PRINT D$
9360  REM
9370  REM    <<< OUTPUT: RG12 >>>
9380  REM
9382  ON PC% GOTO 9390,9384
9384  GOSUB 12955: REM  PRINTER CODE 1
9390  PRINT : PRINT : PRINT "*** RECORD GROUP 12 ***": PRINT : PRINT
9400  PRINT "PHOSPHOROUS PARAMETERS": PRINT
9410  PRINT "TOTAL PHOSPHOROUS CONCENTRATION IN SOIL= ";PC(1);"  G/100
G ":
9420  PRINT "PHOSPHOROUS ENRICHMENT RATIO = ";PC(2)
9430  PRINT "(AVAILABLE/TOTAL) PHOSPHOROUS IN SOIL = ";PC(3)
9440  PRINT
9445  GOSUB 12965: REM  PRINTER CODE 2
9450  RETURN
9460  REM  **********************
9470  REM  *   SUB: RG13        *
9480  REM  **********************
9490  REM
9500  REM   RG13 CONTAINS CONSTANTS FOR ORGANIC MATTER CALCULATIONS
9510  REM
9520 FL% = F1%(13):NF% = RL% / FL%
9530  ON PT% GOTO 9540,9770,9540
9540  HOME
9550  PRINT "*** ORGANIC MATTER PARAMETERS ***": PRINT : PRINT
9560  INPUT "ORGANIC MATTER CONCENTRATION OF SOIL (G/100G) =?";OM(1):
```

```
9570  INPUT "ORGANIC MATTER ENRICHMENT RATIO = ?";OM(2)
9580  REM
9590  REM    <<< WRITE: RG13 >>>
9600  REM
9610 RS%(13) = RI% + 1
9620 R% = RS%(13):K = 1
9630  FOR J = 1 TO 2
9640 B% = FL% * (K - 1)
9650  PRINT D$;"WRITE"ID$",R"R%",B"B%
9660  PRINT OM(J)
9670 K = K + 1
9680  IF K > NF% THEN R% = R% + 1
9690  IF K > NF% THEN K = K - NF%
9700  NEXT J
9710  PRINT D$
9720 RG%(13) = R% - RI%
9730 RI% = R%
9740  REM
9750  REM    <<< READ : RG13 >>>
9760  REM
9770 R% = RS%(13):K = 1
9780  FOR J = 1 TO 2
9790 B% = FL% * (K - 1)
9800  PRINT D$;"READ"ID$",R"R%",B"B%
9810  INPUT OM(J)
9820 K = K + 1
9830  IF K > NF% THEN R% = R% + 1
9840  IF K > NF% THEN K = K - NF%
9850  NEXT J
9860  PRINT D$
9870  REM
9880  REM    <<< OUTPUT: RG13 >>>
9890  REM
9892  ON PC% GOTO 9900,9894
9894  GOSUB 12955: REM  PRINTER CODE 1
9900  PRINT : PRINT : PRINT "*** RECORD GROUP 13 ***": PRINT : PRINT
9910  PRINT "ORGANIC MATTER PARAMETERS": PRINT
9920  PRINT "ORGANIC MATTER CONCENTRATION OF SOIL = ";OM(1)
9930  PRINT "ORGANIC MATTER ENRICHMENT RATIO = ";OM(2)
9940  PRINT
9945  GOSUB 12965: REM   PRINTER CODE 2
9950  RETURN
9960  REM  **********************
9970  REM  *   SUB:RG14   *
9980  REM  ***************
9990  REM
10000  REM     RG14 CONTAINS LOADING FACTORS
10010  REM
10020 FL% = F1%(14):NF% = RL% / FL%
10030  ON PT% GOTO 10070,10150,10070
10040  REM
10050  REM    <<< INPUT: RG14 >>>
10060  REM
10070  GOSUB 11430
10080  REM
10090  REM    <<<  WRITE: RG14  >>>
10100  REM
10110  GOSUB 11810
10120  REM
10130  REM    <<<  READ: RG14  >>>
```

```
10140  REM
10150  GOSUB 12000
10160  REM
10170  REM    <<< OUTPUT: RG14 >>>
10180  REM
10190  GOSUB 12160
10200  RETURN
10210  REM  ********************
10220  REM    <<< SUB:INPUT TO ARRAY >>>
10230  REM  ********************
10240  PRINT : PRINT
10250  PRINT "   *** INPUT:SUB-WATERSHED ***": PRINT
10260  PRINT TITLE$: PRINT
10270  PRINT "INPUT IN UNITS OF ";UN$: PRINT : PRINT
10280  FOR I = 1 TO NR%
10290  PRINT "*** SUB-WATERSHED ";I;"  ***": PRINT
10300  FOR J = 1 TO NC%
10310  PRINT SW$(J);" = ";
10320  INPUT AR(I,J)
10330  IF J = NU% GOTO 10350
10340  NEXT J
10345  PRINT
10350  NEXT I
10360  RETURN
10370  REM  ********************
10380  REM  <<< SUB:WRITE RECORDS>>>
10390  REM  ********************
10400  FOR I = 1 TO NR%
10410  FOR J = 1 TO NC%
10420 B% = FL% * (K - 1)
10430  PRINT D$;"WRITE"ID$",R"R%",B"B%
10450  PRINT AR(I,J)
10490 K = K + 1
10500  IF K > NF% THEN R% = R% + 1
10510  IF K > NF% THEN K = K - NF%
10520  IF J = NU% THEN  GOTO 10540
10530  NEXT J
10540  PRINT D$
10550  NEXT I
10560 MF% = 1
10570  RETURN
10580  REM  ********************
10590  REM  <<< SUB:READ RECORDS >>>
10600  REM  ********************
10610  FOR I = 1 TO NR%
10620  FOR J = 1 TO NC%
10630 B% = FL% * (K - 1)
10640  PRINT D$;"READ"ID$",R"R%",B"B%
10650  INPUT AR(I,J)
10660 K = K + 1
10670  IF K > RL% / FL% THEN R% = R% + 1
10680  IF K > RL% / FL% THEN K = K - RL% / FL%
10690  IF J = NU% GOTO 10710
10700  NEXT J
10710  PRINT D$
10720  NEXT I
10730  RETURN
10740  REM  ********************
10750  REM  <<< SUB: OUTPUT RECORDS>>>
10760  REM  ********************
```

```
10770  IF PC% = 2 THEN  GOSUB 12955: REM  PRINTER CODE
10778  PRINT : PRINT : PRINT "***     RECORD GROUP ";G%;" ***": PRINT
: PRINT
10779  PRINT TITLE$: PRINT
10780  ON PC% GOTO 10782,10794
10782  FOR I = 1 TO NC%: PRINT "SW ";I
10783 K1 = 1
10784  FOR J = 1 TO NC%
10785  PRINT  TAB( K1);AR(I,J);
10786  IF J = NU% GOTO 10790
10787 K1 = K1 + 6
10788  IF K1 > 40 THEN K1 = 1
10789  NEXT J
10790  PRINT
10791  NEXT I
10792  PRINT
10793  GOTO 10880
10794  FOR I = 1 TO NR%
10800  PRINT "SW ";I
10820  POKE 36,7: PRINT AR(I,1);: POKE 36,13: PRINT AR(I,2);: POKE 36,
19: PRINT AR(I,3);: POKE 36,25: PRINT AR(I,4);: POKE 36,31: PRINT AR(I
,5);: POKE 36,37: PRINT AR(I,6);
10821  IF NU% = 6 GOTO 10850
10822  POKE 36,43: PRINT AR(I,7);: POKE 36,49: PRINT AR(I,8);: POKE 36
,55: PRINT AR(I,9);
10824  POKE 36,61: PRINT AR(I,10);: POKE 36,67: PRINT AR(I,11);
10850  PRINT
10860  NEXT I
10870  PRINT
10875  GOSUB 12965: REM  PRINTER CODE 2
10880  RETURN
10890  REM     ****************
10900  REM     *   SUB: CHANGE PARAMETERS  *
10910  REM     ************************
10920  REM    DISPLAY EDITING CHOICES
10930  HOME
10940  PRINT "*** PARAMETER GROUPS ***": PRINT : PRINT
10950  PRINT "  0   FILE DESCRIPTION "
10960  PRINT "  1   CALCULATION OPTIONS"
10970  PRINT "  2   LAND USE AREAS"
10980  PRINT "  3   RAINFALL FACTORS"
10990  PRINT "  4   ERODIBILITY FACTORS"
11000  PRINT "  5   LENGTH FACTORS"
11010  PRINT "  6   SLOPE FACTORS"
11020  PRINT "  7   COVER FACTORS"
11030  PRINT "  8   PRACTICES FACTORS"
11040  PRINT "  9   SEDIMENT DELIVERY RATIOS"
11050  PRINT "  10  NITROGEN PARAMETERS"
11060  PRINT "  11  PHOSPHOROUS PARAMETERS"
11070  PRINT "  12  ORGANIC PARAMETERS "
11080  PRINT "  13  LOADING FACTORS"
11090  PRINT
11100  INPUT "CHANGE NUMBER = ?";CN%
11110 CN% = CN% + 1
11120  REM
11130  REM    <<< GOSUB:CHOOSE DAT ARRAY CHANGE METHOD >>>
11140  REM
11150  GOSUB 11320
11160  REM    LOAD APPROPRIATE VALUES FOR RECORD INDEX RI%
11170  IF AC% = 1 GOTO 11240
```

```
11180 RI% = RS%(CN%) - 1
11190  REM
11200  ON CN% GOSUB 2440,3590,4350,5080,5400,6020,6660,7070,7530,7950,
8390,9010,9530,10020
11210  PRINT "DO YOU WANT TO CHANGE ANOTHER SET OF PARAMETERS ? ( Y OR
 N )": PRINT
11220  INPUT A$
11230  IF A$ = "Y" GOTO 10930
11235  GOTO 11380
11240  GOSUB 12300: REM CHANGE SINGLE ELEMENT
11280  RETURN
11290  REM    ************************
11300  REM    *  SUB: CHOOSE DATA RRAY CHANGE METHOD *
11310  REM  ****************************************
11320  IF CN% < 3 OR CN% = 4 GOTO 11380
11330  IF CN% >  = 11 AND CN% <  = 13 GOTO 11380
11340  PRINT "OPTIONS:"
11350  PRINT "    1 CHANGE SINGLE ELEMENT IN ARRAY"
11360  PRINT "    2 CHANGE ENTIRE DATA ARRAY": PRINT
11370  INPUT "OPTION NUMBER = ?";AC%
11380  RETURN
11390  REM  ******************
11400  REM  *   SUB: RG14 INPUT  *
11410  REM  **********************
11420  REM
11430  HOME
11440  PRINT "***  LOADING FACTORS ***": PRINT : PRINT
11450  PRINT "OPTIONS:"
11460  PRINT "    1 AUTOMATIC LOADING OF STORED VALUES "
11470  PRINT "    2 DIRECT INPUT FROM KEYBOARD ": PRINT
11480  INPUT "OPTION NUMBER = ?";A%
11490  IF A% = 2 GOTO 11680
11500  REM
11510  REM  AUTOMATICALLY READ DATA AND STORE IN ARRAY HF(I,J)
11520  REM
11530  DATA  1,2,3,4,5,6,7,8,9,10,11
11540  DATA  12,13,14,15,16,17,18,19,20,21,22
11550  DATA  23,24,25,26,27,28,29,30,31,32,33
11560  DATA  34,35,36,37,38,39,40,41,42,43,44
11570  DATA  45,46,47,48,49,50,51,52,53,54,55
11580  DATA  56,57,58,59,60,61,62,63,64,65,66
11590  FOR I = 1 TO 6
11600  FOR J = 1 TO 11
11610  READ HF(I,J)
11620  NEXT J
11630  NEXT I
11640  GOTO 11770
11650  REM
11660  REM    DIRECT INPUT FROM KEYBOARD
11670  REM
11680  PRINT "INPUT LOADING FACTORS USING UNITS OF LBS/ACRE/YEAR": PRI
NT
11690  REM
11700  FOR I = 1 TO 6
11710  PRINT LF$(I)
11720  FOR J = 1 TO 11
11730  PRINT "    ";SW$(J);" = ";
11740  INPUT HF(I,J)
11750  NEXT J
11760  NEXT I
```

```
11770  RETURN
11780  REM  ********************
11790  REM  *   SUB:RG14 WRITE   *
11800  REM  ***********************
11810 RS%(14) = RI% + 1
11820 R% = RS%(14):K = 1
11830  FOR I = 1 TO 6
11840  FOR J = 1 TO 11
11850 B% = FL% * (K - 1)
11860  PRINT D$;"WRITE"ID$",R"R%",B"B%
11870  PRINT HF(I,J)
11880 K = K + 1
11890  IF K > NF% THEN R% = R% + 1
11900  IF K > NF% THEN K = K - NF%
11910  NEXT J
11920  PRINT D$
11930  NEXT I
11940 RG%(14) = R% - RI%
11950 RI% = R%
11960  RETURN
11970  REM  ************************
11980  REM  *   SUB:RG14 READ *
11990  REM  ********************
12000 R% = RS%(14):K = 1
12010  FOR I = 1 TO 6
12020  FOR J = 1 TO 11
12030 B% = FL% * (K - 1)
12040  PRINT D$;"READ"ID$",R"R%",B"B%
12050  INPUT HF(I,J)
12060 K = K + 1
12070  IF K > NF% THEN R% = R% + 1
12080  IF K > NF% THEN K = K - NF%
12090  NEXT J
12100  PRINT D$
12110  NEXT I
12120  RETURN
12130  REM  ********************
12140  REM  *   SUB:RG14 OUTPUT *
12150  REM  ********************
12160  ON PC% GOTO 12168,12162
12162  GOSUB 12955: REM  PRINTER CODE 1
12168  PRINT : PRINT : PRINT "***RECORD GROUP 14 ***": PRINT
12170  PRINT " LOADING FACTORS ": PRINT
12180  FOR I = 1 TO 6
12190  PRINT LF$(I)
12200  FOR J = 1 TO 11
12210  PRINT HF(I,J);"    ";
12220  NEXT J
12230  PRINT
12240  NEXT I
12250  PRINT
12255  GOSUB 12965: REM  PRINTER CODE 2
12260  RETURN
12270  REM  ***************************
12280  REM  * SUB: CHNAGE SINGLE ELEMENT IN DATA ARRAY *
12290  REM  ****************************************
12300 RI% = RS%(CN%)
12310  PRINT "RECORD GROUP NUMBER ";CN%: PRINT
12320  PRINT "CHANGE ELEMENT (I,J) IN DATA ARRAY": PRINT
12330  INPUT "ROW NUMBER = ?";II
```

```
12340  INPUT "COLUMN NUMBER = ?";JJ
12350  REM
12360  REM    CONVERT (I,J) TO RECORD (R%) AND FIELD (B%) VALUES
12370  REM
12380  REM  FIND CORRECT VALUES FOR NUMBER OF COLUMNS IN PARTICULAR AR
RAY
12390  REM
12400 CO% = 6
12403  IF CN% = 3 OR CN% = 14 THEN CO% = 11
12410 LN% = CO% * (II - 1) + JJ
12420 FL% = F1%(CN%)
12422 NF% = RL% / FL%
12440 RN = LN% / NF%:RN = RN - .01
12450 R% =  INT (RN) + RS%(CN%)
12455 AN = RN + .01 -  INT (RN)
12456 BN = AN * RL%:CN = BN + .001 - FL%
12460 B% = CN
12466 BN = AN * RL%
12480  REM  READ AND PRINT CURRENT VALUE
12490  PRINT D$;"READ"ID$",R"R%",B"B%
12500  INPUT AA
12510  PRINT D$
12520  PRINT "CURRENT VALUE OF ELEMENT (";II;",";JJ;") = ";AA
12530  PRINT
12540  INPUT "NEW VALUE OF ELEMENT = ?";BB
12550  PRINT D$;"WRITE"ID$",R"R%",B"B%
12560  PRINT BB
12570  PRINT D$
12580  INPUT "DO YOU WANT TO CHANGE ANOTHER ELEMENT IN THE SAME ARRAY
? (Y OR N)";A$
12590  IF A$ = "Y" GOTO 12320
12600  RETURN
12950  REM  ************************
12951  REM  *    SUB: PRINTER CODE 1 *
12952  REM  ************************
12955  PRINT D$;"PR#1": PRINT I$;"7L": PRINT I$;"80N"
12958  RETURN
12960  REM  ************************
12962  REM  *   SUB: PRINTER CODE 2 *
12963  REM  ************************
12965  PRINT D$;"PR#0"
12968  RETURN
```

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]LIST

20000  REM  ****************
20010  REM   <<< SUB:SOIL >>>
20020  REM  ****************
20030  REM
20040  REM  GO SUB:TABLE(SW AREAS)
20050  REM
20070  GOSUB 21260
20080  REM
20090 U1$ = "TONS/YEAR"
20100  REM
20110  REM  <<< UNIVERSAL SOIL LOSS EQUATION >>>
20120  REM
20130 NU% = 6
20140  FOR I = 1 TO NR%
20150  FOR J = 1 TO NU%
20160 SL(I,J) = RF * KF(I,J) * LF(I,J) * SF(I,J) * CF(I,J) * PF(I,J)
20170 SL(I,J) = SL(I,J) * LAR(I,J)
20180  NEXT J
20190  NEXT I
20200  REM
20210  REM  <<< GO SUB:TABLE(SOIL LOSS) >>>
20220  REM
20230  GOSUB 21540
20240  REM
20250  REM   <<< DELIVERED SOIL >>>
20260  REM
20270  FOR I = 1 TO NR%
20280  FOR J = 1 TO NU%
20290 DD(I,J) = SL(I,J) * SD(I,J)
20300  NEXT J
20310  NEXT I
20320  REM
20330  REM  <<< GO SUB:TABLE(DELIVERED SOIL) >>>
20340  REM
20350  GOSUB 21690
20360  REM
20370  REM   <<< GO SUB:LAND USE >>>
20380  REM
20390  GOSUB 22410
20400  REM
20410  REM  <<< SUB-WATERSHED SOIL LOSS >>>
20420  REM
20430  REM
20440  REM   <<< TONS/YEAR >>>
20450  REM
20460  FOR I = 1 TO NR%
20470 A1 = 0
20480  FOR J = 1 TO NU%
20490 A1 = A1 + SL(I,J)
20500  NEXT J
20510 SQ(I) = A1
20520  NEXT I
20530  REM
20540  REM  <<< GO SUB:TABLE(SW SOIL LOSS) >>>
20550  REM
```

```
20560  GOSUB 22010
20570  REM
20580  REM   <<<SUB-WATERSHED DELIVERED SOIL >>>
20590  REM
20600  REM
20610  REM   <<< TONS/YEAR >>>
20620  REM
20630  FOR I = 1 TO NR%
20640 A1 = 0
20650  FOR J = 1 TO NU%
20660 A1 = A1 + DD(I,J)
20670  NEXT J
20680 DQ(I) = A1
20690  NEXT I
20700  REM
20710  REM  <<< GO SUB:TABLE(SW DELIVERED SOIL) >>>
20720  REM
20730  GOSUB 22150
20740  REM
20750  REM  <<< TOTAL SOIL LOSS >>>
20760  REM
20770  REM
20780  REM   <<< TONS/YEAR >>>
20790  REM
20800 TD = 0
20810  FOR I = 1 TO NR%
20820 TD = TD + SQ(I)
20830  NEXT I
20840  PRINT "TOTAL SOIL LOSS": PRINT
20845 TD =  INT (10 * TD + .5) / 10
20850  POKE 36,11: PRINT TD;" TONS/YEAR": PRINT
20860  REM
20870  REM   <<< TOTAL DELIVERED SOIL >>>
20880  REM
20890  REM   <<< TONS/YEAR >>>
20900  REM
20910 TQ = 0
20920  FOR I = 1 TO NR%
20930 TQ = TQ + DQ(I)
20940  NEXT I
20950  PRINT "TOTAL DELIVERED SOIL": PRINT
20955 TQ =  INT (10 * TQ + .5) / 10
20960  POKE 36,11: PRINT TQ;" TONS/YEAR": PRINT : PRINT : PRINT
20970  RETURN
20980  REM  ******************
20990  REM    SUB:NITROGEN
21000  REM  ******************
21010  REM
21020  REM   <<< GO SUB:NITROGEN(EROSION) >>>
21030  REM
21040  GOSUB 23160
21050  REM
21060  REM   <<< GO SUB:NITROGEN(RAIN) >>>
21070  GOSUB 23370
21080  REM
21090  REM   <<< GO SUB:TABLE(LU TOTAL NITROGEN) >>>
21100  REM
21110  GOSUB 23730
21120  REM
21130  REM   <<< GO SUB:TABLE(SW TOTAL NITROGEN ) >>>
```

```
21140  GOSUB 23970
21150  REM
21155 A1 = 0
21160  REM   <<< TOTAL NITOGEN >>>
21170  FOR I = 1 TO NR%
21180 A1 = A1 + NST(I)
21190  NEXT I
21200 TN = A1
21210  PRINT "TOTAL NITROGEN FORWATERSHED =";TN: PRINT
21215  PRINT : PRINT
21220  RETURN
21230  REM  ***************
21240  REM    SUB:TABLE(SW AREA)
21250  REM  ***************
21260  PRINT : PRINT "*** SUB-WATERSHED LAND USE AREAS *** ": PRINT
21270  PRINT "          UNIT= ACRES": PRINT
21280  PRINT "SW";: POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PA
STURE";: POKE 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";
: POKE 36,61: PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
21290  FOR I = 1 TO NR%
21300  PRINT I;
21310 K1 = 7
21320 NU% = 6
21330  FOR J = 1 TO NU%
21340 K1 = K1 + 11
21350  POKE 36,K1: PRINT LAR(I,J);
21360  NEXT J
21370  PRINT
21380  NEXT I
21390  POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN";: POKE 36,61:
PRINT "COMMERCIAL"
21400  FOR I = 1 TO NR%
21420 K1 = 7
21430  FOR J = NU% + 1 TO NC%
21440 K1 = K1 + 11
21450  POKE 36,K1: PRINT LAR(I,J);
21460  NEXT J
21470  PRINT
21480  NEXT I
21485  PRINT : PRINT
21490  RETURN
21500  REM  ***************
21510  REM   SUB:TABLE(SOIL LOSS)
21520  REM  ***************
21530  REM
21540 T1$ = "SOIL LOSS TABLE"
21550  REM
21560  REM   <<< GO SUB:TABLE1 >>>
21570  REM
21580  FOR I = 1 TO NR%
21590  FOR J = 1 TO NU%
21600 UV(I,J) =  INT (10 * SL(I,J) + .5) / 10
21610  NEXT J
21620  NEXT I
21630  GOSUB 21830
21640  RETURN
21650  REM  ***************
21660  REM  <SUB:TABLE(DELIVERED SOIL) >>
21670  REM  ***************
```

```
21680  REM
21690 T1$ = "DELIVERED SOIL TABLE"
21700  REM
21710  REM  <<< GO SUB:TABLE1 >>>
21720  REM
21730  FOR I = 1 TO NR%
21740  FOR J = 1 TO NU%
21750 UV(I,J) =  INT (10 * DD(I,J) + .5) / 10
21760  NEXT J
21770  NEXT I
21780  GOSUB 21830
21790  RETURN
21800  REM  ***************
21810  REM    SUB:TABLE:1
21820  REM  ***************
21830  HOME
21840  PRINT "      ***** ";T1$;" *****": PRINT
21850  PRINT "         (";U1$;" )": PRINT
21860  PRINT "SW";: POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PA
STURE";: POKE 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";
: POKE 36,61: PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
21870  FOR I = 1 TO NR%
21880  PRINT I;
21890 K1 = 7
21900  FOR J = 1 TO NU%
21910 K1 = K1 + 11
21920  POKE 36,K1: PRINT UV(I,J);
21930  NEXT J
21940  PRINT
21950  NEXT I
21955  PRINT : PRINT
21960  RETURN
21970  REM  ***************
21980  REM   SUB:TABLE(SW SOIL LOSS)
21990  REM  ***************
22000  REM
22010 T1$ = "SUB-WATERSHED SOIL LOSS "
22020  REM
22030  REM  <<< GO SUB:TABLE2 >>>
22040  REM
22050  FOR I = 1 TO NR%
22060 UV(I,1) =  INT (10 * SQ(I) + .5) / 10
22070  NEXT I
22080  GOSUB 22270
22090  RETURN
22100  REM  ***************
22110  REM   SUB:TABLE(SW DELIVERED SOIL)
22120  REM  ***************
22130  REM
22140  REM   <<< GO SUB:TABLE2 >>>
22150 T1$ = "SUB-WATERSHED DELIVERED SOIL "
22160  REM
22170  REM   <<< GO SUB:TABLE2 >>>
22180 U1$ = "TONS/YEAR"
22190  FOR I = 1 TO NR%
22200 UV(I,1) =  INT (10 * DQ(I) + .5) / 10
22210  NEXT I
22220  GOSUB 22270
22230  RETURN
22240  REM  ***************
```

```
22250  REM    SUB:TABLE2
22260  REM  ***************
22270  HOME
22280  PRINT "      ***** ";T1$;" *****": PRINT
22290  PRINT "SUB-WATERSHED",U1$: PRINT
22300  FOR I = 1 TO NR%
22310  POKE 36,12: PRINT I;: POKE 36,32: PRINT UV(I,1)
22320  NEXT I
22325  PRINT : PRINT
22330  RETURN
22340  REM  ****************
22350  REM    SUB:LAND USE
22360  REM  ***************
22370  REM
22380  REM  <<<TOTAL SOIL LOSS BY LAND USE >>>
22390  REM
22400  REM   <<< TONS/YEAR >>>
22410  FOR J = 1 TO NU%
22420 A1 = 0
22430  FOR I = 1 TO NR%
22440 A1 = A1 + SL(I,J)
22450  NEXT I
22460 LL(J) = A1
22470  NEXT J
22480  REM
22490  REM   <<< GO SUB:TABLE(LU SOIL LOSS ) >>>
22500  REM
22510  GOSUB 22740
22520  REM
22530  REM   <<< TOTAL DELIVERED SOIL BY LAND USE >>>
22540  REM
22550  REM
22560  REM  <<< TONS/YEAR >>>
22570  REM
22580  FOR J = 1 TO NU%
22590 A1 = 0
22600  FOR I = 1 TO NR%
22610 A1 = A1 + DD(I,J)
22620  NEXT I
22630 LD(J) = A1
22640  NEXT J
22650  REM
22660  REM   <<< GO SUB:TABLE(LU DELIVERED SOIL) >>>
22670  REM
22680  GOSUB 23010
22690  RETURN
22700  REM  ***************
22710  REM   SUB:TABLE(LU SOIL LOSS)
22720  REM  ***************
22730  REM
22740 T3$ = "TOTAL SOIL LOSS BY LAND USE"
22750  REM
22760  REM   <<< GO SUB:TABLE3 >>>
22770  REM
22780  FOR J = 1 TO NU%
22790 UV(1,J) =  INT (10 * LL(J) + .5) / 10
22800  NEXT J
22810  GOSUB 22860
22820  RETURN
22830  REM  ***************
```

```
22840  REM    SUB:TABLE3
22850  REM  ***************
22860  HOME
22870  PRINT "  *** ";T3$;" ***": PRINT
22880  PRINT  SPC( 10);U1$: PRINT
22890  FOR J = 1 TO NU%
22900  PRINT SW$(J);" = ";UV(1,J)
22910  NEXT J
22920  PRINT
22925  PRINT : PRINT
22930  RETURN
22940  REM  **************
22950  REM  SUB:(TABLE(LU SOIL DELIVERED)
22960  REM  **************
22970  REM
22980  REM
22990  REM  <<< GO SUB:TABLE3 >>>
23000  REM
23010 T3$ = "TOTAL DELIVERED SOIL BY LAND USE"
23020 U3$ = "TONS/YEAR"
23030  FOR J = 1 TO NU%
23040 UV(1,J) =  INT (10 * LD(J) + .5) / 10
23050  NEXT J
23060  GOSUB 22860
23070  RETURN
23080  REM  ************************
23090  REM     SUB:NITROGEN(EROSION)
23100  REM  ************************
23110  REM
23120  REM    <<< BY LAND USE >>>
23130  REM
23140  REM    <<< POUNDS/YEAR >>>
23150  REM
23160 AD = 20
23170  FOR J = 1 TO NU%
23180 NLE(J) = AD * LD(J) * RC(1) * RC(2)
23190  NEXT J
23200  REM
23210  REM    <<< BY SUB-WATERSHED >>>
23220  REM
23230  REM    <<<  POUNDS/YEAR >>>
23240  REM
23250  FOR I = 1 TO NR%
23260 NWS(I) = AD * DQ(I) * RC(1) * RC(2)
23270  NEXT I
23280  RETURN
23290  REM  ************************
23300  REM      SUB:NITROGEN(RAIN)
23310  REM  ************************
23320  REM
23330  REM    <<< BY LAND USE >>>
23340  REM
23350  REM    <<< POUNDS/YEAR >>>
23360  REM
23370 AD = 20:B1 = .75
23380  REM
23390  REM    <<< FIND LAND USE AREAS >>>
23400  REM
23410  FOR J = 1 TO NU%
23420 A1 = 0
```

```
23430  FOR I = 1 TO NR%
23440 A1 = A1 + LAR(I,J)
23450  NEXT I
23460 LU(J) = A1
23470  NEXT J
23480  FOR J = 1 TO NU%
23490 NQR(J) = LU(J) * RC(3) * RC(4) * .75 / RC(5)
23500  NEXT J
23510  REM
23520  REM  <<< BY SUB-WATERSHED >>>
23530  REM
23540  REM  <<< POUNDS/YEAR >>>
23550  REM
23560  REM   <<< FIND SUB-WATERSHED AREAS >>>
23570  FOR I = 1 TO NR%
23580 A1 = 0
23590  FOR J = 1 TO NU%
23600 A1 = A1 + LAR(I,J)
23610  NEXT J
23620 LW(I) = A1
23630  NEXT I
23640  FOR I = 1 TO NR%
23650 NPR(I) = LW(I) * RC(3) * RC(4) * .75 / RC(5)
23660  NEXT I
23670  RETURN
23680  REM  **********************
23690  REM     SUB:TABLE(LU TOTAL NITROGEN)
23700  REM  **********************
23710  REM
23720  REM   <<< FIND TOTAL NITROGEN BY LAND USE >>>
23730  FOR J = 1 TO NU%
23740 NTL(J) = NLE(J) * RC(6) * NQR(J)
23750  NEXT J
23760  REM   <<< GO SUB:TABLE4 >>>
23770 T4$ = "TOTAL NITROGEN BY LAND USE"
23780 U4$ = "POUNDS/YEAR"
23790  GOSUB 23850
23810  RETURN
23820  REM  ******************
23830  REM     SUB:TABLE 4
23840  REM  ******************
23850  PRINT "*** ";T4$;" ***": PRINT
23860  PRINT "UNITS= ";U4$: PRINT
23870  PRINT "LAND USE";: POKE 36,32: PRINT "TOTAL NITROGEN"
23880  FOR J = 1 TO NU%
23885 NTL(J) =  INT (10 * NTL(J) + .5) / 10
23890  PRINT SW$(J);: POKE 36,37: PRINT NTL(J)
23900  NEXT J
23905  PRINT : PRINT
23910  RETURN
23920  REM  ****************
23930  REM    SUB:TABLE(SW TOTAL NITROGEN)
23940  REM  *******************
23950  REM
23960  REM    <<< FIND TOTAL NITROGEN BY SUB-WATERSHED >>>
23970  FOR I = 1 TO NR%
23980 NST(I) = NWS(I) * RC(6) * NPR(I)
23990  NEXT I
24000  REM
24010  REM  <<< GO SUB:TABLE5 >>>
```

```
24020  REM
24030 T5$ = "TOTAL NITROGEN BY SUB-WATERSHED"
24040 U5$ = "POUNDS/YEAR"
24050  GOSUB 24100
24060  RETURN
24070  REM  ******************
24080  REM     SUB:TABLE5
24090  REM  ******************
24100  PRINT "*** ";T5$;" ***": PRINT
24110  PRINT "UNITS = ";U4$: PRINT
24120  PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL NITROGEN "
24130  FOR I = 1 TO NR%
24135 NST(I) =  INT (10 * NST(I) - .5) / 10
24140  PRINT "    ";I;: POKE 36,37: PRINT NST(I)
24150  NEXT I
24160  PRINT
24170  RETURN
24180  REM  ***************************
24190  REM  *    SUB:PHOSPHOROUS    *
24200  REM  ***************************
24210  REM
24220  REM
24230  REM    <<< BY LAND USE >>>
24240  REM
24250  REM    <<< POUNDS/YEAR >>>
24260  REM
24270 AD = 20
24280  FOR J = 1 TO NU%
24290 PL(J) = AD * LD(J) * PC(1) * PC(2) * PC(3)
24300  NEXT J
24310  REM
24320  REM    <<< BY SUB-WATERSHED >>>
24330  REM
24340  FOR I = 1 TO NR%
24350 PW(I) = AD * DQ(I) * PC(1) * PC(2) * PC(3)
24360  NEXT I
24370  REM
24380  REM    <<< PRINT TABLES >>>
24390  REM
24400  REM
24410  REM    <<< GOSUB:TABLE(LU TOTAL PHOSPHOROUS )
24420  REM
24430  GOSUB 24550
24440  REM
24450  REM    <<< GOSUB: TABE(SW TOTAL PHOSPHOROUS )
24460  REM
24470  GOSUB 24750
24472  REM    <<< TOTAL PHOSPHOROUS >>>
24474 A1 = 0
24476  FOR I = 1 TO NR%
24478 A1 = A1 + PW(I)
24480  NEXT I
24482 TP = A1
24484  PRINT "TOTAL PHOSPHOROUS FOR WATERSHED = ";TP: PRINT : PRINT :
PRINT
24486  RETURN
24490  REM  ***********************
24500  REM  *   SUB:TABLE(LU TOTAL PHOSPHOROUS )
24510  REM  ****************************
24520  REM
```

```
24530  REM    <<< GOSUB:TABLE 6 >>>
24540  REM
24550 T6$ = "TOTAL PHOSPHOROUS BY LAND USE"
24560 U6$ = "POUNDS/YEAR"
24570  GOSUB 24620
24580  RETURN
24590  REM  ***********************
24600  REM  *   SUB:TABLE 6     *
24610  REM  ***********************
24620  PRINT "***";T6$;" ***": PRINT
24630  PRINT "UNITS = ";U6$: PRINT
24640  PRINT "LAND USE";: POKE 36,32: PRINT "TOTAL PHOSPHOROUS"
24650  FOR J = 1 TO NU%
24655 PL(J) =  INT (10 * PL(J) + .5) / 10
24660  PRINT SW$(J);: POKE 36,37: PRINT PL(J)
24670  NEXT J
24675  PRINT : PRINT
24680  RETURN
24690  REM  ***********************
24700  REM  *   SUB: TABLE( SW TOTAL PHOSPHOROUS )
24710  REM  ***********************************
24720  REM
24730  REM    <<< GOSUB: TABLE 7 >>>
24740  REM
24750 T7$ = "TOTAL PHOSPHPROUS BY SUB-WATERSHED  "
24760 U7$ = "POUNDS/YEAR"
24770  GOSUB 24820
24780  RETURN
24790  REM  ************************
24800  REM  *   SUB: TABLE 7  *
24810  REM  ******************
24820  PRINT "***";T7$;" ***": PRINT
24830  PRINT "UNITS = ";U7$: PRINT
24840  PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL PHOSPHOROUS"
24850  FOR I = 1 TO NR%
24855 PW(I) =  INT (10 * PW(I) + .5) / 10
24860  PRINT I;: POKE 36,37: PRINT PW(I)
24870  NEXT I
24875  PRINT : PRINT
24880  RETURN
24890  REM  ***************************
24900  REM  *   SUB: ORGANIC MATTER *
24910  REM  ***************************
24920  REM
24930  REM
24940  REM    <<< BY LAND USE >>>
24950  REM
24960  REM    <<< POUNDS/YEAR >>>
24970  REM
24980 AD = 20
24990  FOR J = 1 TO NU%
25000 ML(J) = AD * LD(J) * OM(1) * OM(2)
25010  NEXT J
25020  REM
25030  REM    <<< BY SUB-WATERSHED >>>
25040  REM
25050  FOR I = 1 TO NR%
25060 MW(I) = AD * DQ(I) * OM(1) * OM(2)
25070  NEXT I
25080  REM
```

```
25090  REM    <<< PRINT TABLES >>>
25100  REM
25110  REM
25120  REM    <<< GOSUB: TABLE(LU ORGANIC MATTER) >>>
25130  REM
25140  GOSUB 25260
25150  REM
25160  REM    <<< GOSUB: TABLE(SW ORGANIC MATTER )
25170  REM
25180  GOSUB 25450
25182  REM  <<<  TOTAL ORGANIC MATTER FOR SUBWATERSHED >>>
25184 A1 = 0
25186  FOR I = 1 TO NR%
25188 A1 = A1 + MW(I)
25190  NEXT I
25192 TR = A1
25194  PRINT "TOTAL ORGANIC MATTER FOR WATERSHED = ";TR: PRINT : PRINT
 : PRINT
25196  RETURN
25200  REM  ****************************
25210  REM  *   SUB:TABLE(LU ORGANIC MATTER )   *
25220  REM  ****************************************
25230  REM
25240  REM    <<<   GOSUB:TABLE 8  >>>
25250  REM
25260 T8$ = "TOTAL ORGANIC MATTER BY LAND USE"
25270 U8$ = "POUNDS/YEAR"
25280  GOSUB 25330
25290  RETURN
25300  REM  ***************************
25310  REM   *   SUB:TABLE 8   *
25320  REM  ******************
25330  PRINT "***";T8$;" ***": PRINT
25340  PRINT "UNITS = ";U8$: PRINT
25350  PRINT "LAND USE";: POKE 36,32: PRINT " TOTAL ORGANIC MATTER"
25360  FOR J = 1 TO NU%
25363 OL(J) =  INT (10 * OL(J) + .5) / 10
25365 ML(J) =  INT (10 * ML(J) + .5) / 10
25370  PRINT SW$(J);: POKE 36,27: PRINT ML(J)
25380  NEXT J
25386  PRINT : PRINT
25387  RETURN
25390  REM  ****************************
25400  REM  *   SUB:TABLE(SW TOTAL ORGANIC MATTER)  *
25410  REM  ****************************************
25420  REM
25430  REM    <<< GOSUB:TABLE 9 >>>
25440  REM
25450 T9$ = "TOTAL ORGANIC MATTER BY SUB-WATERSHED"
25460 U9$ = "POUNDS/YEAR"
25470  GOSUB 25530
25490  RETURN
25500  REM  ***********************
25510  REM  *   SUB: TABLE 9  *
25520  REM  ******************
25530  PRINT "***";T9$;" ***": PRINT
25540  PRINT "UNITS = ";U9$: PRINT
25550  PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL ORGANICMATTER"

25560  FOR I = 1 TO NR%
```

```
25565 MW(I) =  INT (10 * MW(I) + .5) / 10
25570  PRINT I;: POKE 36,37: PRINT MW(I)
25580  NEXT I
25585  PRINT : PRINT
25590  RETURN
25600  REM  ***********************
25610  REM  *   SUB: LOADING FACTOR CALCULATIONS   *
25620  REM  ***************************************
25625  REM
25630  REM    <<< BY LAND USE AND SUBWATERSHED   >>>
25632  REM
25634  GOSUB 26506
25636  REM
25640  REM    <<< BY LAND USE >>>
25650  REM
25660  REM    CALCULATE POLLUTANT LOADINGS
25670  REM
25680  FOR M = 1 TO 6
25690  FOR J = 1 TO NC%
25700 TA = 0
25710  FOR I = 1 TO NR%
25720 TA = TA + LAR(I,J)
25730  NEXT I
25740 PM(M,J) = HF(M,J) * TA
25750  NEXT J
25760  NEXT M
25770  REM
25780  REM   PRINT POLLUTANT LOAD FOR EACH LAND USE
25790  REM
25800  PRINT "*** POLLUTANT LOADS USING LOADING FACTORS ***": PRINT :
PRINT
25810  PRINT " BY LAND USE (POUNDS/YEAR)": PRINT
25820  FOR M = 1 TO 6
25830  PRINT LF$(M);" : ": PRINT
25840  POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PASTURE";: POKE
 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";: POKE 36,61:
 PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
25850 NU% = 6
25860 K1 = 7
25880  FOR J = 1 TO NU%
25883 K1 = K1 + 11
25885 PM(M,J) =  INT (10 * PM(M,J) + .5) / 10
25890  POKE 36,K1: PRINT PM(M,J);
25910  NEXT J
25920  PRINT
25930  NEXT J
25940  POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN";: POKE 36,61:
PRINT "COMMERCIAL"
25950 K1 = 7
25960  FOR J = NU% + 1 TO NC%
25962 K1 = K1 + 11
25965 PM(M,J) =  INT (10 * PM(M,J) + .5) / 10
25970  POKE 36,K1: PRINT PM(M,J);
25980 K1 = K1 + 11
26000  NEXT J
26010  PRINT
26020  NEXT M
26025  PRINT
26030  REM
```

```
26040  REM    <<< BY SUB-WATERSHED >>>
26050  REM
26060  REM
26070  REM    CALCULATE POLLUTANT LOADING
26080  REM
26090  FOR I = 1 TO NR%
26100  FOR M = 1 TO 6
26110 PJ = 0
26120  FOR J = 1 TO NC%
26130 PJ = PJ + HF(M,J) * LAR(I,J)
26140  NEXT J
26145 PI(I,M) = PJ
26150  NEXT M
26160  NEXT I
26170  REM
26180  REM    PRINT POLLUTANT LOADS FOR EACH SUB-WATERSHED
26190  REM
26210  PRINT "BY SUBWATERSHED        (POUNDS/YEAR)": PRINT
26220  FOR I = 1 TO NR%
26230  PRINT "SUBWATERSHED ";I: PRINT
26240  FOR M = 1 TO 6
26245 PI(I,M) =  INT (10 * PI(I,M) + .5) / 10
26250  PRINT "    ";LF$(M);: POKE 36,33: PRINT PI(I,M)
26260  NEXT M
26270  PRINT
26280  NEXT I
26290  RETURN
26500  REM  ***********************************
26502  REM  * SUB: BY LAND USE AND SUBWATERSHED *
26504  REM  ***********************************
26506  PRINT "*** POLLUTANT LOADS USING LOADING FACTORS ***": PRINT :
PRINT
26508  PRINT "BY LAND USE AND SUBWATERSHED      (POUNDS/ACRE)": PRINT

26510  FOR M = 1 TO 6
26512  PRINT LF$(M);" : ": PRINT
26515  FOR I = 1 TO NR%
26517  PRINT "   SW: ";I: PRINT
26520  FOR J = 1 TO NC%
26525 PA(J) = HF(M,J) * LAR(I,J)
26530  NEXT J
26540  POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PASTURE";: POKE
 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";: POKE 36,61:
 PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
26550 NU% = 6
26555 K1 = 7
26560  FOR J = 1 TO NU%
26565 K1 = K1 + 11
26570 PA(J) =  INT (10 * PA(J) + .5) / 10
26575  POKE 36,K1: PRINT PA(J);
26580  NEXT J
26585  PRINT
26590  POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN ";: POKE 36,61:
 PRINT "COMMERCIAL"
26595 K1 = 7
26600  FOR J = NU% + 1 TO NC%
26605 K1 = K1 + 11
26610 PA(J) =  INT (10 * PA(J) + .5) / 10
26615  POKE 36,K1: PRINT PA(J);
```

```
26620  NEXT J
26625  PRINT
26630  NEXT I
26635  NEXT M
26640  RETURN
```

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