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AGRICULTURE RUNOFF MANAGEMENT (ARM) MODEL - Version II. Refinement and Testing

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AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL VERSION II: REFINEMENT AND TESTING

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FOREWORD

As environmental controls become more costly to implement and the penalties of judgment errors become more severe, environmental quality management requires more efficient analytical tools based on greater knowledge of the environmental phenomena to be managed. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, the Technology Development and Applications Branch develops management or engineering tools to help pollution control officials achieve water quality goals through watershed management.

Refinement and testing of the Agricultural Runoff Management (ARM) Model represents a continuing effort to develop mathematical tools for analyzing and managing agricultural nonpoint pollution. Although more testing and research in specific areas is needed, the application of the model on small agriculture watersheds in Georgia and Michigan indicates that the ARM Model can represent the major environmental factors affecting agriculture runoff and can be a useful tool for planning and analysis.

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ABSTRACT

The Agricultural Runoff Management (ARM) Model has been refined and tested on small agricultural watersheds in Georgia and Michigan. The ARM Model simulates the hydrologic, sediment production, pesticide, and nutrient processes on the land surface and in the soil profile that determine the quantity and quality of agricultural runoff. This report discusses the research and model refinements related to soil moisture and temperature simulation, pesticide degradations, nutrient transformations and plant nutrient uptake. The goal is to evaluate and improve the pesticide and nutrient simulation capabilities of the ARM Model. However, the runoff and sediment modeling is also analyzed since these are the critical transport mechanisms of agricultural chemicals.

Small agricultural watersheds in Watkinsville, Georgia and East Lansing, Michigan, instrumented for continuous monitoring and sampling of runoff, provided data for model testing. In general, comparison of simulated and recorded values indicate that the ARM Model can represent the major processes affecting agricultural runoff, and can be a useful tool for planning and analysis. However, discrepancies do exist and point out the need for more testing and research in specific areas.

Runoff and sediment simulation results are good except following tillage operations. The relationship of agricultural practices to the model runoff and sediment parameters needs to be studied and quantified. Pesticide and nutrient runoff simulations are fair to good when runoff and sediment are accurately represented. Sediment-associated pesticide and nutrient forms are usually better simulated than soluble or solution forms. Pesticides that move both on sediment and in solution remain a problem, indicating the need to further investigate the partitioning mechanism. Pesticide degradation can be adequately represented by a step-wise first-order mechanism if soil pesticide measurements are available; predictive pesticide degradation and attenuation models are needed. Soil nutrient transformations are reasonably simulated with the first-order reactions assumed in the nutrient model. Although simulation of the sediment-associated nutrients in runoff is good, the solution forms, such as nitrate, are not adequately represented. These solution forms are highly sensitive to the simulated interflow component of runoff; thus the soil moisture profile and the separate runoff components need to be more accurately defined to improve the nutrient runoff simulation.

In general, the soil processes occurring in the near surface soil zone exert the major influence on agricultural runoff from small agricultural watersheds and should be further investigated. Recommendations are included for (1) further testing of the ARM Model, (2) investigation of the

algorithm deficiencies noted above, and (3) modifications to promote and simplify use of the ARM Model by the potential user community.

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LIST OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

cm	--centimeters
cms	--cubic meters per second
gm/ha	--grams per hectare
gm/l	--grams per liter
gm/min	--grams per minute
ha	--hectare
kg/ha	--kilograms per hectare
kg/min	--kilograms per minute
m	--meters
mg/l	--milligrams per liter
mg/min	--milligrams per minute
mm	--millimeters
ppm	--parts per million

SYMBOLS

N	--nitrogen
NH_4	--ammonium
NH_4-N	--nitrogen in the ammonium form
NO_2	--nitrite
NO_3	--nitrate
NO_3-N	--nitrogen in the nitrate form
P	--phosphorus
PO_4	--phosphate or orthophosphorus
PO_4-P	--phosphorus in the phosphate form
TKN	--total Kjeldahl nitrogen, i.e. organic nitrogen and ammonia nitrogen

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At Hydrocomp a research team was organized to conduct the work in this project. Dr. Norman H. Crawford, as principal investigator, provided general direction and coordination. The research team was comprised of Anthony Donigian, Douglas Beyerlein, and Harley Davis. Mr. Donigian, as project manager, supervised and reviewed the project work and the final report. Mr. Beyerlein, as associate project manager, directed data preparation and management, software modifications, and pesticide simulation work. Mr. Davis conducted the nutrient model research refinements, calibration, and testing. All team members participated in the hydrology and sediment simulation work. Mr. Guy Funabiki provided graphical and drafting expertise, while Ms. Nancy Sharpe and Ms. Donna Mitchell supplied clerical assistance and support. The final report was typed by Ms. Kathy Francies and edited by Ms. Mitchell.

SECTION 1

INTRODUCTION

Since 1972 the Environmental Research Laboratory in Athens, Georgia (ERL-Athens) has sponsored the development and testing of mathematical models to simulate the quantity and quality of agricultural runoff. The overall goal of the program is to provide state-of-the-art models as tools for analyzing agricultural nonpoint pollution and evaluating the impact and effectiveness of alternative land management procedures. This report is the third in a series of research reports describing the development and testing of the Agricultural Runoff Management (ARM) Model, one of the tools whose development is being sponsored by ERL-Athens.

The initial effort in the ARM Model work produced the Pesticide Transport and Runoff (PTR) Model published in December 1973 (Crawford and Donigian, 1973). The PTR Model includes erosion, pesticide adsorption/desorption, and pesticide attenuation (volatilization and degradation) models interfaced with a pre-existing hydrologic model. Testing of the PTR Model was limited due to data availability. As a result of including snow accumulation and melt routines and developing plant nutrient simulation models, the PTR Model was renamed the ARM Model to reflect the wider scope of application. The ARM Model report (Donigian and Crawford, 1976), describes the model components, includes a brief user manual, and presents initial test results for runoff, sediment, and pesticide simulations for one year of data on two small watersheds in Georgia.

The inital test results and the availability of additional data from Watersheds in Georgia and Michigan provided the impetus for additional testing, evaluation, and refinement of the ARM Model simulation capabilities. Also, the nutrient model had not been tested with observed data prior to publication of the ARM Model report. Accordingly, the work described herein concentrates on evaluating and improving the pesticide and nutrient simulations of the ARM Model. Modeling runoff, sediment, and soil environmental factors (i.e. temperature and moisture) is also discussed in terms of their impact on pesticide and nutrient simulation.

Following the major conclusions and recommendations presented in Sections 2 and 3, respectively, the present status of the ARM Model is summarized in Section 4, emphasizing the significant changes from the version presented in the ARM Model report. The reader should refer to that report for a more complete description of the model components as that material will not be repeated here. Section 5 briefly describes the data collection programs and test watersheds in Georgia and Michigan. Section 6 discusses the simulation of soil moisture and temperature while pesticide degradation and soil

nutrient transformations and corresponding simulation results are provided in Sections 7 and 8, respectively. Sections 9 through 11 present the simulation results for runoff and sediment (Section 9), pesticide content in runoff (Section 10), and nutrient content in runoff (Section 11). The appendices include an update of the input sequence and parameter list, detailed storm event simulation results, and the ARM Model source code (Version II dated 06/10/77).

SECTION 2

CONCLUSIONS

(1) The Agricultural Runoff Management (ARM) Model can represent runoff, sediment, pesticide, and nutrient processes on small agricultural watersheds in Georgia and Michigan. Model testing has shown that the major soil and transport mechanisms that determine the quantity and quality of agricultural runoff can be simulated with the ARM Model.

(2) The hydrologic portion of the ARM Model simulates soil moisture storages and all runoff components. The runoff simulation methodology has been tested and verified on numerous watersheds of all sizes in many geographical areas. However, the representation of the soil moisture profile may be too approximate for detailed simulation of the vertical movement and distribution of agricultural chemicals.

(3) Model testing has shown that the loss of solution phase chemicals, such as nitrates and soluble pesticides, from small watersheds is highly sensitive to the simulated interflow component of runoff. Thus, the assumptions and calibration of interflow characteristics must be evaluated in light of the resulting transport of solution chemicals.

(4) The method of snowmelt simulation in the ARM Model, based on energy-balance calculations, adequately represents the snow accumulation and melt process and the resulting runoff volumes. However, snowmelt hydrographs are not accurately simulated and the impact of frozen ground conditions is not represented. This is likely due to both inaccurate or insufficient meteorologic data and inadequacies in the snowmelt algorithms.

(5) In general, the ARM Model simulation of sediment production on the test watersheds is good when runoff hydrographs and monthly volumes are well simulated. The only exceptions to this are related to the effects of winter freeze/thaw conditions on sediment production and the occurrence of soil detachment and scour by overland flow. These conditions are not currently simulated in the model.

(6) Tillage operations have a major impact on the runoff and sediment producing characteristics of small agricultural watersheds. The ARM Model attempts to evaluate the impact of tillage on sediment production but does not consider the effect on runoff. Consequently storms immediately following tillage operations are not as accurately

simulated for runoff or the resulting sediment loss as storms occurring later in the growing season.

(7) The accuracy of the pesticide and nutrient simulations with the ARM Model is usually a direct function of the accuracy of the runoff and sediment simulation. Although some discrepancies exist, when runoff and sediment are adequately simulated the pesticide and nutrient simulated runoff values closely approximate the observed data.

(8) The adsorbed or sediment-associated forms of both pesticides and nutrients are better simulated with the ARM Model than the corresponding soluble or solution forms. The sediment-associated chemicals, such as adsorbed pesticides, organic nitrogen, and organic phosphorus are more stable and less affected by transformations than the soluble forms like nitrates, phosphates, and soluble pesticides.

(9) The pesticide simulation results indicate that:

(a) Comparison of the single-valued (SV) and nonsingle-valued (NSV) adsorption/desorption functions for partitioning pesticides between the adsorbed and solution phases is inconclusive. The SV function is better for some storms while the NSV function is better for others. The observed tendency of the ratio of adsorbed to solution forms to increase during a growing season is better represented by the NSV function, but it is not clear that this observed behavior is due to an adsorption/desorption mechanism.

(b) Processes that degrade and attenuate pesticides have a major impact on the amount of remaining pesticide available for runoff. Simulation of the aggregate impact of these processes can be reasonably performed by a step-wise first-order degradation approach using different rates following application and later in the growing season. The present state-of-the-art cannot provide a general method for representing the individual degradation mechanisms and the impact of environmental conditions.

(10) The nutrient simulation results indicate that:

(a) The nutrient algorithms can simulate with good accuracy soil nutrient storages and transformations for the summer growing seasons on the test watersheds. For the nonsummer periods, the simulated soil temperatures obtained by regression with air temperature were not applicable, and adequate observed soil nutrient data was not available for comparison. However, the simulated soil nutrient storages behaved in a reasonable fashion throughout an 18-month simulation period.

(b) Initial test results indicate that the accuracy of the simulation of nutrient runoff is limited more by the accuracy of the simulated transport mechanisms than the soil nutrient

storages. Specifically, better definition of the interflow runoff component and vertical moisture movement would significantly improve the nutrient runoff simulation.

(c) Plant uptake of soluble nutrient forms, especially nitrate and phosphate, is a major mechanism controlling the availability of these forms for runoff and vertical leaching. Accurately simulating the time-dependent behavior of plant uptake, in relation to crop growth and fertilizer applications, is critical to evaluating the impact of agricultural operations on nutrient contributions to streams and groundwater.

SECTION 3

RECOMMENDATIONS

(1) Further testing of all portions of the ARM Model is needed to demonstrate the capabilities of the model and to delineate and confirm topics for future research. Past testing has shown that the model can represent the mechanisms determining the quantity and quality of agricultural runoff in two different climatic and geographical regions. Testing in other areas is needed to strengthen confidence in the model and demonstrate its general applicability.

(2) Model testing on larger watersheds, in the general range of 50 to 500 hectares, is needed to evaluate the model's representation of processes in the lower soil zones and chemical contributions to groundwater. In this way, simulation of the movement of soluble chemicals through subsurface pathways to a stream or waterbody can be investigated.

(3) The impact of tillage operations on runoff and sediment production should be quantified and incorporated into the ARM Model. This is especially important because the first events following pesticide and fertilizer applications are the most significant for agricultural chemical runoff.

(4) The relationship of different agricultural land management practices to the ARM Model parameters should be investigated and quantified if the model is to be used to evaluate methods of controlling agricultural nonpoint pollution. The extent to which specific practices can or cannot be simulated with the ARM Model, and the corresponding changes in model parameters needs to be delineated. Such work will likely produce additional recommendations for model modifications to accommodate agricultural practices common to different regions of the country.

(5) Future testing of the pesticide and nutrient simulation algorithms should evaluate the extent to which laboratory measurements and literature values of model parameters can be used to simulate pesticide and nutrient runoff without calibration on recorded data. Although the model algorithms have been designed to use commonly measured values, calibration of parameters has been used to evaluate the pesticide and nutrient algorithms after initial parameter values had been obtained from the literature. General use of the ARM Model will be severely limited if each application requires calibration of certain pesticide and nutrient parameters on recorded data.

(6) To improve the reliability and accuracy of the ARM Model the following recommendations are extended:

(a) Better definition of moisture, temperature, and chemical behavior in the surface soil layer (e.g. 0-1 cm) is needed since the processes in this zone directly affect the quality of surface runoff.

(b) In conjunction with (a), more accurate representation of the entire soil profile and intermediate moisture tranfers is required for detailed simulation of vertical chemical movement.

(c) Refinement of the erosion algorithms should concentrate on inclusion of detachment and scour by overland flow, consideration of gully erosion, and erosion simulation as a function of particle size. This work could significantly improve the sediment simulation and help to interface the ARM Model output with in-stream sediment transport models.

(d) If particle size erosion is added to the ARM Model, the pesticide and nutrient algorithms for sediment related processes should be re-evaluated to incorporate the dependence on particle size.

(e) Predictive models are needed for pesticide attenuation processes such as chemical, photochemical, and biological degradation and volatilization. Ideally, such models should consider the impact of soil environmental conditions (e.g. moisture, temperature, oxygen), be capable of application in various regions of the country, and utilize parameters easily measured in a laboratory.

(f) Evaluation and quantification of the impact of moisture and oxygen conditions on the soil nutrient reaction rates is needed. If this impact is significant, relationships should be developed and added to the ARM Model nutrient algorithms.

(g) Additional nutrient processes such as nitrogen fixation, ammonia uptake by plants, and the impact of nutrient contributions in precipitation, should be evaluated for their effect and possible inclusion in the model.

(7) To promote the general use of the ARM Model for investigation, evaluation, and management of agricultural runoff, the following topics should be considered:

(a) Guidelines for parameter evaluation, calibration, and analysis of simulation results are needed to assist the user in model application. This is especially lacking for the pesticide and nutrient parameters, and may require research to evaluate adsorption parameters, nutrient reaction rates, and nutrient uptake by various crops under field conditions.

(b) Simplification of the model structure and reduction in computer

run time would provide a more user-oriented method of application. Some sacrifice in model accuracy would be justified if this resulted in less user effort in input preparation, parameter evaluation, and calibration.

(c) User workshops and assistance programs should be developed to attract and initiate potential model users. Some technical background and training is necessary for effective use of the ARM Model. Also, the establishment of the model on a central, nation wide computer network would then make the model available to users across the country without the need for separate source codes for each user. This would considerably simplify model updates and technology transfer with advances in the state-of-the-art.

(d) Extensive or repeated model use and model testing require an effective data management system to manipulate and analyze recorded and simulated data series. Analysis of the ARM Model output on a frequency or probability basis with such a data management system is necessary to effectively utilize the information provided by the continuous simulation of the ARM Model. Moreover, such a system is needed to incorporate nonpoint source analysis and simulation in general simulation models for evaluating comprehensive watershed management.

SECTION 4

THE AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL: PRESENT STATUS

This section provides an overall description of the ARM Model and brief discussions of the present versions of the major component programs. The emphasis will be on the significant changes to the component programs that occurred in this study. The reader is referred to the ARM Model report (Donigian and Crawford, 1976) for details of the simulation algorithms.

THE MODEL

The ARM Model simulates runoff (including snow accumulation and melt), sediment, pesticides, and nutrient contributions to stream channels from both surface and subsurface sources. No channel routing procedures are included. Thus, the model is applicable to watersheds that are small enough that channel processes and transformations can be assumed negligible. Although the limiting area will vary with climatic and topographic characteristics, watersheds greater than two to five square kilometers are approaching the upper limit of applicability of the ARM Model.

Figure 4.1 demonstrates the general structure and operation of the ARM Model. The major components of the model individually simulate the hydrologic response (LANDS) of the watershed, sediment production (SEDT), pesticide adsorption/desorption (ADSRB), pesticide degradation (DEGRAD), and nutrient transformations (NUTRNT). The executive routine, MAIN, controls the overall execution of the program; calling subroutines at proper intervals, tranferring information between routines, and performing the necessary input and output functions. Table 4.1 describes the functions of each of the ARM Model components.

In order to simulate vertical movement and transformations of pesticides and nutrients in the soil profile, specific soil zones (and depths) are established so that the total soil mass in each zone can be specified. Total soil mass is a necessary ingredient in the pesticide adsorption/desorption reactions and nutrient transformations. Figure 4.2 depicts the zones and depths, assumed in the ARM Model. The depths of the surface and upper soil zones are specified by the model input parameters, SZDPTH and UZDPTH, with values of two to six millimeters and five to 20 centimeters, respectively. The upper zone depth corresponds to the depth of mixing of soil-incorporated chemicals. It also indicates the depth used to calculate the mass of soil in the upper zone whether agricultural chemicals are soil-incorporated or surface-applied. The lower zone depth of 1.83 meters has proved satisfactory in testing to date.

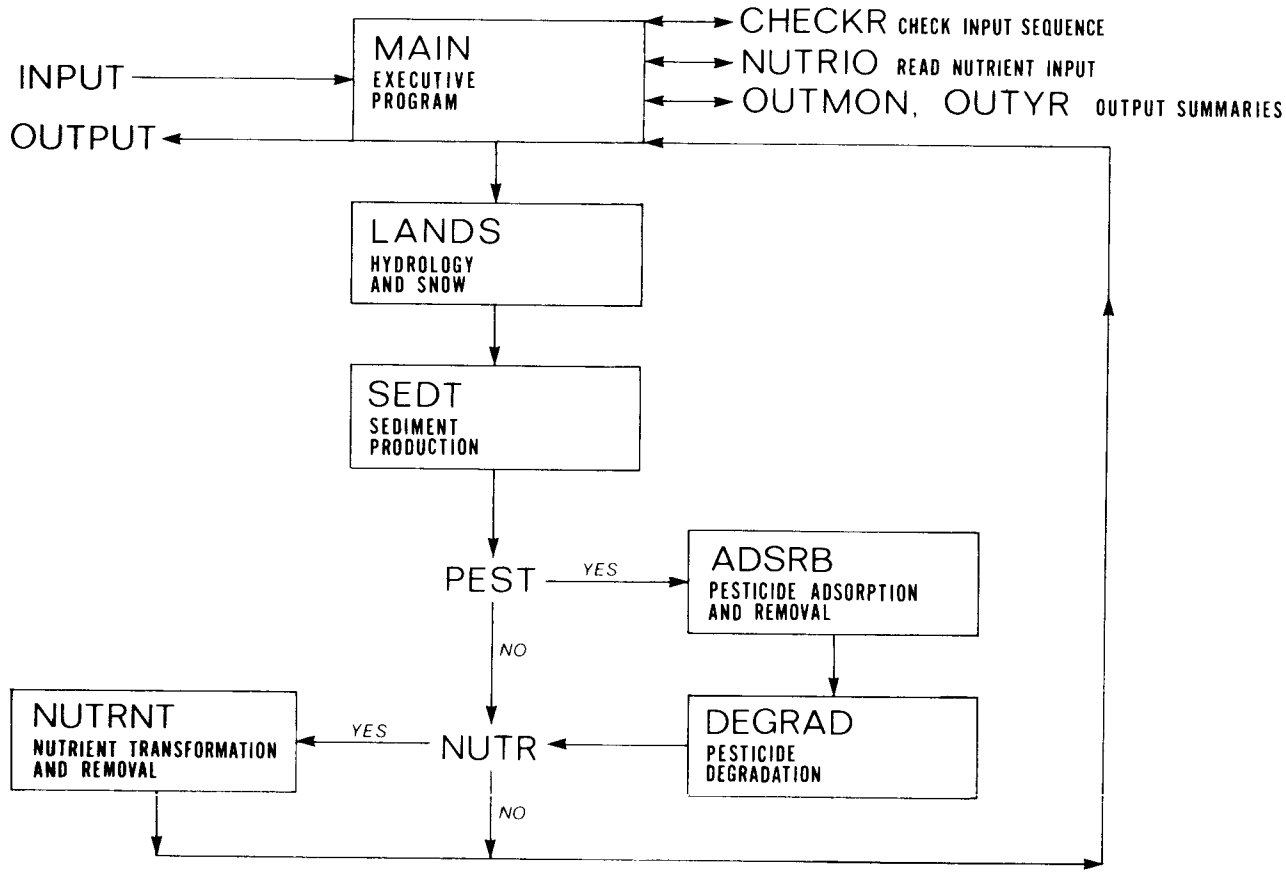


Figure 4.1 ARM model structure and operation

Figure 4.2 Model soil layers for pesticide and nutrient storage

TABLE 4.1 ARM MODEL COMPONENTS

Major Program	Component Subroutine	Function
MAIN		Master program and executive control routine
	CHECKR	Checks input parameter errors
	CHECKS	Checks input parameter errors
	BLOCK DATA	Data initialization for common variables
	NUTRIO	Reads and checks nutrient input data
	OUTMON	Prints monthly output summaries
	OUTYR	Prints yearly output summaries
LANDS		Performs hydrologic simulation and snowmelt calculations
SEDT		Performs erosion simulation
	ERDBUG	Outputs to the printer erosion files written to disk for error checking
ADSRB		Performs pesticide soil adsorption/ desorption simulation
	DSPTN	Performs desorption calculations
DEGRAD		Performs pesticide degradation simulation
NUTRNT		Performs nutrient simulation
	TRANS	Performs nutrient transformations

The transport and vertical movement of pesticides and nutrients, as conceived in the ARM Model, is indicated in Figure 4.3. Pollutant contributions to the stream can occur from the surface zone, the upper zone, and the groundwater zone. Surface runoff is the major transport mechanism carrying dissolved chemicals, pesticide particles, sediment, and adsorbed chemicals. The interflow component of runoff can transport dissolved pesticides or nutrients occurring in the upper zone. Vertical chemical movement between the soil zones is the result of infiltrating and percolating water. From the surface, upper, and lower zones, uptake and transformation of nutrients and degradation of pesticides is allowed. On the watersheds tested, the groundwater zone has been considered a sink for deep percolating chemicals since the groundwater flow contribution has been negligible. However, on larger watersheds this contribution could be significant.

MODEL COMPONENTS

The ARM Model simulates the major processes of importance in agricultural runoff with the following components:

LANDS

The LANDS program simulates all flow components (surface runoff, interflow, groundwater flow) and soil moisture storages by representing the processes of interception, infiltration, overland flow, percolation, evapotranspiration, and snow accumulation and melt. LANDS is basically an accounting procedure for moisture above, at, and beneath the soil surface. It is a modification of the Stanford Watershed Model (Crawford and Linsley, 1966) and the Hydrocomp Simulation Program (Hydrocomp, Inc., 1976). Snow calculations are based on an energy balance approach derived from work by the Corps of Engineers (1965), Anderson and Crawford (1964), and Anderson (1968). The LANDS program used in this study is identical to the previous version (Donigian and Crawford, 1976) except the evapotranspiration index input parameter, K3, can vary on a monthly basis. Since K3 represents the areal density of actively transpiring vegetation, this change allows a better representation of the evapotranspiration opportunity on agricultural watersheds (Johanson and Crawford, 1976).

SEDT

The SEDT program simulates the erosion processes of soil particle detachment by rainfall and transport by overland flow; overland flow values are transferred from the LANDS program. Input parameters allow the user to specify seasonal variations in land cover and the occurrence and impact of tillage operations. The only modification to the SEDT program algorithms performed during this study was the addition of a user-input soil compaction factor (SCMPAC). This factor reduces the amount of detached soil particles available for transport. It is basically a first-order decrease of the surface storage of soil fines performed on a daily basis during nonstorm periods. The SCMPAC parameter attempts to represent the natural aggregation and mutual attraction of soil particles and the compaction of the surface soil zone from which erosion occurs. These processes are a complex function

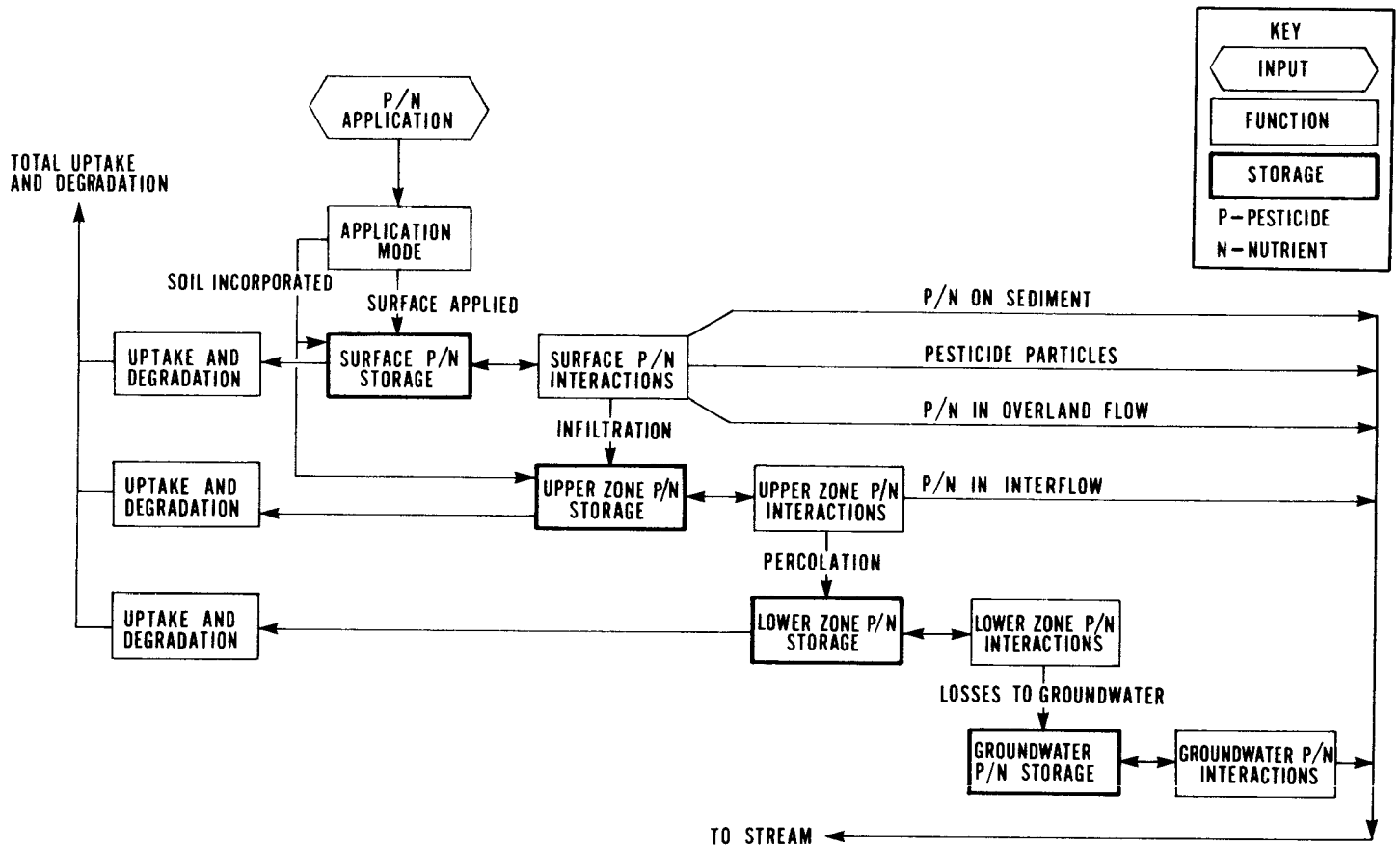


Figure 4.3 Pesticide (P) and nutrient (N) movement in the ARM model

of soil characteristics, meteorologic conditions, and tillage practices for which a detailed simulation is beyond the scope of this study. Further research is needed to quantify the critical compaction mechanisms before simulation algorithms can be developed.

ADSRB

The ADSRB program in conjunction with the DSPTN subroutine simulates the adsorption/desorption processes of pesticides in the soil profile. The algorithms are identical to those discussed in the ARM Model report. The user can choose to employ either single-valued, reversible (Figure 4.4a) or nonsingle-valued, irreversible (Figure 4.4b) adsorption/desorption equations. Testing results of these options are discussed in Sections 9 and 10. The ARM Model has been modified to accept initial pesticide storage and multiple pesticide applications; the necessary input changes are included in Appendix A.

DEGRAD

The DEGRAD program calculates the attenuation and degradation of applied pesticide compounds. Since degradation is the most critical mechanism determining the amount of pesticide available for runoff, a major portion of the current work concentrated on the evaluation of alternative degradation algorithms. The following methods were considered:

(a) Daily first-order degradation.
(b) First-order degradation adjusted for soil moisture and temperature effects.
(c) Step-wise first-order daily degradation.

The present version of the DEGRAD program includes method (c), above, whereby different first-order rates are applied separately to specific time periods after pesticide application. Section 7 discusses each of the above methods and presents tests results.

NUTRNT

The NUTRNT program in conjunction with the TRANS subroutine simulates the nitrogen and phosphorus components of runoff and nutrient transformations in the soil profile. First-order mechanisms are used in all the transformations shown in Figure 4.5. The major changes in the nutrient algorithms during this study are:

(a) Eliminating NO_2 as a separate component and combining NO_2 and NO_3 into one component. Thus the previous K2 and KK2 reaction rates between NO_2 and NO_3 were eliminated.
(b) Eliminating the transformation path between adsorbed NH_4 and the NO_2/NO_3 combination.
(c) Including a regression equation for estimating soil temperature and then adjusting transformation rates for soil temperature changes.
(d) Allowing the user to specify a monthly variation in nutrient

Figure 4.4a Single-valued adsorption/desorption algorithm

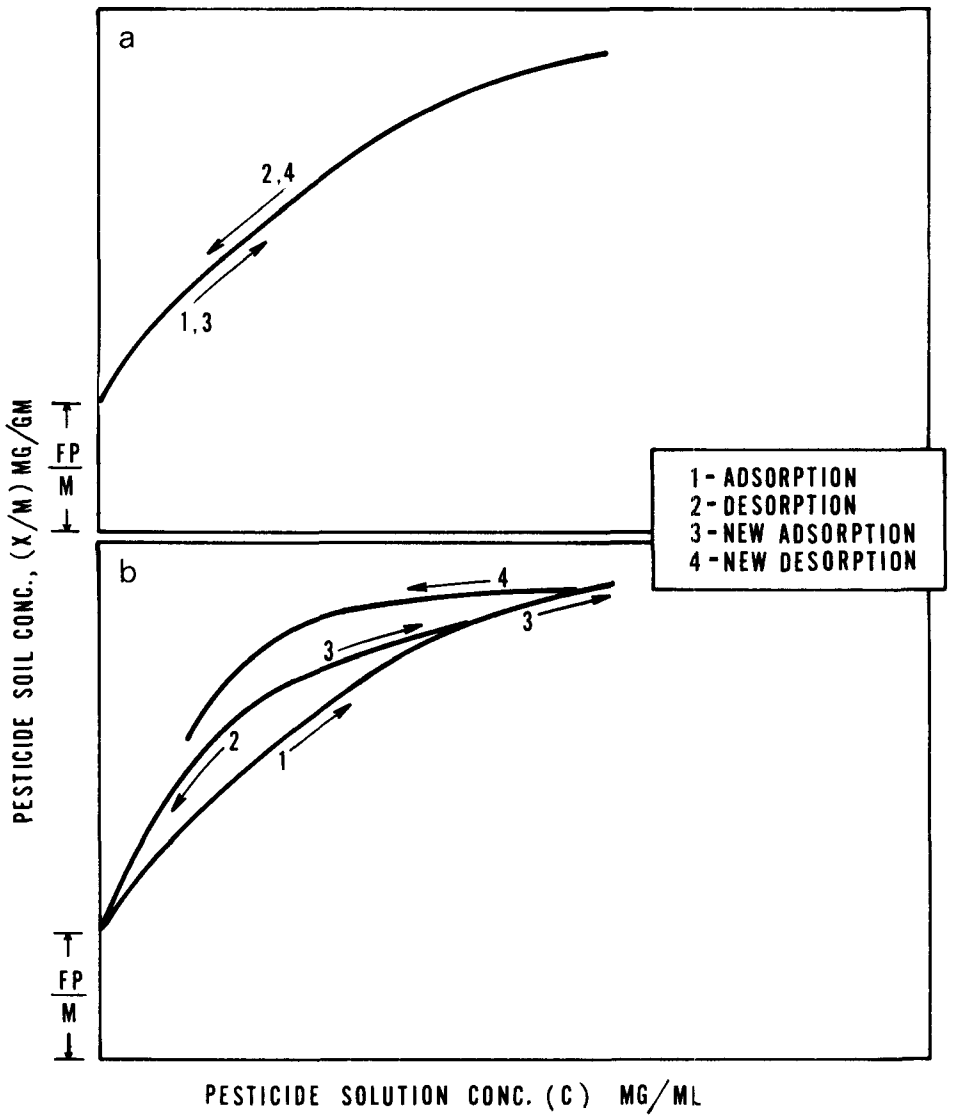
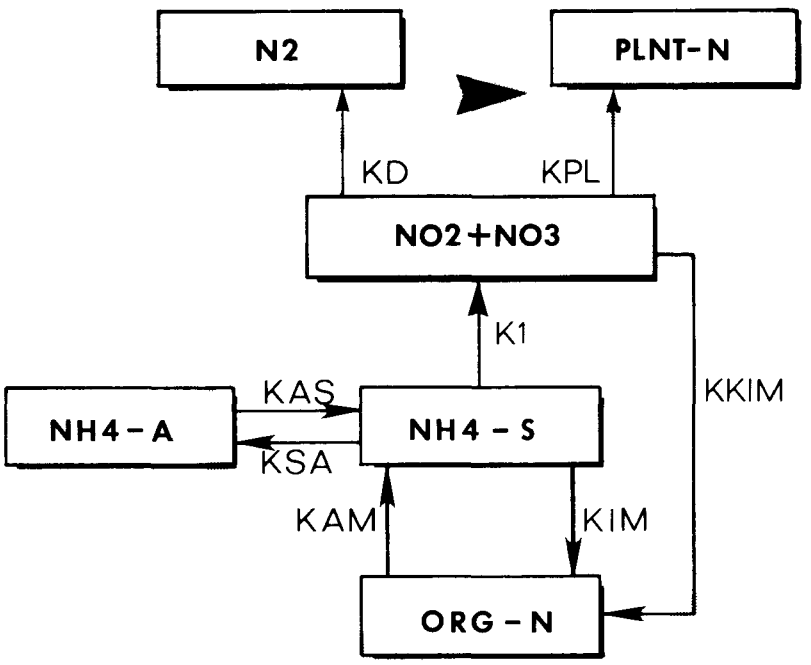
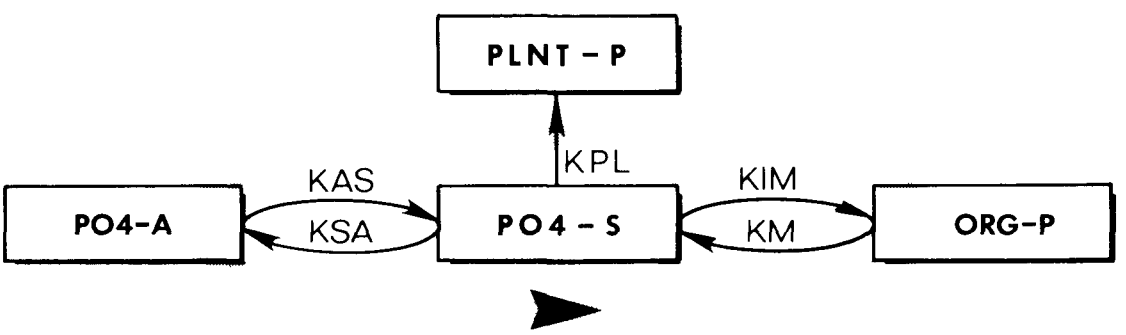


Figure 4.4b Non single-valued adsorption/desorption algorithm

Figure 4.4 Pesticide adsorption/desorption algorithms



A. Nitrogen transformations in ARM model



B. Phosphorus transformations in ARM model

Figure 4.5 Nutrient transformations in the ARM model

uptake by crops.

(e) Modifying algorithms so that transformations are performed in terms of nutrient concentrations in the surface, upper, and lower zones as opposed to nutrient mass in each zone (i.e. kg/ha) as in the previous version.

The above changes are discussed in Sections 6 and 8.

OTHER PROGRAMMING CHANGES

The user will notice two additional changes to the ARM Model source code and input presented in this report. During this study, the ARM Model code was modified in order to operate on a Hewlett-Packard 3000 Series II computer. This required certain internal program modifications due to differences between the HP 3000 and the IBM 360/67 on which the ARM Model was developed. These changes are not apparent to the user. Although the HP3000 does not allow the FORTRAN namelist option, the ARM Model source code in Appendix H retains the namelist option in order to be compatible with input sequences prepared for the previous version of the model.

The ARM Model presently includes an option to output simulated runoff and sediment values to an external storage device (tape, disc, etc) as unformatted FORTRAN records. This option and associated plotting routines were developed in a research effort to develop a basin wide sediment model including in-stream sediment transport simulation (Johanson and Crawford, 1976). Appendix A describes the required input to access this output option in the ARM Model.

SECTION 5

DATA COLLECTION AND ANALYSIS PROGRAMS

The ARM Model development effort is supported by an extensive data collection and analysis program sponsored by the U.S. Environmental Protection Agency's Environmental Research Laboratory in Athens, Georgia (ERL-Athens). Test sites located in Georgia and Michigan have been instrumented for continuous monitoring and sampling of runoff and sediment. Collected samples are refrigerated on site and later analyzed for pesticide and nutrient content. In addition, meteorologic conditions are continuously monitored and soil core samples are taken and analyzed immediately following application and periodically throughout the growing season. Table 5.1 presents pertinent characteristics of the test watersheds. The individual programs in Georgia and Michigan are described in the ARM Model report (Donigian and Crawford, 1976).

During the current study testing efforts were concentrated on the P2 watershed (Figure 5.1) in Georgia and the P6 watershed (Figure 5.2) in Michigan. Both P2 and P6 are natural nonterraced watersheds. Data was available for the 1973 through 1975 growing seasons. Table 5.2 indicates the crops, applied chemicals, target application rates, and dates of application for all test watersheds listed in Table 5.1. P2 and P6 were monitored and analyzed for various pesticides and nutrient forms. This report presents simulation results for both watersheds.

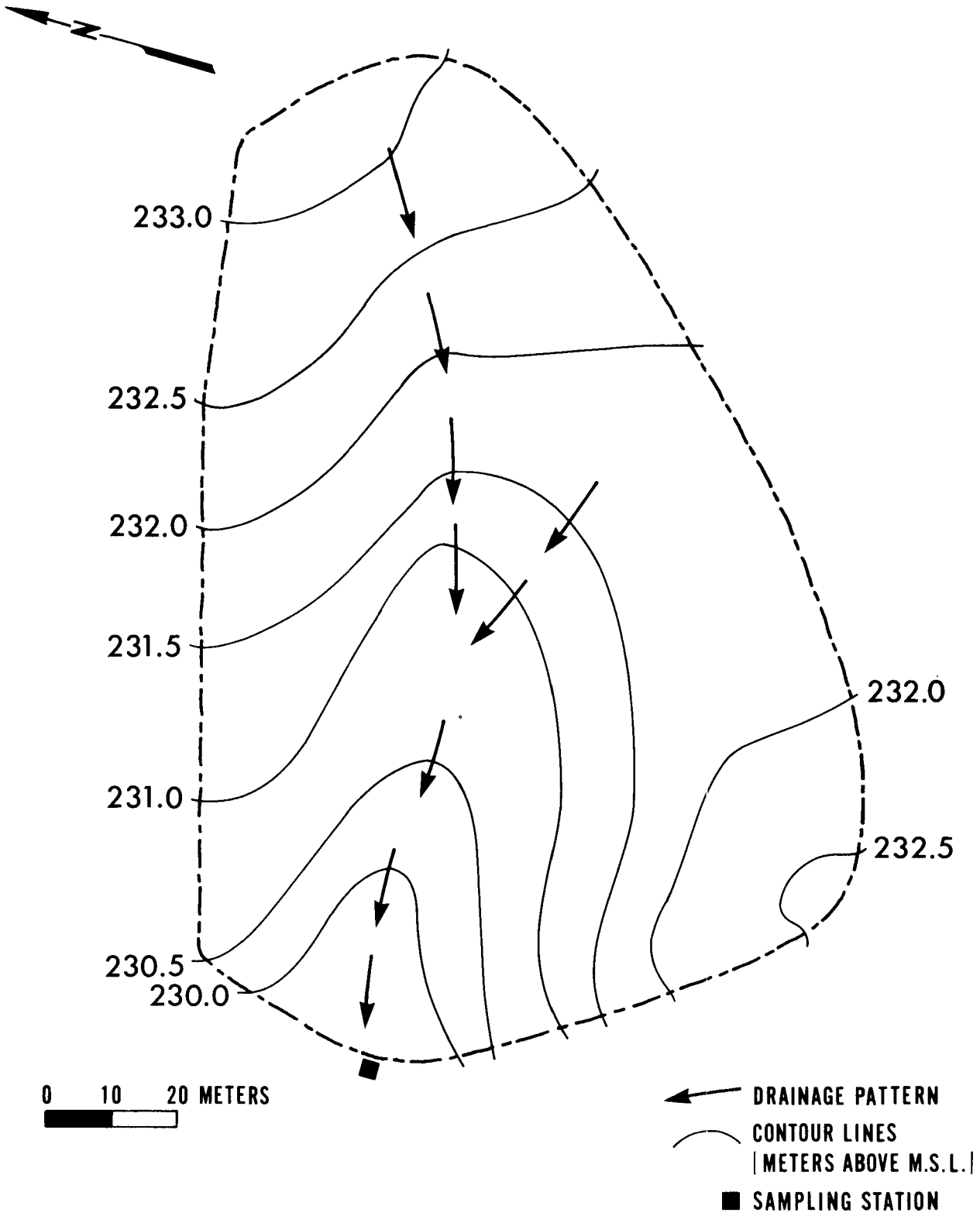


Figure 5.1 P2 Watershed, Watkinsville, Georgia (1.3 ha)

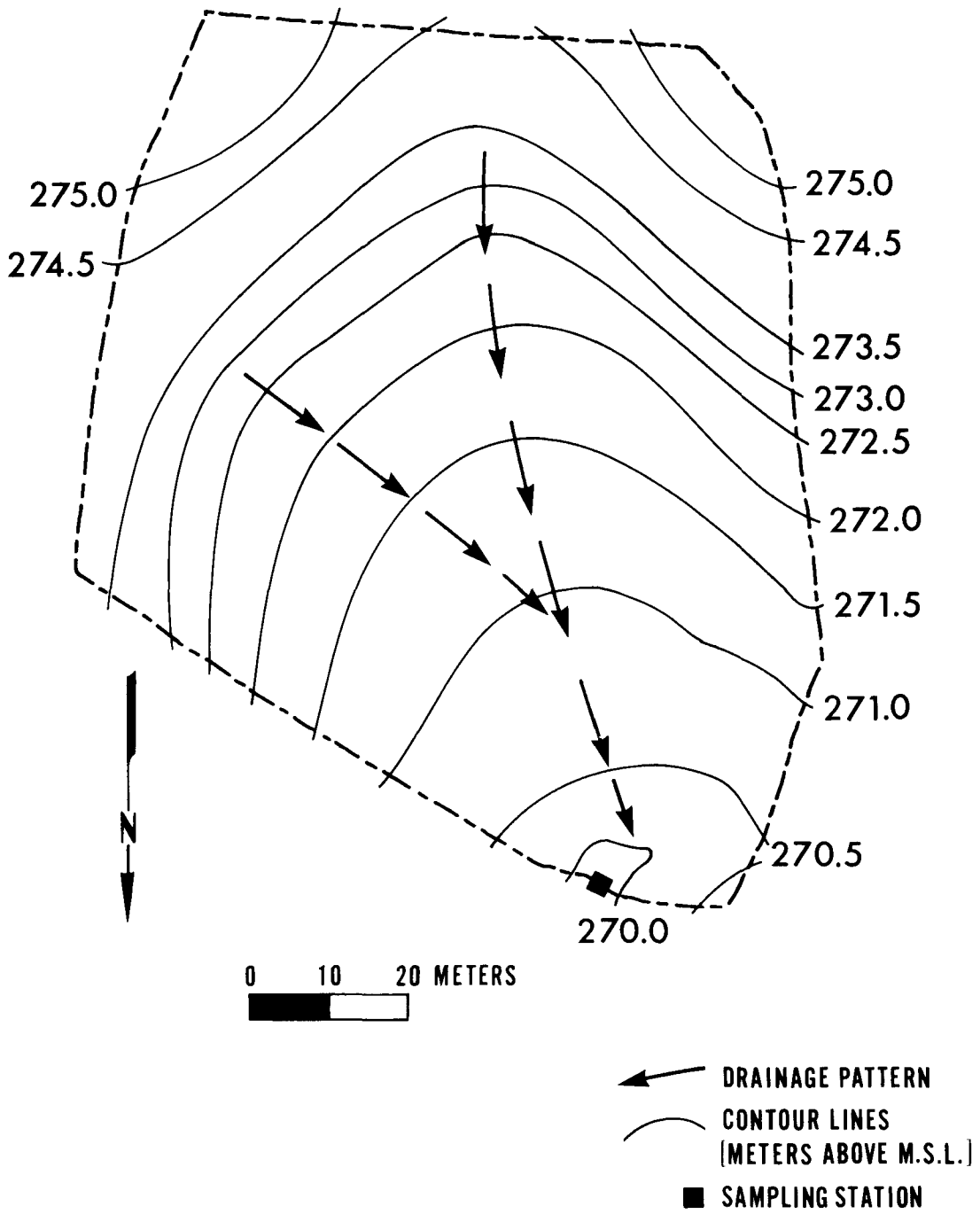


Figure 5.2 P6 Watershed, East Lansing, Michigan (0.8 ha)

TABLE 5.1 WATERSHEDS FOR ARM MODEL TESTING

Watershed Designation	Location	Owner/ Operator	Area (ha)	Mean Elevation (m above msl)	Soils	Conservation
P1	Watkinsville, Georgia	USDA/EPA	2.70	238	Cecil sandy loam	Non terraced grass waterway installed 11/74
P2	Watkinsville, Georgia	USDA/EPA	1.30	231	Cecil sandy loam	non terraced
P3	Watkinsville, Georgia	USDA/EPA	1.26	239	Cecil sandy loam	terraced with grass waterway
P4	Watkinsville, Georgia	USDA/EPA	1.38	239	Cecil sandy loam	terraced with grass waterway
P6	East Lansing, Michigan	Michigan State Univ.	0.80	272	Spinks loamy sand, also Traverse/Hillsdale sandy loam	non terraced
P7	East Lansing, Michigan	Michigan State Univ.	0.55	271	Spinks loamy Sand, also Tuscola Sandy loam	non terraced

TABLE 5.2 CROPPING AND CHEMICAL APPLICATIONS FOR THE TEST WATERSHEDS (1973-75)

WATERSHED	1973 Crop	1973 Applied Chemical	1973 Application[a] Rate (kg/ha)	1973 Application[a] Date	1974 Crop	1974 Applied Chemical	1974 Application[a] Rate (kg/ha)	1974 Application[a] Date	1975 Crop	1975 Applied Chemical	1975 Application[a] Rate (kg/ha)	1975 Application[a] Date
P1	soybean	nitrogen	21	5-22-73	soybean	Nitrogen	17	N5-22-74	sorgham	paraquat[b]	1.12[e]	6-2-75[e]
		phosphorus	19	5-22-73		phosphorus	15	5-22-74		propazine[b]	2.8	6-2-75[c]
		nitrogen	25	6-4-73		paraquat[b]	1.12[e]	5-30-74[c]		nitrogen	90	7-7-75
		phosphorus	22	6-4-73		diphenamid[b]	3.36	5-30-74[c]		2,4 D[b]	0.68	7-7-75
		paraquat[b]	1.12[e]	1-13-73[c]		trifluralin[b]	1.12	5-30-74[c]				
		diphenamid[b]	3.36	6-13-73[c]	barley (winter cover)	nitrogen	73	2-1-75				
		trifluralin[b]	1.12	6-13-73[c]		phosphorus	22	2-1-75				
P2[d]	corn	nitrogen	38	5-11-73[c]	corn	nitrogen	38	4-29-74[c]	corn	nitrogen	22	4-24-75
		phosphorus	17	5-11-73[c]		phosphorus	33	4-29-74[c]		phosphorus	21	4-24-75
		paraquat[b]	1.12[e]	5-11-73[c]		paraquat[b]	1.12[e]	4-29-74[c]		paraquat[b]	1.12	5-21-75
		atrazine[b]	3.36	5-11-73[c]		atrazine[b]	3.36	4-29-74[c]		atrazine[b]	1.68	5-21-75
		nitrogen	112	6-23-73		nitrogen	101	6-11-74		cyanazine[b]	1.68	5-21-75
										2,4-D[b]	2.24	5-21-75[c]
										chloride	112	5-21-75[c]
										nitrogen	112	6-25-75
P3	soybean	nitrogen	21	5-22-73	soybean	nitrogen	17	5-22-74	soybean	nitrogen	0	5-8-75
		phosphorus	19	5-22-73		phosphorus	15	5-22-74		phosphorus	15	5-8-75
		nitrogen	25	6-4-73		paraquat[b]	1.12[e]	5-30-74[c]		paraquat[b]	1.12[e]	5-28-75
		phosphorus	22	6-4-73		diphenamid[b]	3.36	5-30-74[c]		diphenamid[b]	3.36	5-28-75[e]
		paraquat[b]	1.12[e]	6-15-73[c]		trifluralin[b]	1.12	5-30-74[c]		trifluralin[b]	1.12	5-28-75[c]
		diphenamid[b]	3.36	6-15-73[c]								
		trifluralin[b]	1.12	6-15-73[c]								
P4[d]	corn	nitrogen	38.5	5-11-73[c]	corn	nitrogen	38	4-29-74[c]	corn	nitrogen	22	4-24-75
		phosphorus	16.7	5-11-73		phosphorus	33	4-29-74[c]		phosphorus	21	4-24-75
		paraquat[b]	1.12[e]	5-11-73		paraquat	1.12	4-29-74[c]		paraquat[b]	1.12	5-14-75[c]
		atrazine[b]	3.36	5-11-73		atrazine	3.36	4-29-74[c]		atrazine[b]	1.68	5-14-75[c]
		nitrogen	112	6-23-73		nitrogen	112	6-11-74		cyanazine[b]	1.68	5-14-75[c]
	rye (winter cover)			10-5-73	rye (winter cover)			10-15-74		2,4-D[b]	2.24	5-14-75[c]
										chloride	112	5-14-75[c]
										nitrogen	112	6-25-75

(continued)

TABLE 5.2 (continued)

WATERSHED	1973 Crop	Applied Chemical	Application[a] Rate kg/ha	Date	1974 Crop	Applied Chemical	Application[a] Rate kg/ha	Date	1975 Crop	Applied Chemical	Application[a] Rate kg/ha	Date
P6[d]	soybean	trifluralin[b]	1.12	6-8-73[c]	corn	nitrogen	56	5-20-74[c]	corn	nitrogen	56	5-16-75[c]
		nitrogen	26.9	6-8-73[c]		phosphorus	112	5-20-74[c]		phosphorus	112	5-16-75[c]
		phosphorus	26.9	6-8-73[c]		chloride	102	5-20-74[c]		chloride	112	5-16-75[c]
		paraquat[b]	1.00	6-9-73		paraquat[b]	1.12[f]	5-22-74		paraquat[b]	1.12[f]	5-17-75
		diphenamid[b]	3.00	6-9-73		atrazine[b]	4.48	5-22-74		atrazine[b]	2.24	5-17-75
		paraquat	0.92	11-5-73		nitrogen	112	7-8-74		nitrogen	112	6-25-75
		diphenamid	2.77	11-5-73		nitrogen	112	11-7-74				
						chloride	112	11-7-74				
						paraquat[b]	1.12	11-8-74				
						atrazine[b]	2.24	11-8-74				
P7[d]	soybean	trifluralin[b]	1.12	6-8-73[c]	soybean	nitrogen	56	5-20-74[c]	soybean	nitrogen	56	5-16-75[c]
		nitrogen	26.9	6-8-73[c]		phosphorus	112	5-20-74		phosphorus	112	5-16-75[c]
		phosphorus	26.9	6-8-73[c]		paraquat[b]	1.12[f]	5-22-74[c]		chloride	112[f]	5-16-75[c]
		paraquat[b]	1.12	6-9-73		diphenamid[b]	3.36	5-22-74[c]		paraquat[b]	1.12	5-17-75
		diphenamid[b]	3.36	6-9-73		nitrogen	112	11-7-74		diphenamid[b]	3.36	5-17-75
		paraquat[b]	1.12	11-5-73		chloride	112	11-7-74				
		diphenamid[b]	3.36	11-5-73		paraquat[b]	1.12	11-8-74				
						diphenamid[b]	3.36	11-8-74				

Notes:
- a target application rates for nitrogen, phosporus, and the following herbicides:
- b pesticide analyses performed
- d both pesticide and nutrients analyzed for these watersheds, except for 1973 on P6 and P7
- c planting day
- e computation based on cation
- f computation based on dichloride salt

Common Name	Chemical name
2,4 D	(2,4-dichlorophenoxy) acetic acid
atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino-s-triazine
cyanazine	2-chloro-4-(1-cyano-1-methylethylamino)-6-ethylamino-s-triazine
diphenamid	N,N-dimethyl-2,2-diphenylacetamide
paraquat	1,1'-dimethyl-4,4'-bipyridinium ion
propazine	2-chloro-4,6-bis(isopropylamino)-s-triazine
trifluralin	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine

SECTION 6

SOIL ENVIRONMENT SIMULATION

The soil environment plays a key role in the modeling of pesticide and nutrient behavior as these constituents await transport from the land to the stream. Soil moisture and soil temperature are two major characteristics of the soil environment that affect pesticide and nutrient behavior by their impact on chemical and biological transformations. In order to evaluate the significance of these impacts, methods of simulating soil moisture and temperature were developed and incorporated into the ARM Model. Simulated soil moisture and temperature were then used to evaluate alternative pesticide degradation models (Section 7). Also, soil temperature is used to adjust nutrient transformation rates in each of the vertical soil zones.

This section discusses the methods developed for simulating soil moisture and temperature in each of the vertical soil zones represented in the ARM Model. Test results are presented and recommendations for future research topics are provided. In addition, the problem of leaching or vertical movement of pollutants is addressed as a function of soil moisture conditions and soil characteristics. The extent of leaching of applied chemicals determines the amount of pollutants available for transport from each vertical soil zone during a storm event. A procedure to simulate the leaching characteristics of a watershed within the framework of the present hydrologic model is described.

SOIL MOISTURE SIMULATION

Since the LANDS routine of the ARM Model continuously calculates indices of the moisture status of the soil profile, the goal of the soil moisture simulation was to quantify the relationship between these indices and percent soil moisture values for the surface, upper, and lower zones. The LANDS routine (Figure 6.1) continuously determines the amount or depth of water in storage in each zone. Nominal storage values, determined through calibration, are specified for the upper (UZSN) and lower (LZSN) zones. The soil moisture conditions of these zones are represented as the ratios of the existing storages (UZS and LZS) to their nominal storage capacity. As these capacities are nominal and not absolute, the ratios UZS/UZSN and LZS/LZSN can have values greater than one. Consequently, these ratios are related to percent soil moisture, but are not actual soil moisture values. For the surface zone no nominal storage capacity is specified. The surface zone is considered to be the zone of wetting by overland flow and contains moisture only when overland flow is occurring.

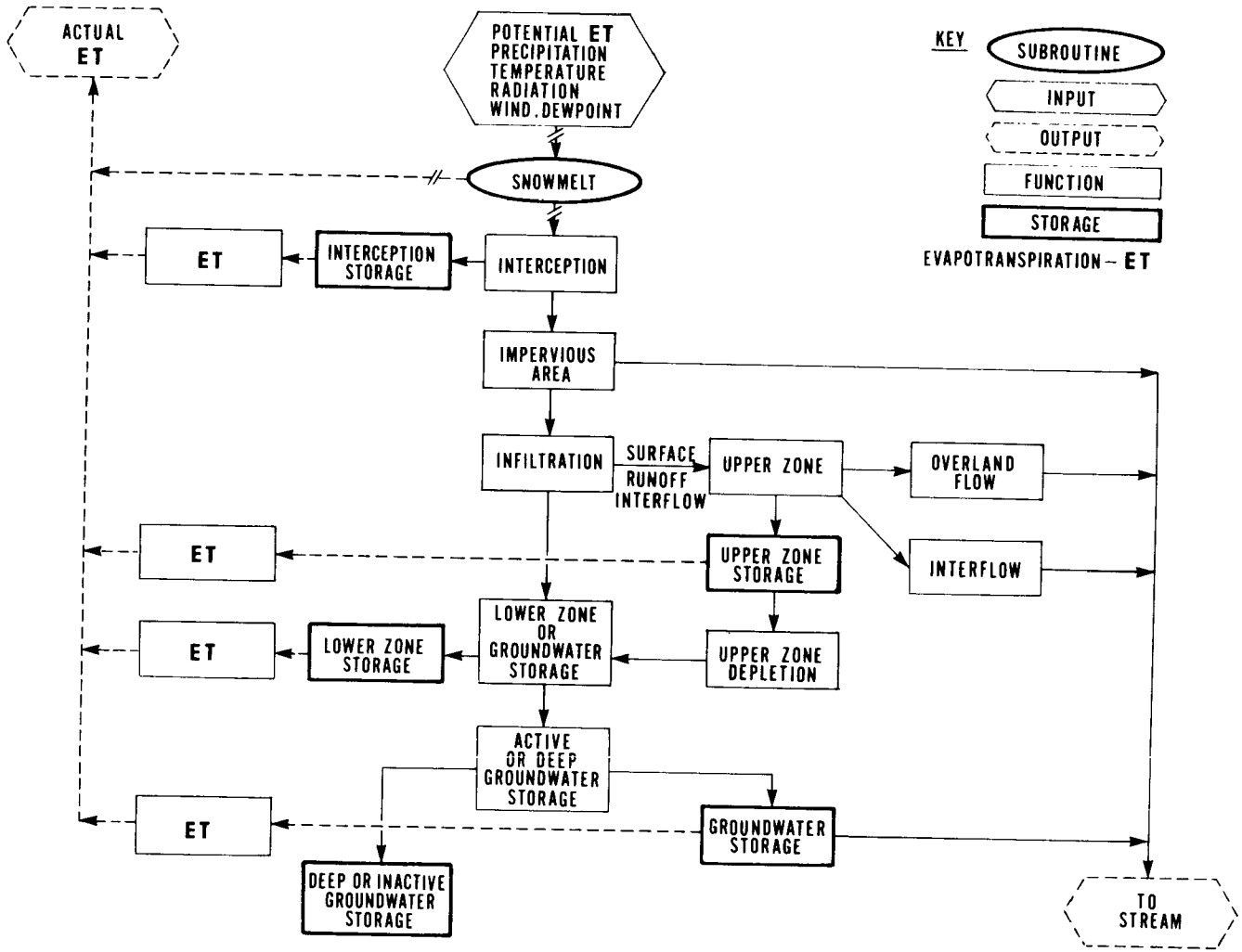


Figure 6.1 LANDS simulation

To obtain soil moisture values, relationships were developed between the upper and lower zone ratios and recorded soil moisture data collected on the Georgia watersheds. Daily maximum and minimum UZS/UZSN values were compared to daily percent soil moisture values at five cm depth for the summer of 1973 (Figure 6.2). Obviously, the single daily recorded soil moisture values in Figure 6.2 demonstrate much less variability than the calculated range of UZS/UZSN values. This is to be expected since the calculated ratios include both storm and nonstorm periods, while the recorded measurements are generally made during non-storm periods after percolation and re-distribution of the soil water has occurred. In general, the upper zone ratio and the 5 cm soil moisture behave in a similar manner. From this comparison the following linear relationship for the upper zone soil moisture was developed:

$$x = \frac{y + 0.48}{24} \tag{6.1}$$

where x = soil moisture fraction (by weight) at 5 cm depth.
y = UZS/UZSN

Figure 6.3 show how the simulated maximum and minimum soil moisture values from Equation 6.1 compare with the 5 cm recorded data. As noted above, the maximum and minimum simulated values are more variable but they generally bracket the recorded values during storm periods. During dry periods the simulated values are generally lower than recorded. However, the overall accuracy is sufficient for evaluating the pesticide degradation algorithms.

For the lower zone we compared the LZS/LZSN ratio with recorded soil moisture at 23 and 38 cm (Figure 6.4). The lower zone ratio is much less variable than the upper zone ratio and behaves much like the 38 cm depth recorded soil moisture. This indicated that the 38 cm depth soil moisture could be simulated using the ratio LZS/LZSN. The relationship developed is given by Equation 6.2:

$$x = 0.1404\ y^{2.66} \tag{6.2}$$

where x = soil moisture fraction (by weight) at 38 cm depth
y = LZS/LZSN

Figure 6.5 shows that the simulated and recorded soil moisture values at 38 cm are in good agreement for the 1973 growing season on the P3 watershed. Although Equation 6.2 may not be valid for other seasons, the simulation is sufficiently accurate for evaluating pesticide degradation models with the summer data on the Georgia watersheds.

The surface zone is the only remaining portion of the soil profile in which soil moisture needs to be calculated. Since the model assigns moisture to the surface zone only when overland flow occurs, the surface soil moisture is usually zero except during storm events when the soil moisture is determined by the following equation:

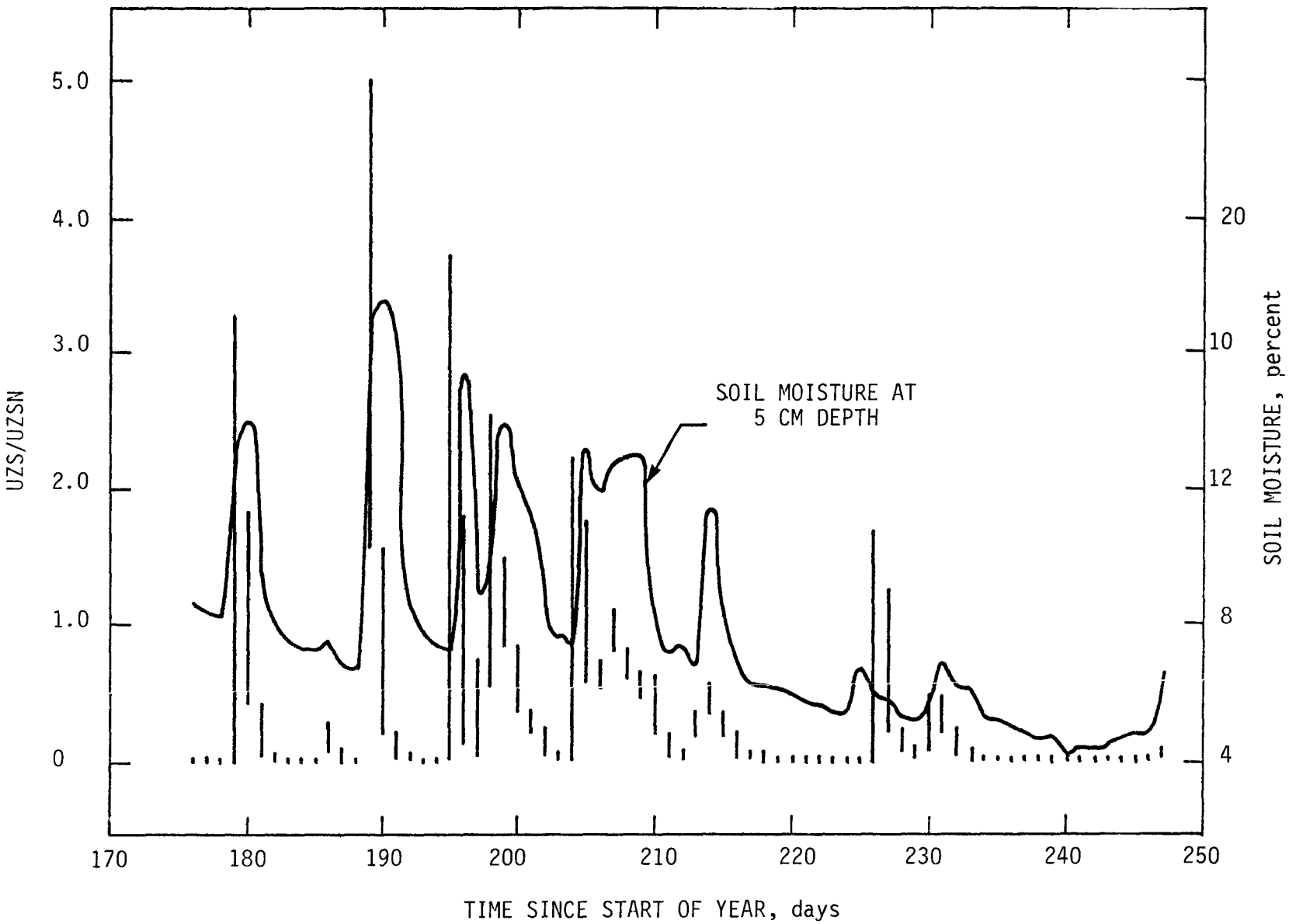


Figure 6.2 Comparison of soil moisture and UZS/UZSN at Watkinsville, 1973

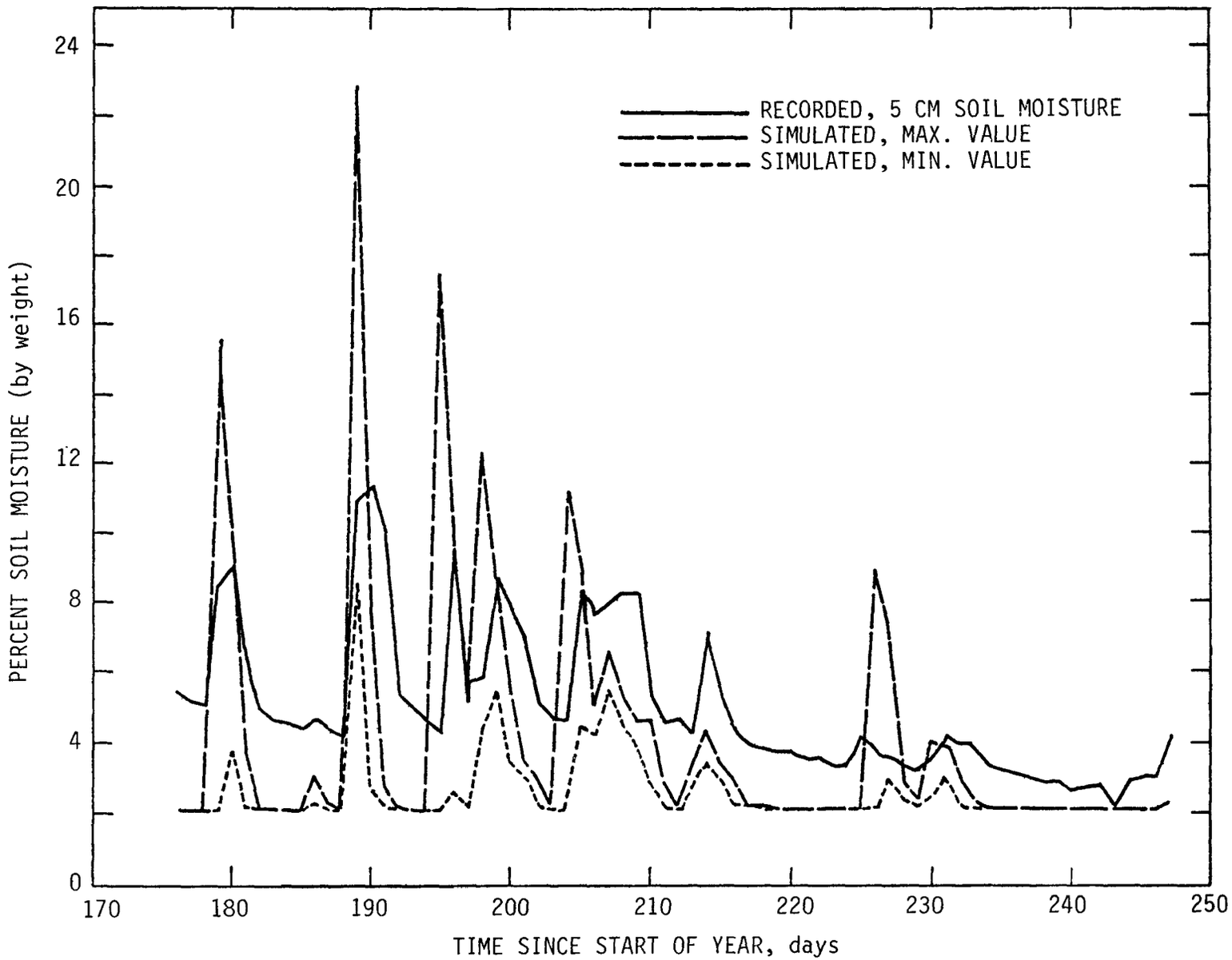


Figure 6.3 Soil moisture at 5cm depth at Watkinsville, 1973

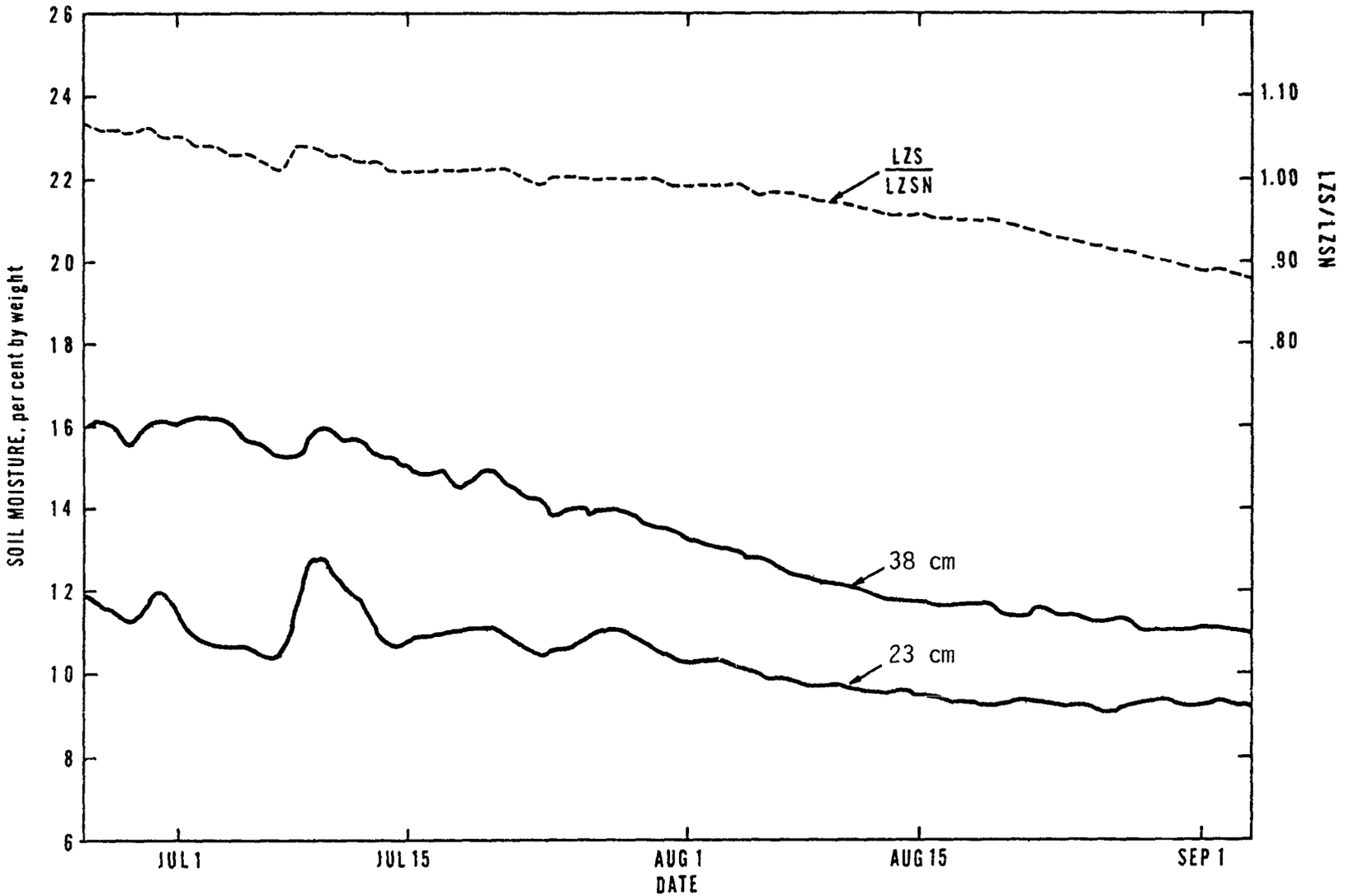


Figure 6.4 Comparison of soil moisture and LZS/LZSN at Watkinsville, 1973

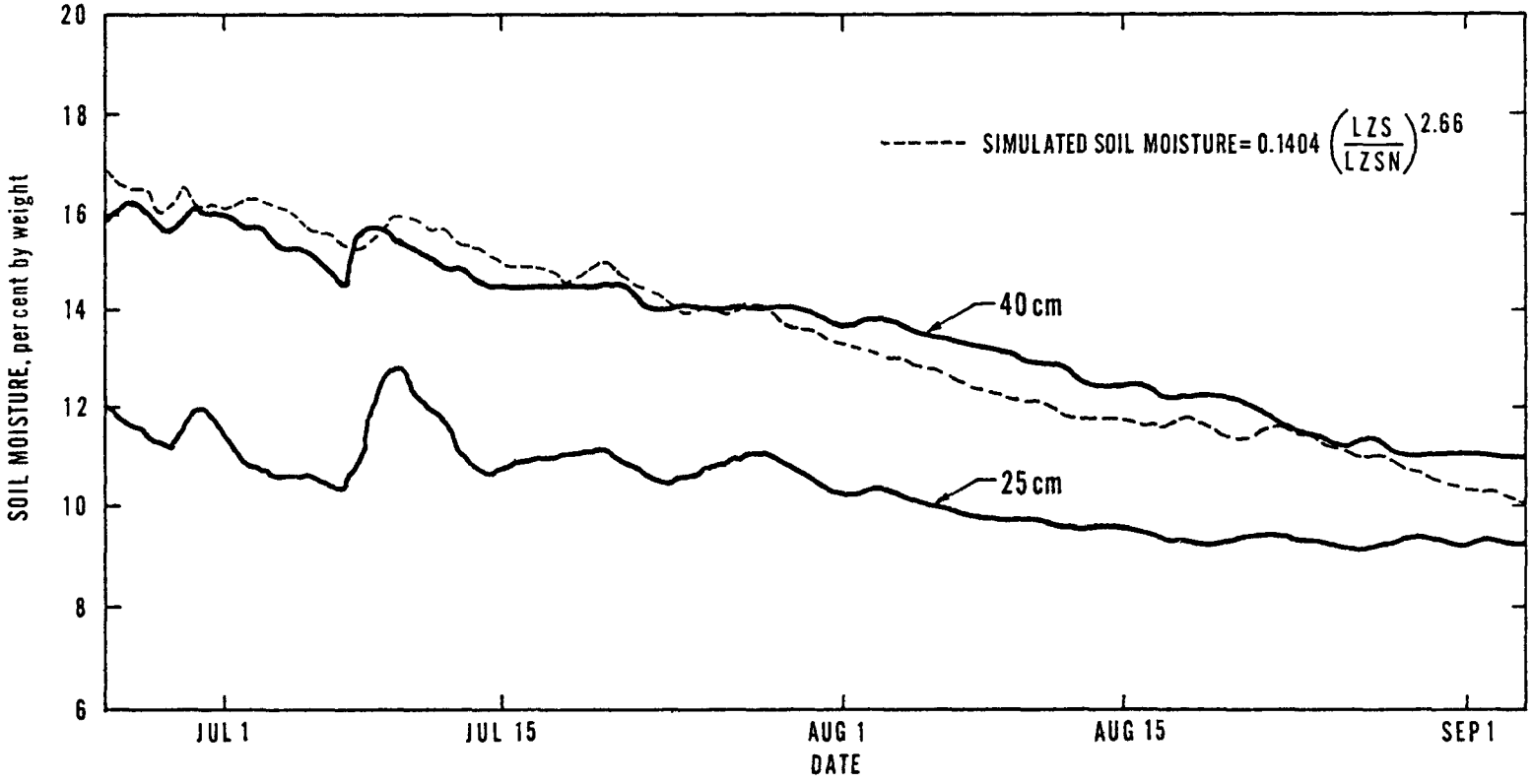


Figure 6.5 Soil moisture at 40 cm depth at Watkinsville, 1973

$$X(t) = VTOW * RESB(t)/M \quad (6.3)$$

where X(t) = soil moisture fraction (by weight) at the surface zone during time interval t.
VTOW = 45302.4*AREA, a constant to convert depth of water to weight of water.
RESB(t) = depth of water in each block of the surface zone during time interval t.
M = weight of soil for each block of the surface zone.

Obviously Equation 6.3 is a gross approximation of the soil moisture behavior in the surface soil layer of a watershed. However, this representation was satisfactory for our purposes since a detailed accounting of the surface zone characteristics was not possible in this project. Future modeling work should investigate more detailed methods of representing the surface zone.

With the above equations, soil moisture can be approximated at 3 points: the surface zone, at 5 cm depth, and at 38 cm depth. To evaluate the variability of soil moisture values with depth and time, we analyzed recorded soil moisture data for the period of April through November 1974 for the Georgia watersheds. As would be expected, soil moisture is most variable at the surface, and the variation decreases with depth. Below 50 cm the moisture values are relatively uniform. The maximum observed values irrespective of depth were in the range of 20 to 30 percent. The data indicated that the soil moisture profile can be approximated given the following assumptions:

(1) Linear interpolation can be used to calculate soil moisture values between 5 and 38 cm depth.
(2) Simulated soil moisture values at 38 cm depth will be representative of moisture values at greater depths.

Thus, the three soil moisture equations and the above assumptions allow the ARM Model to calculate soil moisture at all necessary depths. Currently it is assumed in the model that the five and 38 cm depths are representative of the upper and lower zones, respectively. The accuracy of the simulated results compared to the recorded data is sufficient for evaluation of the alternative pesticide degradation algorithms. As will be discussed in Section 7, the degradation algorithm that corrects for soil moisture conditions was not found to be the best approach to pesticide degradation. Therefore, simulated values of percent soil moisture are not currently used in the ARM Model. However, the soil moisture equations remain in the LANDS subroutine (Appendix D) and with only minor programming changes could be available for other uses in the model.

LEACHING OF SOLUTES

The vertical movement or leaching of soluble pollutants (solution pesticides and nutrients) affects the amount of soluble pollutant available for transport to the stream from each vertical soil zone. The leaching of soluble pollutants is important since they can reach the stream by (1)

overland flow from the surface zone, (2) interflow from the upper zone, and (3) groundwater flow through the pathway of the lower and groundwater zones. On the other hand, sediment-associated pollutants are transported solely from the land surface where erosion takes place.

Initial nutrient simulation results showed that solution nutrients, as representd in the model, were percolating much more rapidly than indicated by the recorded data. In fact the nonreactive solutes not adsorbed to soil particles, such as NO_3 and Cl, were simulated as completely washed to the lower zone from the surface and upper zones with only minimal rainfall amounts. Soluble PO_4 and NH_4 behaved similarly but the impact was not as dramatic because the simulated adsorption process allowed the adsorbed PO_4 and NH_4 to remain in the surface and upper zones. Further investigation showed that rapid leaching also occurred for the soluble pesticide forms but eluded detection because of the simulated adsorption/desorption process and the small pesticide fraction in soluble form. The end result of the rapid leaching was the depletion of soluble pollutants in the surface and upper zones and the absence of these forms in surface runoff and interflow.

Analysis of the simulation results and review of the model algorithms showed that the following factors contributed to the rapid leaching problem:

(1) Assumptions on the areal variation of infiltration characteristics in LANDS.
(2) Extremely small values of UZSN calibrated on the Georgia watersheds.
(3) Model assumptions relating chemical movement to simulated water movement.

The LANDS routine algorithms were originally developed for natural, rural watersheds where the assumption of spatially varying infiltration rates is more applicable than for managed agricultural lands. Agricultural practices like plowing, harrowing, cultivating, and terracing tend to establish relatively uniform properties on the land surface to the depth of tillage operations. The infiltration function in LANDS (Figure 6.1) distributes, in each time step, the available moisture on the land surface to the upper, lower, and groundwater zones as a function of the lower zone soil moisture and the input infiltration rate. The portion assigned to the upper zone is then divided among the overland flow, interflow, and upper zone storage components. The remaining portion of the available moisture is assigned to and reaches the lower zone or groundwater zone. In the initial work on the LANDS algorithms, the upper zone was considered a noncontinuous layer of near surface and detention storage and the lower zone was assigned the infiltrated moisture directly from the surface. With our present layered representation of the soil profile (Figure 4.2), this moisture assigned to the lower zone must first travel through the surface and upper soil zones. On its way to the lower zone, this moisture component transports soluble pollutants from the other zones and thus is the basic cause of the rapid leaching problem.

In developing a solution to the leaching problem we decided to retain the

present LANDS algorithms as a constraint on any solution approach adopted. The success of LANDS and related versions of the Stanford Watershed Model, and the emphasis on pesticide and nutrient simulation in this work precluded a major revision of the LANDS algorithms. This decision should be re-evaluated in future work if a more detailed simulation of the soil profile is required. However, as will be discussed below and in Sections 7 and 8, correcting the second and third factors contributing to the rapid leaching has provided a satisfactory solution to the problem for our purposes.

The second factor contributing to the rapid leaching problem was the extremely small UZSN value determined by calibration of the Georgia watersheds in previous studies (Crawford and Donigian, 1973; Donigian and Crawford, 1976). A UZSN value of 0.13 cm (0.05 in) was needed to simulate the surface runoff response of the watersheds to the high intensity, short duration summer thunderstorms. Such a small UZSN effectively represents an upper zone 2 to 3 cm deep, whereas the actual depth of the upper zone was specified as 15 cm. This conflict points out the need for the calibrated parameters to be compatible with the user's perception of the soil profile. With minimal storage capacity in the upper zone, as indicated by the small UZSN, the moisture assigned to the lower zone in each time interval completely depletes the soluble pollutants residing in the upper zone. To correct this situation, the P2 watershed was recalibrated to obtain a more realistic value of 1.27 cm (0.5 in) for UZSN at the expense of some accuracy in the surface runoff simulation (Section 9). The higher UZSN significantly slowed the leaching rate but did not completely solve the problem. This lead to an evaluation of the leaching computations in the model as discussed below.

With the four soil zones in our assumed soil profile (Figure 4.2), soluble chemicals can be transferred from the surface to the upper zone, from the upper zone to the lower zone, and from the lower zone to the groundwater zone. The way in which chemical movement between zones was calculated, which contributed to the rapid leaching, can be represented as:

$$FP = D/(S + D) \tag{6.4}$$

where FP = fraction of soluble chemical leached from the zone
D = moisture leached from the zone or passing through the zone
S = moisture storage in the zone

Since S + D is the total moisture in the zone, Equation 6.4 simply states that the moisture fraction leaving a zone transports the corresponding fraction of the amount of soluble chemical available in the zone. FP, which is always less than or equal to 1.0, is calculated in each time interval for each soil zone and is applied to the mass of each soluble chemical (e.g. NO_3, solution PO_4, solution NH_4, Cl) stored in the zone. The values of S and D are determined in LANDS and transferred to the pesticide and nutrient routines.

For the surface zone, S is greater than zero only during a storm event since no moisture storage parameter is provided. The value of FP is close

to 1.0 most of the time; thus, all soluble chemicals applied to the surface zone are leached to the upper zone at the first rainfall event following application. This is a reasonable approximation because of the small depth of the surface zone. For the lower zone, the moisture storage S is large (46 cm for the Georgia watersheds) compared to D, and the resulting FP is small during any time interval. Consequently, the major leaching problem occurred from the upper zone where the original small UZSN produced a corresponding small or zero value for S in the upper zone resulting in an FP value close to 1.0. This caused the rapid leaching of all soluble chemicals from the upper zone to the lower zone for even minor rainfall events. With an upper zone depth of 15 cm, such rapid leaching was contrary to both the physical mechanisms and the recorded data.

Although the recalibrated UZSN slowed the leaching rate, the basic cause of the problem was the assumption inherent in Equation 6.4 that the solute movement always occurs at the same rate as the simulated water movement. Frere (1975) states that a bell-shaped distribution will develop about the solute peak concentration due to nonuniform water movement. This nonuniformity is similar in concept to the spatial variation of infiltration simulated in LANDS. Rao et al. (1976b) have indicated that the peak solute concentration will move with the wetting front when the incoming water and solute enters initially dry soil. For moist soils, the solute peak will lag behind the wetting front because the soil water present in the profile will be displaced ahead of the incoming water. This displacement process is adequately represented in the model by Equation 6.4 at high moisture conditions but not at low moisture levels in the upper zone. Therefore, leaching factors have been incorporated into the upper (UZF) and lower (LZF) zone calculations to adjust the simulated leaching process. For the upper zone, solute leaching is now calculated as follows:

$$USRP = UDS * FP * UZFM \tag{6.5}$$

where

$$UZFM = UZS/(UZF*UZSN), UZFM \leq 1.0 \tag{6.6}$$

USRP = upper zone soluble chemicals removed by leaching or percolation, kg/ha
UDS = upper zone soluble chemicals initially present, kg/ha
FP = water percolation factor from Equation 6.4
UZSN = nominal upper zone soil moisture capacity, cm
UZF = upper zone chemical percolation factor

Since the multiplication factor UZFM is always less than or equal to 1.0, solute leaching is lower than that previously calculated. The quantity UZF*UZSN represents a soil moisture condition whereby the initial soil water and associated solute can be completely displaced by incoming water, i.e. plug-flow or piston-type displacement can occur. Thus, when UZS is greater than or equal to UZF*UZSN, UZFM equals 1.0 and the initial solute is displaced by the fraction of the soil water percolated, FP. When UZS is less than UZF*UZSN, UZFM is less than 1.0 and serves to reduce the solute percolated from that calculated by complete displacement. Physically, the case of UZS less than UZF*UZSN can be visualized as a dry soil condition whereby moisture can move through empty flowpaths in the upper zone without transporting solutes stored in the zone. UZFM evaluated as the ratio

UZS/(UZF*UZSN) would then represent the fraction of available flowpaths through the upper zone where no solute transport occurs. Thus, when UZFM equals 1.0 all flowpaths are occupied and complete displacement occurs. Although this description may not be a precise explanation of the physical processes, it does indicate the behavior of the simulated leaching process in the model that has been satisfactory to date. Figure 6.6 indicates how UZFM varies for different values of UZF and the UZS/UZSN ratio.

For consistency, a lower zone leaching factor (LZF) that functions similarly to UZF has been incorporated in the lower zone calculations. Currently UZF and LZF are user-specified calibration parameters with internal default values of 1.0. These parameters affect both pesticide and nutrient leaching. They should be calibrated on soil storage and percolation characteristics of a nonreactive solute, such as chloride, so that the leaching effect will not be masked by transformations. The magnitude and sensitivity of the leaching factors will depend upon soil and solute characteristics and the UZSN and LZSN values. A watershed with sandy, highly permeable soil will have smaller values than a watershed with less permeable soils and hardpans. UZF values of 5.0 and 1.0 were used for P2 and P6 watersheds, respectively. LZF was kept at 1.0 for both watersheds. The lower calibrated UZF value for P6 was understandable since this watershed is sandier and more permeable than P2.

In summary, the method of representing solute leaching described above was added to the ARM Model to reduce rapid solute leaching resulting from the vertical moisture transfer simulated in the LANDS program. It provides a flexible mechanism for the user to approximate the vertical distribution of solutes in the soil profile. Although the solution procedure is not rigorous with regard to the actual leaching process, it is compatible with the LANDS routine and appears to provide sufficient accuracy at the present time. If future work requires greater reliability, research efforts should concentrate on a joint evaluation of the solute leaching and the infiltration/percolation processes.

SOIL TEMPERATURE SIMULATION

Soil temperature simulation is needed to test soil pesticide degradation algorithms and adjust nutrient transformation rates. Nutrient

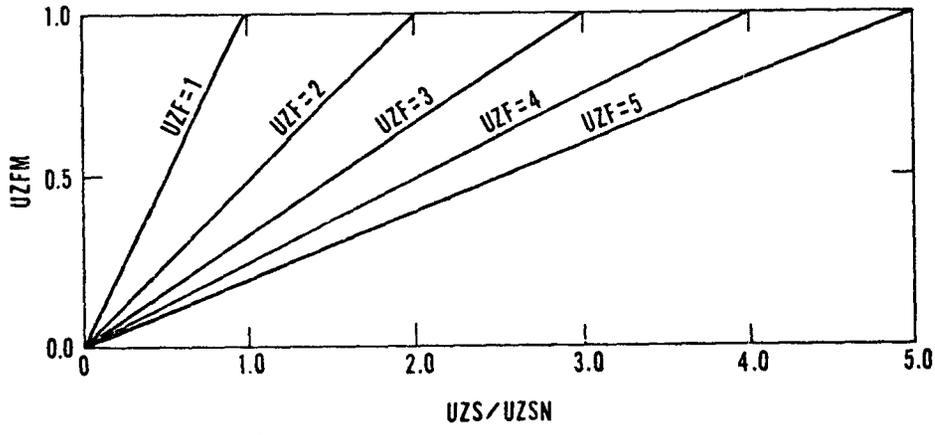


Figure 6.6 Variability of UZFM with UZF

transformation rates in the ARM Model are corrected for soil temperatures by a simplified Arrhenius equation. Both the pesticide and nutrient algorithms need a reasonably accurate input of soil temperatures in the surface, upper, and lower zones in order to model soil processes.

Various approaches to soil temperature simulation were considered in this work. The most physically realistic approach would be a detailed energy balance model based on work similar to that of DeVries (1958) or Wierenga and DeWit (1970). However, development of an energy balance soil temperature model as a function of solar radiation, air temperature, crop cover, and soil properties was considered beyond the scope of this project.

Consequently, other less rigorous approaches were studied. Davidson and Choy (1974) developed a diurnal soil temperature model that uses surface soil temperature to calculate soil temperature at any depth as a pure harmonic function of time around an average value. Air temperature and solar radiation correlations were used to calculate the surface soil temperatures. Simulation results from the Davidson and Choy model were compared to a linear regression approach based on air temperature and solar radiation for eight days of recorded hourly summer data from Watkinsville, Georgia. Since the regression approach was slightly more accurate and easier to implement, it was chosen for soil temperature simulation in the ARM Model.

Soil temperature data at various depths from Watkinsville, Georgia were used to further test and derive regression equations for each of the soil zones. The data were recorded on small plots consisting of Cecil fine sandy loam located next to the P3 and P4 watersheds. Using eight days (July 21-28, 1973) of recorded soil temperature at 1 cm depth, the following regression equation for the surface zone was derived:

$$STEMP = -29.67 + 1.351(AT) \tag{6.7}$$

where STEMP = surface zone temperature, ^{o}C
AT = air temperature at 120 cm, ^{o}C

Originally radiation was also included as an independent variable in the equation, but its effect was so minor that it was eliminated. The upper zone temperature (UTEMP), based on the computed surface zone temperature, is calculated from the following regression developed from soil temperatures at the 5 cm depth:

$$UTEMP = -3.22 + 0.675(STEMP) \tag{6.8}$$

After the above equations were developed on eight days of data, they were then used to generate the surface zone and upper zone values for the 1 cm and 5 cm recorded data in Figures 6.7 and 6.8. The data were measured on small plots planted in soybeans on June 5. The accuracy of the simulation, within 10 to 15 percent of observed data, is reasonable since canopy shading effects were ignored. The hourly air temperature values used to produce these results were generated by the ARM Model from input daily maximum and minimum air temperatures. The ARM Model assumes that the daily maximum air

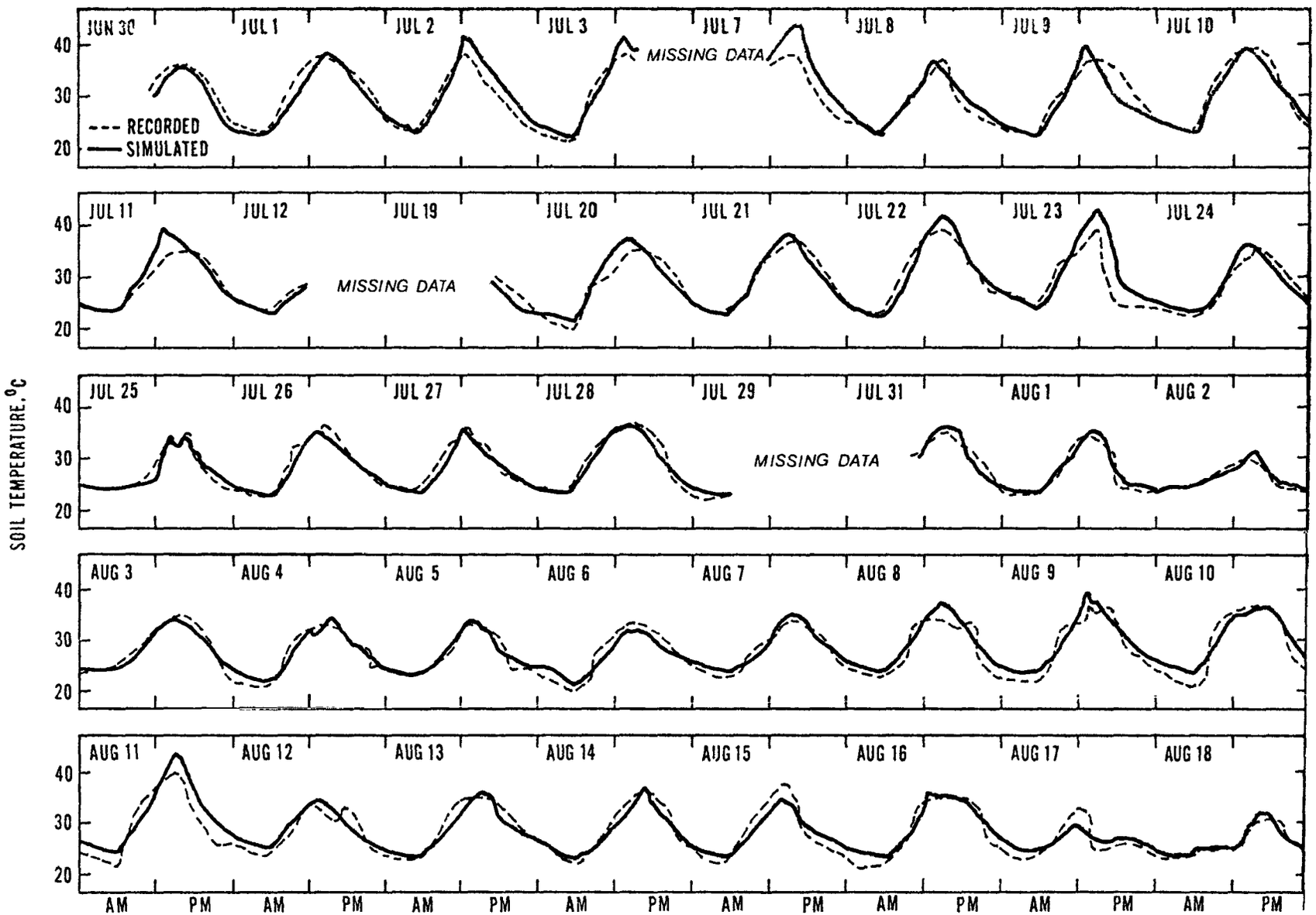


Figure 6.7 Surface zone temperature simulation at Watkinsville, 1973 (continued)

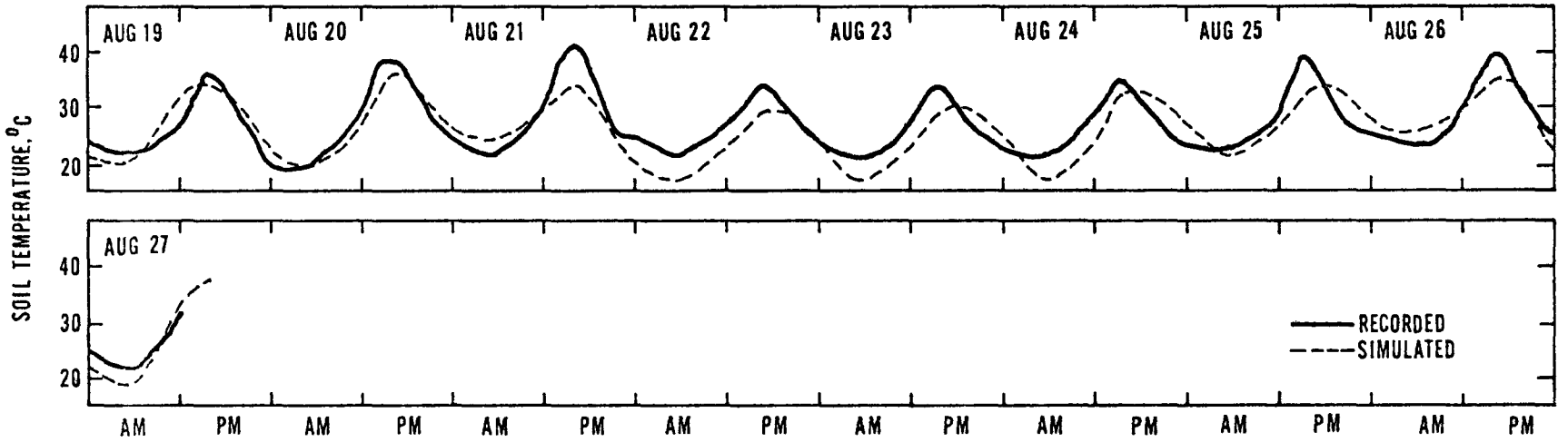


Figure 6.7 (Continued)

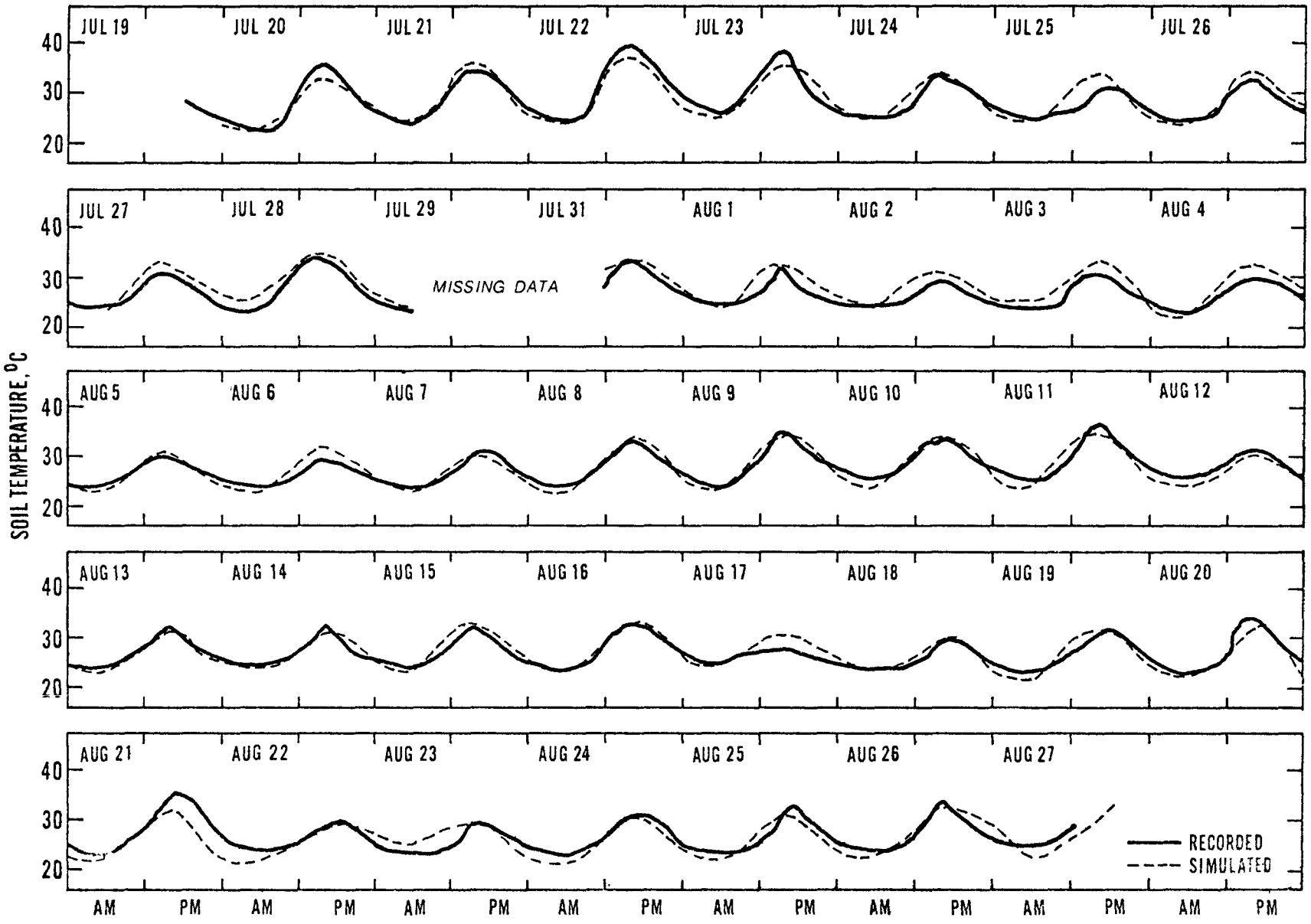


Figure 6.8 Upper zone temperature simulation at Watkinsville, 1973

temperature occurs between 3 and 4 p.m. and that the minimum occurs between 6 and 7 a.m. The other hourly values are derived from a sinusoidal interpolation between the maximum and minimum temperatures.

The above equations for the surface and upper zones were also tested for the summer of 1975. The results are shown in Figures 6.9 and 6.10. During this period the recorded data were taken from small plots planted in corn. The simulated results are somewhat less accurate than the 1973 simulation but are still generally within 15 percent. Deviations of this magnitude (10 to 20 percent) do not appear to be detrimental to the simulation of soil transformations. Rao et al. (1976b) of the University of Florida, using first-order reaction rates in a nitrogen transformation model, have indicated that a twofold increase in the reaction rates should not result in significant differences in the amounts of nitrogen transformed. However, sensitivity analysis using the actual calibrated reaction rates should be performed in order to test this conclusion in the ARM Model.

For the Michigan test watersheds observed soil temperature values at the 5 cm depth were used to develop a regression equation for the upper zone. Maximum and minimum air and soil temperature values for July and August, 1974, provided the basis for the following equation;

$$UTEMP = 7.20 + 0.39(AT) \tag{6.9}$$

The recorded data were taken from Miami fine sandy loam under fescue grass. The simulation results (Figure 6.11) are again generally within 15 percent. However, regression equations based on max-min air temperatures appear to be less accurate than ones based on hourly values as in Georgia. Also, the observed values in Figure 6.11 are for fescue grass whereas the equation was used for corn and soybean watersheds.

A different regression equation for the upper zone was developed for the summer of 1975 and provided significantly better results than Equation 6.9 used for 1974. Thus, different equations were used for the two summer periods simulated. Figure 6.12 shows the simulation results for the 1975 summer using the following equation:

$$UTEMP = -4.29 + 0.63(AT) \tag{6.10}$$

Since no soil temperature data were available for the nonsummer period at Watkinsville, the same regression equations were used for the entire simulation period. In Michigan maximum and minimum winter soil data were available for comparison with the regression equation. The observed winter soil temperatures were considerably more stable than the predicted values. The insolating effect of snow and ice extremely dampened the daily effect of air temperature on soil temperatures. Special consideration for the nonsummer months will be needed for winter simulation runs in areas where snow accumulation is significant.

The soil temperature values calculated for the upper zone were also used for the surface zone for the Michigan P6 watershed since no observed data shallower than 5 cm were available. The lower zone and groundwater zone

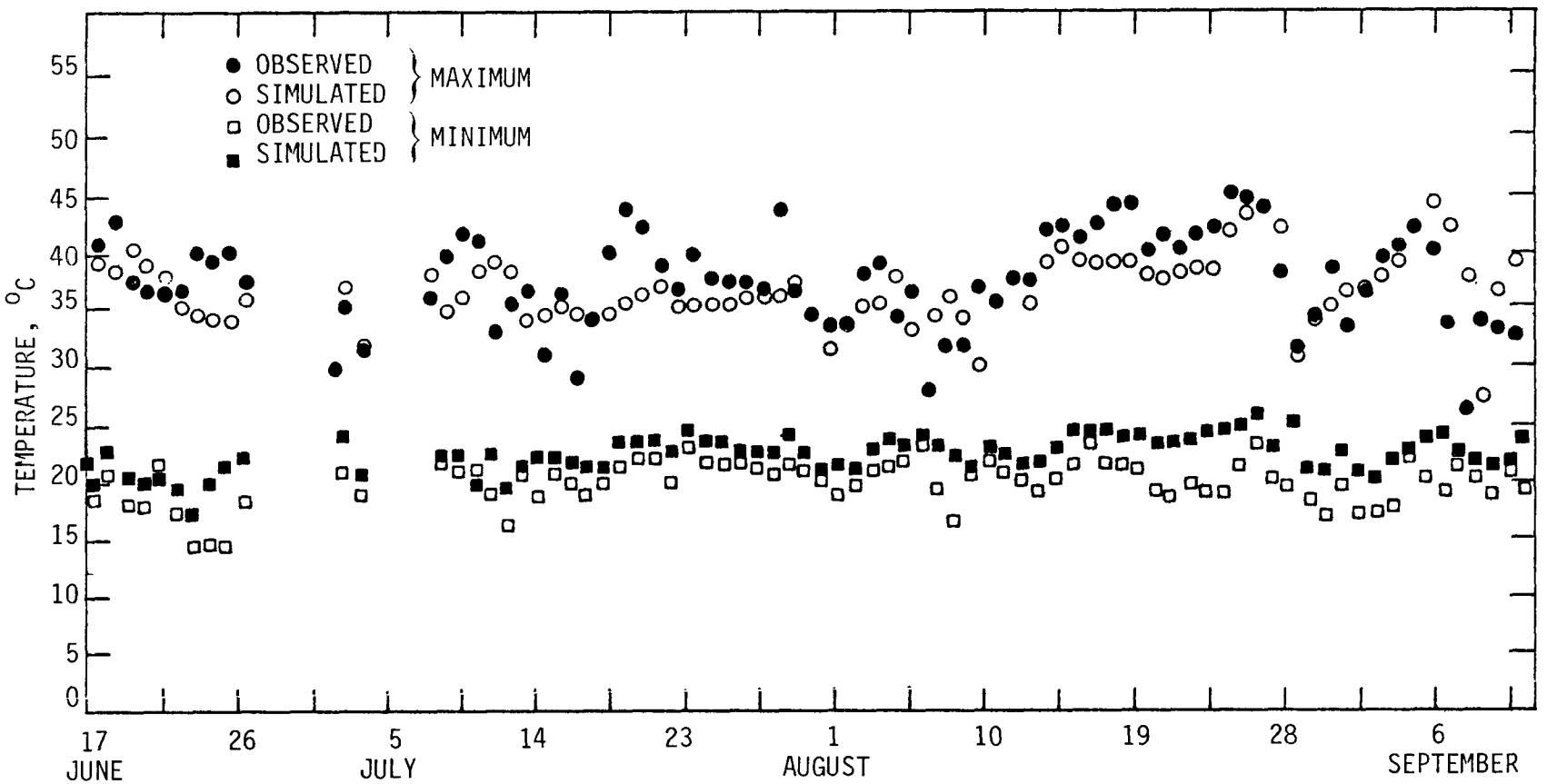


Figure 6.9 Surface zone maximum and minimum daily temperature results at Watkinsville, 1973

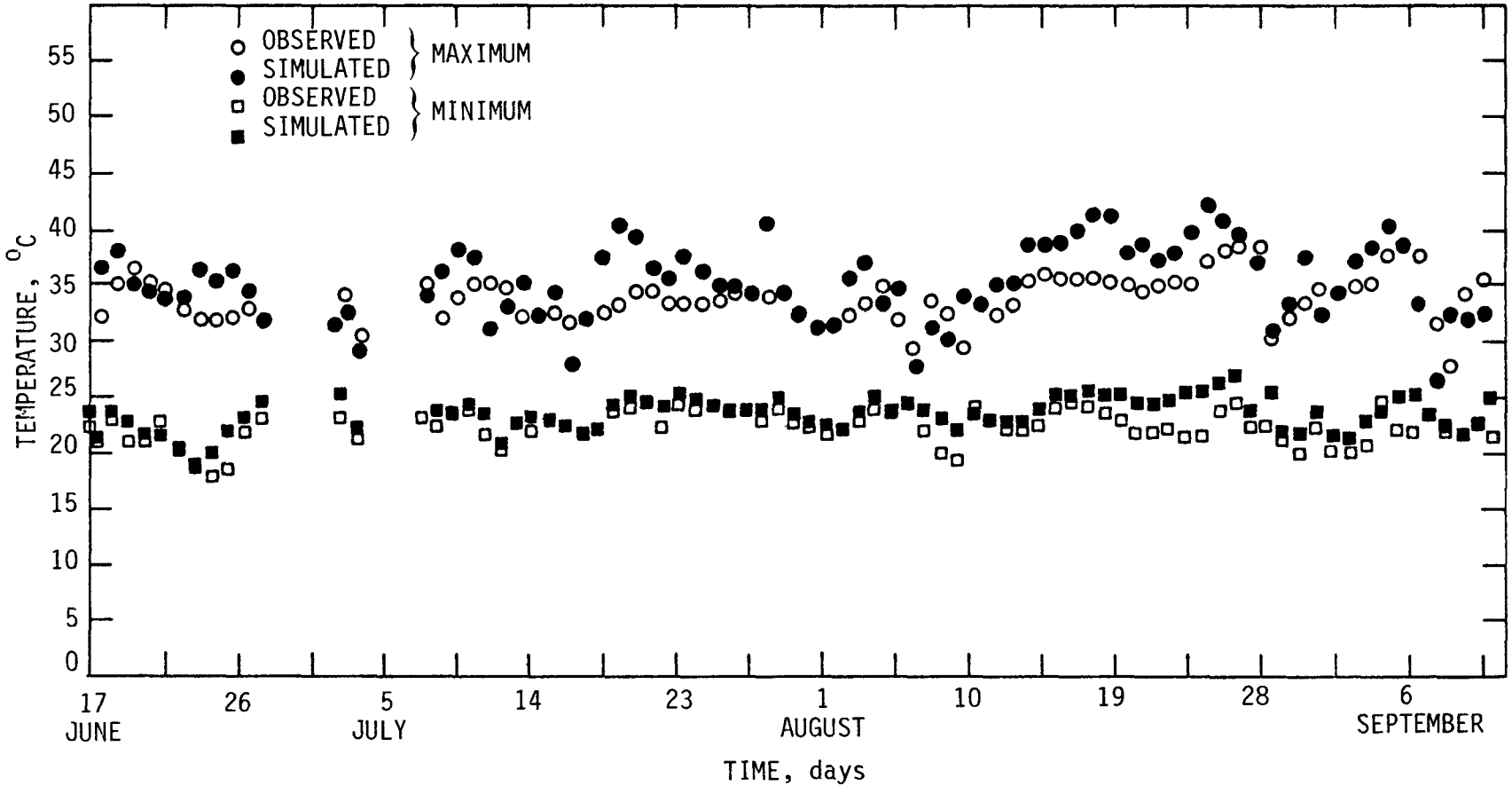


Figure 6.10 Upper zone maximum and minimum daily temperature results at Watkinsville, 1975

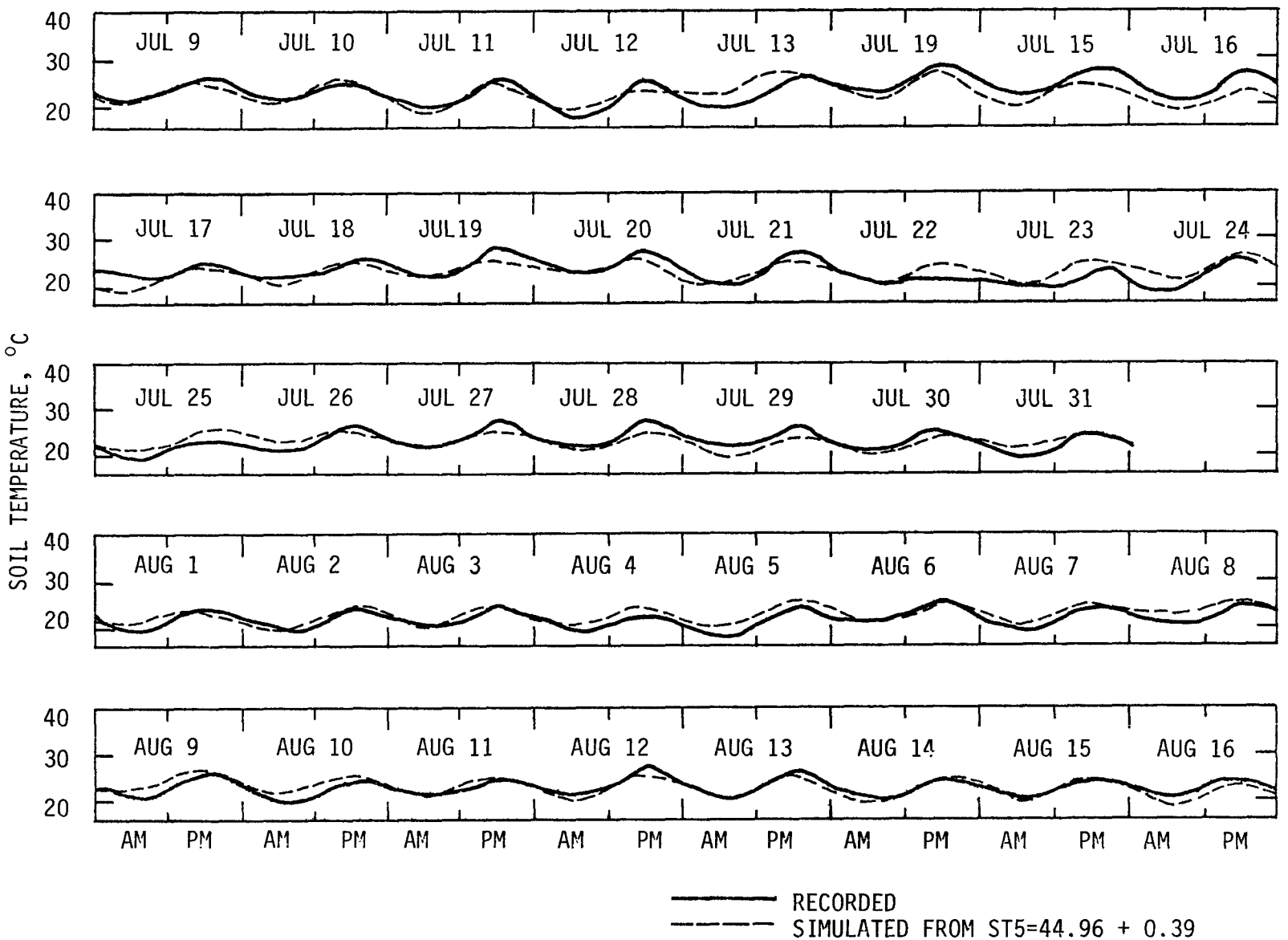
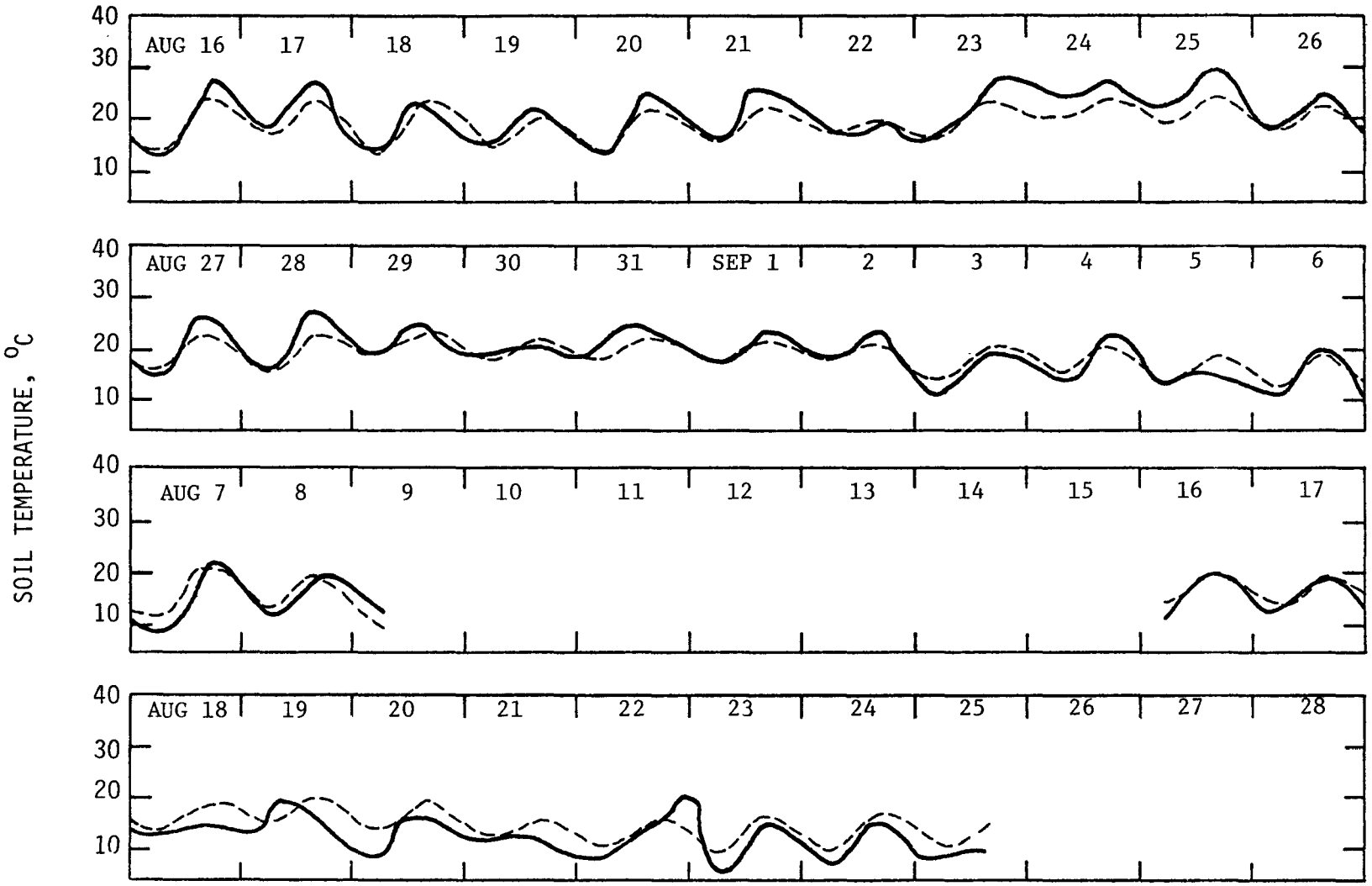


Figure 6.11 Upper zone temperature simulation at East Lansing, 1974



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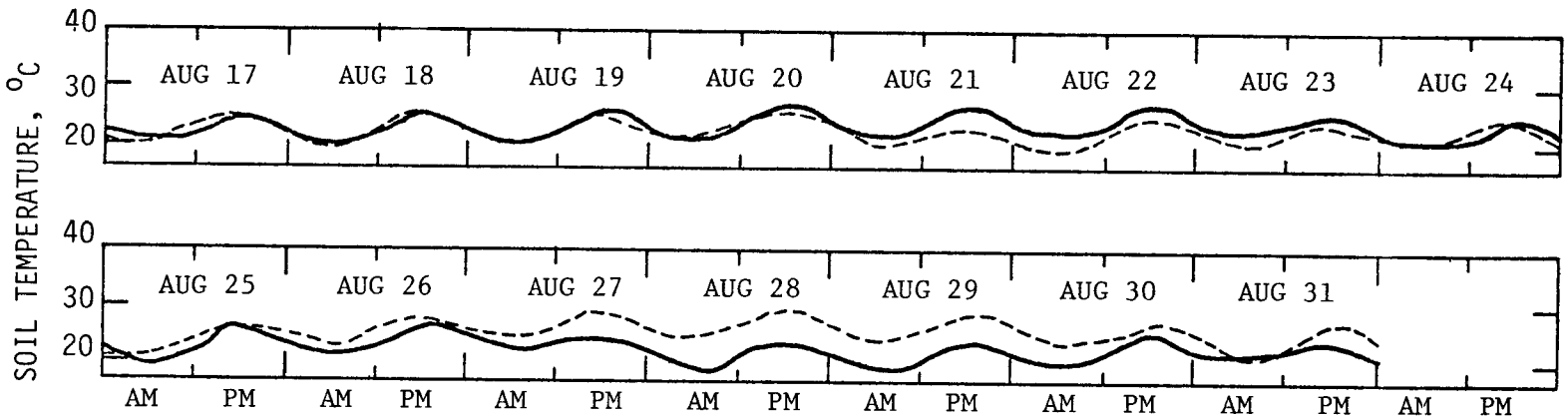

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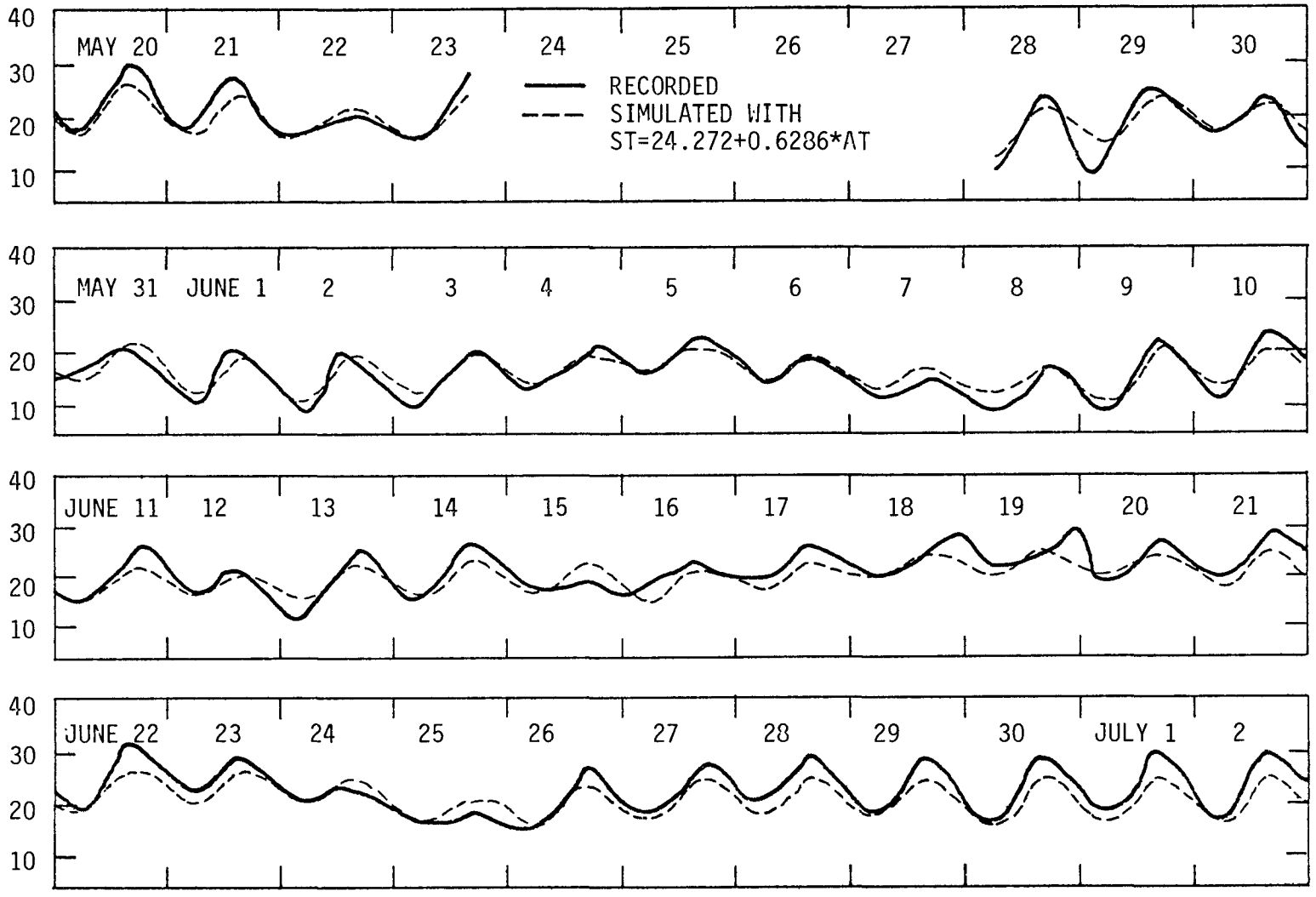


Figure 6.12 Upper zone temperature simulation at East Lansing, 1975 (continued)

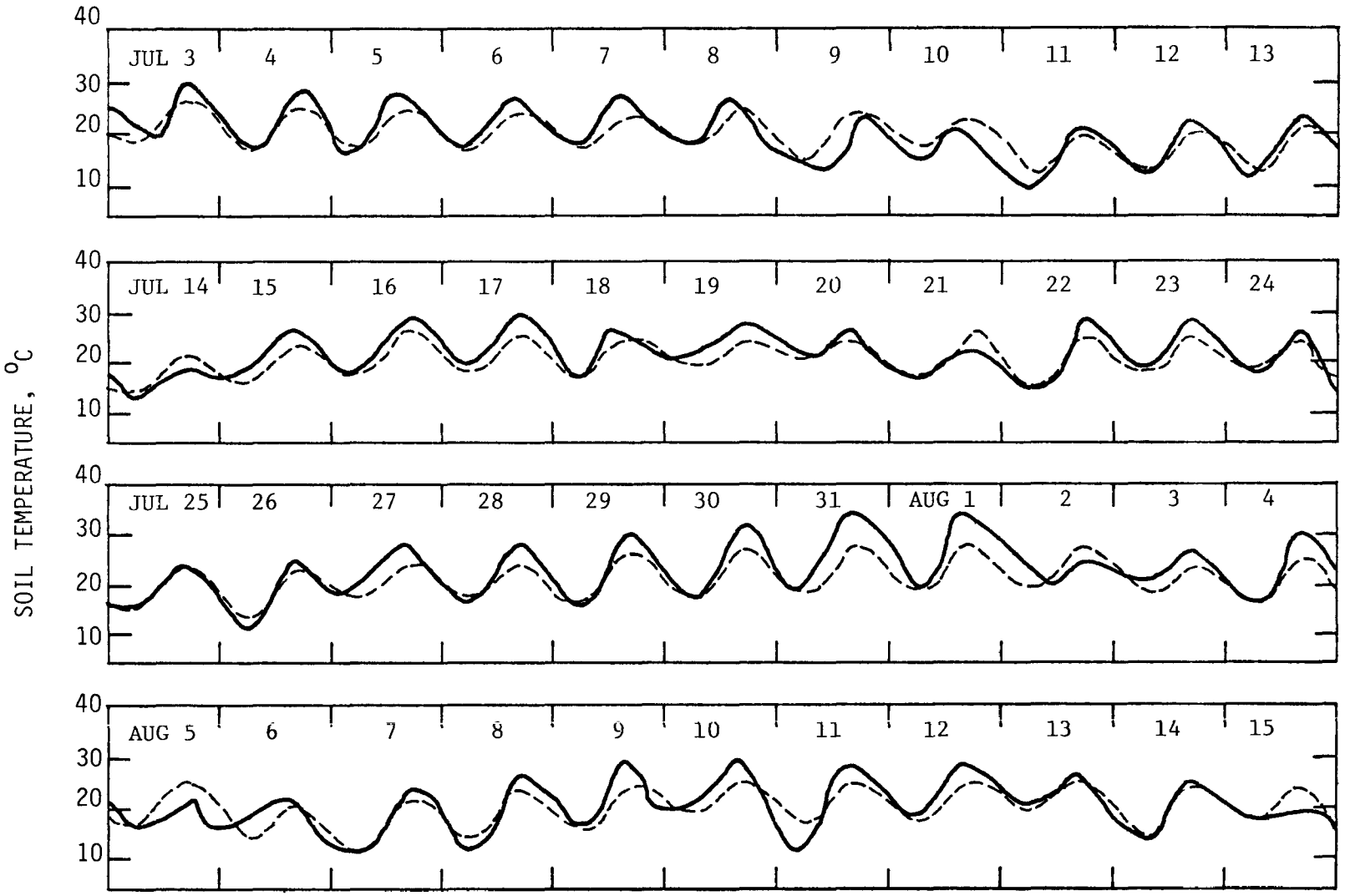


Figure 6.12 (Continued)

temperatures in both Georgia and Michigan were not based on air temperature since they are not considered very sensitive to diurnal fluxes, but are sensitive to seasonal fluxes. Daily average temperatures for these zones are simulated by interpolating average monthly soil temperature input values. Figure 6.13 shows that 60 cm soil temperatures at Watkinsville, Georgia varied no more than 3 Celsius degrees over a 2.5 month summer period. Figure 6.14 shows the seasonal variation of soil temperatures at 120 cm at East Lansing, Michigan. Monthly extremes are within 6 Celsius degrees of the monthly average.

Since the average temperatures of the lower and groundwater zone should be similar, the same simulated values were used for both of these zones. Lower zone monthly values for the Michigan watersheds were estimated from the values in Figure 6.12. For the Georgia watersheds monthly averages were not available for the nonsummer months so estimates for this period were made from Knoxville, Tennessee (1972-1974) 51 cm values. The values are given in Table 6.1.

The linear regression approach to soil temperature simulation currently used in the model is simple and practical. It appears adequate for simulating the summer growing season. However, refinement of the regression equation is needed for the nongrowing season and winter periods. Model users will need to develop the required temperature regression coefficients when the model is applied to watersheds in other geographical areas. In the future, a physically based model relating soil temperatures to watershed and meteorologic conditions should be implemented in the ARM Model.

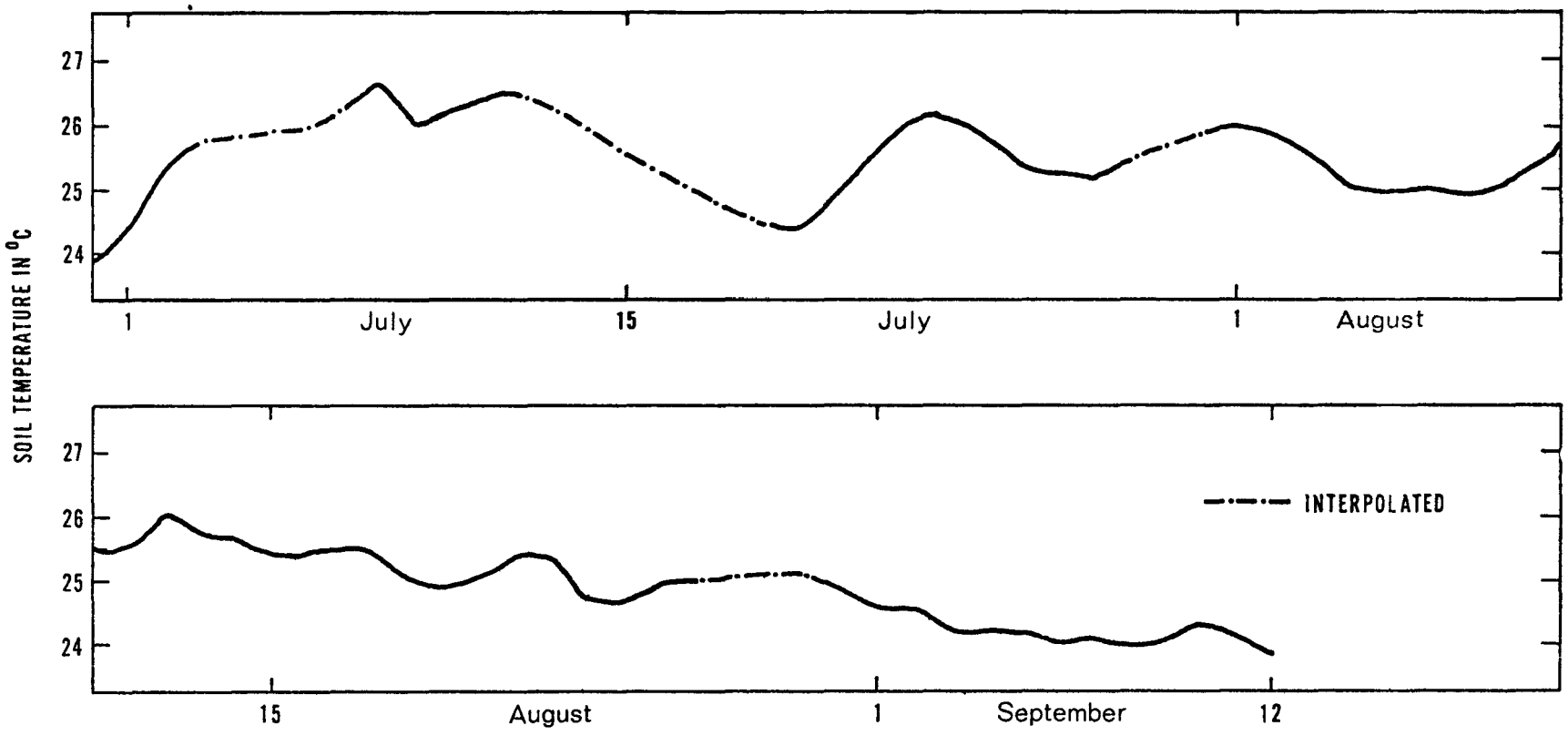


Figure 6.13 Soil temperature at 60 cm depth at Watkinsville, 1973

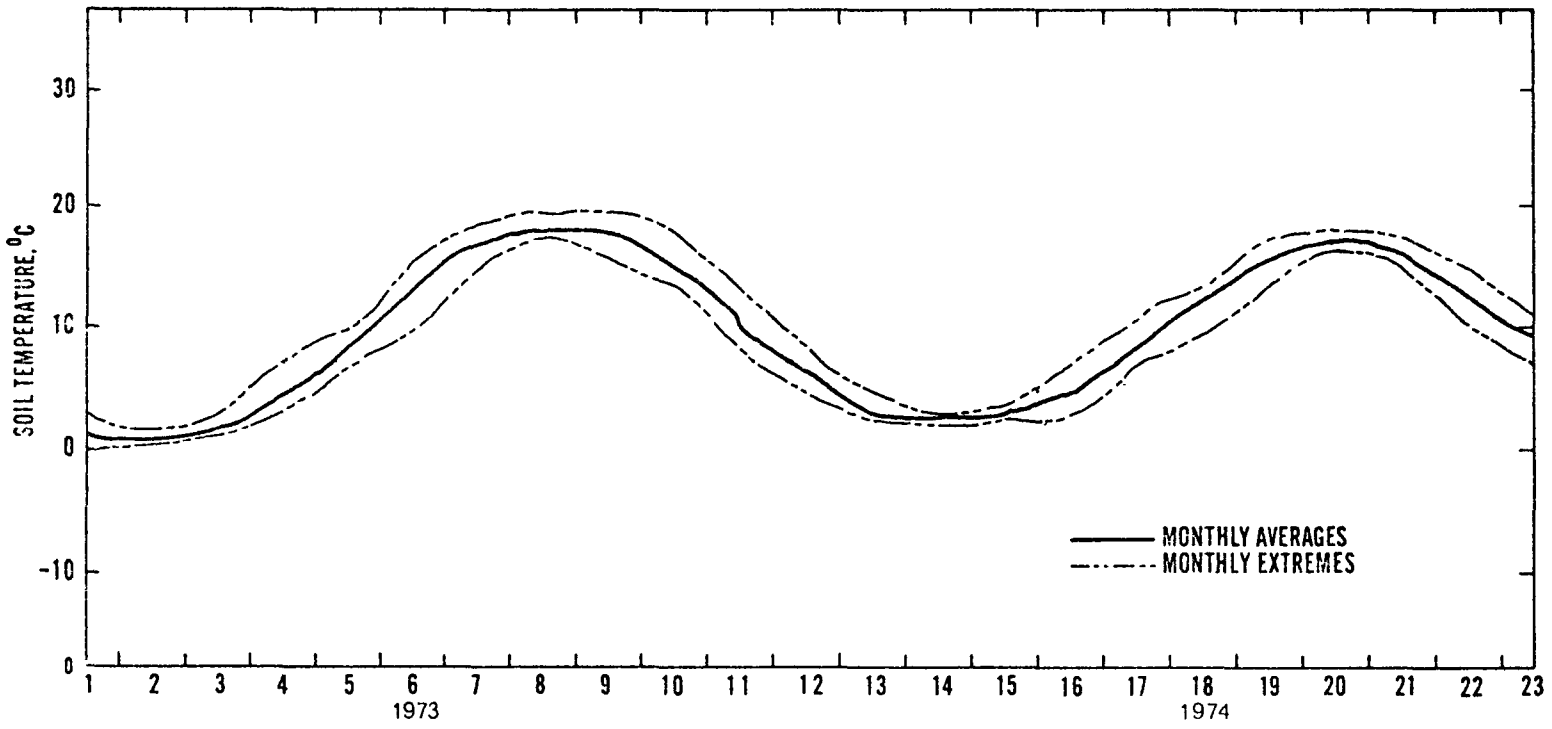


Figure 6.14 Soil temperature at 60 cm depth at East Lansing, January 1973-November 1974

TABLE 6.1 LOWER ZONE AVERAGE MONTHLY SOIL TEMPERATURES FOR THE TEST AREAS (^{o}C)

Month	Watkinsville, GA	E. Lansing, MI
January	8.9	3.4
February	8.3	3.4
March	11.7	2.8
April	13.9	4.5
May	18.3	9.2
June	22.8	13.6
July	25.0	16.9
August	25.0	18.4
September	24.4	18.1
October	21.7	14.8
November	14.4	10.7
December	10.6	6.8

SECTION 7

SOIL PESTICIDE DEGRADATION SIMULATION

Decay or degradation of pesticides by biological and chemical processes is the major mechanism for the attenuation of pesticides on a watershed. Studies conducted by ERL-Athens have found that less than ten percent of the applied pesticides are lost via runoff (Smith et al., 1977). Thus, for many pesticides, e.g. diphenamid and atrazine, over 90 percent of what is applied is degraded in the soil. Since the amount of pesticide in the soil is the major factor in determining the amount available to runoff, an accurate simulation of pesticide degradation is vital to correctly simulate pesticide transport from a watershed. Consequently, alternative degradation simulation algorithms have been studied to determine the most accurate method of simulating pesticide decay that can be generally applied within the framework of the ARM Model.

As discussed in previous reports (Crawford and Donigian, 1973; Donigian and Crawford, 1976), the ARM Model initially used a first-order degradation algorithm. Pesticide decay was directly proportional to the amount of pesticide in the soil. For some pesticides (atrazine and diphenamid) the first-order decay rate was found to initially degrade the pesticide too slowly and then later in the season too quickly. In Figure 7.1 the relationship between the simulated and observed decay curves demonstrates this problem. Thus, for runoff events early in the crop season the amount of pesticide available for runoff was too great, while later in the season not enough was available. This made simulation of atrazine and diphenamid runoff difficult.

ALTERNATIVE DEGRADATION ALGORITHMS

Since the simple first-order degradation approach was not accurate enough for a good simulation of pesticide runoff other approaches were studied. One alternative was a first-order degradation algorithm corrected for the effects of soil moisture and temperature. This environmental approach (Steen, 1975) was derived from laboratory studies of diphenamid and was described as a subsurface degradation algorithm. However, in our evaluation we incorporated the algorithm into both the surface and upper zones. The equation for this approach is:

$$K = Kopt\ e^{(AK(Moist-Mopt)^2)}\ e^{(BK(Temp-Topt))} * \left[\frac{Tmax-Temp}{Tmax-Topt}\right]^{BK(Tmax-Topt)} \qquad (7.1)$$

where K = actual degradation rate for the interval ($days^{-1}$)

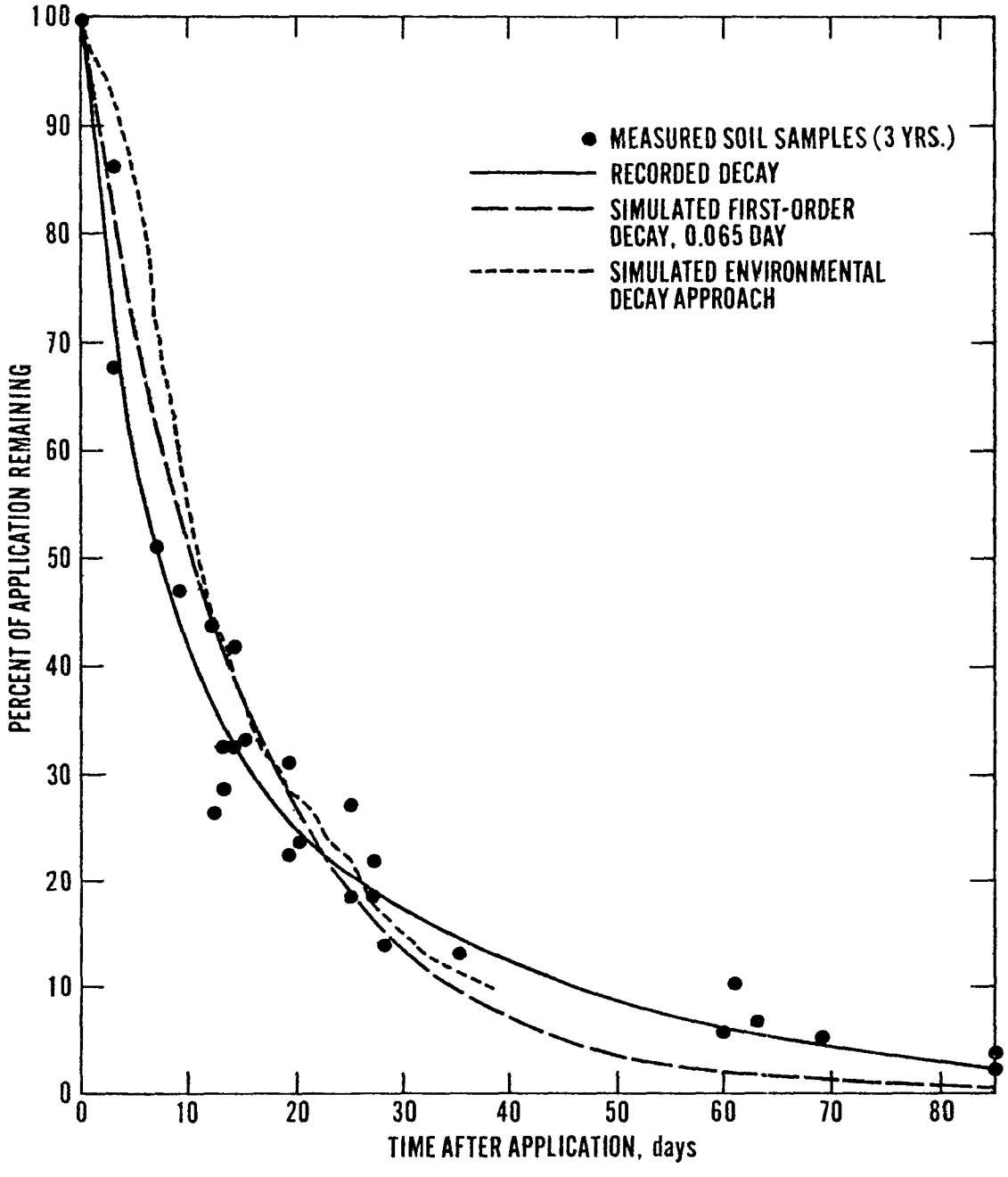


Figure 7.1 Comparison of atrazine degradation rates for the P2 watershed

Kopt = optimum degradation rate, day^{-1}
Mopt = optimum soil moisture content, percent by weight
Moist = actual or simulated soil moisture content for the interval, percent by weight
Tmax = maximum soil temperature at which biological degradation occurs, °C
Topt = optimum soil temperature, °C
Temp = actual or simulated soil temperature for the interval, °C
AK = constant
BK = constant

For diphenamid Kopt was found to equal 0.123 day^{-1}, Mopt equals 0.175, Tmax equals 40°C, Topt equals 35°C, AK equals -100, and BK equals 0.05.

As shown in Figure 7.2, the degradation rate is sensitive to changes in soil moisture and temperature. Thus, correctly modeling these influences (as discussed in Section 6) should provide a more accurate calculation of pesticide degradation than given by the simple first-order degradation approach. However, test results did not support this hypothesis. The

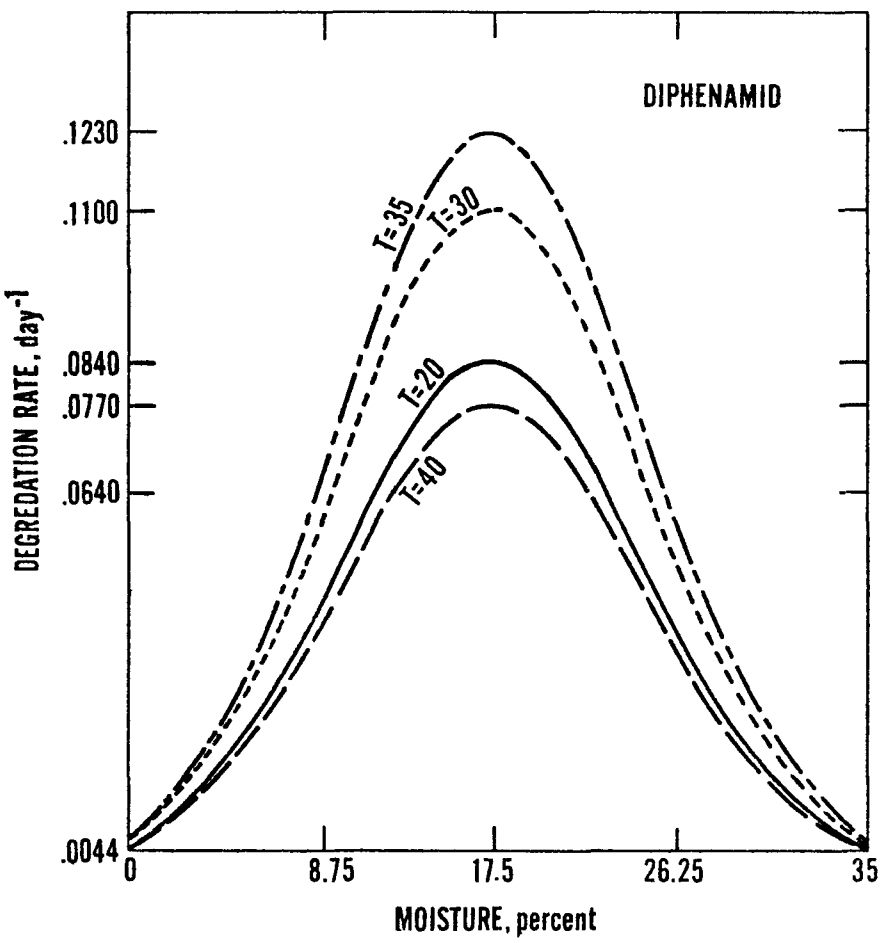


Figure 7.2 Environmental effects on dephenamid degradation rates

changes to the actual degradation rate, K, from the daily fluctuation of soil moisture and temperature proved to be relatively minor and deviated only slightly in the long run from the simple first-order degradation approach. This led to results similar to the simple first-order degradation approach.

A comparison of the simple first-order degradation approach and the environmental degradation approach (Figure 7.1) shows that the latter simulated the amount of degradation less accurately than the simple first-order approach in the period immediately after application. This early period is critically important in correctly determining the amount of pesticide runoff. The first significant runoff event after application usually removes the largest amount of pesticide for the season, because less pesticide is available for runoff as the season progresses. It is in this early period prior to the first runoff event that the environmental approach fails. Failure to correctly simulate pesticide degradation occurs because the environmental factors (soil moisture and temperature) are not at optimum conditions for biological decay in the surface zone where application occurs. Thus, degradation by biological processes is minimal as reflected by the high percent of application amount remaining in the soil (Figure 7.1). However, chemical processes (to be discussed below) are the dominating degradation component for this period and are not handled by the environmental degradation approach.

Sensitivity tests were conducted on the Steen equation (Equation 7.1). Daily max-min air temperature, which is used as input to the ARM Model, was changed by $\pm$ 10 Celsius degrees. In two sensitivity trials the resultant pesticide decay after application is changed only slightly from the base conditions. In the same manner soil moisture values were changed by $\pm$ 30 percent. This gives a greater change in response from the base conditions than seen in the temperature sensitivity tests, but still the changes are not substantially different from the base (Figure 7.3).

The relative insensitivity of the environmental degradation model to the daily fluctuations of soil moisture and temperature does not justify the required effort to simulate and incorporate the moisture and temperature effects. Also, the constants AK and BK will vary with pesticide characteristics and soil characteristics; they must be evaluated through calibration with recorded data. For these reasons the environmental approach has not been implemented in the current version of the ARM Model.

Detailed collection and analysis of atrazine remaining on the P2 watershed in the summer of 1975 provided enough data to develop a better understanding of the degradation processes. From this understanding a more accurate degradation algorithm than the first-order approach was developed. This new approach is the step-wise degradation algorithm. The ERL-Athens researchers found that for some pesticides (atrazine and diphenamid) the degradation rate changes substantially with the first major storm after application (Smith et al, 1976). Decay rate changes can be explained by existing soil conditions. Prior to the pesticide application the soil is loosely tilled. Tillage breaks up thermal and hydraulic conductance between the surface and subsurface soil layers. This enables the existence of sizable temperature

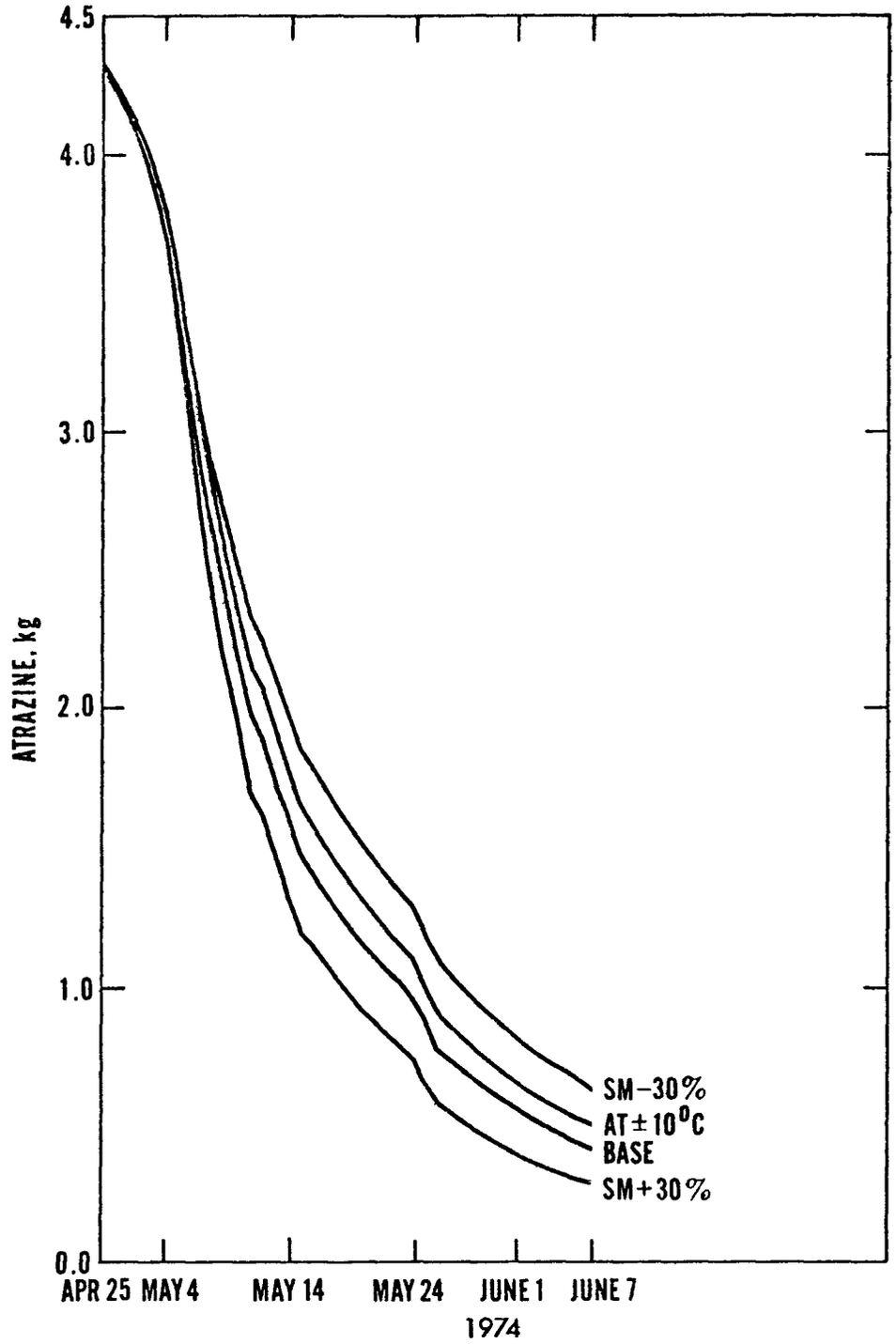


Figure 7.3 Environmental approach sensitivity trials

gradients near the soil surface, both relative to subsurface soil temperature and air temperature. For the first two or three days after pesticide application the surface soil temperature was 15 to 30 Celsius degrees hotter than the air temperature on P2. This gradient gradually decreased with time as the soil compacted. Then a rainstorm further compacted the surface layer, established strong conductance with the subsurface soils, and markedly decreased surface soil temperatures.

The high surface soil temperatures immediately after pesticide application result in pesticide degradation by chemical processes. This greatly diminishes once the surface soil temperature drops after a significant rainfall. At this point in time biological processes take over in playing the major role in pesticide degradation. The simple first-order approach and the more complex environmental approach by Steen fail in that they consider only biological decay. They cannot correctly represent the rapid decay caused by chemical processes without incorrectly representing the slower decay by biological processes. Both decays can be considered first-order mechanisms, but at significantly different reation rates. The step-wise degradation approach has the capability of reproducing the effects of more than one first-order decay rate during a crop season. Thus, both chemical and biological decay processes can be easily represented in the simulation of pesticide degradation.

SIMULATION RESULTS

As discussed previously, the simple first-order and environmental approaches to pesticide degradation give poor results. The step-wise approach gives good results. This is true for the simulation of atrazine on the P2 watershed for 1973 through 1975. A decay rate of 0.10 per day is used prior to the first runoff event after each application. After the first runoff event a decay rate of 0.04 per day is used. Figure 7.4 shows the simulated amount of atrazine in the soil from 1973 through 1975 respectively. The atrazine remaining in the soil is low in 1973 compared to measured soil samples. However, the same step-wise decay rates in 1974 and 1975 give excellent results. The low values in 1973 may result from a poor knowledge of the actual amount of atrazine applied that season. Disc filter monitoring of application rates in 1974 indicated that the amount of pesticide applied was 13 percent greater than the planned amount. A similar discrepancy would help to explain the 1973 results shown in Figure 7.4.

Paraquat, unlike atrazine and diphenamid, does not exhibit step-wise decay mechanisms; the simple first-order decay or a step-wise decay with the same decay rate at all times works reasonably well. Considering the variability in the recorded values, a constant decay rate of 0.002 per day adequately represents the decay of paraquat over long time spans, as is shown in Figure 7.5.

A study of the decay rates of atrazine and paraquat on the P6 watershed in Michigan shows some differences from the results on the P2 watershed. Atrazine was applied three times on the P6 watershed during the period of May 1974 through September 1975. From the few soil core samples taken

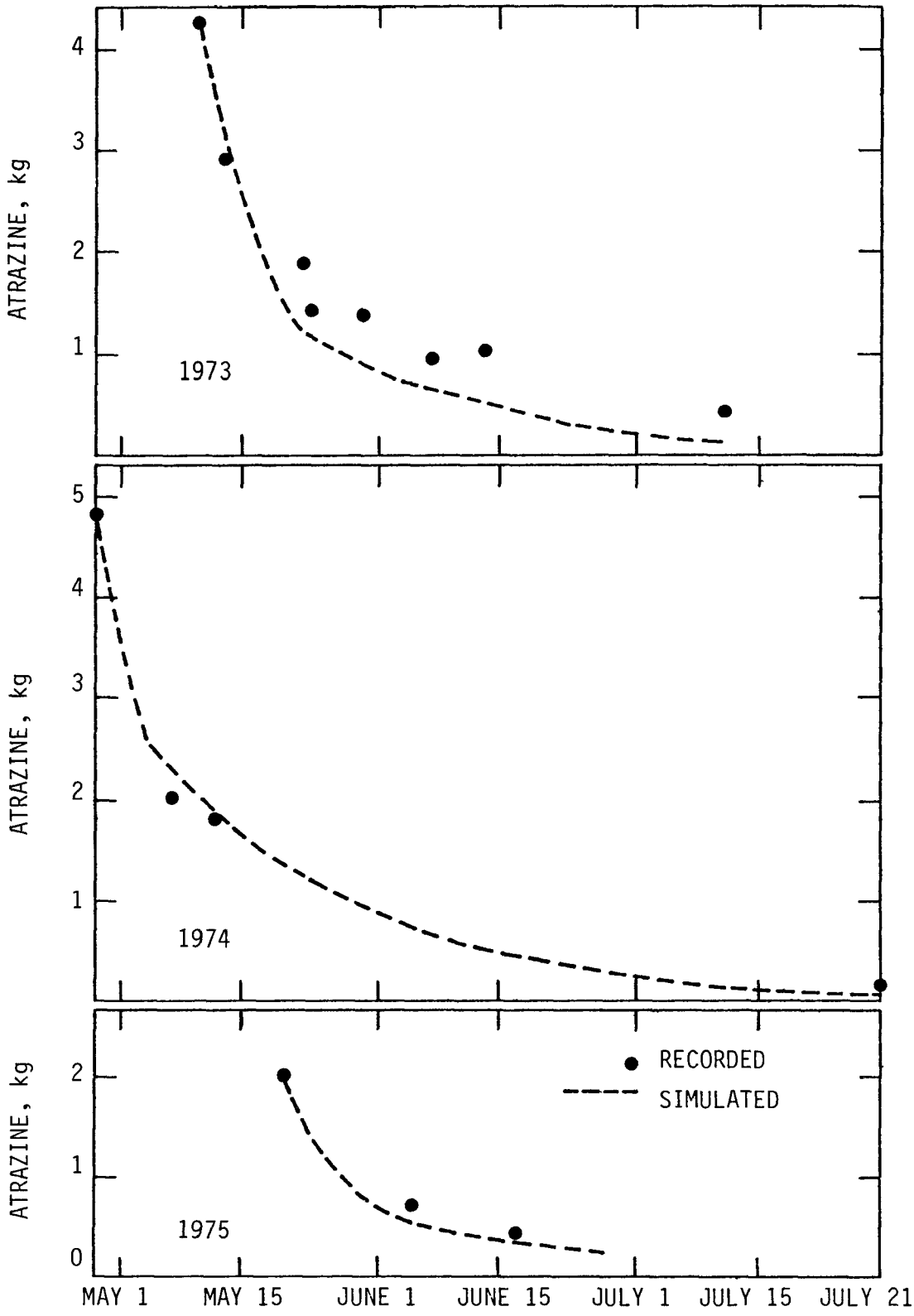


Figure 7.4 Atrazine in soil storage on the P2 watershed

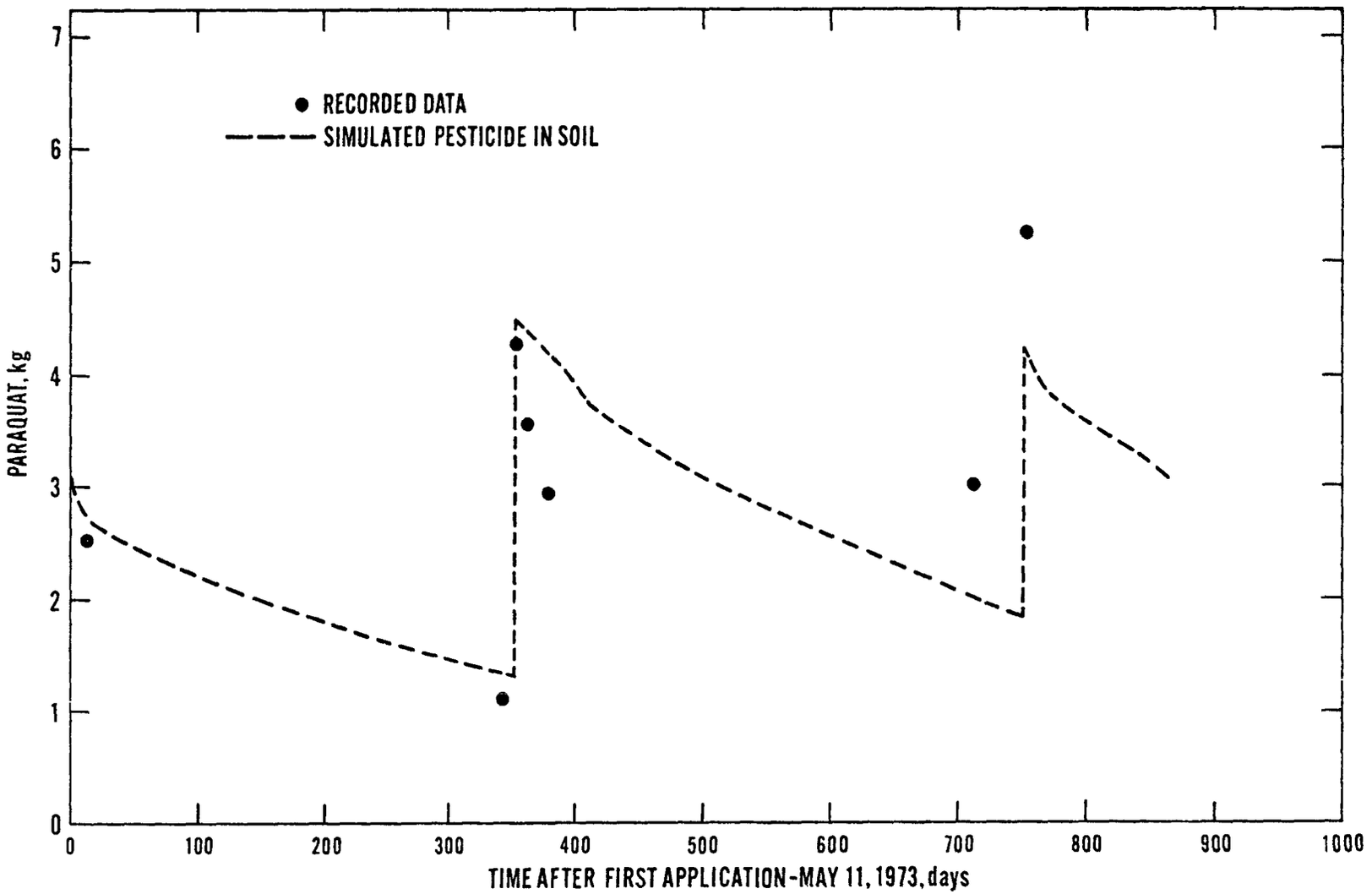


Figure 7.5 Paraquat in soil storage on the P2 watershed, 1973-1975

during this period it appears that chemical decay is a minor mechanism compared to biological decay. These results differ from those on the P2 watershed in Georgia and show the impact of different climatic regimes on the mechanisms controlling pesticide degradation. This observation is complicated, however, by the scarcity of measured soil core samples on the P6 watershed. Atrazine was measured on ten different dates during this 17 month period (Figure 7.6). The measured values all appear to be high; possibly as a result of problems in the sampling procedures. Similar questions are evident in the paraquat results shown in Figure 7.6. The recorded values in the 0 to 30 cm depth are so unusual and inconsistent that the actual rate of paraquat degradation can not be accurately determined. The amount of paraquat measured in the surface layer of soil (0-1 cm) is more consistent, but the actual values are impossible to explain except in terms of sampling problems. Thus, for the simulation of atrazine and paraquat on the P6 watershed degradation rates could not be calibrated because of discrepancies in the collected data. For atrazine it is assumed that biological decay is the only major degradation mechanism. A decay rate of 0.04 per day is used. For paraquat a constant decay rate of 0.002 per day is selected based on the assumption that the degradation rate will not differ substantially from that used on the P2 watershed. The inability to verify these assumptions makes good simulation results for atrazine and paraquat runoff from the P6 watershed difficult. This will be fully discussed in Section 10.

SUMMARY

The step-wise degradation approach works well for the pesticides studied. However, it is a simple approximation of chemical and biological processes at work in breaking pesticides down into other compounds. If the environmental degradation approach, described above, could better represent these processes (both chemical and biological) and have previously determined values for its input constants for all pesticides then it would be the preferable approach. In addition, if more long-term (multi-year) daily monitoring of pesticide mass and associated moisture and temperature values in the soil were made, a more accurate environmental approach could be developed. Further research in this and the better understanding of the chemical and biological decay processes would result in a more accurate pesticide degradation submodel.

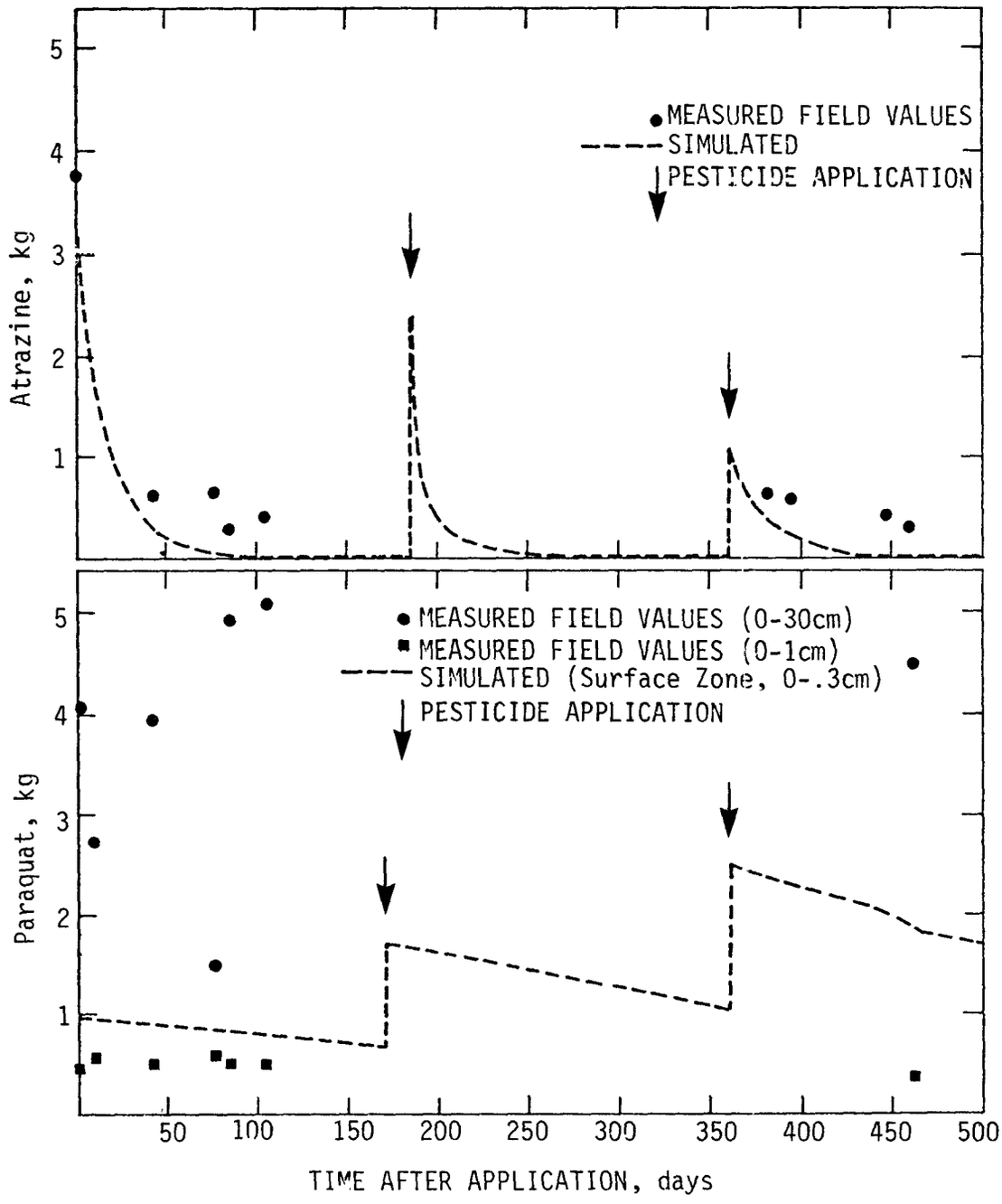


Figure 7.6 Atrazine and paraquat in soil storage on the P6 watershed, 1974-1975

SECTION 8

SOIL NUTRIENT SIMULATION

Nutrient modeling in the ARM Model involves the simulation of both soil nutrient storages and the transport or washoff of nutrients. Section 11 discusses the nutrient runoff simulation while this section discusses the simulation of soil nutrient storages and transformations. Beginning with a discussion of the major model changes since the last report (Donigian and Crawford, 1976), this section continues with a discussion on how optimum first-order reaction rates were obtained. The reaction rate values for the test watersheds are presented along with the soil nutrient storage simulation results. This section concludes with recommendations for future research and possible model improvements.

MAJOR MODEL CHANGES

During this project modifications were made to the nutrient model to simplify model operation and more accurately represent certain processes. The major changes to the nutrient model include:

(1) Elimination of certain transformation paths.
(2) Calculation of transformed nutrients as a function of soil water content and nutrient concentrations in each soil zone as opposed to nutrient mass.
(3) Simulation of plant uptake as a function of monthly uptake factors as opposed to crop canopy.

Transformation Processes

The changes in the transformation processes have been incorporated in Figure 4.5. The phosphorus transformations remain the same, but those for nitrogen were changed by combining the nitrite (NO_2) and nitrate (NO_3) forms. This resulted in the elimination of the reactions of NO_2 oxidation to NO_3 (K2 rate), and NO_3 reduction to NO_2 (KK2 rate). NO_2 was combined with NO_3 to simplify the model and to avoid using extremely large oxidation rates from NO_2 to NO_3. The NO_2 form could have been completely eliminated from the model since it is not persistant in most agricultural soils or in surface runoff due to rapid oxidation to NO_3. However, NO_2 remains in the model in the combined form ($NO_2 + NO_3$) in case it occurs in any future simulation work. Also, the combined form indicates that NO_2 is an intermediate step in the nitrification and denitrification processes. However, for most agricultural watersheds, the component of NO_2 plus NO_3 can be considered as NO_3.

One additional change in the nitrogen transformation processes was made; the nitrification reaction rate, K1, occuring from the adsorbed phase of ammonium (NH_4-A) was eliminated, because it has not been observed in laboratory tests (Davidson and Rao, 1976). Also, Mehran and Tanji's model (1974) of soil nitrogen transformations does not have a nitrification pathway from the adsorbed NH_4 form.

These changes are included in the summary of the reaction rate definitions in Table 8.1 and in the coupled system of differential equations in Table 8.2. Certain clarifications of these tables and Figure 4.5 need to be made. Plant nitrogen uptake occurs only in the NO_3 form since NO_2 is toxic to plants (Black, 1968). If persistant NO_2 occurs in the watershed, plant uptake should normally be reduced. Also, denitrification rates in the literature based on NO_3 will be larger than the input denitrification rate in the model, KD, since KD is based on the amounts NO_2 plus NO_3. Finally, the N_2 form represents any form of denitrified nitrogen in the gaseous form, including nitrous oxides.

Nutrient Transformation Calculations

Nutrient transformations were previously based on the nutrient mass in each soil zone, but were changed in this project to being based on the nutrient mass per mass of soil or soil water in each zone. Except for the groundwater zone, transformations were calculated in terms of kilograms per hectare of each nutrient form in each zone. Since the surface, upper, and lower zones have specified depths, the reactions were previously based on the nutrient mass per total volume of the zone, i.e. a volume-based concentration. The groundwater zone has no specified depth so the transformations were based merely on kilograms per hectare. The use of concentrations based on mass not volume is considered more theoretically consistent with first-order reaction rates. Most of the literature on adsorption/desorption reports reaction rates based on concentration on the soil mass and soil water mass. Plant uptake rates are also typically based on nutrient concentration in the soil water.

The reaction rates in the model were changed to a mass concentration basis for all the zones except the groundwater zone; the groundwater zone tranformations remain in terms of kg/ha. The NH_4 desorption rate, KAS, is now based on the concentration of adsorbed NH_4 on the soil mass. Likewise the nitrogen mineralization rate, KAM, is based on the organic nitrogen mass per soil mass. The PO_4 desorption rate, KAS, and the mineralization rate, KM, are also respectively based on the concentration of adsorbed or combined PO_4, and organic phosphorus per soil mass. All the other reaction rates are based on the mass of the nutrient per mass of soil water in the zone.

Additional model changes were made for calculating the soil and water masses. Soil bulk densities are now specified separately for each soil zone. The bulk densities and the volume of the zone are used to calculate the soil mass. The LANDS program calculates the moisture stored in each soil zone during each time interval for the hydrology simulation. The moisture values are then used in the nutrient model to evaluate nutrient

TABLE 8.1 DEFINITION OF N AND P REACTION RATES

Rate	Definition
Nitrogen	
K1	Nitrification rate of ammonium in solution (NH_4-S) to nitrite and nitrate (NO_2+NO_3)
KD	Denitrification rate of nitrite and nitrate to gaseous nitrogen (N_2)
KPL	Uptake rate of nitrate (and nitrite) by plants (Plnt-N)
KAM	Mineralization or ammonification rate of organic nitrogen (Org-N) to ammonium in solution
KIM	Immobilization rate of ammonium in solution to organic nitrogen
KKIM	Immobilization rate of nitrate to organic nitrogen
KSA	Exchange rate of ammonium from solution to adsorbed phase (NH_4-A)
KAS	Exchange rate of ammonium from adsorbed phase to solution
Phosphorus	
KM	Mineralization rate of organic phosphorus (Org P) to solution phosphate (PO_4-S)
KIM	Immobilization rate of solution phosphate to organic phosphorus
KPL	Uptake of solution phosphate by plants (Plnt-P)
KSA	Adsorption or combining of solution to adsorbed or combined phase (PO_4-A)
KAS	Desorption or dissolving or adsorbed or combined phase to solution phosphorus

note: All rates are based on the N or the P amounts of the form.

TABLE 8.2 COUPLED SYSTEM OF DIFFERENTIAL EQUATIONS FOR NITROGEN TRANSFORMATIONS

Organic Nitrogen:

$$\frac{d}{dt}\{ORG\text{-}N\} = KIM\ \{NH_4\text{-}S\} + KKIM\ \{NO_3{+}NO_2\} - KAM\ \{ORG\}$$

Solution Ammonia:

$$\frac{d}{dt}\{NH_4\text{-}S\} = KAM\ \{ORG\text{-}N\} - (KSA + K1 + KIM)\{NH_4\text{-}S\} + KAS\ \{NH_4\text{-}A\}$$

Adsorbed Ammonia:

$$\frac{d}{dt}\{NH_4\text{-}A\} = KSA\ \{NH_4\text{-}S\} - KAS\ \{NH_4\text{-}A\}$$

Nitrate:

$$\frac{d}{dt}\{NO_3{+}NO_2\} = K1\ \{NH_4\text{-}S\} - (KD + KKIM + KPL)\ \{NO_3{+}NO_2\}$$

Nitrogen Gas:

$$\frac{d}{dt}\{N_2\} = KD\{NO_3{+}NO_2\}$$

Plant Nitrogen:

$$\frac{d}{dt}\{PLNT\text{-}N\} = KPL\{NO_3{+}NO_2\}$$

concentrations and transformations. Hence, reasonable simulation of the soil water storages, especially in the upper and lower zones, is needed for reliable transformation simulation.

In the model the soil moisture storage value in the upper zone is specified by UZS. It is the primary moisture component for upper zone transformations during nonstorm days. During storm days, UZS is augmented by the interflow component and infiltrating moisture that passes through the upper zone. UZS is primarily dependent upon the rainfall, evapotranspiration, and the input nominal upper zone storage value (UZSN). Care must be taken to use reasonable values for UZSN with regard to the depth of the upper zone so that realistic upper zone moisture values are simulated. All nutrient transformations in the model are discontinued at very low moisture values, which are not uncommon when very low UZSN values (less than 2 mm) are used. Nutrient transformations are inhibited at low moisture levels because some minimum moisture content is generally required as a medium for transformations. Black (1968) discusses the decrease in plant uptake, mineralization, and nitrification in dry soils. This same stopping of transformations in the model also occurs in the lower and surface zones at low moisture values. However, the lower zone soil moisture almost never reaches this level, and the surface zone moisture is always zero except when runoff is occurring. Hence, surface zone transformations do not occur except during storm events. This makes the surface zone a conceptually stable zone for the nutrient model. Such a stable zone has the advantage of simpler application; the amount and concentration of soil-associated nutrients available for erosion are relatively constant. A disadvantage is that a more active simulation of the surface zone may be needed for simulating soluble nutrients. Further testing of the model will determine this.

Groundwater transformations are performed in the model in the same manner as described in the previous report. The reactions are still based on mass of nutrients per area. The total groundwater is not simulated, and the depth and bulk density of the groundwater zone are not typically known. So it was considered undesirable to change the basis for groundwater transformations. A highly sophisticated model is needed to accurately simulate groundwater movement, transport, and transformations of chemicals.

Plant Uptake

Simulation of crop uptake of nutrients is important to soil nutrient simulation since it usually removes more nutrients from the soil system than any other process. To improve the ARM nutrient model, crop uptake was changed from being based on crop cover to being based on a user-specified uptake factor. Uptake by the crop was based on the monthly fraction of the cover which is an input factor. The previous algorithm was:

$$KPL = KPL_{max} * COVER \tag{8.1}$$

where KPL = plant uptake reaction rate, day^{-1}
$COVER$ = crop canopy fraction for the watershed
KPL_{max} = maximum rate of plant uptake, day^{-1}

However, further analysis of nitrogen uptake curves, such as those of Viets (1965), show uptake to occur most during periods of rapid growth and not when the crop canopy was fullest. Hence, to improve plant uptake simulation an input factor of monthly uptake was introduced. Separate monthly uptake factors for the lower zone and upper layers (surface and upper zones) were added to the model. These factors work basically the same as the COVER factor. The new algorithm is:

$$KPL = KPL_{max} * UPTK \tag{8.2}$$

where UPTK = average fraction of maximum uptake occurring during a month

Figure 8.1 compares the previous method (Equation 8.1) of distributing plant uptake using COVER and the new method using the uptake factor (Equation 8.2). The actual uptake is approximated from Figure 15 of Viets (1965) and from personal communication with Boyd Ellis (1976) of Michigan State University. The old method has the maximum uptake occurring in August and September when the plant is fully grown, while the new method has maximum uptake occurring in July. The major part of the uptake would come from the upper zone in June and early July and from the lower zone in late July and early August.

EVALUATING NUTRIENT REACTION RATES

Optimum nitrogen and phosphorus transformation reaction rates are input to the nutrient model. They are the main factors influencing simulation of soil nutrient storages. Each reaction rate is specified for each soil zone. These reaction rates are optimum at 35°C and above, and at lower soil temperatures the rates are reduced according to a simplified Arrhenius Equation. The procedure used for evaluating reaction rates and temperature coefficients was to search the literature for initial estimates and then adjust these values by calibration on observed soil storage and runoff data.

The most comprehensive literature found applicable to field conditions was that of Stanford and Smith (1972). They determined nitrogen mineralization rate constants for 39 widely differing soils. The mineralization rates did not significantly differ among the soils. These rates were based on mineralizable N, so an estimate of the mineralizable N in the soil was made as a fraction of Total N. Rather than change the input storage values to potentially mineralizable N, the literature rates were lowered by the mineralizable N estimate. These rates for each watershed tested were used for mineralization of both organic nitrogen (KAM) and phosphorus (KM). They were considered the most reliable rates and were not changed during the calibration process. These are also net mineralization rates so immobilization rates were set to zero.

Other literature (Mirsa, et al., 1974; Starr, et al., 1974; Mehran and Tanji, 1974) was not nearly as comprehensive for field conditions, but was useful in determining initial rate values and relative magnitudes. Reaction rates obtained for particular soils gave indications of the magnitude of initial nitrification rates (K1) and NH_4 exchange (KSA and KSA). The cation exchange capacity also provided an estimate of the extent of NH_4 adsorption.

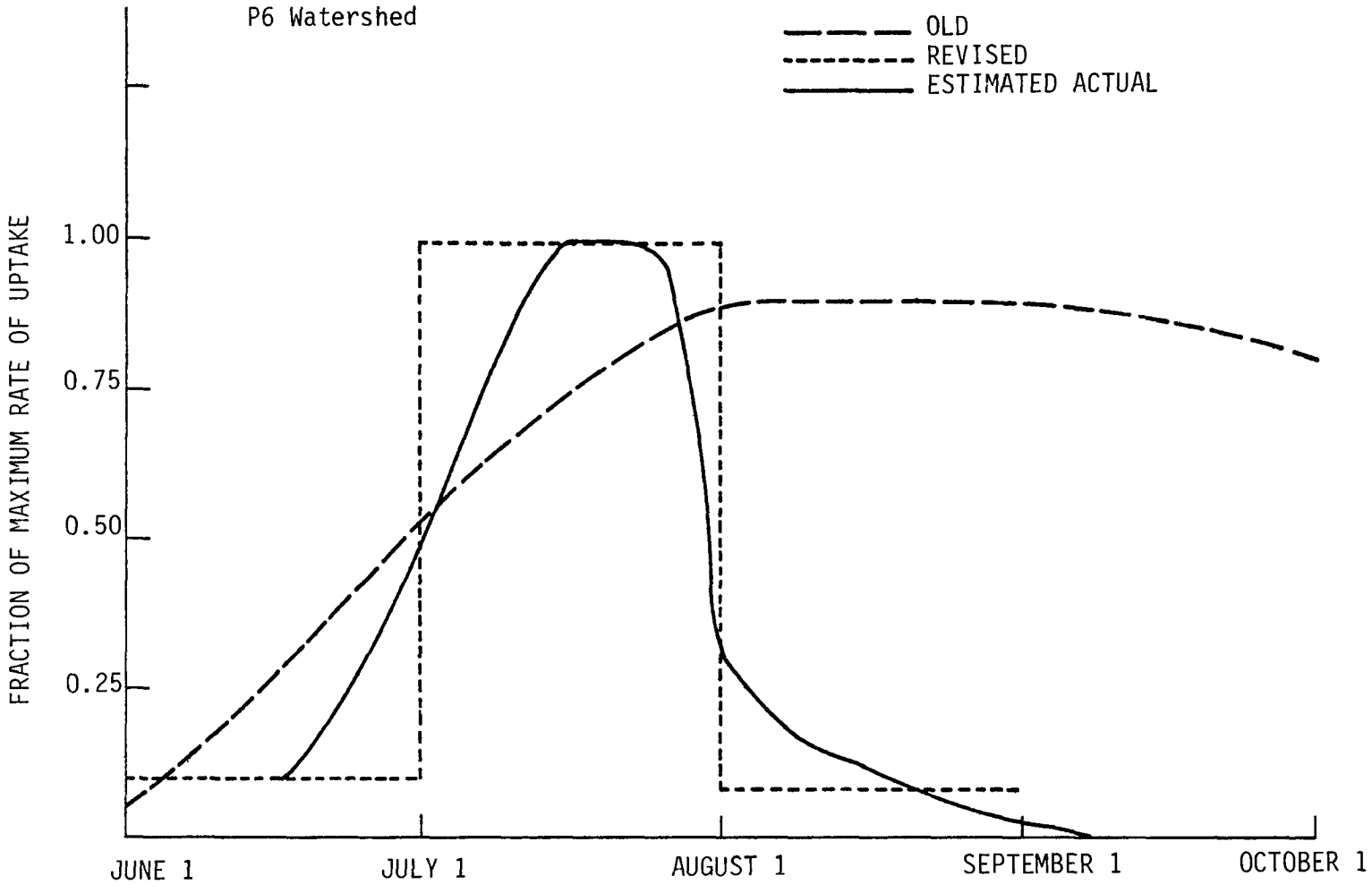


Figure 8.1 Comparison of plant uptake functions

Research done by nutrient modelers at the University of Florida also provided information on the magnitude and sensitivity of reaction rates (Rao, et al., 1976a; Mansell, et al., 1976).

Quantitative relationships for the effect of temperature on nitrogen transformations were more prevalent in the literature. The temperature relationship for nitrification and denitrification was obtained from the modeling work of Hagin and Amberger (1974). The mineralization rate temperature coefficient was determined from data of Stanford, et al. (1973) and compared with Hagin and Amberger (1974). The plant uptake rate temperature coefficient was determined from data of Van Den Honert and Hooymans (1955). The adsorption/desorption rates coefficient values were estimated from the other values and soil water viscosity. The corresponding nitrogen coefficients were also used for phosphorus.

The same temperature coefficients were used for each watershed and remained unchanged throughout the calibration period. However, many of the reaction rates were calibrated to the specific conditions of each test watershed. The plant uptake rate, KPL, was adjusted to obtain desired results since no rate data was found in the literature for these field conditions. KPL was adjusted to produce plant uptake in the range of values estimated for the growing season. The distribution of seasonal crop uptake was estimated from observed data of plant growth and distributed by the inputted monthly fraction of maximum uptake. The month with the most growth was assumed to have the maximum uptake occurring at the input optimum rates; thus, that monthly uptake factor was 1.0. The values used are in Table 8.3. Different values were used each year of simulation due to different crop growth rates.

The observed soil nutrient storages and nutrient runoff values were used to calibrate the less certain reaction rates. The proportion of NH_4 to NO_3 was directly regulated by K1, as well as indirectly by KSA and KAS. Particular attention was given to the upper and surface zone rates since these zones have a greater effect on the simulated nutrients in the runoff from the small test watersheds. Small values of KD were introduced to lower the excess simulated nitrogen in the soil after the desired plant uptake amount was satisfied. Broadbent and Clark (1965) estimated 10 to 15 percent of the annual mineral nitrogen input to agricultural areas is lost by denitrification. PO_4 exchange rates KSA and KAS were estimated from the amounts observed in the runoff.

Table 8.4 contains the reaction rates used in the test watersheds. These values were calibrated on the runoff results as well on soil storage values, so they may not be directly applicable to pure soil transformation studies. However, they are generally within the range of such values in the literature. Since the surface zone transformations occur only during storm events the rate values should be evaluated with that taken into account. The surface exchange and mineralization rates were adjusted to produce the simulated amounts of NH_4 and PO_4 in the runoff.

TABLE 8.3 FRACTION OF MAXIMUM MONTHLY PLANT UPTAKE OF NUTRIENTS USED IN THE MODEL FOR THE P2 AND P6 WATERSHEDS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
P2 Watershed												
1974												
Upper layers	.20	.20	.20	.20	.15	.75	.20	.07	0	0	.20	.20
Lower zone	.20	.20	.20	.20	.03	.55	.45	.10	0	0	.20	.20
1975												
Upper layers	.20	.20	.20	.20	0	.90	1.0	.05	0	0	.20	.20
Lower zone	.20	.20	.20	.20	0	.80	1.0	.10	0	0	.20	.20
P6 Watershed												
1974												
Upper layers	0	0	0	0	0	.09	1.0	.06	0	0	0	0
Lower zone	0	0	0	0	0	.01	1.0	.125	0	0	0	0
1975												
Upper layers	0	0	0	0	0	1.0	.50	.05	0	0	0	0
Lower zone	0	0	0	0	0	.30	.75	.055	0	0	0	0

TABLE 8.4 NUTRIENT REACTION RATES FOR THE P2 AND P6 WATERSHEDS

P2 WATERSHED

Nitrogen Rates (day^{-1})	K1	K2	KPL	KAM	KIM	KKIM	KSA	KAS
Surface	1.000	.0000	.1000	.0000	.0000	.0000	1.0000	.2000
Upper Zone	.2000	.0060	.1300	.0020	.0000	.0000	1.0000	.2500
Lower Zone	.1000	.0020	.0250	.0020	.0000	.0000	1.0000	.2000
Groundwater	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.050	1.070	1.070	1.070	1.070	1.070	1.050	1.050

Phosphorus Rates (day^{-1})	KM	KIM	KPL	KSA	KAS
Surface	.0200	.0000	.0100	1.0000	.0150
Upper Zone	.0020	.0000	.7000	1.0000	.0015
Lower Zone	.0020	.0000	.8000	1.0000	.0050
Groundwater	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.070	1.070	1.070	1.050	1.050

P6 WATERSHED

Nitrogen Rates (day^{-1})	K1	KD	KPL	KAM	KIM	KKIM	KSA	KAS
Surface	3.000	.0000	.2500	.0150	.0000	.0000	5.000	.7500
Upper Zone	1.2500	.0500	.4000	.0015	.0000	.0000	.7500	.3000
Lower Zone	.7000	.0000	.0900	.0015	.0000	.0000	1.0000	.4000
Groundwater	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.050	1.070	1.070	1.070	1.070	1.070	1.050	1.050

Phosphorus Rates (day^{-1})	KM	KIM	KPL	KSA	KAS
Surface	.0150	.0000	.0100	1.0000	.0100
Upper Zone	.0015	.0000	2.1000	.5000	.0060
Lower Zone	.0015	.0000	1.7000	.5000	.0050
Groundwater	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.070	1.070	1.070	1.050	1.050

SOIL NUTRIENT SIMULATION RESULTS

The reaction rates in Table 8.4 were used in the simulation of soil nutrient storages. The nutrients stored in the surface and upper zones are the primary sources of nutrients in surface runoff (Section 11). The soil storage results for the P2 watershed are presented in Figures 8.2 and 8.3. Figure 8.2 contains the surface zone and upper zone soil storages of total Kjeldahl nitrogen (TKN = ORGANIC N + NH_4-N) and NO_3-N. The observed values are calculated from composite areal samples taken from the surface to 7.5 cm depth. They correspond to the simulated surface zone plus upper zone results. The surface zone results are for the top 3.2 mm. Due to the shallowness of this zone no observed values were taken or estimated. Figure 8.3 provides the corresponding lower zone soil storages. The observed values are also from composite areal and depth samples for 7.5 cm to 190 cm. The 152 cm to 190 cm component of these observed values was estimated. Figure 8.4 gives merely the simulated solution PO_4-P and Organic P results since no observed data was available. On the P2 watershed, a single set of reaction rates was calibrated for both the 1974 and 1975 growing seasons.

Soils were not sampled as deeply for the P6 watershed as for P2, so only surface zone and upper zone results are presented for P6. However, more nutrient forms were analyzed. Figure 8.5 presents the NO_3-N and the Available P results while Figure 8.6 contains the NH_4 and Organic N results. The observed values again are from composite areal samples from the surface to 7.5 cm depth and correspond to the upper zone plus surface zone values. The P6 watershed was calibrated on the period of May 22, 1974 through September 30, 1974. The calibrated reaction rates were then used to simulate the 1975 growing season, June 1 through September 30; however, the soil storage, plant uptake, and the soil temperature regression constants input values were all reset. After the summer 1975 results proved satisfactory, a single run was made from May 22, 1974 through May 8, 1975. The pronounced peaks of the upper and surface zone storage of both watersheds are the result of fertilizer applications (Table 8.5). Unless NO_3 was applied directly, the NO_3 peak rose slowly after the fertilizer NH_4 had been oxidized.

The simulation of soil nutrients requires the input of initial soil nutrient storages (Table 8.6) which correspond to the starting values in Figures 8.3-8.6. The Available P values include both solution and adsorbed PO_4. The initial values for the upper zone and lower zone nutrient forms that were not analyzed were estimated from other forms analyzed, data from related soil series in the area, prior data analyzed from the watershed, prior fertilizer applications, or observation of runoff results. The lower zone estimates were not considered as crucial as the upper zone values since that zone does not directly influence the nutrients measured in the surface runoff from these small test watersheds. However, the initial surface zone values are critical to the nutrients simulated on the sediment, namely the organic and adsorbed forms of nitrogen and phosphorus. These values were obtained by averaging the observed concentration on the runoff sediment.

The other major nutrient storage value is that of plant uptake and storage. Corn (Zea mays L.) was planted both years on both watersheds. The crop

TABLE 8.5 N AND P FERTILIZER APPLICATIONS

WATERSHED	DATE	FORM APPLIED	N (kg/ha)	P (kg/ha)	MEANS OF APPLYING
P2	4-29-74	sulphate of ammonia	38	33	incorporated pellets
	6-11-74	50% urea, 50% ammonia	101	-	spray, sidedressed
	4-24-75	ammonium nitrate, superphosphate	22	21	incorporated pellets
	6-25-75	50% urea, 50% ammonia	112	-	spray, sidedressed
P6	5-20-74	ammonium nitrate, monocalcium phosphate	68*	93*	incorporated pellets
	7-8-74	ammonium nitrate	130*	-	sidedressed
	11-7-74	ammonium nitrate	130*	-	no incorporation, pellets broadcasted
	5-16-75	ammonium nitrate, monocalcium phosphate	68*	131	incorporated pellets
	6-25-75	ammonium nitrate	64*	-	sidedressed

* delivered application rate

TABLE 8.6 INITIAL SOIL STORAGES AND BULK DENSITIES

WATERSHED and DATE	ZONE	BULK DENSITY g/cm	ORG-N	NH_4-N (sol)	NH_4-N (ads)	NO_3	ORG-P (sol)	PO_4-P (sol)	PO_4-P (ads)
			kg/ha						
P2 5-1-74	surface	1.6	100.9	2.24	22.42	2.24	13.45	1.12	40.35
	upper	1.6	420.3	4.48	44.84	3.36	112.1	0.39	341.8
	lower	1.6	2802.	6.73	22.42	237.6	896.6	1.12	151.3
P2 6-10-75	surface	1.6	22.42	0.22	6.16	0.57	23.54	0.0	44.83
	upper	1.6	479.7	4.48	48.83	13.20	112.1	0.34	336.2
	lower	1.6	2690.	6.72	22.42	213.0	896.6	40.35	112.1
P6 5-22-75	surface	1.02	76.2	0.45	1.12	2.19	30.3	0.10	7.44
	upper	1.16	571.6	8.97	22.98	30.71	196.1	14.90	113.5
	lower	1.59	2339.	10.09	25.78	112.1	1121.	30.0	270.7
P6 6-1-75	surface	1.02	77.3	0.22	1.02	0.34	45.95	1.46	2.91
	upper	1.16	493.2	4.81	11.21	22.30	246.6	1.52	125.1
	lower	1.59	1667.8	22.4	56.04	170.4	896.6	22.42	224.2

notes: sol - solution form
ads - adsorbed form

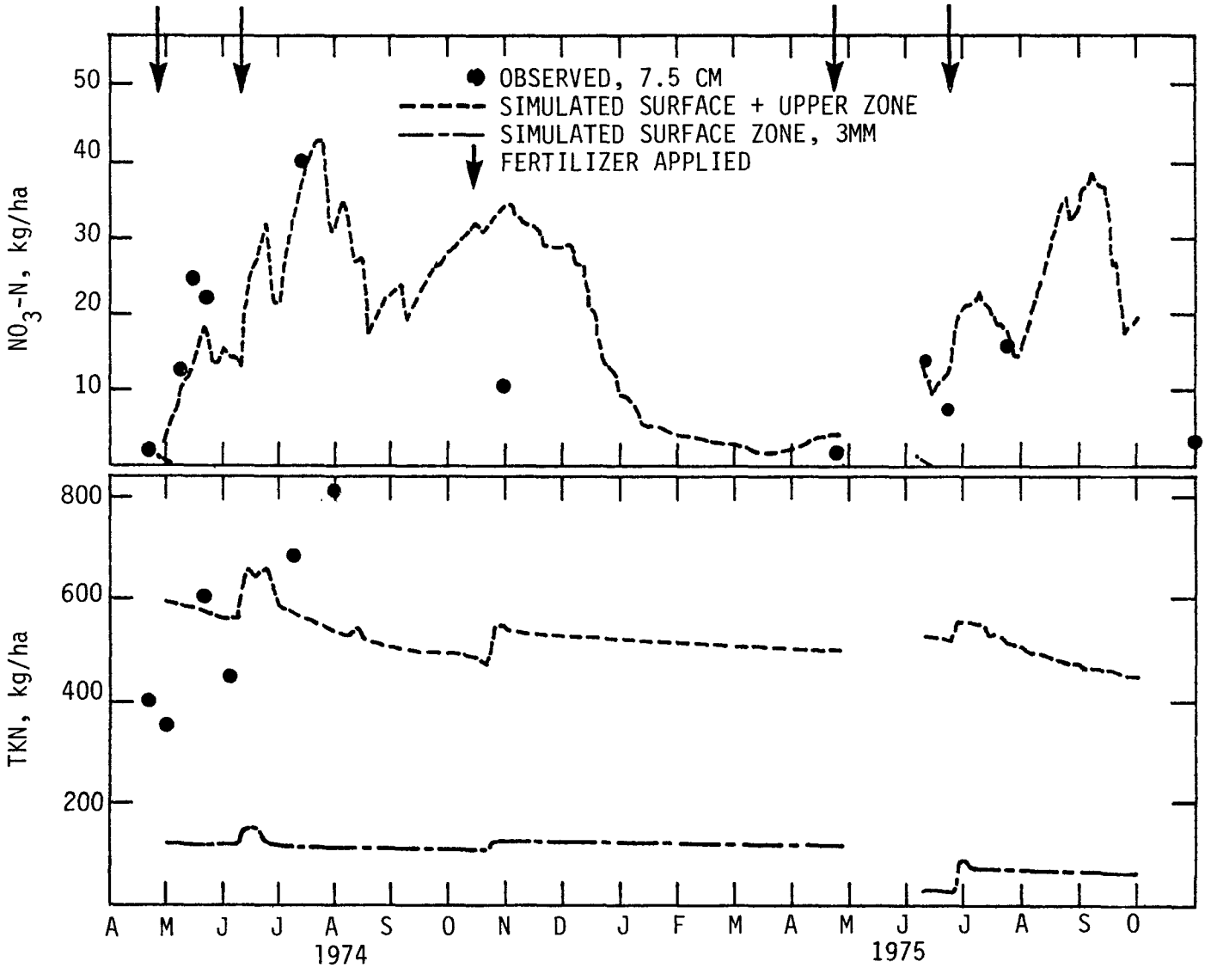


Figure 8.2 NO_3 and TKN in surface and upper zone storage on the P2 watershed

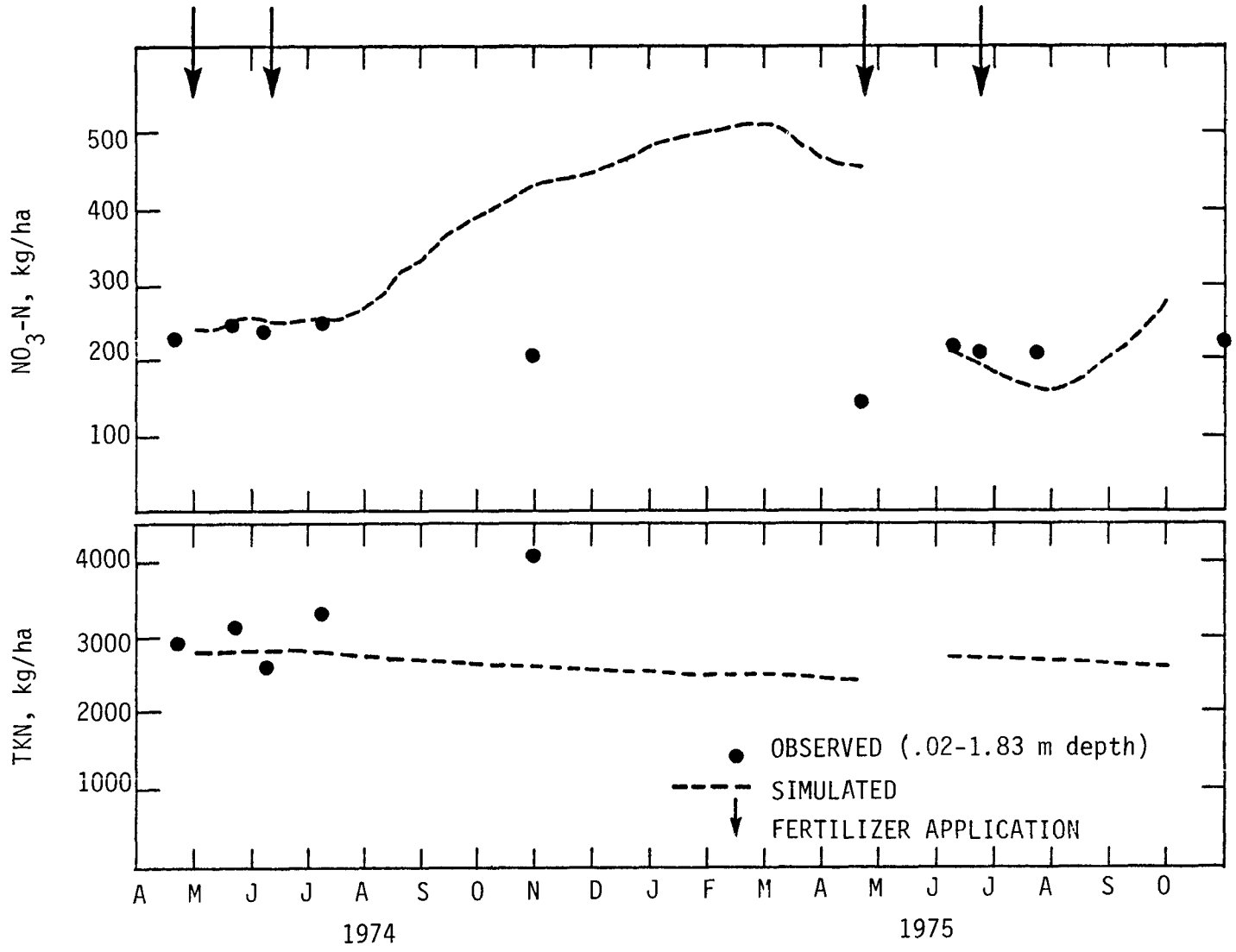


Figure 8.3 NO_3 and TKN in lower zone storage on the P2 watershed

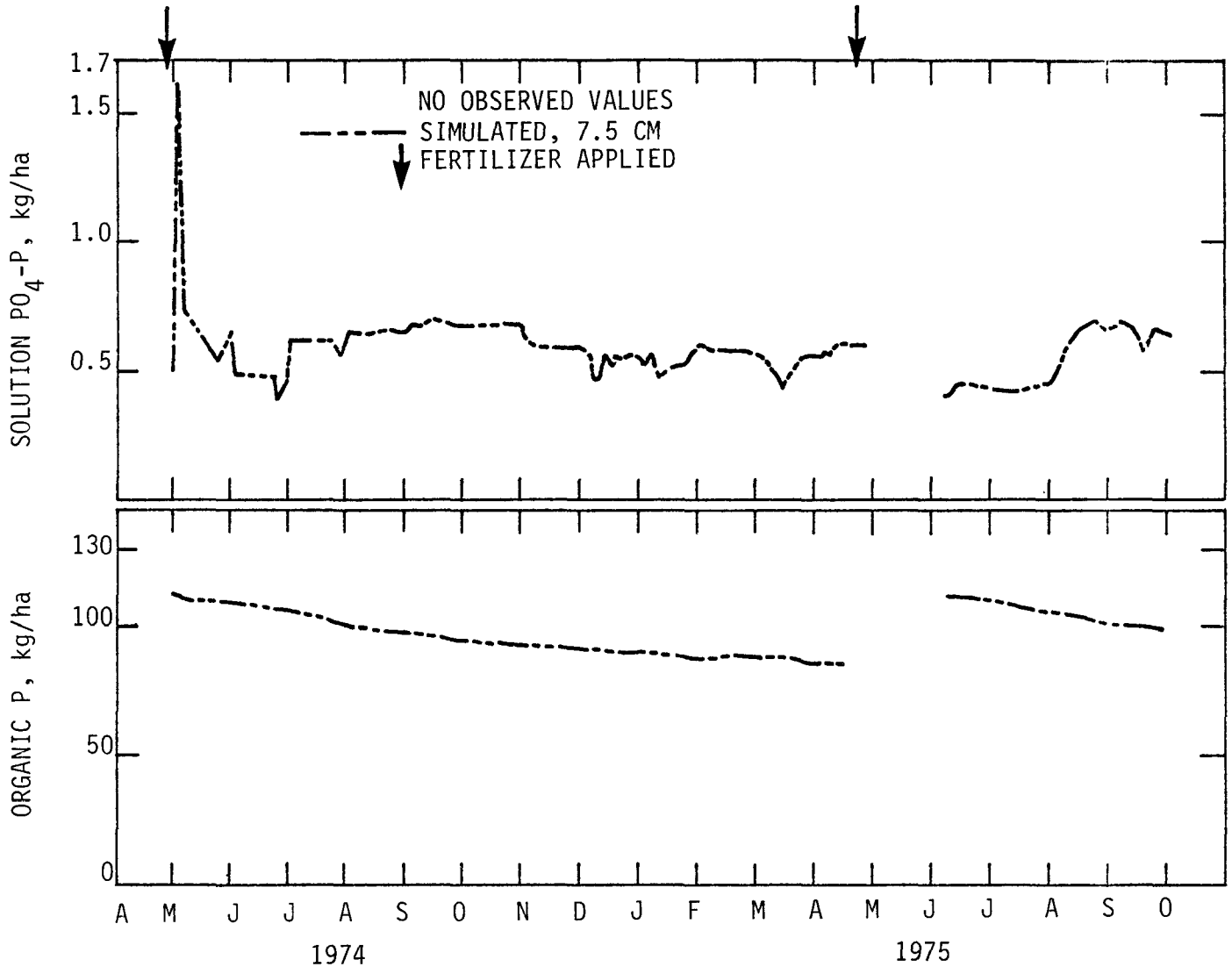


Figure 8.4 PO_4 and organic P in upper zone storage on the P2 watershed

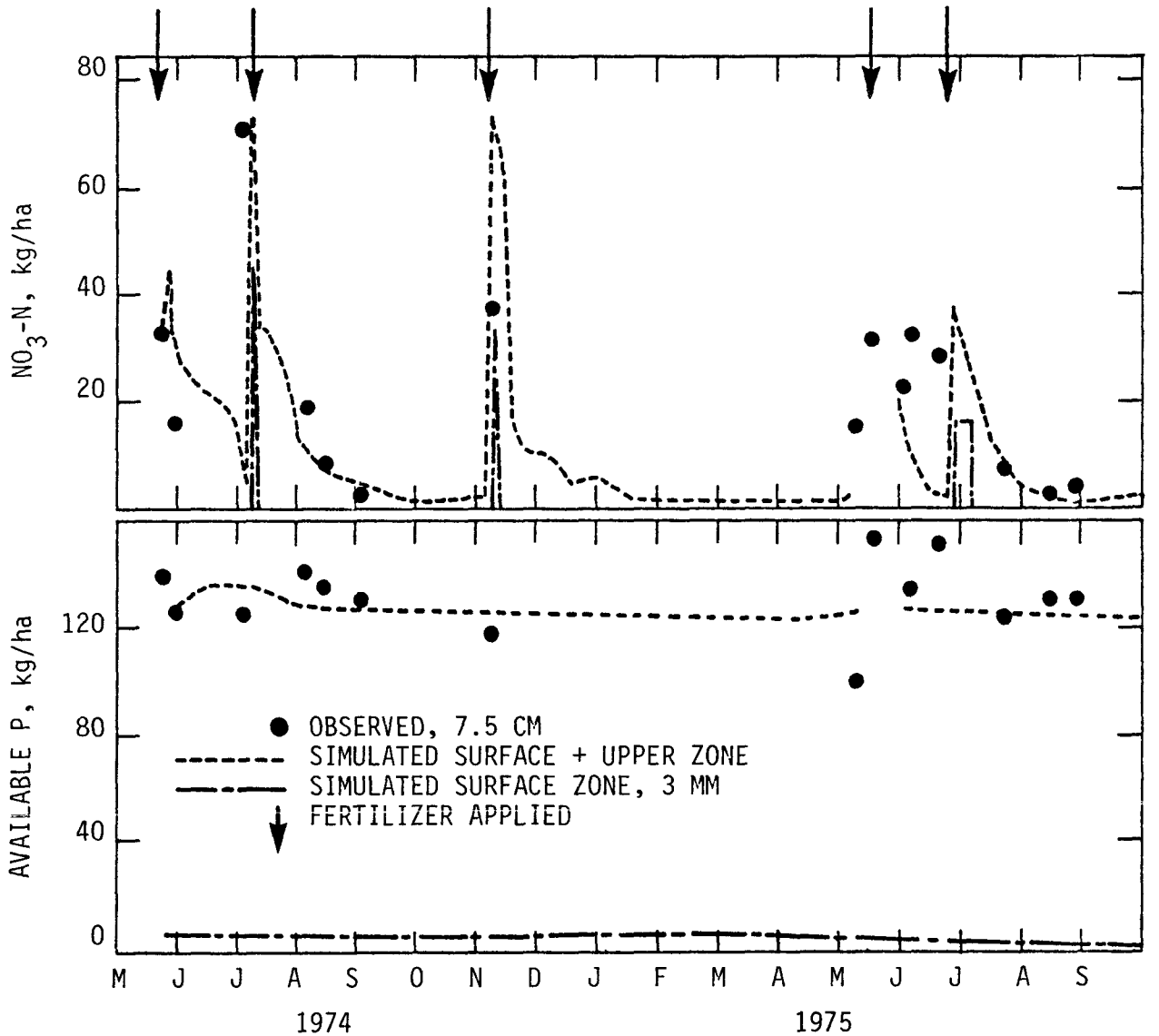


Figure 8.5 NO_3 and available P in surface and upper zone storage on the P6 watershed

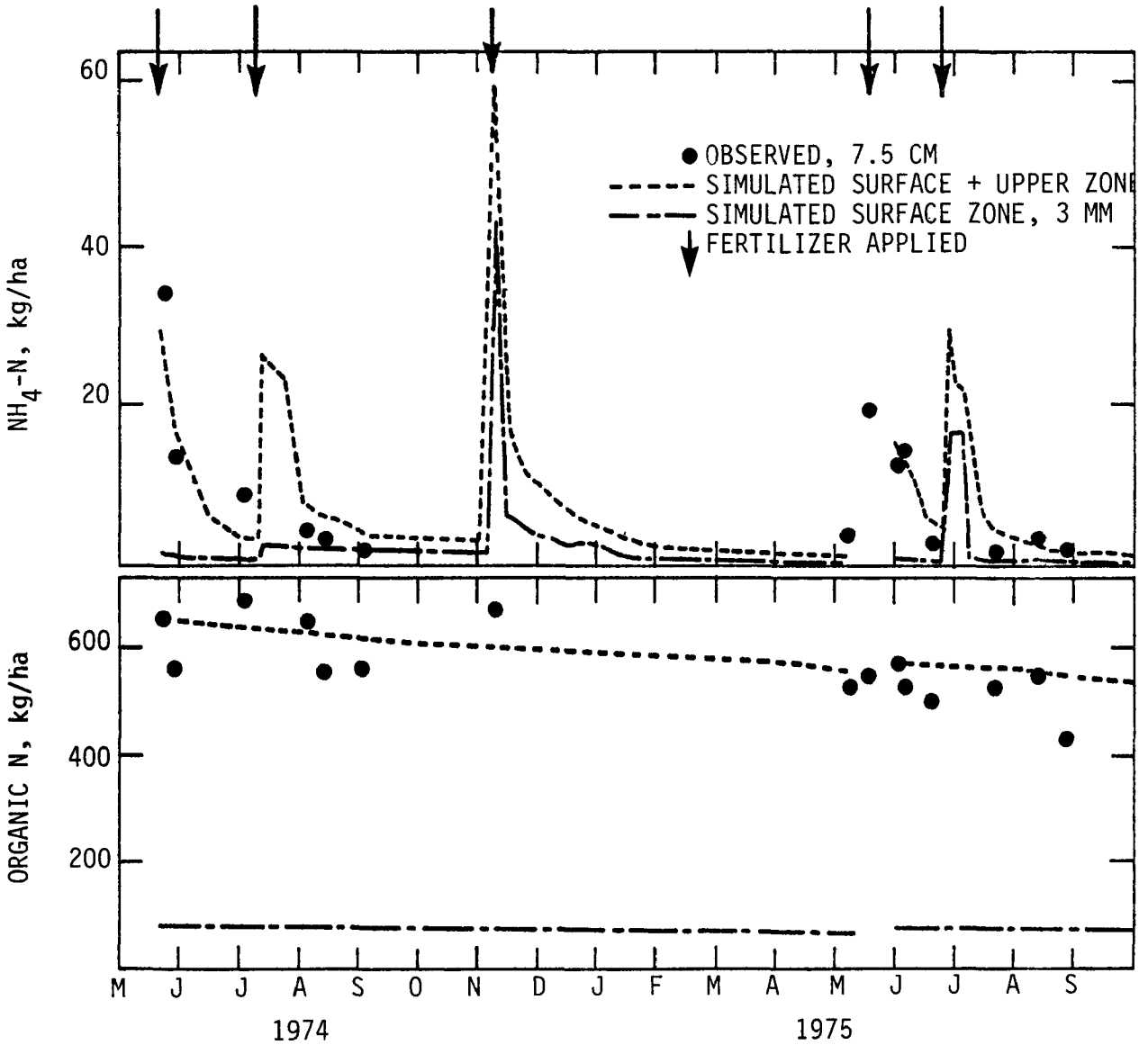


Figure 8.6 NH_4 and organic N in surface and upper zone storage on the P6 watershed

uptake simulation results are shown in Figure 8.7; no observed values were available. The planting dates are given in Table 5.2. In 1974, the P2 watershed crop uptake was limited by lack of moisture during the early growing season, so the 1974 uptake was simulated lower than 1975. The P6 watershed growing conditions were better than P2, so more nutrients were considered removed by the corn.

In general the simulation of the soil nutrient storages by the ARM Model is reasonably within the expected range of the observed values, especially since the observed values are an average that may vary 10-20 percent from the actual value. Hubbard (1975) calculated a standard deviation of 11.32 ppm about a mean of 113.95 ppm for 1974 Available P in the top 15 cm of the P6 watershed. Organic N and Organic P will vary even more. In addition, localized concentrations of fertilizer after application will increase the varibility of the samples. Therefore, considering the assumed variability of the observed values, the simulation results are good, with the exception of NO_3.

The P6 early July 1974 and June 1975 upper zone NO_3 simulation values are much lower than the observed values. Since the simulated NH_4 values are reasonable, the low NO_3 values are probably due to too little NH_4 being oxidized. Hubbard (1975) believed that the higher observed NO_3 values in the early July 1974 period are due to upward migration. The Cl concentration is also higher in the upper zone during that period. Since Cl does not undergo transformation, it is reasonable to assume both the NO_3 and Cl migrated upward during early July 1974 and June 1975. The ARM Model does not account for upward migration of pollutants so the simulation during these periods is lower. However, NO_3 in the runoff was over simulated during these periods, so an under simulation of the soil storage did not affect the simulation of nutrients in the runoff.

The poor NO_3 simulation in the fall and winter for both watersheds for each zone is partially caused by the poor temperature simulation. The regression equations that generate summer soil temperatures over simulate the fall and winter temperatures. The over simulation of these temperatures resulted in more mineralization and nitrification occurring during this period, resulting in the gradual increase of NO_3 in the lower zone (Figure 8.4). The over simulation of the lower zone values for the P2 watershed may also indicate the need for more percolation of nutrients to groundwater.

The surface zone simulated values show the effect of the rapid leaching of soluble nutrients from that zone. The rapid decline of the surface zone NO_3 and NH_4 for P6 (Figures 8.5 and 8.6) show this effect. Nearly complete removal of solutes from a surface layer 3.2 mm thick would be expected.

With the exception of when NO_3 was poorly simulated, the simulation of soil nutrient forms is good and satisfactory for our purposes. The simulation of both upper and lower zone NO_3 during the 1974 growing season for P2 (Figures 8.2 and 8.3) is good. It is not until late in the season that over simulation occurs. The simulation of TKN and Organic N for both watersheds (Figures 8.2, 8.3, and 8.6) is consistently within the range of observed values. In addition, the simulation of both Organic N and P (Figures 8.4

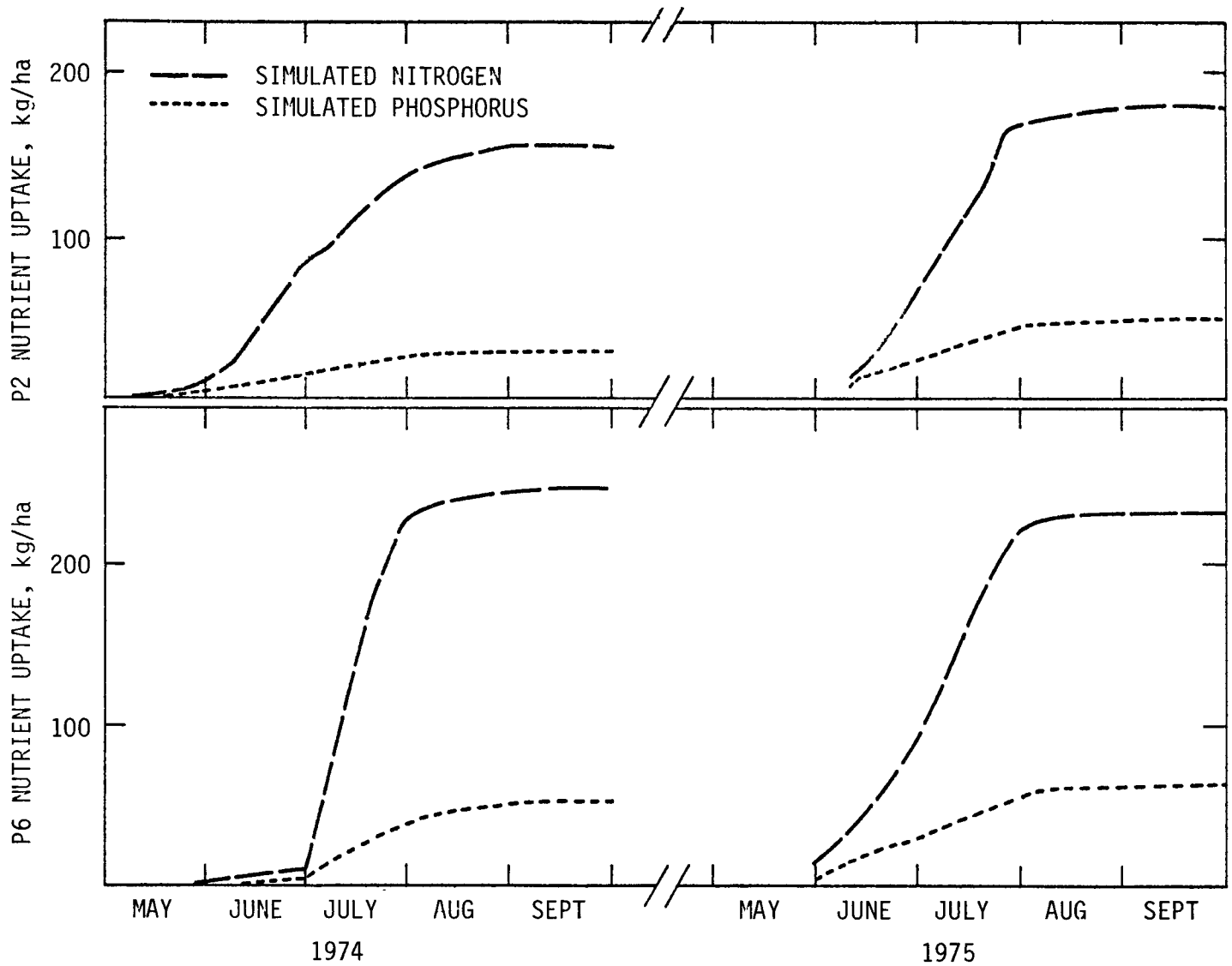


Figure 8.7 Simulated crop nutrient uptake from the P2 and P6 watersheds

and 8.6) is relatively stable as expected under actual field conditions. Likewise, Available P is within the range of observed values as well as being realistically stable. In summary, the first-order kinetic approach to soil nutrient storage simulation in the ARM Model is quite satisfactory.

The simulation of plant uptake storage also appears to be adequate. The monthly uptake factors and plant uptake reaction rates were versatile enough to produce the desired results. The crop uptake was calibrated based on observed crop growth and estimated total uptake. The distribution of the estimated total uptake was also based on the observed crop growth and was accomplished by using the monthly uptake factors.

MODEL IMPROVEMENTS AND FUTURE RESEARCH

As shown by the simulation results, the ARM nutrient model can satisfactorily represent the behavior of soil nutrient storages of most nutrient forms. Further testing of the current algorithms should be done before major changes are made. Sensitivity tests on the effect of reaction rate changes to soil storage changes under field conditions are needed. Likewise the effects of temperature changes on soil storages also need to be studied. More testing on different watershed soil and crop conditions is necessary to further evaluate the general applicability of the model. Testing and analysis of surface zone transformations and their impact on surface runoff and leaching processes is a major topic for future research. Changes should be made on the surface zone simulated behavior as indicated by future testing.

As further testing of the nutrient storage simulation is done, modifications may be needed to improve the model's applicability under varying field conditions. One of the first considerations should be to introduce the effect of moisture and oxygen content on the reaction rates. This would be needed if denitrification is significant. Also the effect of pH and carbon content may vary enough under some conditions to significantly influence reaction rates. Nitrogen fixation, ammonium uptake by plants, ammonium volatilization, and nutrients in precipitation could be introduced into the model. However, since these factors would further complicate application of the model, they should not be introduced until needed.

The simulation results and model development have uncovered specific areas where more field research is needed. For example, first-order reaction rate values applicable to field conditions are a major deficiency in the current literature. Also research is needed to develop more quantitative relationships between first-order reaction rates and various environmental factors (moisture, oxygen, pH). Most importantly, nitrogen and phosphorus uptake by different crops under field conditions needs to be described in a more quantitative manner. As this research is accomplished, the developed relationships could be incorporated into the ARM Model to allow more accurate and reliable modeling of soil nutrients.

SECTION 9

RUNOFF AND SEDIMENT SIMULATION RESULTS

The P2 and P6 watersheds were selected for simulation testing of the ARM Model because both pesticides and nutrients had been applied and then sampled in the runoff and the soil profile. Both are nonterraced watersheds and P6 is the larger of the Michigan watersheds. Also the data collected on these watersheds contained a minimum of inconsistencies and errors. This combination of requirements provided the best conditions in which to test all components of the ARM Model. Model testing for runoff and sediment loss was performed on the P2 watershed for the period of record, May 1973 through September 1975. The P6 watershed was simulated from May 1974 through September 1975. Data for the P6 watershed prior to May 1974 was questionable due to uncontrolled seepage under the outflow weir. This was corrected in April 1974.

Simulation of hydrology and sediment processes must be sufficiently accurate to allow evaluation of the pesticide and nutrient simulation results. Pesticides and nutrients are transported from the watershed either in solution in the runoff water or adsorbed onto eroded sediment paricles. Thus, pesticide and nutrient runoff results are dependent on the simulated runoff and sediment loss. Similarly, the simulated vertical movement of pesticides and nutrients in the soil profile depends on the model's representation of infiltration, percolation, and soil moisture processes.

Although the agreement between simulated and recorded runoff and sediment loss discussed below is generally good, discrepancies do exist. Some are a result of problems or errors in data collection and analysis. Such obvious errors must be considered when evaluating simulation results. Others are due to limitations of the hydrology and sediment algorithms of the model. Recommendations on how these limitations can be overcome and where additional research is necessary will be discussed at the end of this section.

P2 WATERSHED SIMULATION

A monthly volume comparison of simulated and recorded runoff on the P2 watershed (Figure 9.1) shows that the simulation of runoff is good for the important summer months. In the winter months (December through March) there is the tendency to over simulate runoff. This happens because of the new set of calibration parameter values used since the initial calibration of the Georgia watershed (the calibration parameter values can be found in Table 9.1). The major changes made were in the values of UZSN and INFIL. The input value of UZSN (upper zone nominal storage) was increased from 0.05

TABLE 9.1 INPUT FOR THE P2 AND P6 WATERSHEDS

Parameter	P2 Watershed Original	P2 Watershed Revised	P6 Watershed
Hydrology			
UZSN	0.05	0.50	0.20
LZSN	18.0	18.0	9.00
L	200.0	100.0	60.0
SS	0.025	0.025	0.06
NN	0.20	0.20	0.20
A	0.0	0.0	0.0
EPXM	0.12	0.12	0.12
PETMUL	1.0	1.0	1.0
K3			
January	0.30	0.30	0.20
February	0.30	0.30	0.20
March	0.30	0.30	0.20
April	0.40	0.40	0.20
May	0.40	0.40	0.30
June	0.50	0.50	0.30
July	0.70	0.70	0.50
August	0.80	0.80	0.45
September	0.60	0.60	0.40
October	0.50	0.50	0.30
November	0.40	0.40	0.20
December	0.30	0.30	0.20
INFIL	0.50	0.10	0.30
INTER	0.70	0.59	0.80
IRC	0.0	0.0	0.0
K24L	1.0	1.0	1.0
KK24	0.6	0.6	0.0
K24EL	0.0	0.0	0.0
KV	0.0	0.0	0.0
Snow			
RADCON			1.0
CCFAC			1.0
SCF			1.4
ELDIF			0.0
IDNS			0.14
F			0.0
DGM			0.0
WC			0.03
MPACK			1.0
EVAPSN			0.4
MELEV			892.0
TSNOW			32.0

(continued)

TABLE 9.1 (continued)

Parameter	P2 Watershed Original	P2 Watershed Revised	P6 Watershed
PETMIN			35.0
PETMAX			40.0
WMUL			1.0
RMUL			1.0
KUGI			0.0
Sediment			
COVPMO			
January	0.60	0.60	0.00
February	0.60	0.60	0.00
March	0.60	0.60	0.00
April	0.60	0.60	0.00
May	0.00	0.00	0.00
June	0.15	0.15	0.05
July	0.60	0.60	0.55
August	0.85	0.85	0.90
September	0.75	0.85	0.90
October	0.60	0.60	0.80
November	0.60	0.60	0.00
December	0.60	0.60	0.00
TIMTIL,YRTIL,SRERTL (max. of 12 events)			
	115,74,1.0	115,74,1.0	140,74,1.0
	114,75 2.0	114,75,2.0	136,75,0.8
JRER	1.90	1.90	2.2
KRER	0.08	0.08	0.15
JSER	1.30	1.70	1.40
KSER	0.25	0.50	0.50
SCMPAC	0.02	0.02	0.001
Initial Conditions			
Date	5/11/73	5/11/73	5/20/74
UZS	0.10	1.0	0.50
LZS	19.5	24.0	11.0
SGW	0.0	0.0	0.0
GWS	0.0	0.0	0.0
ICS	0.0	0.0	0.0
OFS	0.0	0.0	0.0
IFS	0.0	0.0	0.0
PACK			0.0
DEPTH			0.0
SRERI	2.0	2.0	1.0

to 0.50 while INFIL (the mean infiltration rate) was decreased from 0.50 to 0.10. These changes produced compensating effects and were necessary to achieve more reasonable soil moisture storage values for simulating vertical transport of solutes. By changing these parameters more runoff was simulated during the winter months. By lowering the value of INFIL less water could infiltrate and thus more was available for runoff. The long duration, low intensity winter storms allowed the lower INFIL value to have a pronounced effect. However, the summer runoff was not substantially changed due to the high intensity, short duration summer thunderstorms and the higher upper zone moisture storage maintained by the higher UZSN.

Actually, the revised parameters (higher UZSN, lower INFIL) do not as accurately represent the summer thunderstorms as the original parameters because of the lesser effect of INFIL on these short duration, intense storms. Moreover, it is questionable whether infiltration and subsurface characteristics can be accurately calibrated on these small watersheds. Bruce, et al. (1976) have concluded that the surface soil horizon (0-18 cm) basically determines the infiltration and resulting runoff characteristics for a major portion of a runoff event on these small Georgia watersheds. Subsurface characteristics do not effect infiltration until 30-40 minutes into an event. Consequently, the simulated impact of the summer thunderstorms is more dependent on UZSN than INFIL. The revised parameter values are a compromise between runoff and soil moisture simulation. They adequately represent the runoff for the summer months and give more reasonable soil moisture storages values. For these reasons the new set of values was selected over the old.

This conflict between hydrology parameter values best suited for surface runoff and those best for soil moisture storages has not been completely resolved. The LANDS section of the ARM Model was not originally designed to accurately simulate detailed soil moisture movement. Nor is a simple solution available. A detailed discussion of this problem is in Section 6.

Although the P2 watershed monthly simulated and recorded sediment loss (Figure 9.1) compare reasonably well, problems do exist. The 1974 recorded sediment loss is lower than the other years. In 1974 tillage and planting occurred in late April and the first major sediment producing event occurred about 60 days later. In 1973 and 1975, tillage and planting was in mid-May with the first major event about 15-20 days later. Thus, the extra lag time and intervening changes on the watershed in 1974 appears to be the major factor for the lower sediment loss.

Sediment loss as represented in the model, results from rainfall detachment of soil particles and transport of these particles or fines to the stream by surface runoff. In addition, production of soil fines by tillage operations significantly contributes to the total fines available for transport. As shown in Figure 9.1, the major sediment loss occurs within 2 to 3 months following tillage operations. Changes in crop canopy and settling and compaction of the soil surface are the major processes occurring in this intervening period that determine the sediment-producing impact of the first event following tillage. The ARM Model accepts 12 monthly crop cover values

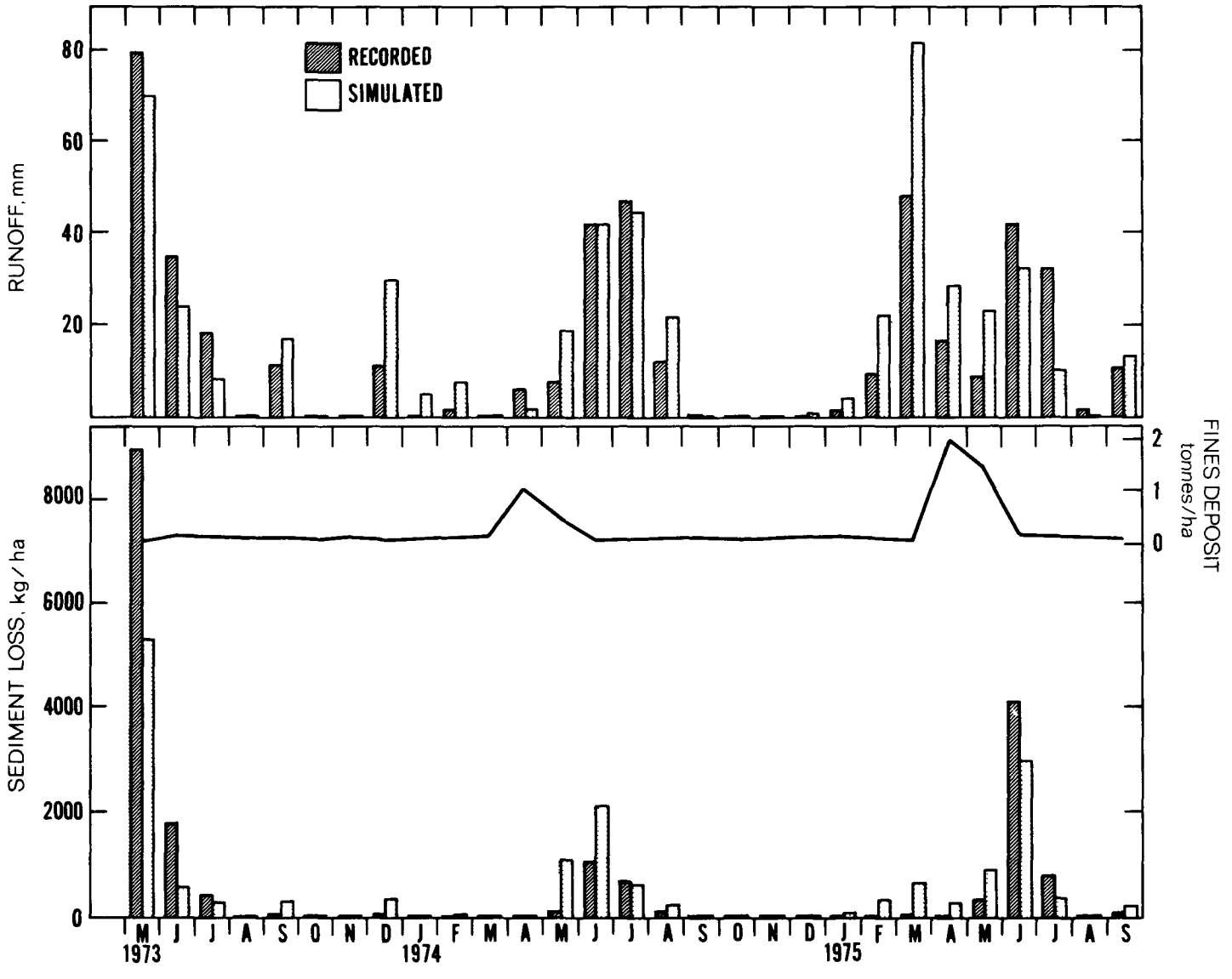


Figure 9.1 Monthly runoff and sediment loss from the P2 watershed

for the first day of each month; crop cover on any day is determined by linear interpolation. Thus for multi-year simulation runs the crop cover is the same for corresponding days in each year of the simulation. For the P2 watershed, the average cover calculated by this procedure underestimates the crop cover in 1974 and overestimates the cover in 1973 and 1975. This effect contributes to the differences in Figure 9.1. Separate calibration runs with different cover values for each year would improve the agreement between the simulated and recorded sediment loss.

To account for the settling and compaction of the soil surface following tillage, a new parameter SCMPAC has been added to the ARM Model to decrease on each nonrain day the amount of fines available for transport. SCMPAC is essentially a first-order decay parameter that reduces the soil fines storage in the following manner:

$$SRER(T) = SRER(T-1)*(1.0 - SCMPAC) \qquad (9.1)$$

where SRER(T) = soil fines storage on day T, tonnes/ha
SRER(T-1) = soil fines storage on day T-1, tonnes/ha
SCMPAC = soil compaction factor, day^{-1}

On the watershed the decrease in soil fines is due to natural settling and aggregation of particles, and compaction by rainfall and agricultural operations. These processes are complex functions of soil characteristics, meteorologic conditions and agricultural practices. The use of the SCMPAC parameter is a simple approximation of the overall impact of the above processes within the scope of this project. Future research should consider more detailed methods of representation.

A SCMPAC value of 0.02 for the P2 watershd helped to reduce the fines storage and resulting sediment loss in 1974. Even with this compaction rate the simulated sediment loss in 1974 was substantially greater than recorded. Within the limitations of the sediment model, the only remaining option was to assume that tillage operations in 1974 produced less fines than in 1973 and 1975. Thus, the sediment simulation results in Figure 9.1 are based on 2.24 tonnes/ha of fines produced by tillage in 1974 and 4.48 tonnes/ha in 1973 and 1975. This further points out the need to investigate the impact of tillage on sediment fines production.

With the above adjustments, the individual hydrographs and sediment graphs for the P2 watershed show good agreement between simulated and recorded results for the major storms during the summers of all three years (Figure 9.2-9.4). Other storm event graphs for the P2 watershed can be found in Appendix B. However, the effect of tillage in dampening the peak of the recorded hydrograph and retarding the overland flow is noticable in the storms of May 24, 1974 and June 11, 1975 (Figure 9.3 and 9.4, respectively). The hydrologic algorithms included in the ARM Model do not handle this man-made phenomenon. Thus, over simulation of early season storms is to be expected. Storms occurring later in the crop season when the soil has become compacted do not exhibit this problem. In general, an accurate runoff simulation will produce reasonable sediment simulation results on the P2 watershed. Tillage and other man-related activities (terracing, contour,

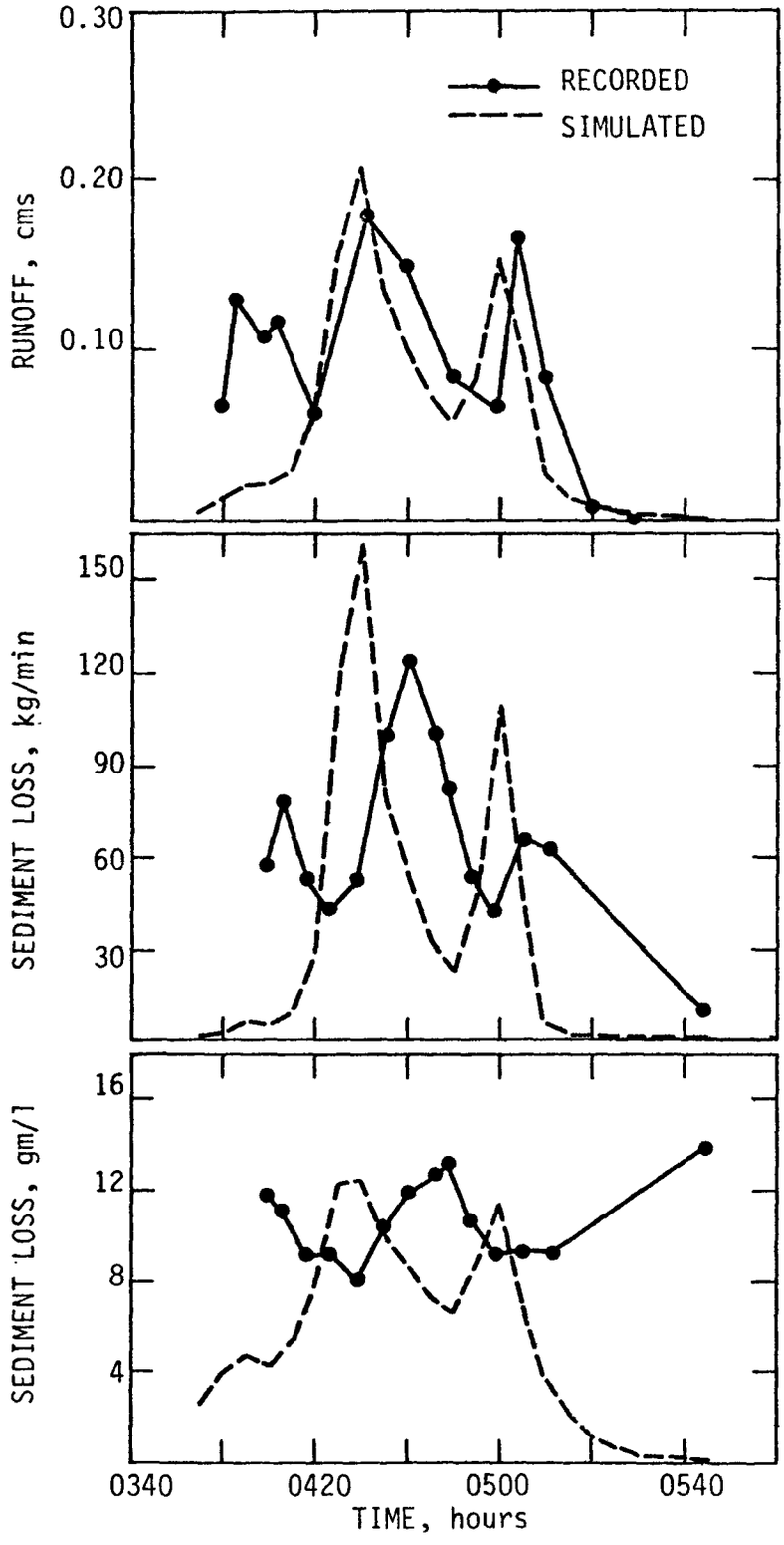


Figure 9.2 Runoff and sediment loss from the P2 watershed for the storm of May 28, 1973

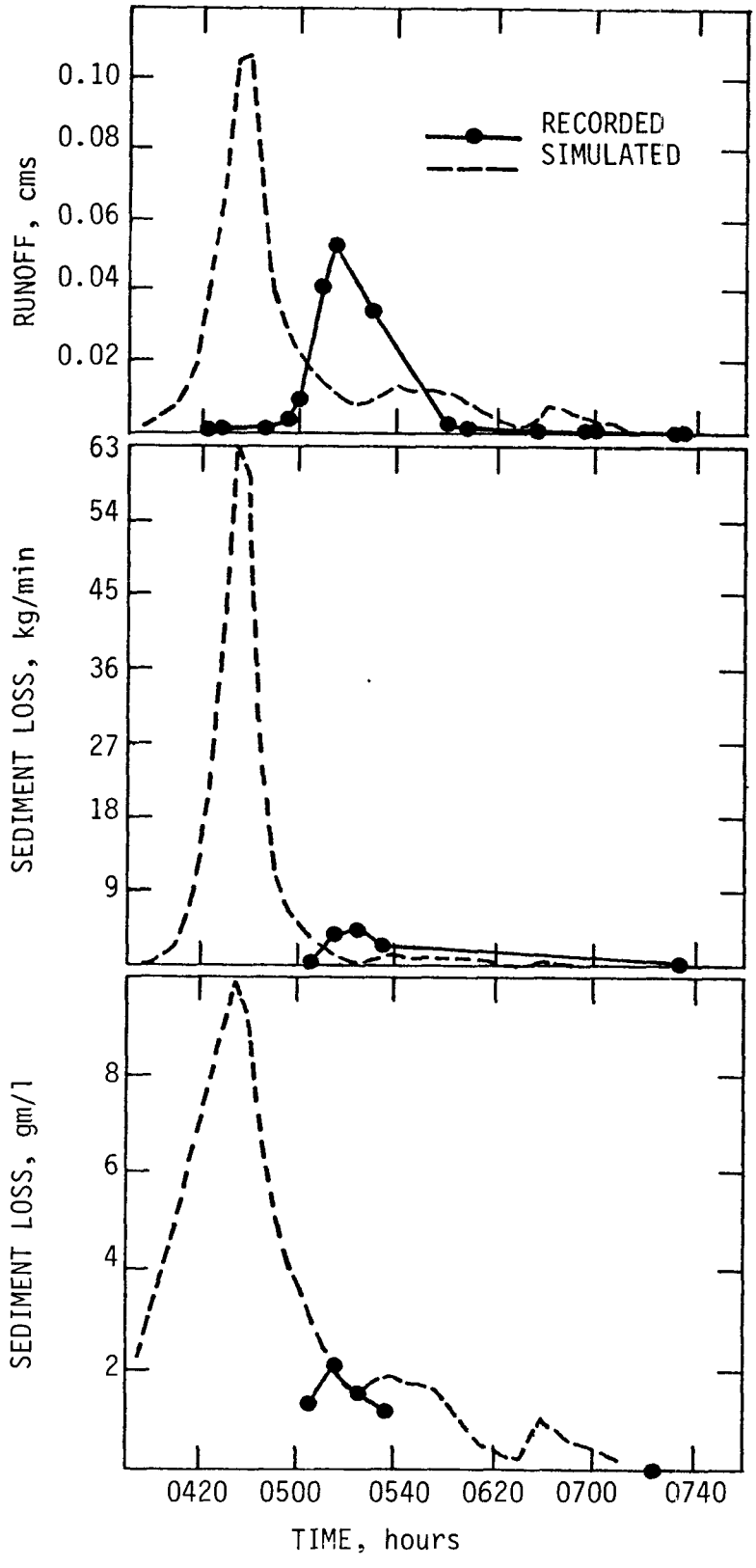


Figure 9.3 Runoff and sediment loss from the P2 watershed for the storm of May 24, 1974

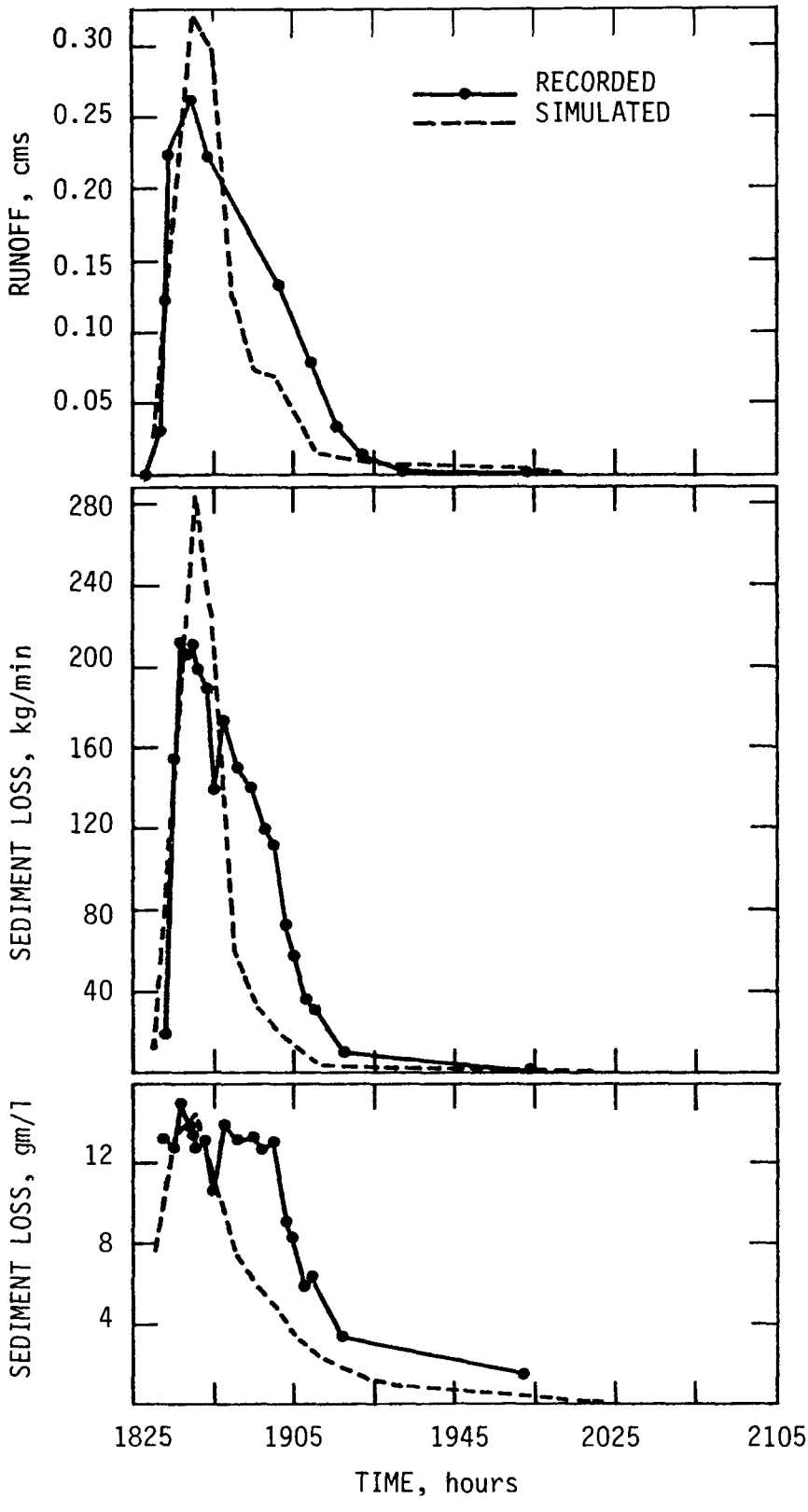


Figure 9.4 Runoff and sediment loss from the P2 watershed for the storm of June 11, 1975

planting, grass waterways, etc.) disturb the hydrologic characteristics of a watershed as stated above. Further research is needed to fully understand how these management practices affect runoff and how their influence can be incorporated into the LANDS segment of th ARM Model.

P6 WATERSHED SIMULATION

Like the P2 watershed, the monthly runoff and sediment loss simulation for the P6 watershed is generally quite good (Figures 9.5). However, problems with the simulation of snowmelt and runoff during the months of February and March 1975 are evident. These problems, which result in an under simulation of runoff during these months, are attributed to difficulties in properly simulating snowmelt. During winter periods frozen ground conditions severely decrease infiltration rates resulting in greater runoff than would otherwise occur. Also, temperature gradients in the soil profile can result in upward movement of moisture that would be available for runoff during the thaw periods.

Although the ARM Model snowmelt routine decreases infiltration for freezing conditions, the complex frozen ground processes that determine the resulting snowmelt and runoff are not adequately represented. Thus, the simulated runoff is considerably less than recorded for February and March 1975. Research is needed to better understand how this phenomenon of frozen ground can best be simulated.

Except for April 1975, monthly sediment loss on the P6 watershed compared well between the simulated and recorded results, as shown in Figure 9.5. The April discrepancy is due entirely to simulation of the April 18 storm (Figure 9.6). Runoff during this storm is simulated quite well while sediment is grossly under simulated. The low sediment concentrations for this storm are due to more sediment fines on the watershed available for transport than was simulated by the sediment algorithms. Freeze-thaw cycles during the winter could have produced fines which were washed from the watershed during this first major spring storm. Also, detachment or scour by runoff, which is not presently simulated, likely contributed to the high recorded sediment concentrations especially with the saturated surface soil conditions existing on the watershed. Detachment by runoff is a significant mechanism to some degree on most watersheds. Its incorporation and simulation in the ARM Model would allow better representation of the highly variable nature of erosion, and should be the next major improvement to the sediment algorithms.

Except for the April 1975 storm the simulated and recorded runoff and sediment loss (Figures 9.6 and 9.7 and Appendix C) for individual storm events is generally quite good. However, some events (not included) exhibit a problem with the areal variation in rainfall. The two adjoining watersheds, P6 and P7, are a good example of how areal rainfall variation can make simulation difficult. One raingage was used for both watersheds. Runoff from each watershed was measured separately. The runoff record from P7 is different from the neighboring P6 watershed. The model assumes that the recorded rainfall falls uniformly over the entire area, and produces runoff in response to this uniform rainfall. But in fact thunderstorm

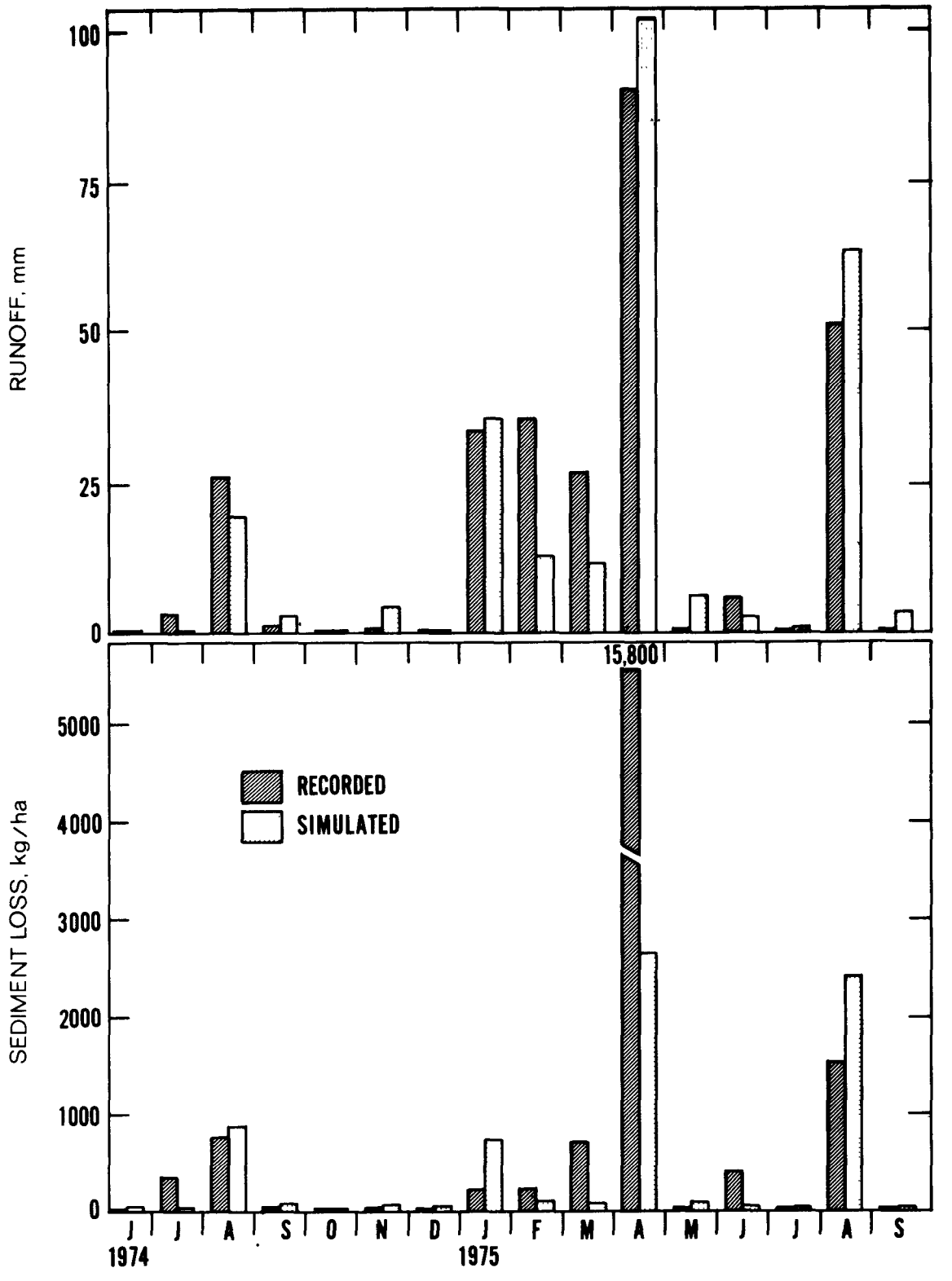


Figure 9.5 Monthly runoff and sediment loss from the P6 watershed

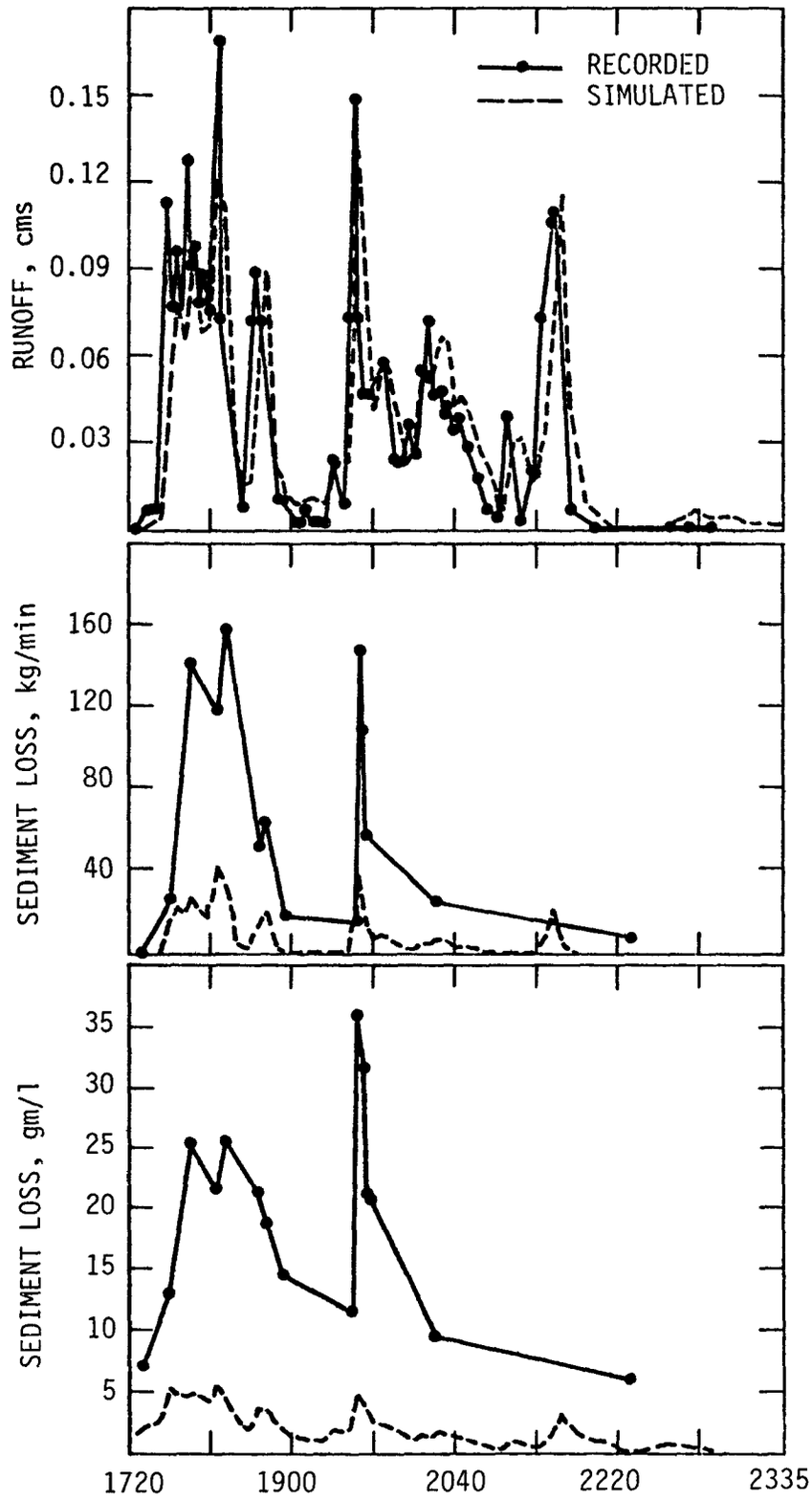


Figure 9.6 Runoff and sediment loss from the P6 watershed for the storm of April 18, 1975

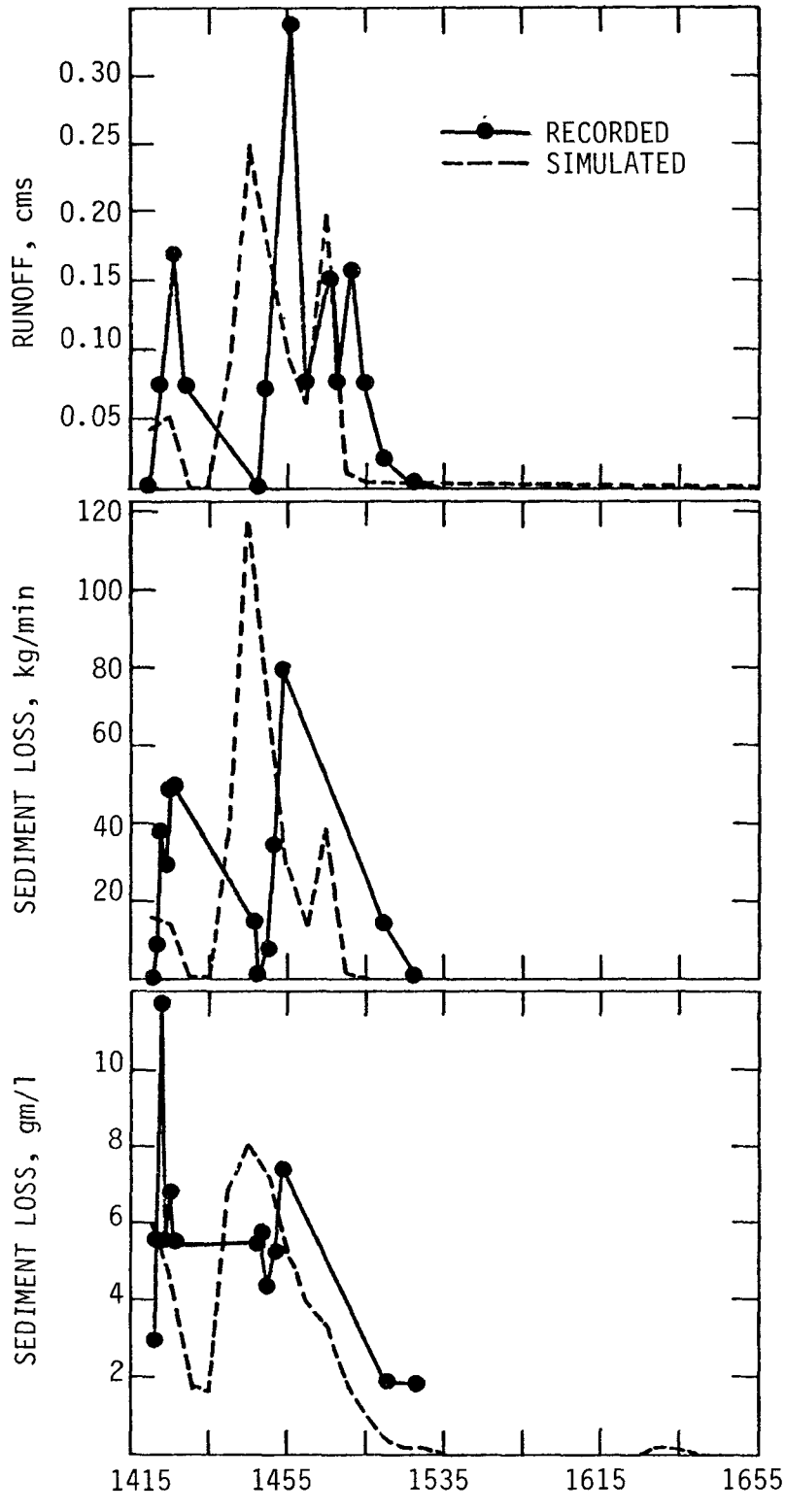


Figure 9.7 Runoff and sediment loss from the P6 watershed for the storm of August 20, 1975

rainfall, typically seen in the summer at the watershed sites, is not uniform but intense and localized. Consequently, the accuracy of the simulation decreases as the amount of areal variability of the rainfall increases. An understanding of this potential problem is vital in reviewing the runoff and sediment loss results of the P6 watershed.

A discussion of the runoff and sediment loss simulation is not complete without mention of mass removal and concentration graphs when viewing sediment loss results. Concentration (measured in mg/l) fluctuates according to the amount of runoff water available. It is an indication of the importance of the possible pollutant (in this case sediment) in the waterway and directly influences the quality of the receiving waters. This type of measurement is important in streams containing water year-round, as the organisms in the streams are sensitive to changes in concentrations of pollutants and particularly toxic substances. However, the streams in the P2 and P6 watersheds exist only during storm events. They receive no groundwater and therefore are simply dry waterways when surface runoff and interflow are not occurring. In cases like these, mass removal (kg/minute) is a better indicator of the effects of watershed management and the pollutant loss expected from different events and practices. Mass removal also shows a direct connection between the pollutant loss and its transport mechanism, runoff. Thus, it is a good indication of the ability to simulate the combined runoff-sediment loss process.

SUMMARY

A review of the simulation results of runoff and sediment loss on the P2 and P6 watersheds shows that they are reasonable and can be used to evaluate pesticide and nutrient runoff simulation. Problems that are present in the results have been isolated and discussed. Some (e.g., areal variability of rainfall) cannot be corrected without major additions to the ARM Model and the data collection procedures. Other problems can be solved with further research and development of simulation methods. Detachment of soil fines by runoff can and should be included in the model. The development of such algorithms should be a major priority in future research. Simulation of all the erosion processes by particle size should be investigated to evaluate the potential benefits for the simulation of sediment, pesticide, and nutrient transport as a function of particle size. Such work would be especially beneficial to coupling the ARM Model to a stream transport model to simulate sediment and attached pollutant movement throughout a watershed.

Research is also necessary for a more complete modeling of the effects of agricultural management practices on both runoff and sediment loss. Parameter changes that reflect different agricultural activities need to be quantified. In addition, parameters that are directly affected by these activites may need monthly or seasonal values. This has been done for crop cover (COVPMO) and index to actual evaporation (K3) in the current version of the model. Investigation of seasonal variations for nominal upper zone storage (UZSN) and infiltration (INFIL) should be undertaken.

SECTION 10

PESTICIDE RUNOFF SIMULATION RESULTS

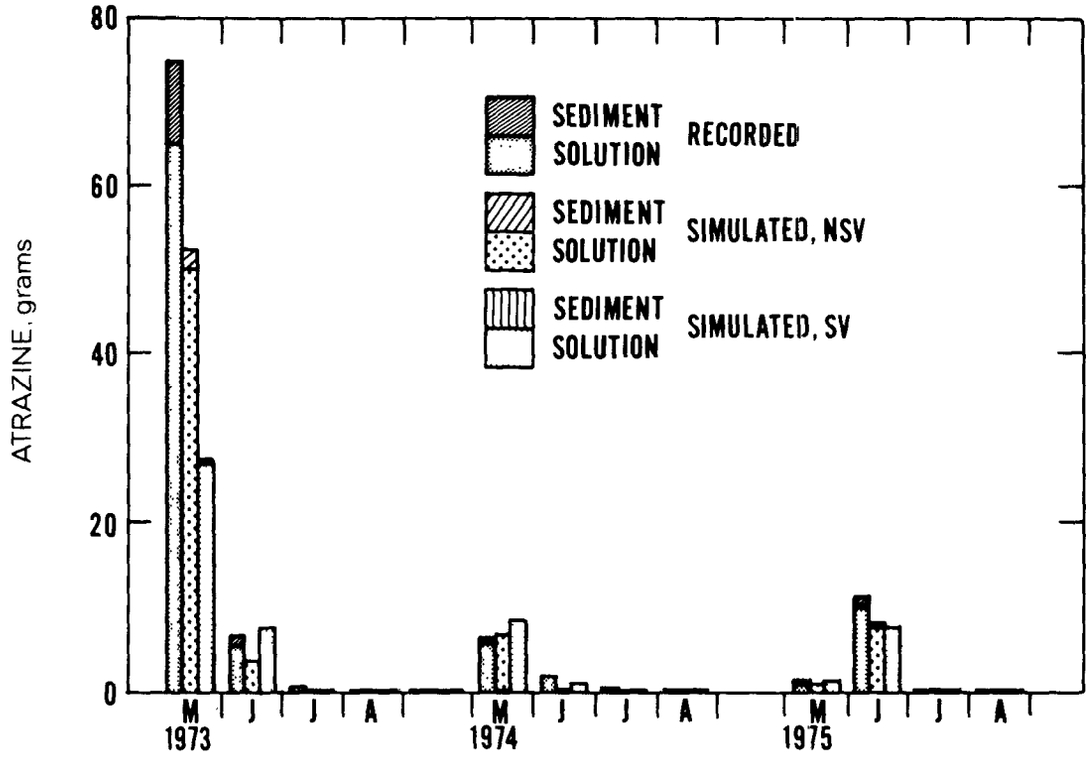
The pesticides paraquat (1,1'-dimethyl -4,4-bipyridinium ion) and atrazine (2 - chloro-4-ethylamino-6-isopropylamino-s-triazine) were applied to both the P2 and P6 watersheds during the 1973-1975 growing seasons. These pesticides have been simulated by the ARM Model and the amount of pesticide runoff compared with recorded data. This section discusses the pesticide simulation results and the problems encountered along with conclusions and recommendations related to pesticide simulation.

Paraquat is a highly ionic herbicide that rapidly and irreversibly adsorbs onto sediment particles. Thus, the amount of paraquat washed off a watershed is directly related to the amount of sediment eroded. By comparison, atrazine both dissolves in water (35 ppm) and adsorbs on sediment. Thus, the study of atrazine allows the comparison of the single-valued (SV) and nonsingle-valued (NSV) adsorption/desorption pesticide functions. Evaluation of these functions is important as the majority of pesticides are transported by both runoff and sediment. The division between the water and sediment phase is critical to the evaluation of the potential pollutional impact of different pesticides. Highly soluble pesticides will infiltrate deeper into the soil profile than less soluble ones. Soluble pesticides will be affected by practices reducing runoff while soil erosion control will limit the wash off of pesticides transported on sediment particles. Thus, determining the ability of the SV and NSV algorithms to correctly divide a pesticide between its adsorbed and solution phase coupled with an accurate degradation approach is essential to a good simulation of pesticide runoff.

MONTHLY SIMULATION RESULTS

The comparison of monthly simulated and recorded runoff amounts of paraquat on the P2 watershed (Figure 10.1 and Table 10.1) is good. Paraquat, as noted above, is not found in solution and, therefore, is dependent on eroded sediment as its transport mechanism. Paraquat simulation is high compared to the recorded data in May and June, 1974. A review of the P2 sediment loss simulation will show that these months are over simulated for sediment loss. Thus, a better simulation of sediment removed on the P2 watershed will result in closer agreement between simulated and recorded paraquat removal for this period.

The P2 atrazine results also show a good comparison between simulated and recorded monthly runoff values (Figure 10.1 and Table 10.1). Figure 10.1 also shows the results of using both the SV and NSV algorithms for atrazine



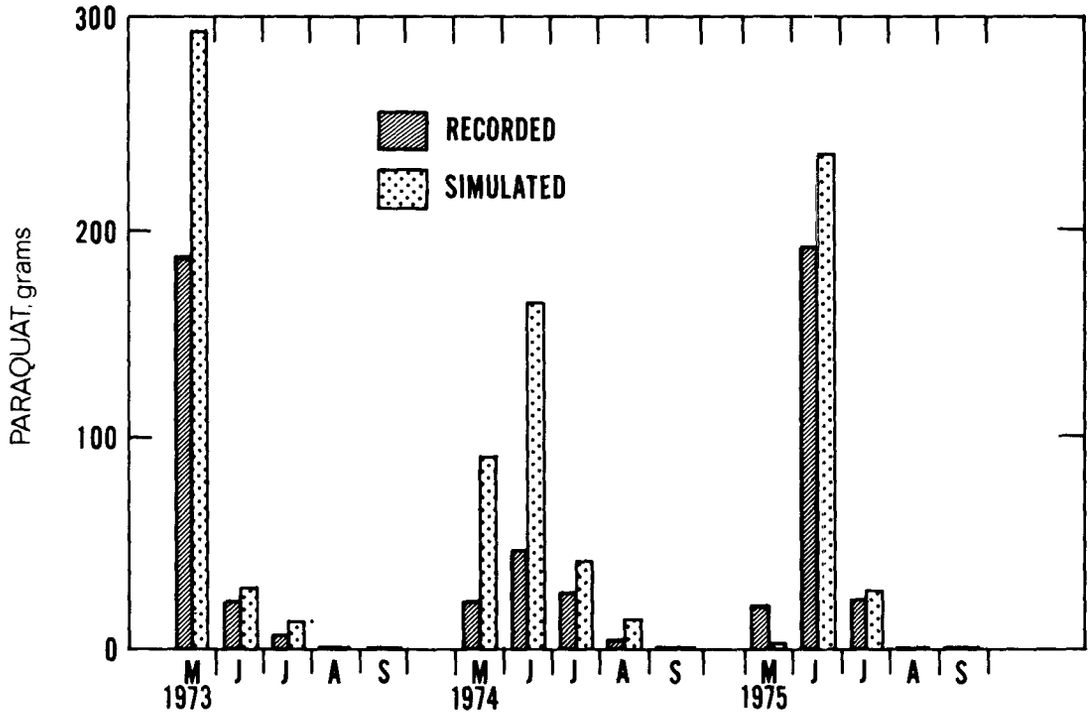


Figure 10.1 Monthly pesticide removal from the P2 watershed

TABLE 10.1 PESTICIDE RUNOFF SIMULATION RESULTS FOR THE P2 WATERSHED

		Atrazine						Paraquat	
		Recorded		NSV Simulation		SV Simulation		Recorded	Simulated
		(sed)	(sol)	(sed)	(sol)	(sed)	(sol)	(sed)	(sed)
1973	May	10	65	2	50	1	27	188	294
	Jun	1	5	0	4	0	8	23	29
	Jul	0	1	0	0	0	0	7	14
	Aug	0	0	0	0	0	0	0	0
	Sep	0	0	0	0	0	0	0	13
	Total	11	71	2	54	1	35	218	350
1974	May	1	6	0	7	0	9	23	91
	Jun	0	1	0	0	0	1	47	164
	Jul	0	0	0	0	0	0	27	42
	Aug	0	0	0	0	0	0	5	15
	Sep	0	0	0	0	0	0	0	0
	Total	1	7	0	7	0	10	102	312
1975	May	1	1	0	1	0	1	20	34
	Jun	1	10	1	8	0	8	191	237
	Jul	0	0	0	0	0	0	25	27
	Aug	0	0	0	0	0	0	5	15
	Sep	0	0	0	0	0	0	0	0
	Total	2	11	1	9	0	9	236	312

notes: NSV - nonsingle-valued adsorption/desorption
SV - single-valued adsorption/desorption simulation
sol - solution form
sed - sediment adsorbed form

simulation. In addition, a breakdown is given for the recorded atrazine transported in solution and on sediment. Atrazine runoff results for SV and NSV algorthms differ little except in the first summer: May and June of 1973. However, looking at all three summers when atrazine was applied on the P2 watershed the NSV results generally look better than the SV results in terms of removal in solution, which is the major removal mechanism. Little atrazine is removed on sediment (less than .15 percent of the total amount of atrazine removed). For the comparison of NSV and SV's ability to simulate atrazine removal on sediment, the NSV results produce more removal, although less than recorded. But because of the small amounts of atrazine measured as removed from the P2 watershed it cannot be said that the results are conclusive. Also, problems arise from the variability in determining the value for K in the Freundlich adsorption/desorption algorithm. Because of the lack of laboratory data evaluating the Freundlich constants for the watershed soils exact values have not been determined. Moreover laboratory determinations will often produce a range of values. This variability in K hinders evaluation of the relative merits of using either the SV or NSV algorithm.

A further complication, but one which tends to support the concept of NSV adsorption/desorption, is the relative change in partitioning of runoff atrazine between the adsorbed and solution forms during the growing season. Recorded data has shown the pesticide's tendency to adsorb onto sediment particles increases with time after application. NSV adsorption/desorption will produce the same phenomenon, but it is not clear that this is the mechanism responsible for these observations in the field data. More laboratory research into this question is necessary to verify this observation and the physical and chemical reasons behind it.

The simulation of paraquat and atrazine on the P6 watershed (Figure 10.2 and Table 10.2) was not as good as the P2 pesticide simulation. Paraquat runoff results are acceptable, except for the month of August, 1975. Sediment removal for this month is high; paraquat removal is higher. However, it is difficult to determine where the problem lies. Review of paraquat data collected from soil core samples and discussion with EPA personnel familiar with the sampling program on the P6 watershed indicate that the recorded data must be viewed with caution. Uncertainty in the accuracy of this data makes evaluation of the pesticide results difficult.

The monthly atrazine runoff results on the P6 watershed show even less resemblance between the simulated and recorded values than was the case for paraquat. The accuracy of the recorded data can be questioned, but other problems are also evident. Runoff is over simulated in May 1974 due to the hydrologic impact of plowing and planting operations not being represented in the model. The storm on May 29, 1974 occurred eight days after application and removed all of the atrazine for the month of May. For this storm there was a large amount of atrazine available for runoff in the surface zone and it was simulated as running off in solution during this storm. Atrazine was again applied in November, 1974. This application was followed by cold weather and snow. The lowered temperatures decreased the rate of biological degradation (although there is no soil core data to confirm this hypothesis) and more atrazine was then available for runoff

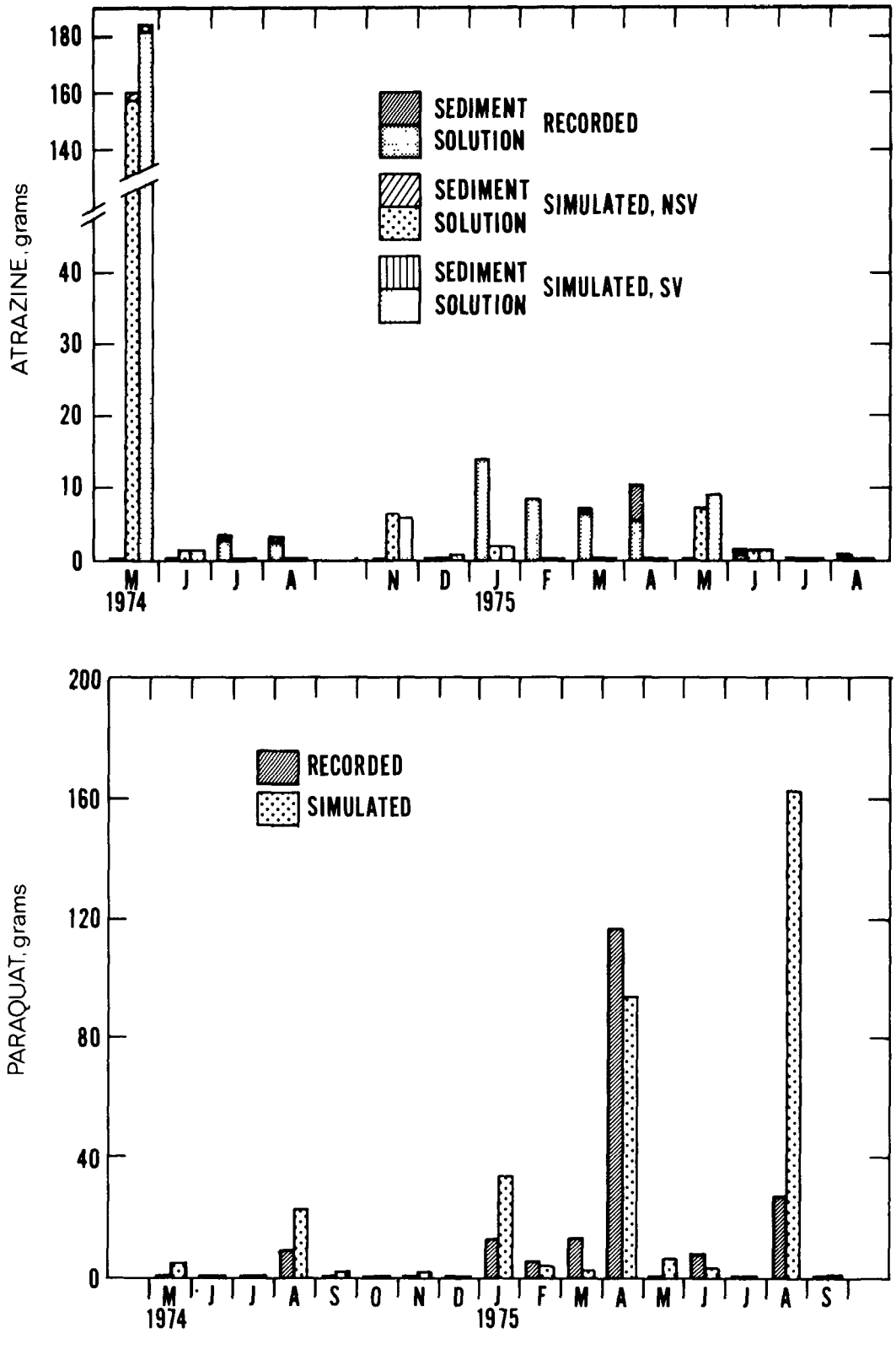


Figure 10.2 Monthly pesticide removal from the P6 watershed

TABLE 10.2 PESTICIDE RUNOFF SIMULATION FOR THE P6 WATERSHED

		Atrazine						Paraquat	
		Recorded		NSV Simulation		SV Simulation		Recorded	Simulated
		(sed)	(sol)	(sed)	(sol)	(sed)	(sol)	(sed)	(sed)
1974	May	0	0	3	137	3	152	0	5
	Jun	0	0	0	1	0	1	0	0
	Jul	1	3	0	1	0	1	0	0
	Aug	2	1	0	0	0	0	9	23
	Sep	0	0	0	0	0	0	0	2
	Oct	0	0	0	0	0	0	0	0
	Nov	0	0	0	0	0	0	0	2
	Dec	0	0	0	0	0	0	0	0
Total		3	4	3	139	3	154	9	32
1975	Jan	0	14	0	2	0	2	12	34
	Feb	0	9	0	0	0	0	6	4
	Mar	1	6	0	0	0	0	13	3
	Apr	5	5	0	0	0	0	117	94
	May	0	0	0	0	0	0	0	6
	Jun	0	1	0	1	0	1	8	4
	Jul	0	0	0	0	0	0	0	0
	Aug	0	1	0	0	0	0	27	163
	Sep	0	0	0	0	0	0	0	1
		6	36	0	3	0	3	183	309

notes: NSV - nonsingle-valued adsorption/desorption
SV - single-valued adsorption/desorption simulation
Sol - solution form
Sed - sediment adsorbed form

during warm melt periods later in January, February, March, and April of 1975 than simulated. A biologically oriented degradation approach which uses soil temperatures would be better able to handle this problem of pesticide winter application and degradation.

STORM EVENT SIMULATION

An analysis of individual pesticide runoff events on the P2 watershed soon after application shows that they match recorded results very well (Figures 10.3-10.5). The paraquat simulation (Figure 10.3) matches the sediment simulation for the storm of May 28, 1973, as one would expect. Atrazine removal by sediment for this event is low (Figure 10.4), but still within the range of accuracy required. But even with the use of NSV adsorption/desorption the amount of atrazine removed is not as great as was recorded. Simulation of atrazine removed in solution is excellent however.

It can be seen at later events after application (Figures 10.6) that the simulated amount of atrazine is not as great as that recorded. The reason for the small amount of atrazine runoff is that only a relatively small amount is available for runoff. Atrazine (and other soluble pesticides) can be removed from the watershed by transport on sediment particles eroded from the surface zone, runoff in overland flow interacting with the surface layer, and runoff in interflow coming from the upper zone. Interflow contributes less than overland flow/surface runoff in transporting atrazine from the watershed. For the P2 watershed interflow contributes from 21 percent (NSV adsorption/desorption) to 48 percent (SV) of the total atrazine removed. This compares to 74 percent (NSV) to 51 percent (SV) for atrazine removed by surface runoff. This fact, combined with knowledge that the ARM Model permits soluble pesticides to percolate faster from the surface zone to the upper zone than is actually observed (Figure 10.7), results in an understanding of why the simulation of atrazine runoff decreases in accuracy with time since application. Retardation of soluble pesticide movement from the surface to upper zone (perhaps in the same manner as is done for solute leaching from the upper to lower zone) would keep more pesticide available on the surface for runoff and sediment transport.

Additional pesticide runoff simulation results for paraquat and atrazine for the P2 watershed will be found in Appendix B. Appendix C contains individual paraquat and atrazine runoff results for the P6 watershed. Tables 10.3 and 10.4 provide the pesticide parameter values and the amount of pesticides applied on the two watersheds.

SUMMARY

A review of the pesticide runoff simulation results show that while in general the results are good, problems still exist. Solution pesticides show greater variability than the adsorbed forms and are not simulated as accurately with the ARM Model. A better understanding of the movement and interactions of soluble pesticides in the upper layers of the soil is needed to better simulate their transport by surface runoff and interflow.

Pesticides attached to sediment are relatively stable and are simulated

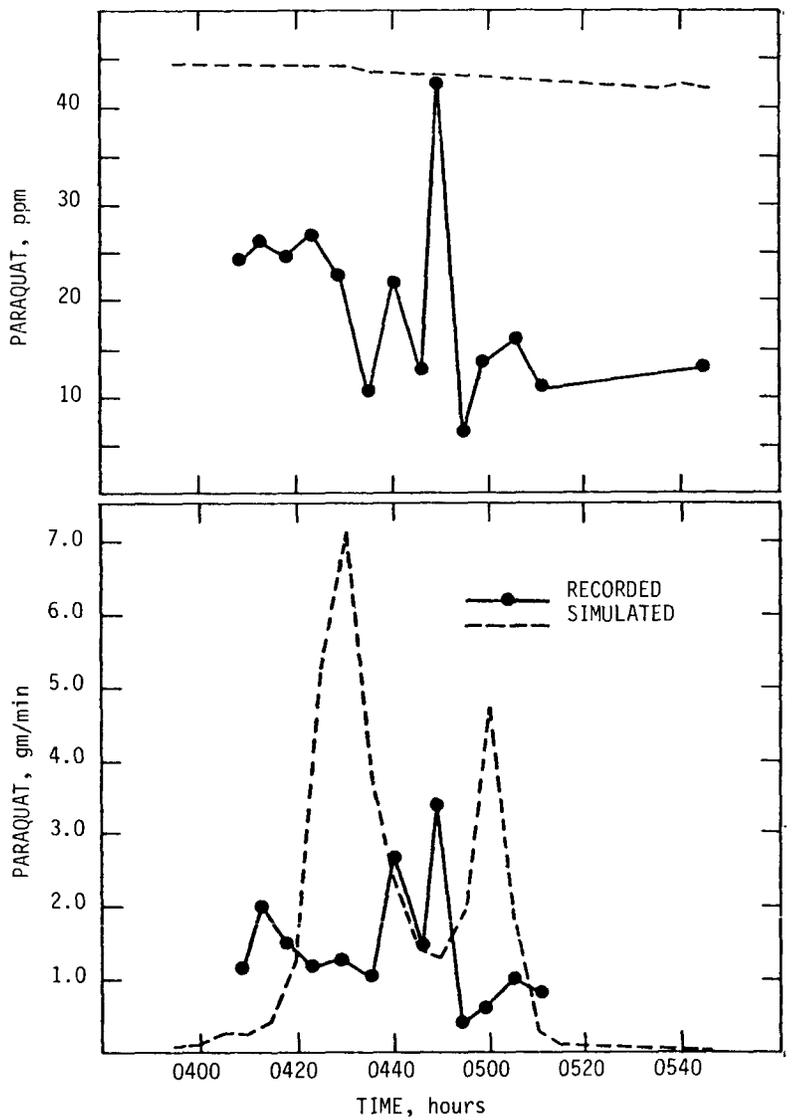


Figure 10.3 Paraquat removal from the P2 watershed for the storm of May 28, 1973

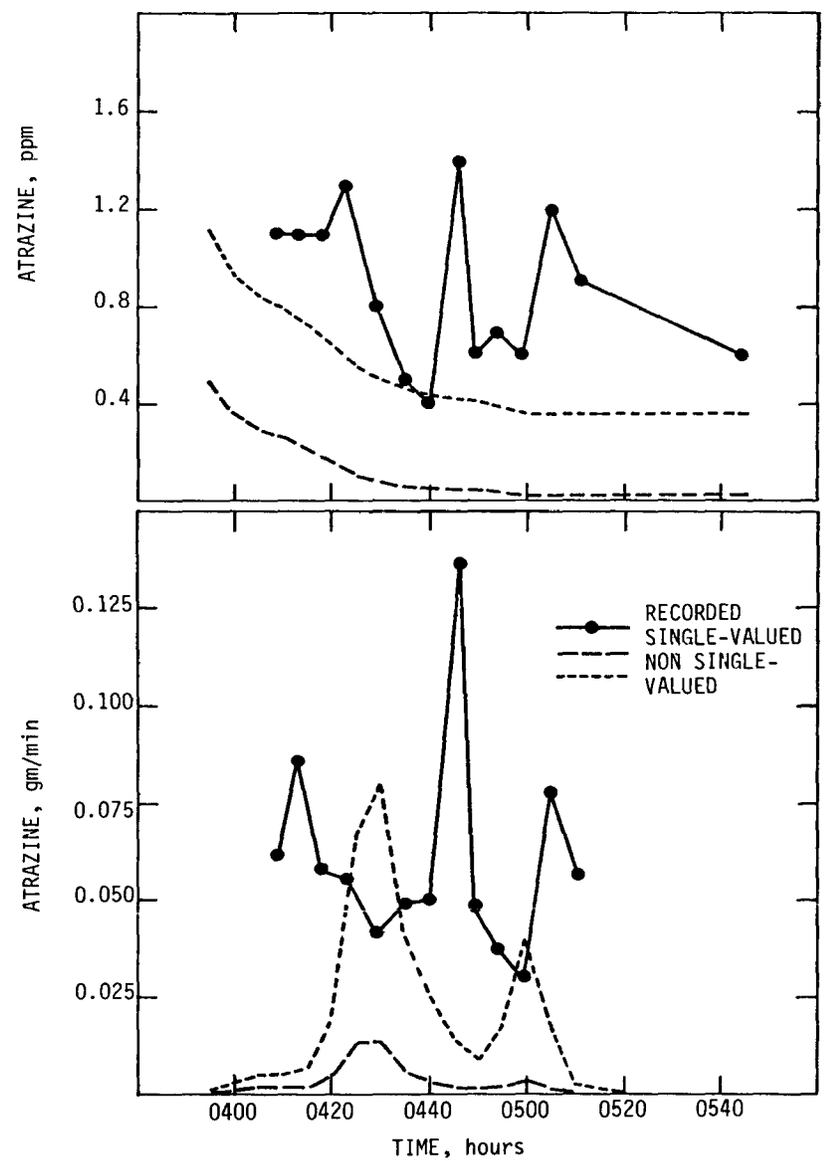


Figure 10.4 Atrazine removal on sediment from the P2 watershed for the storm of May 28, 1973

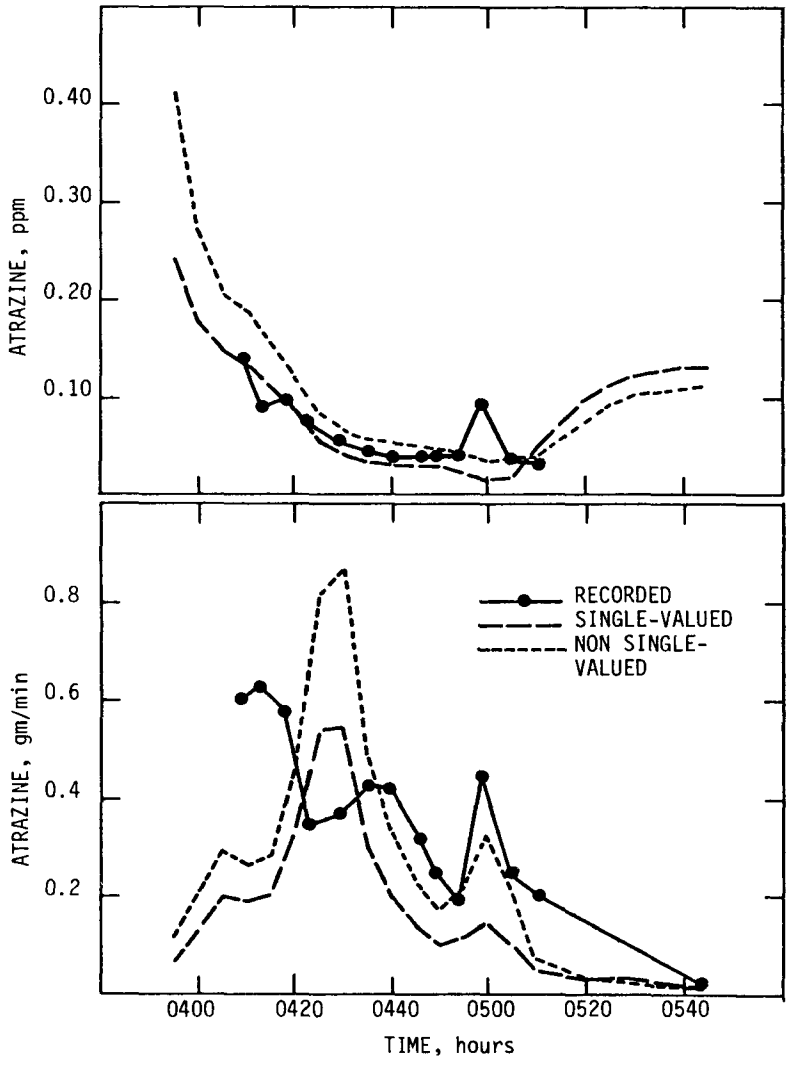


Figure 10.5 Atrazine removal in solution from the P2 watershed for the storm of May 28, 1973

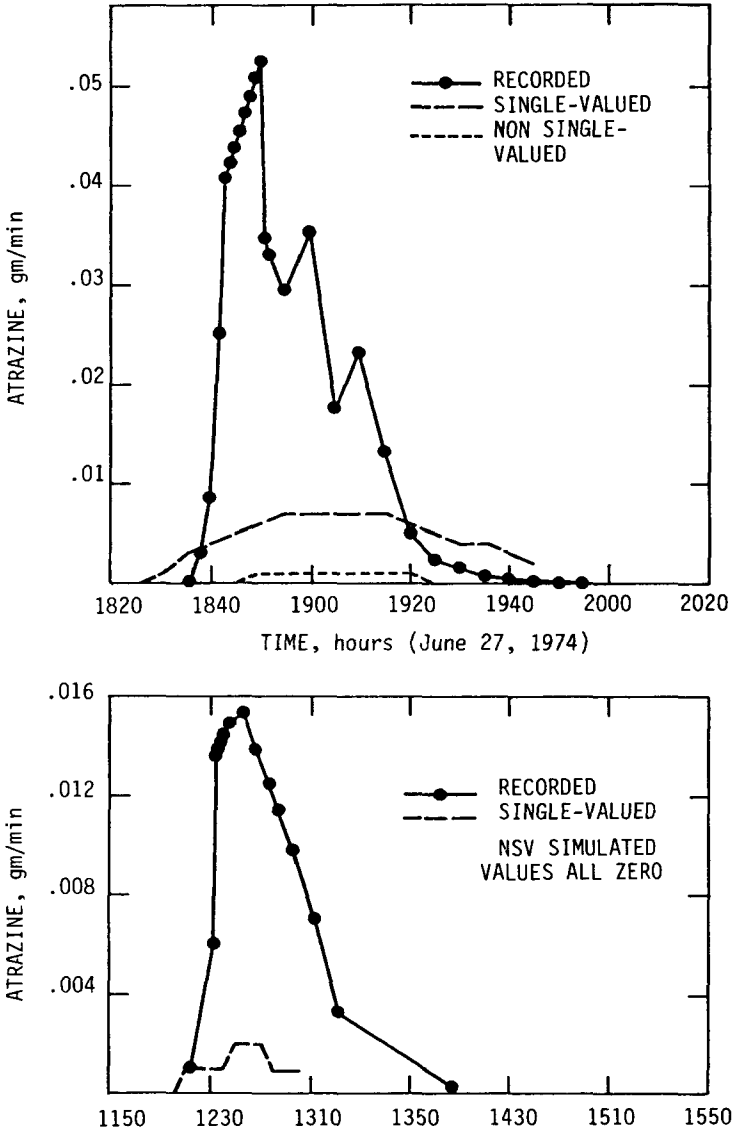


Figure 10.6 Atrazine removal in solution from the P2 watershed for the storms of June 27, and July 27, 1974

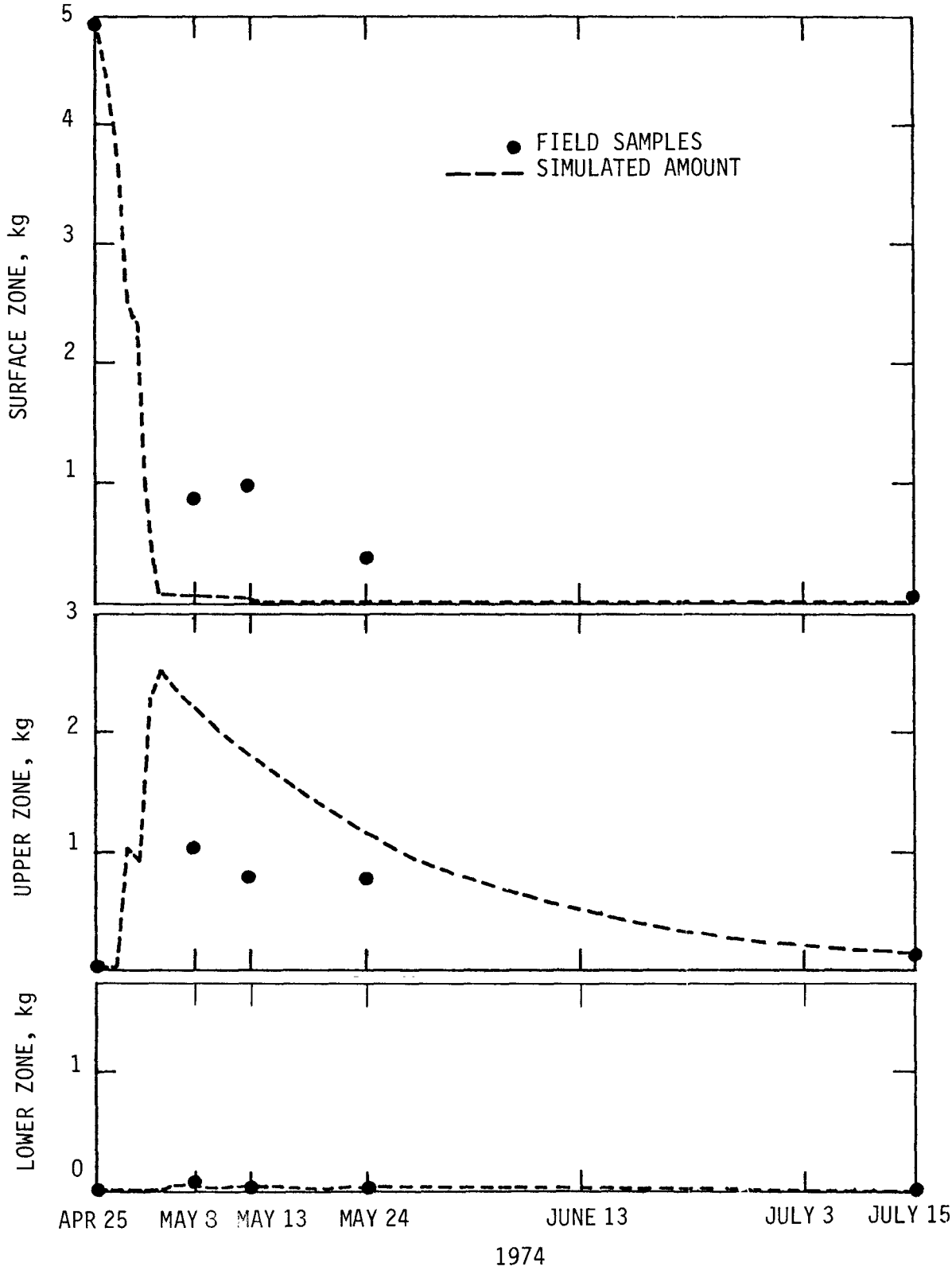


Figure 10.7 Atrazine in soil storage by zone on the P2 watershed

TABLE 10.3 PESTICIDE PARAMETER VALUES

	P2 Watershed		P6 Watershed	
	Atrazine	Paraquat	Atrazine	Paraquat
CMAX	0.000035	0.000010	0.000035	0.000010
DD	0.0	0.0003	0.0	0.0003
K	2.0	120.0	4.0	120.0
N	1.0	2.0	1.0	2.0
NP	2.3	4.6	2.3	4.6
KDG1	1.10	0.002	0.05	0.002
KDG2	0.04	0.002	0.05	0.002
SZDPTH	0.125	0.125	0.125	0.125
UZDPTH	6.125	6.125	6.125	6.125
BDSZ	99.9	99.9	63.7	63.7
BDUZ	99.9	99.9	72.4	72.4
BDLZ	99.9	99.9	99.0	99.0
UZF	3.0	3.0	1.0	1.0
LZF	1.5	1.5	1.0	1.0

TABLE 10.4 PESTICIDE APPLICATIONS

Watershed	Date	Pesticide	Target Rate (kg/ha)	Monitored Rate (kg/ha)
P2	5/11/73	atrazine	3.36	--
	7/29/74	atrazine	3.36	3.81
	5/21/75	atrazine	1.68	1.54
	5/11/73	paraquat	1.53*	2.36
	4/29/74	paraquat	1.53*	2.45
	5/21/75	paraquat	1.53*	1.93
P6	5/22/74	atrazine	4.50	3.95
	11/8/74	atrazine	2.25	3.00
	5/17/75	atrazine	2.25	1.38
	5/22/74	paraquat	1.12*	1.22
	11/8/74	paraquat	1.12*	1.29
	5/17/75	paraquat	1.12*	1.78

* computation based on dichloride salt

considerably better than dissolved pesticide forms. The accuracy of the simulation depends on how well the surface zone and degradation mechanisms are represented. If erosion by particle size is to be implemented (discussion in Section 9) adsorption and desorption of pesticides onto sediment by particle size should also be included. Research has demonstrated a preference of certain pesticides to adsorb onto sediment dependent on particle size and composition. If the ARM Model can take advantage of this knowledge the simulation of pesticides may be improved.

The relative accuracy of using the NSV adsorption/desorption approach over the SV approach cannot be demonstrated until the constants used in the Freundlich equations (K, N, and NP) are determined with more accuracy. Thus, it is recommended that laboratory analysis of this problem be done for all pesticides applied on the Georgia and Michigan watersheds and for these soil types. Once these values are known with more certainty then a more valid comparison of the relative merits of the NSV and SV adsorption/desorption algorithms can be made.

A study of the effects of environmental changes on the behavior of pesticides in the soil would be useful. As discussed in Section 7, temperature and moisture conditions affect pesticide degradation and degradation affects the amount of pesticide runoff. At the Michigan P6 watershed it was seen that winter pesticide simulation was poor, probably because of the model's inability to take into account the effect of low temperature on biological decay of atrazine. Thus, the ability to incorporate environmental effects such as temperature and moisture in pesticide simulation will allow the use of the ARM Model in a greater range of climatic conditions.

SECTION 11

NUTRIENT RUNOFF SIMULATION RESULTS

The goal of the nutrient modeling effort was to test and evaluate the behavior of the nutrient model on the Georgia (P2) and Michigan (P6) watersheds. To accomplish this goal, the hydrology and sediment simulation results (Section 9) provided the transport mechanisms for the nutrient runoff simulation discussed below. Section 8 presented the soil nutrient simulation results which provide the initial conditions and source values for nutrient runoff components. The coupling of the transport mechanisms and soil nutrient storages results in the simulation of nutrient contributions to a stream. This section will present and evaluate the monthly nutrient runoff and the storm event simulation results and discuss the overall functioning of the model. It will conclude with a summary of results and recommendations for further study.

MONTHLY SIMULATION RESULTS

The monthly total removal of nitrogen (N) and phosphorus (P) for the P2 and P6 watersheds, divided into sediment and solution components, is presented in Figures 11.1 and 11.2, respectively. The forms of nitrogen on sediment for both watersheds are illustrated in Figure 11.3, while the forms of nitrogen in solution are presented in Figure 11.4. Figure 11.5 provides the simulated and recorded phosphorus in solution for both watersheds. The corresponding values for these graphs are given in Tables 11.1 and 11.2. All these results should be considered in light of the simulated runoff and sediment values given in Tables 11.1 and 11.2 and in Section 9.

The results should be interpreted with the knowledge that the nutrient related parameters for the P2 watershed were calibrated on both the 1974 and 1975 summer periods. This provided a single set of reaction rates that were subsequently used for both summer periods. Following the calibration, the entire period from April 1974 through April 1975 was simulated to evaluate the model behavior during the nonsummer period. The P6 watershed was calibrated only on the summer 1974 period. The calibrated nutrient reaction rates were then used for the 1975 summer period and provided reasonable results. As on the P2 watershed, a single simulation run was then made from May 1974 to May 1975 to evaluate the nonsummer simulation. The nutrient storages, monthly plant uptake fractions, and soil temperature regression constants were then reset on June 1, 1975 for the summer 1975 simulation.

Some general comments can be made on the simulation of Total P and Total N, as presented in Figures 11.1 and 11.2 and Tables 11.1 and 11.2. Generally

TABLE 11.1 NUTRIENT RESULTS FOR THE P2 WATERSHED

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Total P
				(Sol)	(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)
		(mm)	(kg/ha)	(gm/ha)						
1974										
May	Rec	7.6	102.1	57.2	18.2	42.1	222.1	123.8	2.3	150.9
	Sim	18.3	1145.3	437.1	464.0	276.8	901.1	2510.6	33.6	1189.4
June	Rec	41.9	968.0	487.7	901.7	214.4[b]	1897.2	1778.4[b]	74.3	922.5[a]
	Sim	41.4	2138.1	187.2	159.2	918.8	346.4	4997.7	13.4	2155.9
July	Rec	47.0	684.6	100.8[b]	304.4	225.1	1098.0[b]	2361.8	27.2	359.5
	Sim	44.0	600.6	0.0	20.2	239.9	20.2	1346.3	3.4	583.4
Aug	Rec	12.2	104.3	82.4	271.5[c]	69.2	379.5	258.8	10.0	58.8
	Sim	18.7	224.0	21.3	224.0	85.2	245.3	493.1	21.3	213.7
Sept	Rec	0.6	0.9	8.9	0.0	4.8	10.2	12.2	1.0	1.5
	Sim	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oct	Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nov	Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec	Rec	0.1	0.0	1.2	0.2	0.0	5.6	0.0	0.3	0.0
	Sim	0.6	11.2	0.0	3.4	4.5	7.9	26.8	1.1	11.1
1975										
Jan	Rec	1.5	3.4	3.0	5.0	2.5	14.6[c]	21.4	6.0	1.2[b]
	Sim	3.1	65.0	46.0	29.1	21.3	75.1	151.1	6.7	197.1
Feb	Rec	9.3	13.2	-	-	-	-	-	-	-
	Sim	20.4	351.9	23.9	216.3	112.1	456.2	821.1	54.9	326.4
Mar	Rec	48.1	59.3	58.5	25.1	233.3	954.8	908.8	90.3	82.4
	Sim	78.5	340.7	473.0	661.3	206.2	1,134.3	1,561.4	176.0	623.8
Apr	Rec	16.5	22.3	16.5	0.0	56.2	432.5	411.1	34.3	18.0
	Sim	27.9	271.2	124.4	192.8	75.1	317.2	614.5	53.8	247.2

(continued)

TABLE 11.1 (continued)

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Total P
				(Sol)	(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)
		(mm)	(kg/ha)	(gm/ha)						
May	Rec	8.9	340.7	67.2	43.7	83.5	172.3	117.2[b]	8.1	218.6
	Sim	22.6	889.8	-	-	-	-	-	-	-
		Plant uptake and initial storages were reset for the simulation run beginning June 10.								
June	Rec	41.9	4,124.6	298.4	114.0	547.5	1,214.3	1,083.3	42.5	2,933.5
	Sim	30.0	3,117.5	397.9	273.5	357.5	671.4	1,695.9	40.3	4,083.7
July	Rec	32.3	973.1	183.7	397.8	568.8[c]	893.2	2,465.5[c]	17.5	778.3
	Sim	9.8	401.2	254.4	237.6	384.4	492.0	548.4	14.6	400.8
Aug	Rec	1.6	11.2	103.2	18.3[c]	11.6	124.2[c]	46.6	4.7	16.6
	Sim	0.2	2.3	54.9	21.3	1.1	76.2	1.1	2.2	1.1
Sept	Rec	10.6	90.9	58.3	34.6	183.8[c]	476.8	183.8[c]	15.0	221.5
	Sim	12.4	248.8	552.6	385.6	218.6	938.2	317.7	43.7	419.9
TOTAL except Feb. & May '75	Rec	261.9	7,144.7	1,459.8	2,159.3	2,271.4	7,723.0	9,655.5	325.4	5,544.7
	Sim	285.0	8,565.9	2,548.8	2789.4	2,787.4	5,225.3	14,264.6	410.1	10,127.1

a. Total value is an estimate because of missing samples.
b. Excludes certain minor storm events that were not sampled.
c. questionable value

Sol - solution form
Sed - sediment adsorbed form

TABLE 11.2 NUTRIENT RESULTS FOR THE P6 WATERSHED

Month		Runoff (mm)	Sediment (kg/ha)	NO_3-N	NH_4-N (Sol)	NH_4-N (Sed)	Total N (Sol)	Total N (Sed)	PO_4-P (Sol)	Avail P (Sed)	Total P (Sed)
				(gm/ha)							
1974											
June	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.3	2.	527.6	28.1	0.0	555.7	5.1	32.6	1.1	2.3
July	Rec	3.0	389.	116.8	0.1	0.3	220.9	1177.4	0.3	1.6	31.0
	Sim	0.5	9.	166.1	44.9	0.0	211.0	18.7	9.0	2.2	8.5
Aug	Rec	25.8	796.	196.3	123.9	63.0	726.3	2506.3	67.4	220.3	1424.5
	Sim	19.8	928.	389.5	86.4	64.0	475.9	2196.8	68.5	208.8	1064.3
Sep	Rec	0.8	35.	4.3	16.6	2.4	22.1	99.6	2.8	10.9	16.3
	Sim	2.7	72.	86.4	37.0	3.4	123.4	153.8	38.2	15.7	76.4
Oct	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nov	Rec	0.6	10.	4.5	5.1	0.5	11.4	22.5	1.3	3.3	4.4
	Sim	4.3	78.	1107.9	209.9	3.4	1317.8	156.5	103.3	16.8	75.8
Dec	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.2	0.	120.1	0.0	0.0	120.9	0.0	12.3	0.0	0.0
1975											
Jan	Rec	33.2	248.	218.4	359.5	-	897.3	573.4	77.4	-	410.6[a]
	Sim	35.3	753.	862.1	504.0	31.4	1366.2	1668.2	390.6	390.6	661.0
Feb	Rec	35.1	244.	330.1	664.8	-	1505.4	727.4[a]	165.5	-	474.4[a]
	Sim	12.6	101.	490.5	241.3	2.3	731.8	212.6	299.7	21.3	99.5
Mar	Rec	26.5	723.	364.9	647.3	-	1479.9	2370.0[a]	139.5	-	1558.5[a]
	Sim	11.5	72.	451.2	177.4	0.0	628.6	148.0	217.8	14.6	69.6
Apr	Rec	88.7	12,315.	674.	625.	243.[b]	2133.	31510.	590.	1378.[b]	16,538.
	Sim	100.3	2,640.	745.	280.	14.	1025.	5390.	594.9	509.6	2,604.9
May	Rec	0.1	3.	1.5	1.0	-	4.0	5.9	0.4	0.4	3.8
	Sim	0.6	91.6	-	-	-	-	-	-	-	-
		Plant uptake, initial storages, and soil temperature regression constants were reset for the simulation beginning June 1.									
June	Rec	5.8	410.	40.5	60.6	12.9	178.1	1035.4[a]	49.0	41.1	644.5[a]
	Sim	2.6	54.	617.4	113.3	1.1	730.7	127.0	47.1	4.5	78.8
July	Rec	0.1	2.	0.9	0.8	-	2.5	8.3	0.4	0.3	4.1
	Sim	0.7	13.	275.0	68.5	0.0	343.5	28.3	18.0	1.1	18.7

(continued)

TABLE 11.2 (continued)

Month		Runoff (mm)	Sediment (kg/ha)	NO_3-N (Sol)	NH_4-N (Sol)	NH_4-N (Sed)	Total N (Sol)	Total N (Sed)	PO_4-P (Sol)	Avail P (Sed)	Total P (Sed)
				(gm/ha)							
Aug.	Rec	50.0	1629.	208.0[a]	290.8[a]	36.4[a]	747.4[a]	3959.6[a]	284.9[a]	99.9[a]	2191.6[a]
	Sim	62.6	2329.	354.7	191.9	56.1	546.6	5430.0	275.0	202.1	3334.3
Sept	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	3.1	18.	68.5	41.5	0.0	100.0	37.4	83.1	1.2	22.8
TOTAL	Rec	269.5	16,801.	2,158.7	2,794.5	-	7,924.3	43,989.9	1,390.8	-	23,297.9
Except May	Sim	256.5	7,069.	6,262.0	2,024.2	175.7	8,277.1	15,5 2.4	2,300.1	1,389.6	8,116.9

a. Total value is an estimate because of missing samples
b. Excludes certain minor storm events that were not sampled.

Sol - Solution form
Sed - Sediment adsorbed form

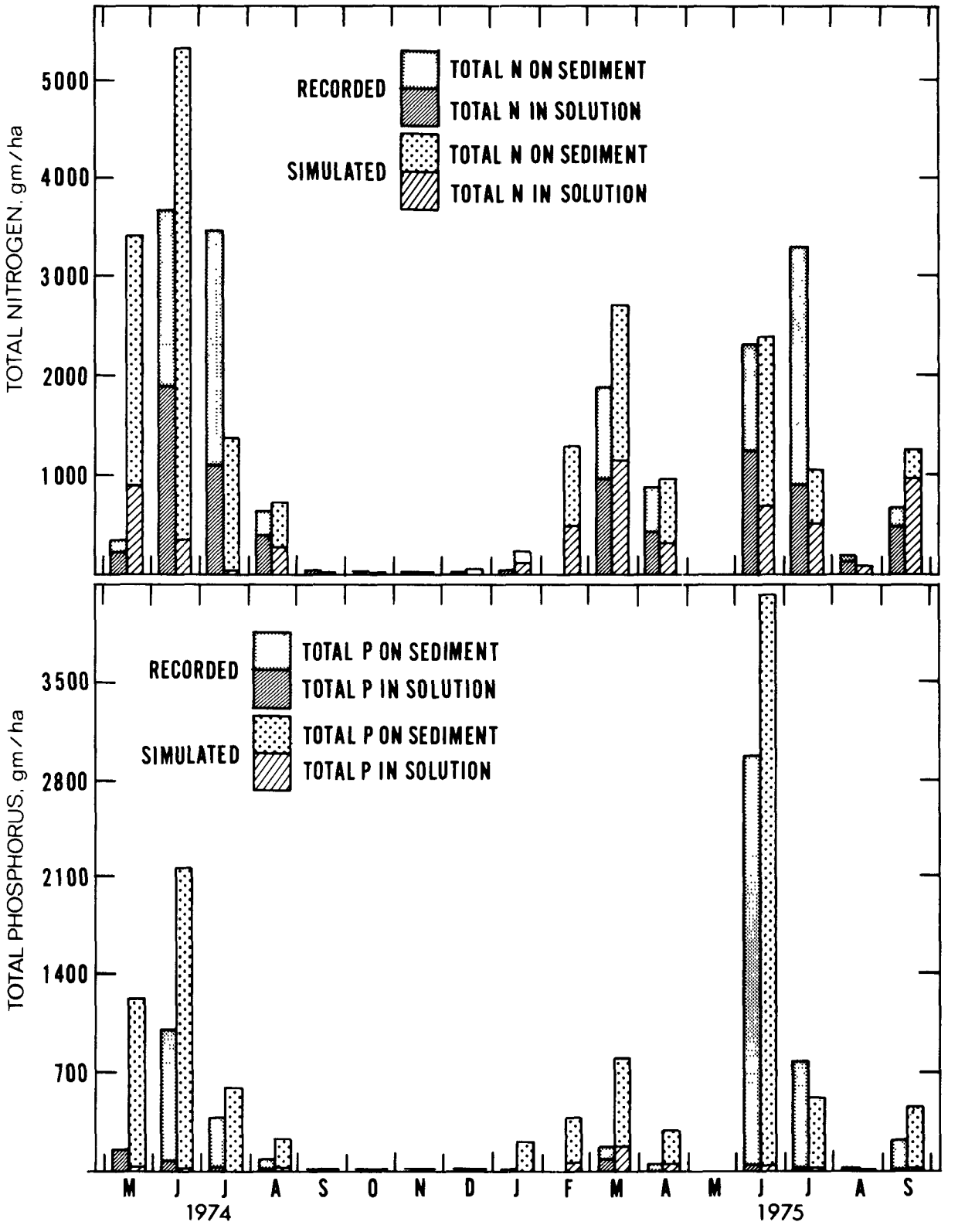


Figure 11.1 Monthly total nitrogen and phosphorus runoff from P2 watershed

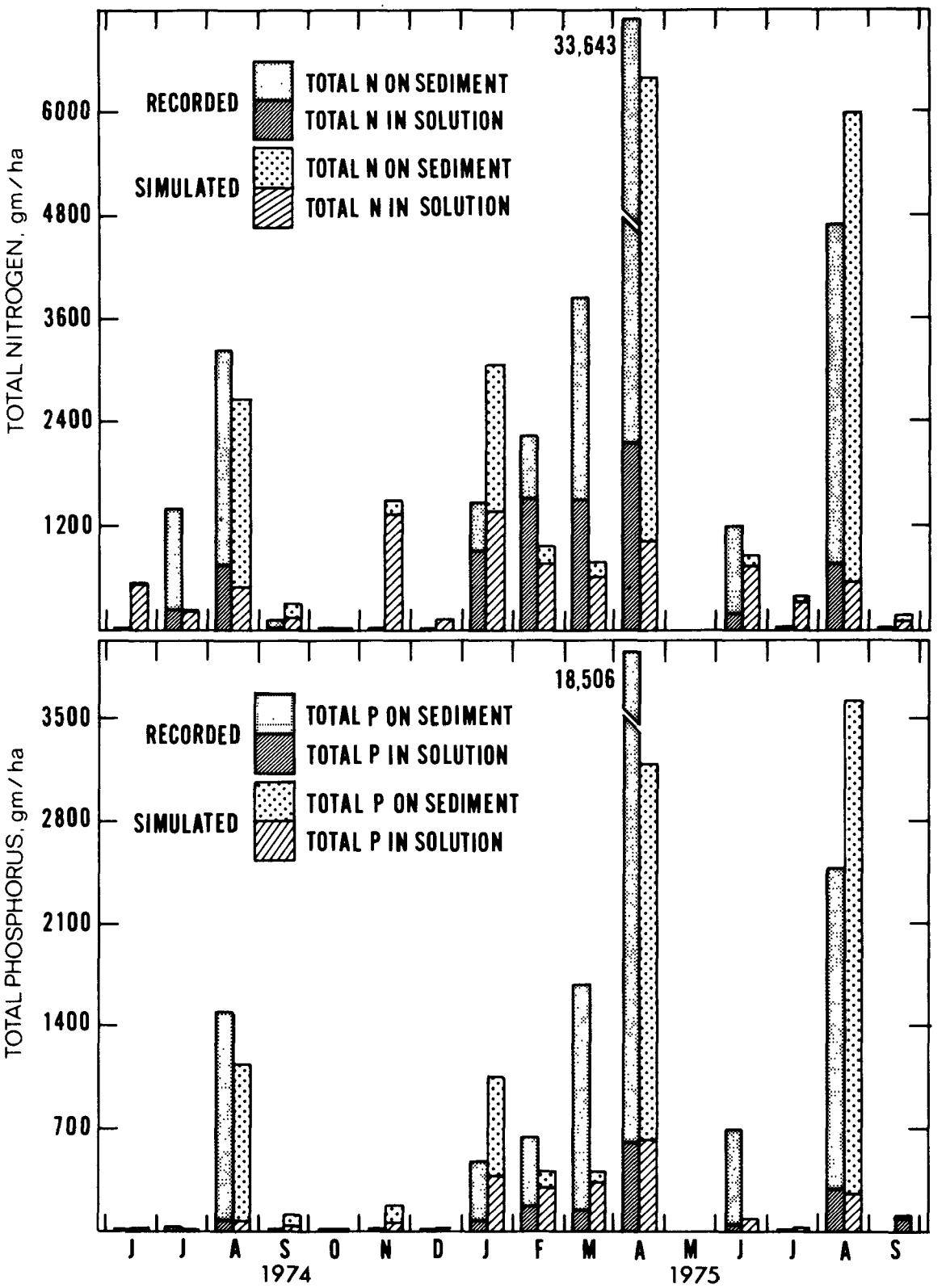


Figure 11.2 Monthly total nitrogen and phosphorus runoff from the P6 watershed

the accuracy of the simulation results for total nutrients corresponds well with that for runoff and sediment removal. For example, when sediment was under simulated on the P6 watershed for April 1975 so was Total N and Total P. For some of the monthly results this relationship to runoff and sediment simulation was not as strong. Moreover, in some cases runoff and sediment loss are over simulated and nutrients are under simulated. Examples of this behavior occur on the P2 watershed for the months of July 1974 and June 1975. In July 1974 runoff is high, sediment removal is low, but Total N removal is low and Total P removal is high. In June 1975, both runoff and sediment simulation is low while Total N and Total P removal are high. A similar event occurs on the P6 watershed where during August 1974 runoff is under simulated, sediment loss over simulated, yet both Total N and Total P are under simulated. These seeming inconsistencies are due to particular solution or sediment nutrient forms comprising most of the observed nutrient loss and corresponding discrepancies in simulating the associated transport mechanism.

In general, the simulation of monthly Total N and Total P for the entire test period gives reasonable results as an initial test of the nutrient algorithms. For the entire simulation period the Total N removal on the P2 watershed is simulated within 13 percent of the recorded value, while Total P is over simulated by 80 percent. The over simulation was partially caused by the over simulation of sediment loss. For the P6 watershed, with the exclusion of April 1975, the Total N and Total P removals for the entire simulation period are good: within 6 percent of the recorded values.

The sediment portion of the runoff for both watersheds carries more nitrogen and phosphorus than does the solution component of the runoff. However, the solution nitrogen does at times contribute to much of the Total N removal. Phosphorus in solution is a smaller portion of the Total P washoff on the P2 watershed than on P6. This is likely caused by less phosphorus fertilizer applied on P2.

The sediment nutrients are either organic or inorganic forms. Measurements of inorganic phosphorus on sediment were not made except for some analysis of Available P (Table 11.2). It is assumed that most of the phosphorus associated with the sediment was in the organic form. Most of the simulated phosphorus is organic. Thus, the results presented and discussed for Total P can be considered to be similar to the simulation of the Organic P content of the sediment.

Breakdown of the forms of Total N attached to the sediment are shown in Figure 11.3. Much more sediment associated nitrogen is organic than inorganic. Like phosphorus, the Organic N simulation is similar to the Total N results. The accuracy of the simulation depends on the accuracy of the sediment simulation. However, the simulation results for the inorganic fraction, NH_4-N, varies. The largest portion of NH_4-N is found in the summer after spring fertilization. Generally, the simulation of NH_4-N is reasonably good, particularly when the sediment simulation is good.

The solution nutrient simulation results like the sediment results are strongly influenced by the simulation of the transport mode. The runoff

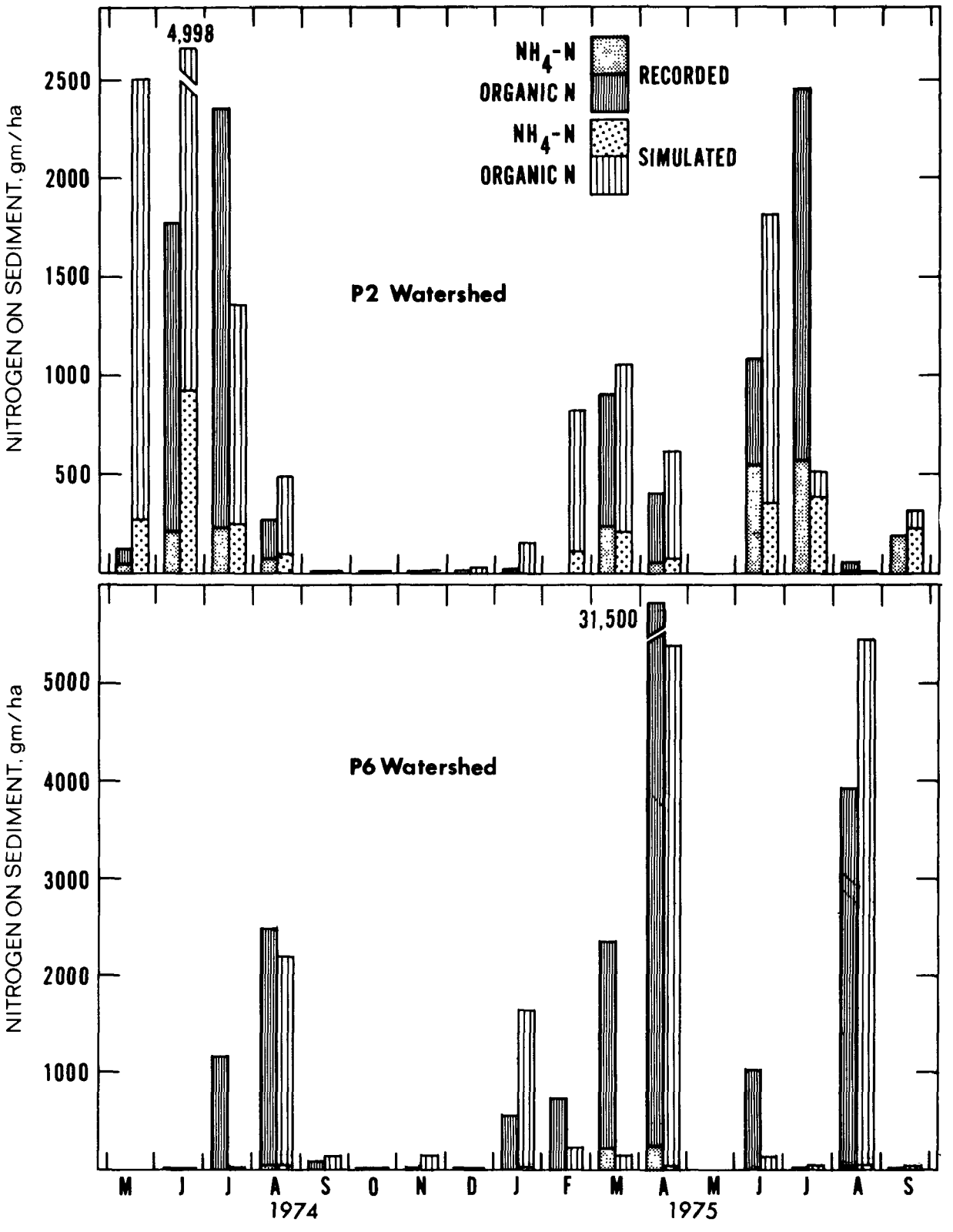


Figure 11.3 Monthly organic N and NH_4 on sediment from the P2 and P6 watersheds

simulation, discussed in Section 9, influences the amount of nutrient removed in solution. Most of the soluble nutrient removal comes from the interflow component of runoff. Hence, the interflow hydrology parameter, INTER, has a major impact on the solute runoff simulation. For example, INTER for P2 was reduced from 0.70 to 0.59 for the nutrient simulation. This resulted in a minor difference in the runoff simulation (less than 3 percent increase) during the period of May 1, 1974 through September 30, 1974. However, this reduction in INTER decreased NO_3-N in solution from 4.52 kg/ha to 0.64 kg/ha during this period.

The simulated and recorded forms of nitrogen in solution are shown in Figure 11.4. The nutrient model does not simulate Organic N in solution even though the recorded results show that there can be large amounts of Organic N relative to inorganic forms. The large amounts of Organic N found in the water phase of the runoff may have been actually attached to sediment particles that passed the filtering process in the laboratory analysis. Organics may also have occurred in solution by the disassociation of sediment organics in the runoff samples.

NO_3-N and NH_4-N in solution are simulated by the model. The overall result of the NO_3-N simulation is to over simulate NO_3-N on the P6 watershed and slightly over simulate it on P2. The over simulation of P6 NO_3-N runoff cannot be directly attributed to the runoff since it is under simulated. For P6, the simulation of NO_3-N is worse than average during the months of June and November, 1974 and June and July, 1975. The simulated soil storages (Figure 8.5) of NO_3-N are higher than recorded in November and lower than observed in both Junes, but the July storage is close to the observed values. However, the soil storage and runoff results do not account for the over simulation of NO_3 for the three summer months. This situation indicates a need to further study the transport mechanisms. The influence of the interflow parameter on NO_3-N runoff simulation appears to be more important than the soil storage simulation. The November over simulation of NO_3-N can be explained by the over simulation of both runoff and soil storage.

The simulation of NO_3-N for the P2 watershed generally follows the hydrology simulation, except for some of the summer months. The effect of the over simulation of soil NO_3-N (Figure 8.2) during the winter did not compound the effect of the over simulation of the runoff. NO_3-N in the summer months is slightly over simulated even considering the effect of the runoff results. The main exception is the under simulation of NO_3-N in July 1974. No NO_3-N in solution occurs during this month because no interflow is simulated. The inconsistent NO_3-N simulation indicates that further study of the hydrology simulation for the P2 watershed and the transport mechanisms is needed.

The simulation of NH_4-N in solution for the entire simulation period is good. The recorded NH_4-N in solution for both watersheds is slightly greater than the NO_3-N. The results are generally better for NH_4 -N than NO_3-N on both of the watersheds, although the NH_4-N simulation results generally follow the NO_3-N trends. However, for the winter period on the P2 watershed, NH_4-N is over simulated; very little NH_4-N is

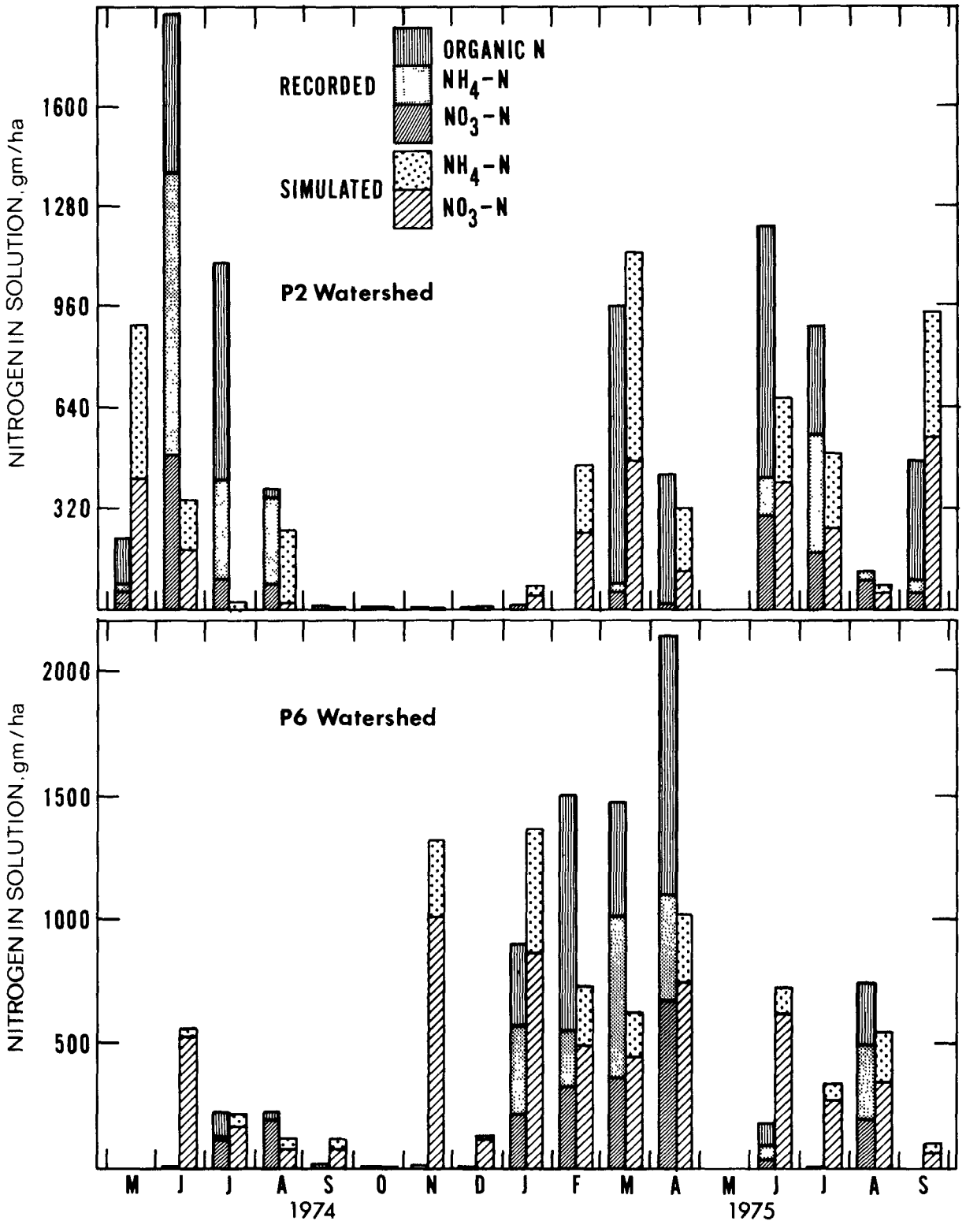


Figure 11.4 Monthly NH_4, NO_3, and organic N removal in solution from the P2 and P6 watershed

recorded in the P2 runoff during this period. The over simulation is perhaps due to over mineralization of organics to NH_4-N in the soils during this period. Much more NH_4-N is recorded for the Michigan P6 watershed during the winter because of fertilization in November and the possibility of NH_4-N in the snow.

Monthly PO_4-P in solution is shown in Figure 11.5. Much more PO_4-P is in solution from the P6 watershed than from P2 mainly because more fertilizer was applied to P6: 224 kg/ha compared to 54 kg/ha. Although some inconsistencies exist, the overall simulation of solution PO_4-P from the P2 watershed is good, particularly in view of the slight over simulation of runoff. The P6 simulation of PO_4-P is high, mostly because of the over simulation of the winter period. However, the P6 summer months are over simulated when the recorded values are less than 3 gm/ha. Otherwise the three major summer runoff months of August 1974 and June and August 1975 for P6 are well simulated for PO_4-P in solution.

The nutrient model at present simulates monthly results of nutrients on sediment better than nutrients in solution. The value of a more accurate sediment than solution nutrient simulation will depend on whether short term or long term effects are most important. Soluble inorganic nutrients have a more immediate impact on water quality than the sediment-associated nutrients since they are more readily used by algae than either the organic or sediment forms. Thus, soluble nutrients can directly contribute to accelerated eutrophication. However, over the longer term organics and sediment-associated inorganics can decompose and release inorganics in solution available for stimulation of aquatic growth.

STORM EVENT SIMULATION

Analysis of storm event simulation results is needed to determine how well the model is representing the separate solution and sediment nutrients in relation to their transport components. Figures 11.6 to 11.11 present the simulated and recorded values for the June 11, 1975 storm on the P2 watershed. Figures 11.12 to 11.17 show analogous results for the August 27, 1974 storm on the P6 watershed. The results are presented in both concentration and mass removal (gm/min) units. Also, each graph pertains either to the solution or sediment transport mode of the specific component. Other storm event graphs of nutrient simulation results are contained in Appendices B and C. As is noted in the discussion of the monthly results, the event graphs should be viewed relative to the corresponding runoff and sediment graphs in Section 9 and the appendices.

In order to evaluate the storm events simulations, an explanation of the recorded data is needed. Each recorded data point is the mean concentration or mass removal since the previous sample. If a long time span occurs between samples, intermediate values can vary considerably. For example, in Figure 11.6 a recorded concentration of 1430 ppm at time 20:02 is actually an average value of all the concentrations of TKN on sediment from time 1917 to 2002. The actual values vary significantly about the mean of 1430 ppm. This is especially true if there are significant variations in runoff or sediment transport in the intervening

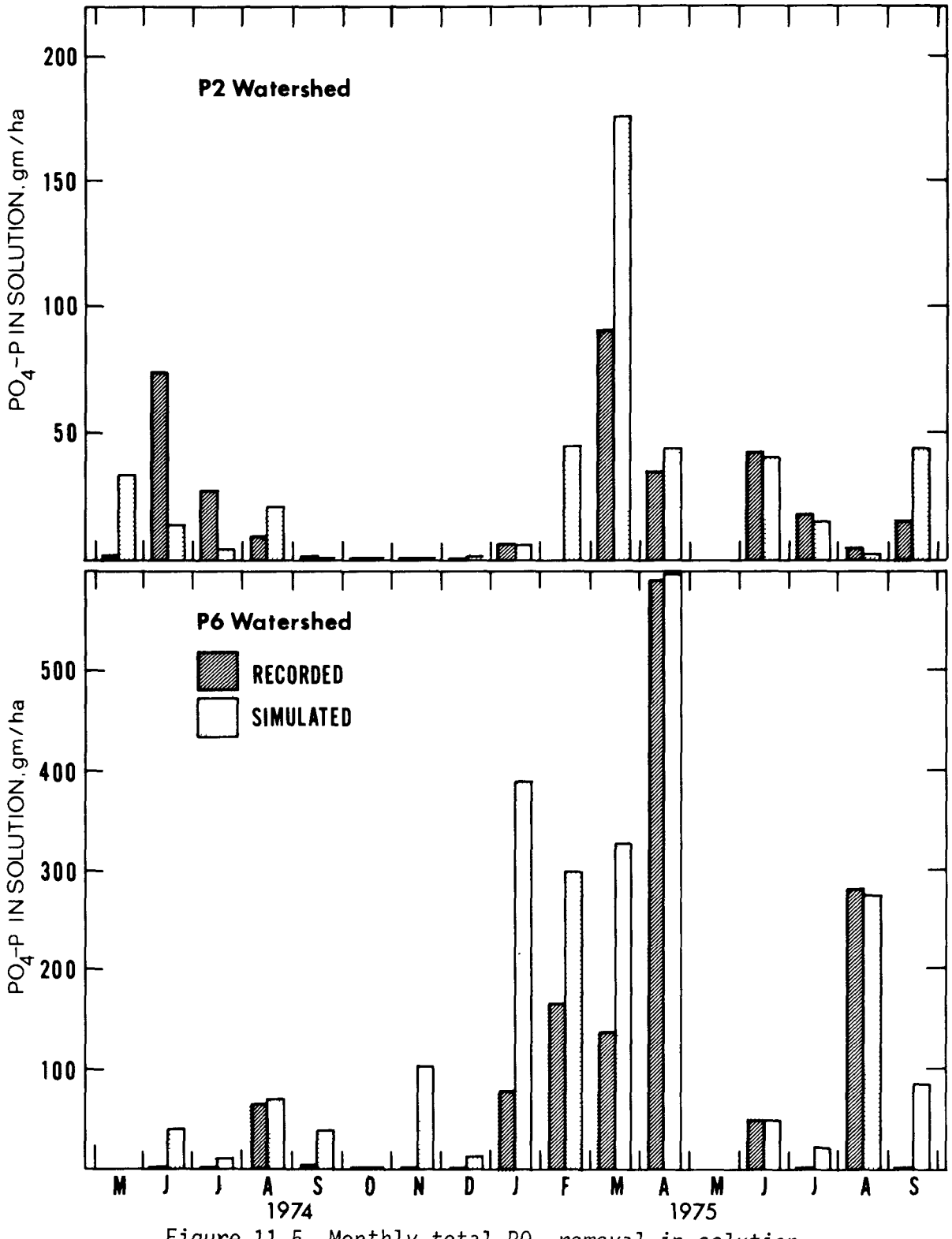


Figure 11.5 Monthly total PO_4 removal in solution from the P2 and P6 watersheds

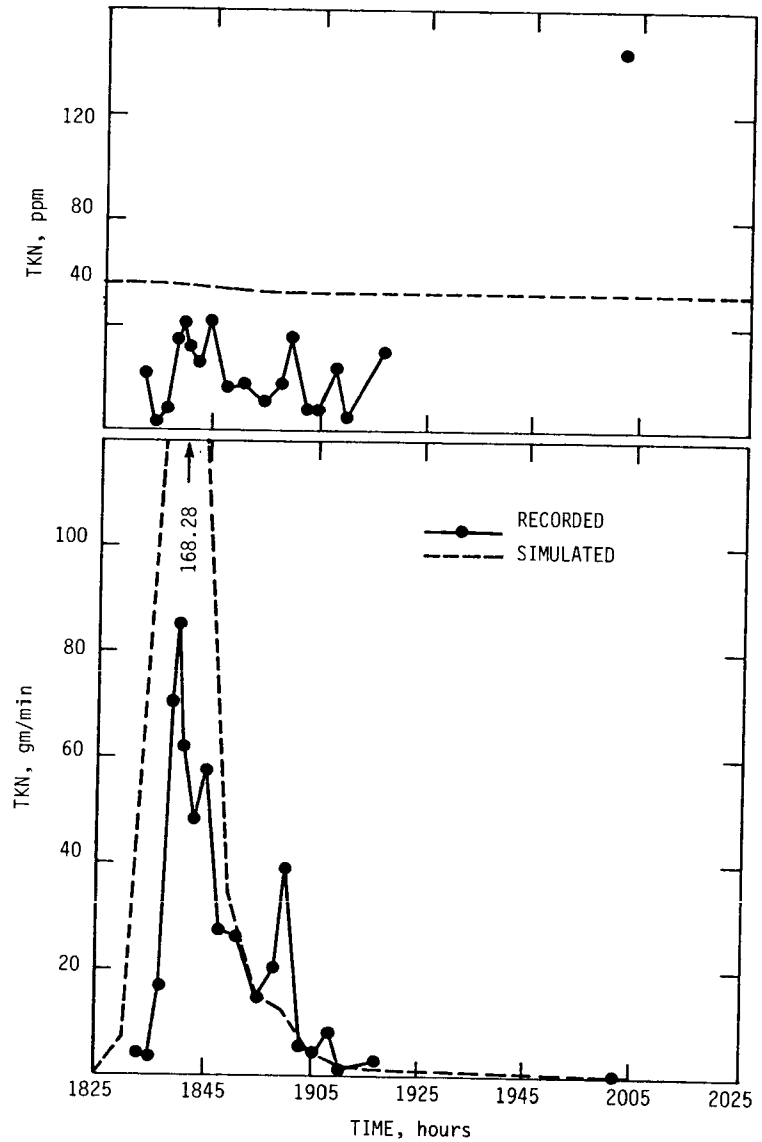


Figure 11.6 TKN removal on sediment from the P2 watershed for the storm of June 11, 1975

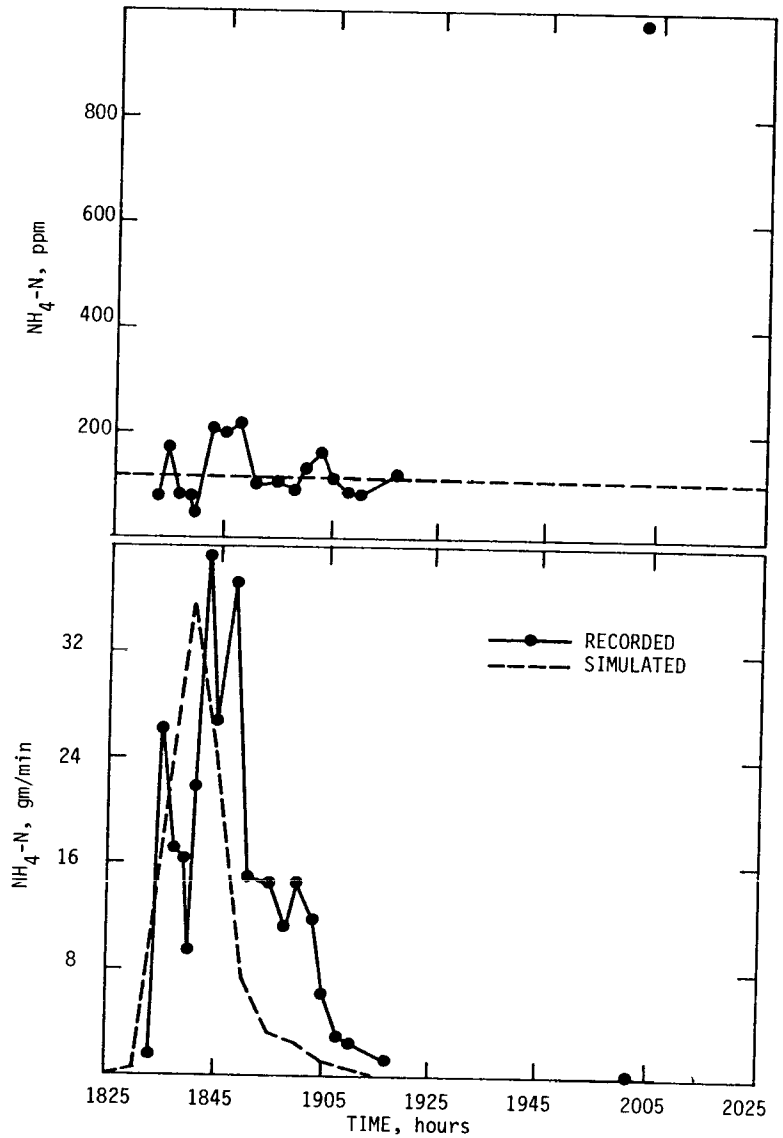


Figure 11.7 NH_4 removal on sediment from the P2 watershed for the storm of June 11, 1975

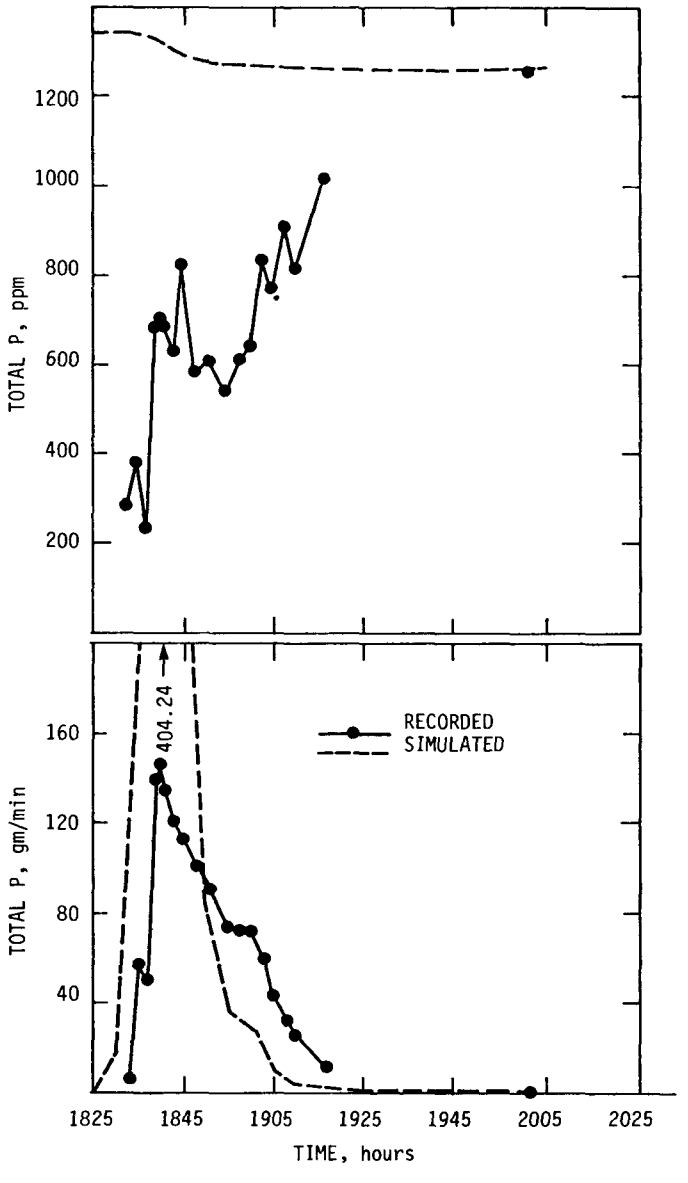


Figure 11.8 Total P removal on the sediment from the P2 watershed for the storm of June 11, 1975

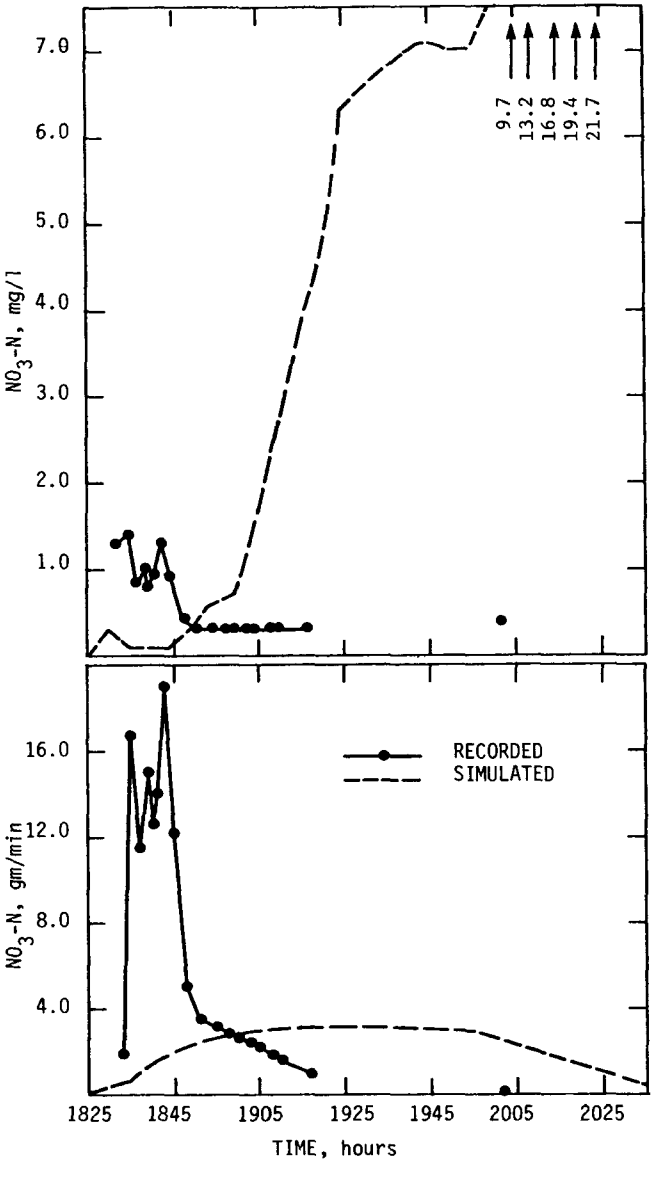


Figure 11.9 NO_3 removal in solution from the P2 watershed for the storm of June 11, 1975

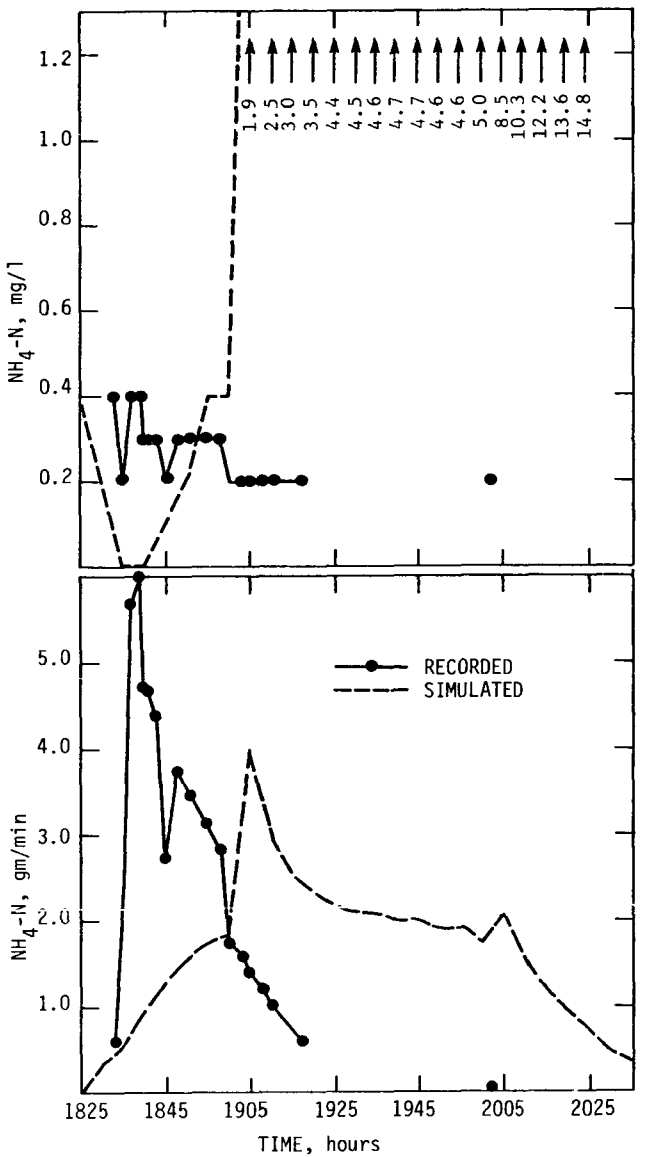


Figure 11.10 NH_4 removal in solution from the P2 watershed for the storm of June 11, 1975

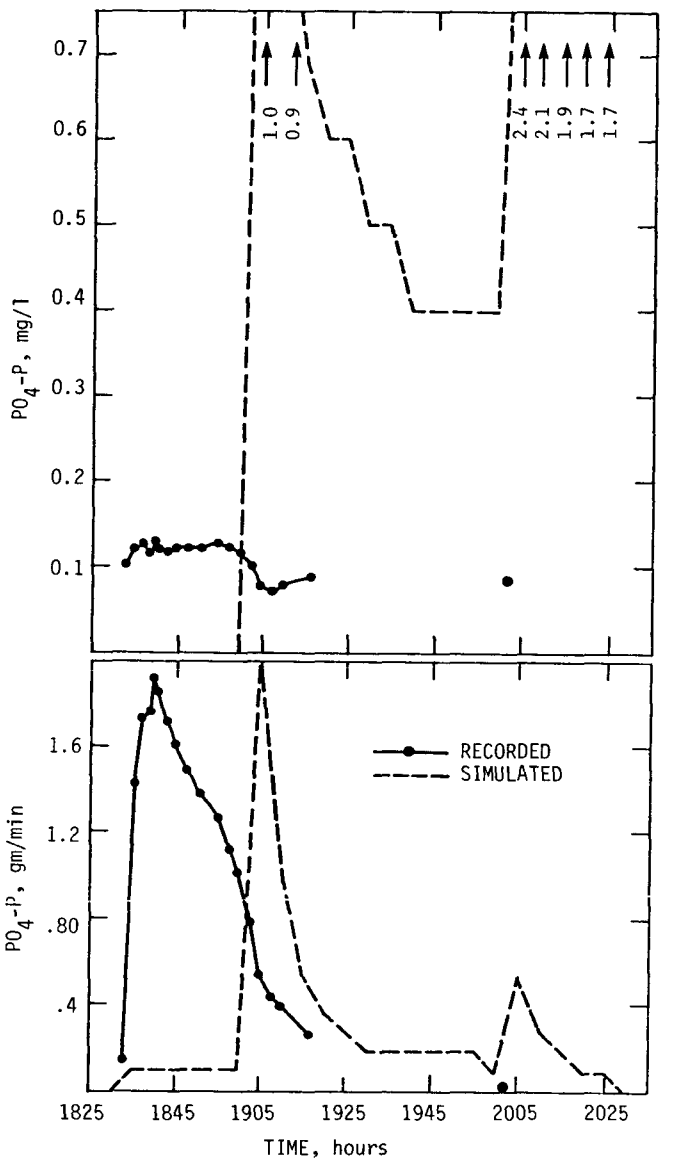


Figure 11.11 PO_4 removal in solution from the P2 watershed for the storm of June 11, 1975

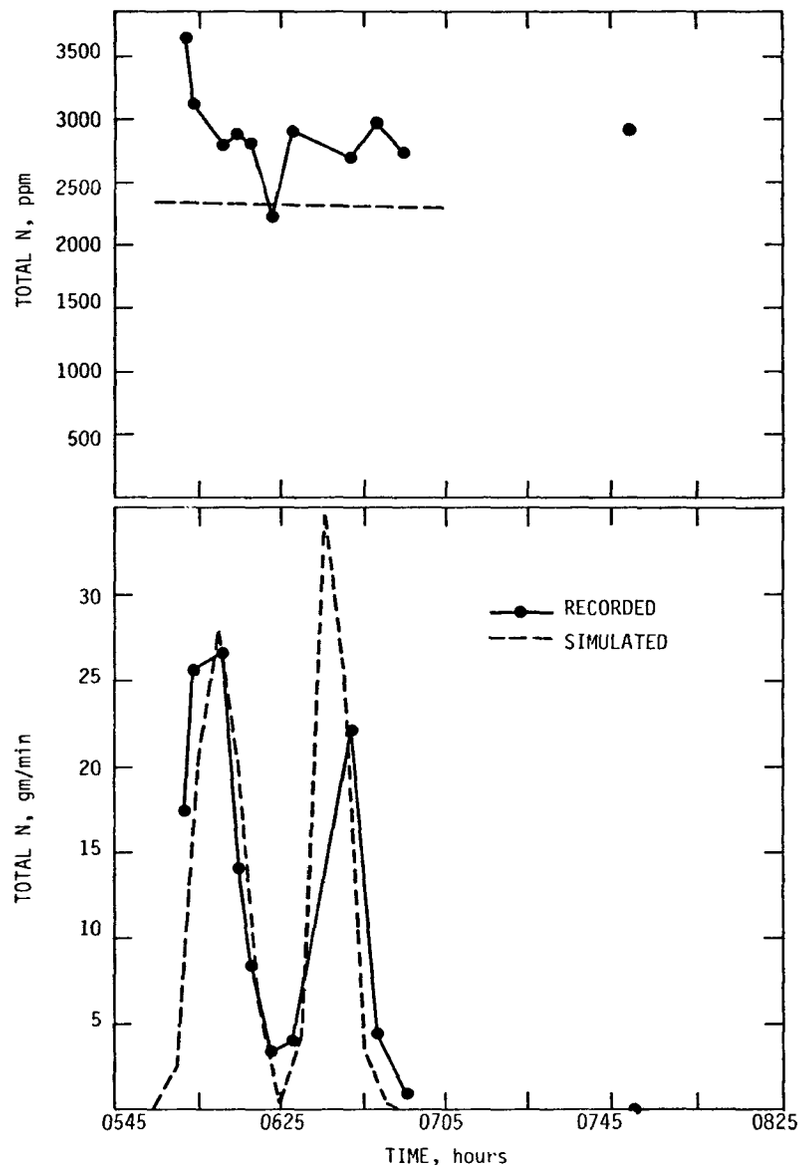


Figure 11.12 Total N removal on sediment from the P6 watershed for the storm of August 27, 1974

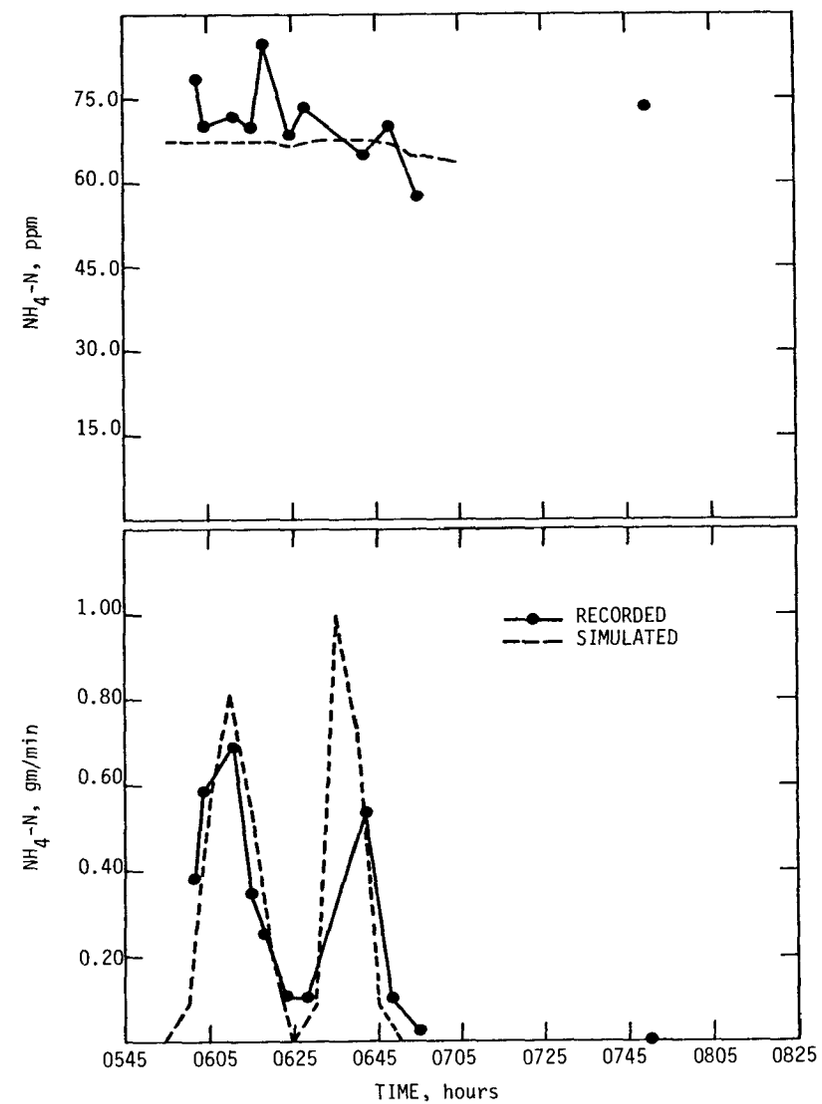


Figure 11.13 NH_4 removal on sediment from the P6 watershed for the storm of August 27, 1974

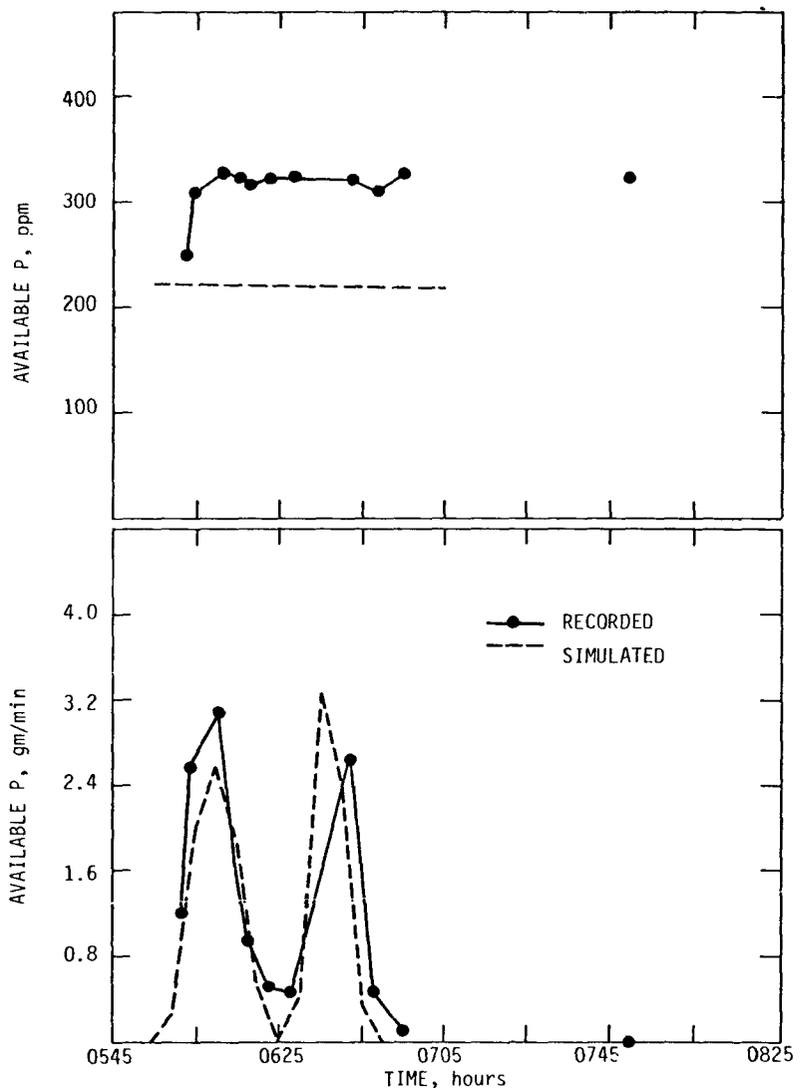


Figure 11.14 Available P removal on sediment from the P6 watershed for the storm of August 27, 1974

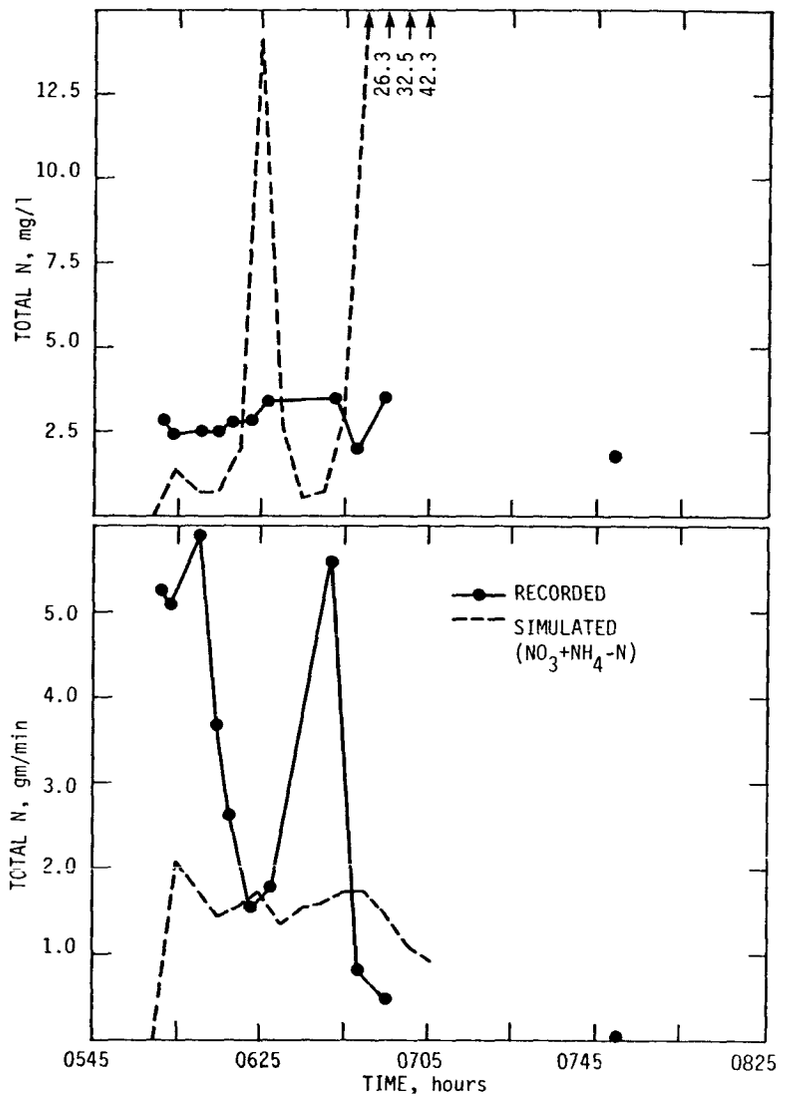


Figure 11.15 Total N removal in solution from the P6 watershed for the storm of August 27, 1974

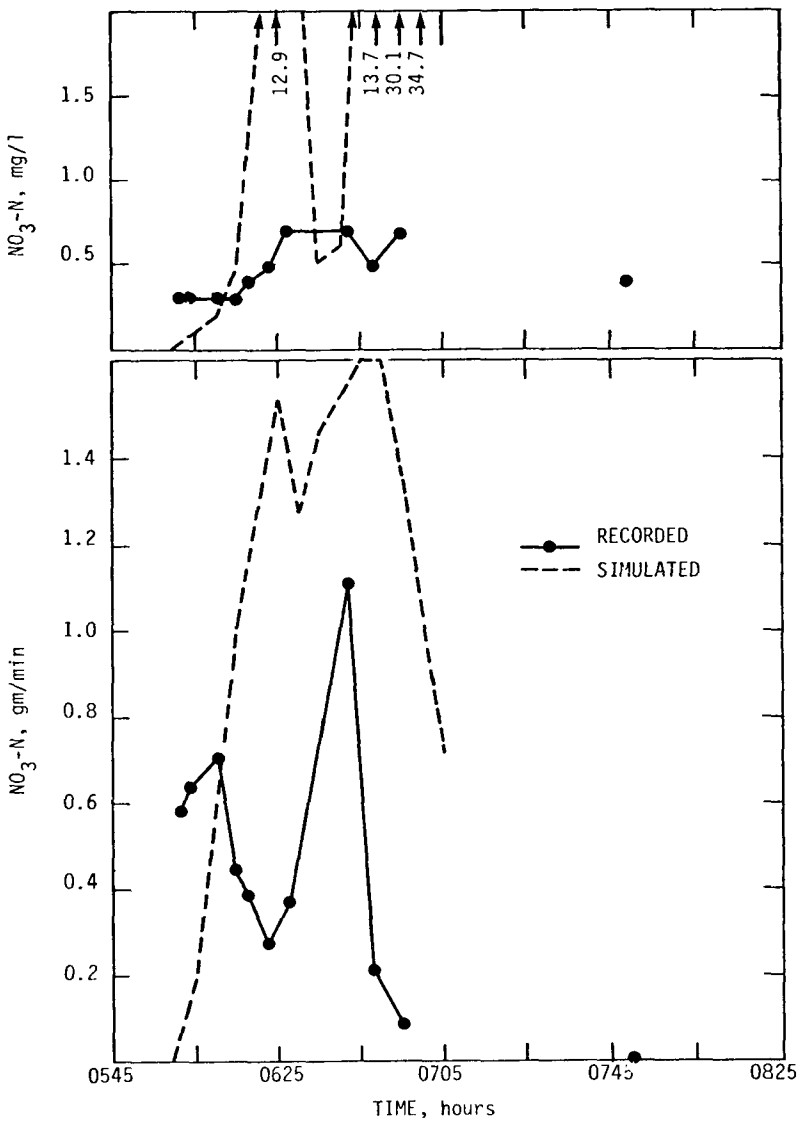


Figure 11.16 NO_3 removal in solution from the P6 watershed for the storm of August 27, 1974

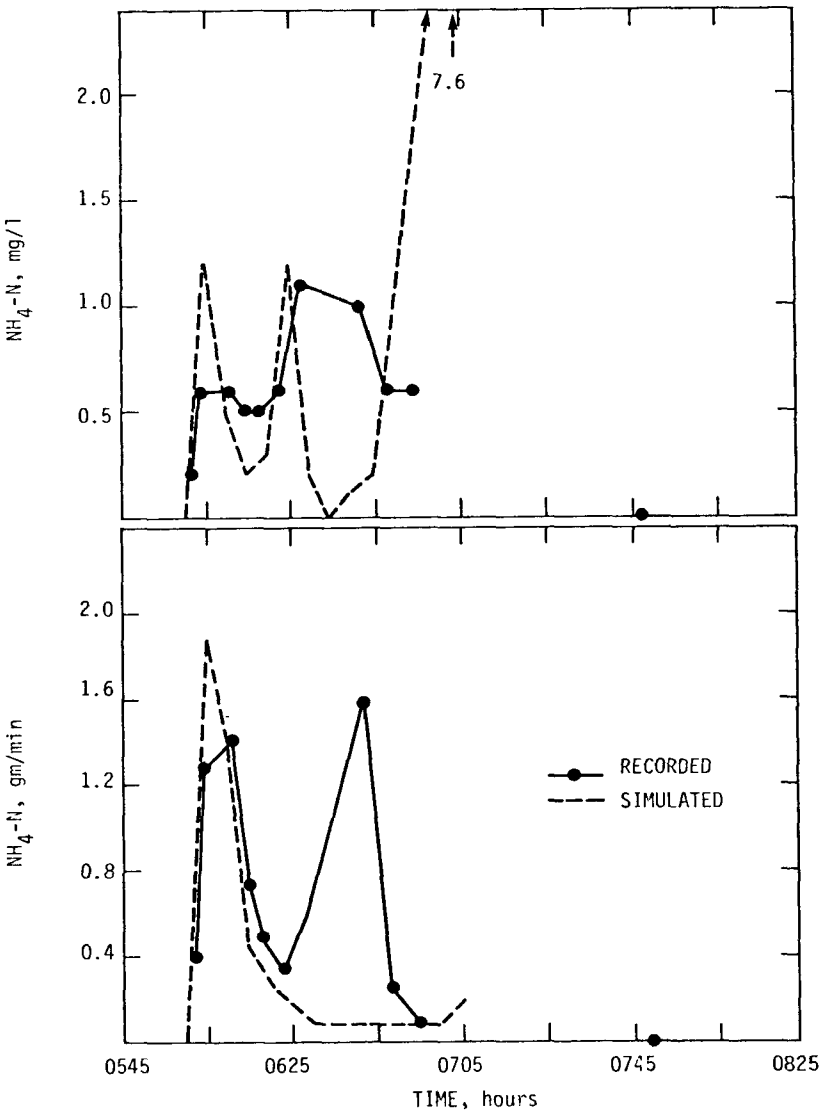


Figure 11.17 NH_4 removal in solution from the P6 watershed for the storm of August 27, 1974

period as occurs near the end of a storm event. Hence, for such long intervals between samples, the recorded data points are not connected.

Some general conclusions can be made concerning all the individual storm event results. The summer nutrient simulation is generally better than the winter. The poor winter nutrient simulation is partially due to inaccurate runoff, sediment, and soil temperature simulation. Nutrient simulation on the P6 watershed is also generally better than on P2. This is true for both the sediment and solution nutrient forms. The poor sediment nutrient simulation on P2 is because the concentration of nutrients varied from one storm event to the next more than it did for P6, for which the model simulates the concentration as remaining fairly stable.

The less accurate soluble nutrient simulation on the P2 watershed compared to P6 is because interflow is a smaller portion of total runoff and is more variable. Consequently, soluble nutrients transported mostly in interflow demonstrate the same highly variable nature as the simulated interflow component. This is particularly noticeable in the concentration graphs towards the end of a storm event. For example, NO_3-N concentration in Figure 11.9 becomes relatively large toward the end of the June 11 event. The other soluble nutrients behave similarly to some degree. This can be explained by the fact that interflow, which contains most or all of the soluble nutrients in a more concentrated form than surface runoff, makes up most of the flow towards the end of the storm event. This results in a higher concentration at the end of the storm event than earlier when the flow is diluted by surface runoff. Thus the discrepancies in the soluble nutrient simulation are the direct result of interflow fluctuations. However, the total mass removed from the watershed which is less affected by concentration variations is generally within the range of the recorded values.

NO_3-N is the most difficult solution component to simulate. This is particularly noticeable in the P6 storm results where large variations occur. NO_3-N is difficult because it is affected by many transformations as well as being soluble and thereby easily transported by and in the water. The other nutrients simulated in solution, NH_4-N and PO_4-P, do not undergo as many transformations and are also found in adsorbed form. Since the adsorbed form is usually more stable than the solution form, NH_4-N and PO_4-P are simulated somewhat better than NO_3-N.

All the solution nutrient results including NO_3-N are closer to the recorded values in mass per minute than in concentration (ppm). Since nutrients are not toxic to aquatic life in these small quantities, the simulation of total mass of nutrients in the runoff is considered more crucial than concentration. Moreover, eutrophication which occurs most readily in lakes is dependent more on the total nutrient input than on localized storm concentrations. Thus, simulation of the total mass loading of nutrients should be the primary goal of nutrient modeling in the runoff. The simulation of nutrient loadings with the ARM nutrient algorithms meets this goal since mass loadings are simulated better than instantaneous concentrations.

The simulation of nutrients on sediment, which affect long term eutrophication, is simulated more consistently than soluble nutrients. The concentration of nutrients on sediment in the runoff is simulated as being equal to the concentration in the surface soil zone. This would be modified if selective or particle size erosion could be simulated and incorporated into the ARM Model. Then the nutrient concentration in runoff would be dependent on the nutrients' preference for specific particle sizes and the amounts of these particles removed by runoff from the surface zone. However, with the current version of the model the simulated concentration of nutrients on the soil varies little during a storm event. The mass of nutrient removed on the sediment will still vary depending on how much sediment is being removed during the time period simulated. The storm event simulation results of the sediment-associated nutrient concentration and mass removal (shown in Figures 11.6-11.8 and 11.12-11.14) are quite good. However, for the other major events contained in Appendix B and C, the results show greater variations due primarily to discrepancies in the sediment loss simulation. Nevertheless, the overall simulation of sediment associated nutrients for storm events is better than soluble nutrients and is reasonably close to the recorded values.

SUMMARY

The nutrient model provides a reasonable framework for simulation of nutrient runoff. The results show that the model can be calibrated to a variety of situations. The soil storage simulation provides a reasonably accurate representation of the soil nutrients which are the sources for nutrient components in runoff. Nutrient simulation is found to rely heavily on the hydrology and sediment simulation. Within the present framework of the nutrient model, the accuracy of the nutrient simulation is a direct function of the ability to correctly simulate runoff and sediment loss. Overall, the ARM nutrient model is able with proper calibration to give reasonable estimates of nutrient mass in runoff. However, further study is needed in the area of nutrient transport through surface and subsurface pathways. This involves the study of surface and upper zone relationships, especially soil moisture, surface runoff, and interflow simulation. Even though the nutrients on sediment are simulated better than those in solution, the relationships of nutrient components to erosion processes should be studied. The behavior and transport of nutrients at the soil surface is an important topic for future research. With this additional knowledge, the ARM Model could more accurately simulate nutrients in the soil and in the runoff.

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TABLE A1. ARM MODEL INPUT PARAMETER DESCRIPTION

TYPE	NAME	DESCRIPTION
Control	HYCAL	Specifies type of information desired PROD-production run, prints full tables for each interval as specified by PRINT CALB-calibration run, prints removal values for each interval as specified by PRINT
	INPUT	Input units, ENGL-english, METR-metric
	OUTPUT	Output units, ENGL-english, METR-metric, BOTH-both
	PRINT	Denotes the interval of printed output, INTR-each interval, HOUR-each hour, DAYS-each day, MNTH-each month
	SNOW	NO-snowmelt not performed, YES,snowmelt calculations performed
	PEST	NO-pesticides not performed, YES-pesticide calculations performed
	NUTR	NO-nutrients not performed, YES-nutrients calculations performed
	ICHECK	ON-checks most of the hydrology, snow (if used), sediment, and pesticide (if used) input parameter values and prints out error and warning statements for input parameter values that are outside of acceptable value limits, OFF-no check is made
	DISK	NO-no output written to disk YES-LSRO and/or EROS written to disk
	IDEBUG	OFF-no output to check values written to disk ON-print echo of output written to disk
	CHAR	RUNOFF-Lands Surface RunOff (LSRO) output SEDIMENT-EROSion (EROS) from sediment output OVERLAND-Runoff fRom Overland Surface (RROS) output
	TITLE	Title for data set on disk (80 char)
	DSNFLO	Data set number for LSRO file
	DSNERS	Data set number for EROS file
	DSNROS	Data set number for RROS file
	INTRVL	Time interval of operation (5, 15, or 60 minutes)
	HYMIN	Minimum flow for printed output during a time interval
	AREA	Watershed area
	BGNDAY BGNMON BGNYR	Date simulation begins-day, month, year
	ENDDAY ENDMON ENDYR	Date simulation ends-day, month, year

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Hydrology	UZSN	Nominal upper zone soil moisture storage
	UZS	Initial upper zone soil moisture storage
	LZSN	Nominal lower zone soil moisture storage
	LZS	Initial lower zone soil moisture storage
	L	Length of overland flow to channel
	SS	Average overland flow slope
	NN	Manning's n for overland flow
	A	Fraction of area that is impervious
	EPXM	Maximum interception storage
	PETMUL	Potential evapotranspiration data correction factor
	K3	Index to actual evaporation on a monthly basis (12 values)
	INFIL	Mean infiltration rate
	INTER	Interflow parameter, alters runoff timing
	IRC	Interflow recession rate
	K24L	Fraction of groundwater recharge percolating to deep groundwater
	KK24	Groundwater recession rate
	K24EL	Fraction of watershed area where groundwater is within reach of vegetation
	SGW	Initial groundwater storage
	GWS	Initial groundwater slope
	KV	Parameter to allow variable recession rate for groundwater discharge
	ICS	Initial interception storage
	OFS	Initial overland flow storage
	IFS	Initial interflow storage
Snow	SNOWPRINT	NO-hourly snow tables not printed during snow pack periods YES-hourly snow tables printed
	RADCON	Correction factor for radiation melt
	CCFAC	Correction factor for condensation and convection melt
	SCF	Snow correction factor for raingage catch deficiency
	ELDIF	Elevation difference from temperature station to mean watershed elevation
	IDNS	Initial density of new snow
	F	Fraction of watershed with complete forest cover
	DGM	Daily groundmelt
	WC	Water content of snowpack by weight
	MPACK	Water equivalent of snowpack for complete watershed coverage
	EVAPSN	Correction factor for snow evaporation
	MELEV	Mean elevation of watershed
	TSNOW	Temperature below which precipitation becomes snow

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
	PACK	Initial water equivalent of snowpack
	DEPTH	Initial depth of snowpack
	PETMIN	Minimum temperature at which PET occurs
	PETMAX	Temperature at which PET is reduced by 50 percent
	WMUL	Wind data correction factor
	RMUL	Radiation data correction factor
	KUGI	Index to forest density and undergrowth
Sediment	COVPMO	Fraction of crop cover on a monthly basis (12 values)
	TIMTIL	Time when soil is tilled (Julian day, i.e. day of the year, e.g. January 1 = 1, December 31 = 365/366) (12 dates)
	YRTIL	Corresponding year (last two digits only) for TIMTIL (12 values)
	SRERTL	Fine deposits produced by tillage corresponding to TIMTIL and YRTIL (12 values)
	JRER	Exponent of rainfall intensity in soil splash equation
	KRER	Coefficient in soil splash equation
	JSER	Exponent of overland flow in sediment washoff equation
	KSER	Coefficient in sediment washoff equation
	SRERI	Initial fines deposit
	SCMPAC	Rate by which soil fines are decreased per day on non-rain days
Pesticide	PESTICIDE	Title word to begin the reading of pesticide input parameters
	APMODE	Application mode, SURF-surface applied, SOIL-soil incorporated
	DESORP	NO-single-valued adsorption/desorption used, YES-non-single-valued adsorption/desorption algorithm used
	PSSZ	Initial pesticide storage in surface zone
	PSUZ	Initial pesticide storage in upper zone
	PSLZ	Initial pesticide storage in lower zone
	PSGZ	Initial pesticide storage in groundwater zone
	TIMAP	Time of pesticide application (Julian day) (12 values)
	YEARAP	Year of pesticide application (last two digits only) (12 values)
	SSTR	Pesticide application for entire watershed (12 values)
	CMAX	Maximum solubility of pesticide in water
	DD	Permanent fixed adsorption capacity
	K	Coefficient in Freundlich adsorption equation
	N	Exponent in Freundlich adsorption equation
	NP	Exponent in Freundlich desorption equation
	DDG	Julian day when KDG(1) begins (max. of 12 values)
	YDG	Corresponding year in which DDG applies
	KDG	Pesticide decay rate (per day) (max. 12 values)

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Soil	LZTEMP	Lower zone temperature on a monthly basis (12 values)
	ASZT	Slope of surface zone soil temperature regression equation
	BSZT	Surface zone soil temperature regression equation
	AUZT	Slope of upper zone soil temperature regression equation
	BUZT	Upper zone soil temperature regression equation
	SZDPTH	Surface layer soil depth
	UZDPTH	Upper zone depth or depth of soil incorporation
	BDSZ	Bulk density of surface zone soil
	BDUZ	Bulk density of upper zone soil
	BDLZ	Bulk density of lower zone soil
	UZF	Upper zone chemical percolation factor
	LZF	Lower zone chemical percolation factor
Nutrient		
	TSTEP	Timestep of chemical and biological transformations, must be an integer number of time steps in a day, and an integer number of simulation intervals (INTRVL) in a TSTEP, range of TSTEP is 5 or 15 minutes to 1440 minutes, but the solution technique works best at 60 minutes or less.
	NAPPL	Number of fertilizer applications, values may range from 0 to 5
	TIMHAR	Time of plant harvesting, Julian day of the year, value may range from 0 to 366
	ULUPTK	Fraction of maximum crop uptake of nutrients for the the upper layers (surface and upper zone) on a monthly basis (12 values), should be 1.0 or less
	LZUPTK	Fraction of maximum crop uptake of nutrients for the lower zone on a monthly basis (12 values), should be 1.0 or less
Nitrogen Reaction Rates		
	K1	Oxidation rate of solution ammonium
	KD	Reduction rate of nitrite and nitrate to gaseous nitrogen
	KPL	Uptake rate of nitrate by plants
	KAM	Ammonification or mineralization rate of ORG-N to ammonium
	KIM	Immobilization rate of solution ammonium to ORG-N
	KKIM	Immobilization rate of nitrate (and nitrite) to ORG-N
	KSA	Transfer rate of ammonium from solution to adsorbed (adsorption)
	KAS	Transfer rate of ammonium from adsorbed to solution (desorption)

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Phosphorus Reaction Rates		
	KM	Mineralization rate of ORG-P to solution phospate
	KIM	Immobilization rate of solution phosphate to ORG-P
	KPL	Uptake rate of phosphate in solution
	KSA	Transfer rate of phosphate from solution to adsorbed form
	KAS	Transfer rate of phosphate from adsorbed to solution form
Nitrogen Storages		
	ORG-N	Organic nitrogen in or attached to soil
	NH4-S	Ammonium in solution
	NH4-A	Ammonium adsorbed to soil
	NO2+N03	Nitrite and nitrate
	N2	Gaseous nitrogen forms from denitrification
	PLNT-N	Plant nitrogen
Phosphorus Storages		
	ORG-P	Organic phosphorus in or attached to soil
	P04-S	Phosphate in solution
	P04-A	Phosphate adsorbed to soil
	PLNT-P	Plant phosphorus
Chloride Storage		
	CL	Chloride

TABLE A2. ARM MODEL INPUT SEQUENCE AND PARAMETER ATTRIBUTES
(excluding Nutrient input and parameters)

Namelist Name	Parameter Name	Type	English Units	Metric Units
	Watershed name (up to 72 characters)			
	Chemical name and/or run information (up to 80 characters)			
	HYCAL	character		
	INPUT	character		
	OUTPUT	character		
	PRINT	character		
	SNOW	character		
	PEST	character		
	NUTR	character		
	ICHECK	character		
	DISK	character		
	IDEBUG	character		
	CHAR	character		
	TITLE	(up to 80 characters)		
	DSNFLO	integer		
	DSNERO	integer		
	DSNROS	integer		
CNTL	INTRVL	integer	minutes	minutes
	HYMIN	real	cubic feet/sec	cubic meters/sec
	AREA	real	acres	hectares
STRT	BGNDAY	integer		
	BGNMON	integer		
	BGNYR	integer		
ENDD	ENDDAY	integer		
	ENDMON	integer		
	ENDYR	integer		
LND1	UZSN	real	inches	millimeters
	UZS	real	inches	millimeters
	LZSN	real	inches	millimeters
	LZS	real	inches	millimeters
LND2	L	real	feet	meters
	SS	real		
	NN	real		
	A	real		
	EPXM	real	inches	millimeters
	PETMUL	real		
LND3	K3	real		

(continued)

TABLE A2 (continued)

Namelist Name	Parameter Name	Type	English Units	Metric Units
LND4	INFIL	real	inches/hour	millimeters/hour
	INTER	real		
	IRC	real		
	K24L	real		
	KK24	real		
	K24EL	real		
LIND5	SGW	real	inches	millimeters
	GWS	real		
	KV	real		
	ICS	real	inches	millimeters
	OFS	real	inches	millimeters
	IFS	real	inches	millimeters
	SNOWPRINT	character		
SNO1	RADCON	real		
	CCFAC	real		
	SCF	real		
	ELDIF	real	1000 feet	kilometers
	IDNS	real		
	F	real		
SNO2	DGM	real	inches/day	millimeters/day
	WC	real		
	MPACK	real	inches	millimeters
	EVAPSN	real		
	MELEV	real	feet	meters
	TSNOW	real	degrees F	degrees C
SNO3	PACK	real	inches	millimeters
	DEPTH	real	inches	millimeters
SNO4	PETMIN	real	degrees F	degrees C
	PETMAX	real	degrees F	degrees C
	WMUL	real		
	RMUL	real		
	KUGI	integer		
CROP	COVPMO	real		
MUD1	TIMTIL	integer	days	days
MUD2	YRTIL	integer	year	year
MUD3	SRERTL	real	tons/acre	tonnes/hectare

(continued)

TABLE A2 (continued)

Namelist Name	Parameter Name	Type	English Units	Metric Units
SMDL	JRER	real		
	KRER	real		
	JSER	real		
	KSER	real		
	SRERI	real	tons/acre	tonnes/hectare
	SCMPAC	real		
	PESTICIDE	character		
	APMODE	character		
	DESORP	character		
PSTR	PSSZ	real	pounds/acre	kilograms/hectare
	PSUZ	real	pounds/acre	kilograms/hectare
	PSLZ	real	pounds/acre	kilograms/hectare
	PSGZ	real	pounds/acre	kilograms/hectare
PST1	TIMAP	integer	day	day
PST2	YEARAP	integer	year	year
PST3	SSTR	real	pounds/acre	kilograms/hectare
AMDL	CMAX	real	pounds/pound	kilograms/kg
	DD	real	lbs. pesticide/ lbs. soil	kgs. pesticide/ kgs. soil
	K	real		
	N	real		
	NP	real		
DEGD	DDG	integer	day	day
DEGY	YDG	integer	year	year
DEGR	KDG	real	per day	per day
LZTP	LZTEMP	real	degrees F	degrees C
RETP	ASZT	real		
	BSZT	real		
	AUZT	real		
	BUZT	real		
DPTH	SZDPTH	real	inches	millimeters
	UZDPTH	real	inches	millimeters
	BSDZ	real	pounds/cubic ft	grams/cubic cm
	BDUZ	real	pounds/cubic ft	grams/cubic cm
	BDLZ	real	pounds/cubic ft	grams/cubic cm
	UZF	real		
	LZF	real		

TABLE A3. ARM MODEL NUTRIENT PARAMETER INPUT SEQUENCE AND ATTRIBUTES

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
NUTRIENT			Character	1-8			Name to indicate start of nutrient input sequence.
	&NUTRIN		Character	2-8			Namelist name of nutrient control information.
		TSTEP	Integer	Any	minutes	minutes	Length of timestep for chemical and biological transformations. There must be an even number of time steps in a day, and an even number of simulation intervals in a TSTEP. Range = 5 or 15 to 1440.
		NAPPL	Integer	Any			Number of nutrient applications over a year of simulation. Values may range from 0 to 5.
		TIMHAR	Integer	Any	day	day	Time of plant harvesting, Julian day of the year. Value may range from 0 to 366.
		&END	Character	Any			Indicate end of namelist input of nutrient control information.
	&PLANTU		Character	2-8			Namelist name for upper layers plant uptake informations.
		ULPTK	Real	Any			12 values of fraction of maximum monthly crop uptake of nutrients, should be 1.0 or less.
	&PLANTL		Character	2-8			Namelist name for lower zone plant uptake information.
		LZUPTK	Real	Any			12 values of fraction of maximum monthly crop uptake should be 1.0 or less.
REACTION RATES			Character	1-14			Name to indicate start of nutrient input sequence.
	NITROGEN		Character	1-8			Indicates nitrogen reaction rate will follow.
	SURFACE		Character	1-7			Surface layer reaction rates follow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	UPPER ZONE		Character	1-10			Upper zone reaction rates follow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	LOWER ZONE		Character	1-10			Lower zone reaction rates folow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of dissolved ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	GROUNDWATER		Character	1-11			Groundwater reaction rates follow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	TEMPERATURE COEFFICIENTS		Character	1-23			Temperature coefficients for reaction rates.
		THK1	Real	1-8	per day	per day	
		THKD	Real	9-16	per day	per day	
		THKPL	Real	17-24	per day	per day	
		THKAM	Real	25-32	per day	per day	Temperature coefficients for corresponding nitrogen reactions, should be greater than or equal to 1.0.
		THKIM	Real	33-40	per day	per day	
		THKKIM	Real	41-48	per day	per day	
		THKSA	Real	49-56	per day	per day	
		THKAS	Real	57-64	per day	per day	
	PHOSPHORUS		Character	1-10			Indicates phosphorus reaction rates will follow.
	SURFACE		Character	1-7			Surface layer reaction rates.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution. by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	UPPER ZONE		Character	1-10			Upper zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution. by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	LOWER ZONE		Character	1-10			Lower zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.
		KIM	Real	9-16	per day	per day	Immobilization rate of dissolved P04-P to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	GROUNDWATER		Character	1-11			Lower zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution by plants
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	TEMPERATURE COEFFICIENTS		Character	1-23			Temperature coefficients for reaction rates.
		THKM	Real	1-8	per day	per day	
		THKIM	Real	9-16	per day	per day	Temperature coefficients for phosphorus reactions, should be greater than or equal to 1.0.
		THKPL	Real	17-24	per day	per day	
		THKSA	Real	25-32	per day	per day	
		THKAS	Real	33-40	per day	per day	
END			Character	1-3			'END' terminates input of rates. Nitrogen and phosphorus rates are optional, program defaults them to 0.0 if not specified.
INITIAL			Character	1-7			Initialization of soil constituents follows.
	NITROGEN		Character	1-8			Initial nitrogen forms follow.
	SURFACE		Character	1-7			Surface layer initialization follows.
		NBLK	Integer	16			Number of blocks which will be input. 0 or 1 indicate the average concentration over the surface layer in input on one line, and NBLK=5 means five lines of input follow, one line per block. Only 0,1,5 allowed. A blank in col. 16 is read as 0.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	UPPER ZONE		Character	1-10			Upper zone initialization follows.
		NBLK	Integer	16			Number of blocks which will be input. 0 or 1 indicate the average concentration over the surface layer in input on one line, and NBLK=5 means five lines of input follow, one line per block. Only 0,1,5 allowed. A blank in col. 16 is read as 0.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	LOWER ZONE		Character	1-10			Lower zone initialization.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	GROUNDWATER		Character	1-11			Groundwater zone initialization.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH3-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH3-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate.
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	PHOSPHORUS		Character	1-10			Initial phosphorus forms follow.
	SURFACE		Character	1-7			Surface layer.
		NBLK	Integer	16			Number of blocks which will be input.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	UPPER ZONE		Character	1-10			Upper zone phosphorus initialization.
		NBLK	Integer	16			Number of blocks which will be input.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	LOWER ZONE		Character	1-10			Lower zone initialization.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed to soil.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	GROUNDWATER		Character	1-11			Groundwater initialization.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.

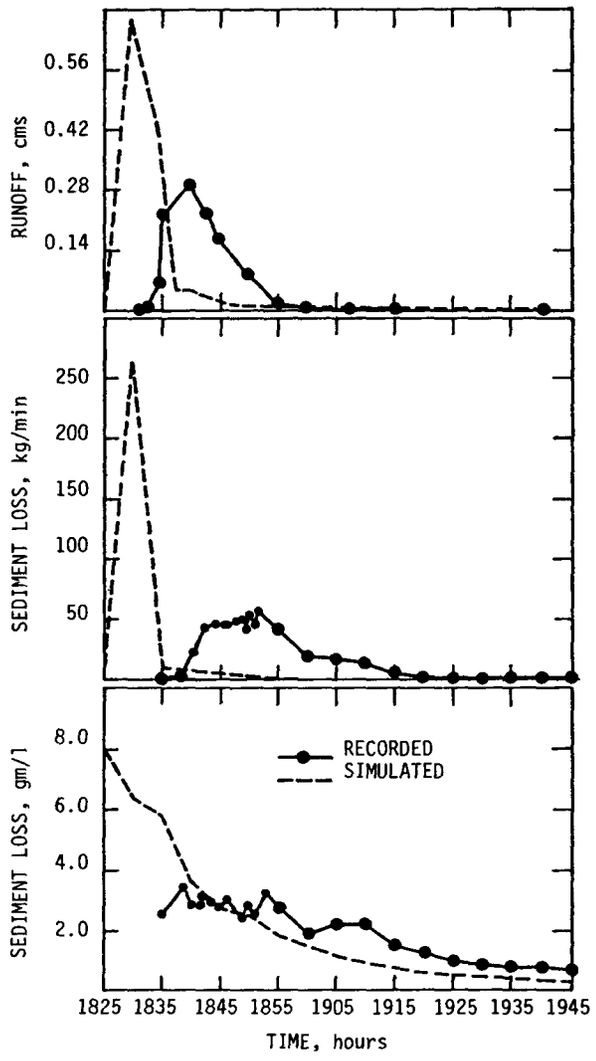

Figure B1 Runoff and sediment loss from the P2 watershed for the storm of June 27, 1974

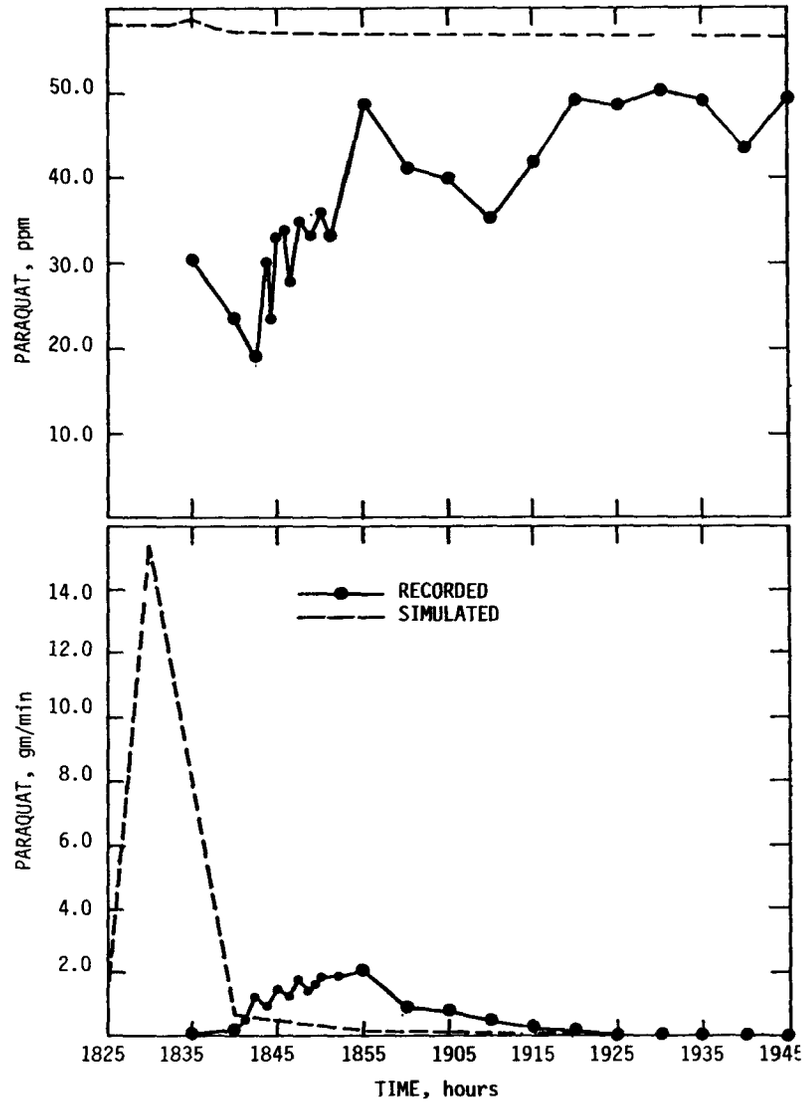

Figure B2 Paraquat removal on sediment from the P2 watershed for the storm of June 27, 1974

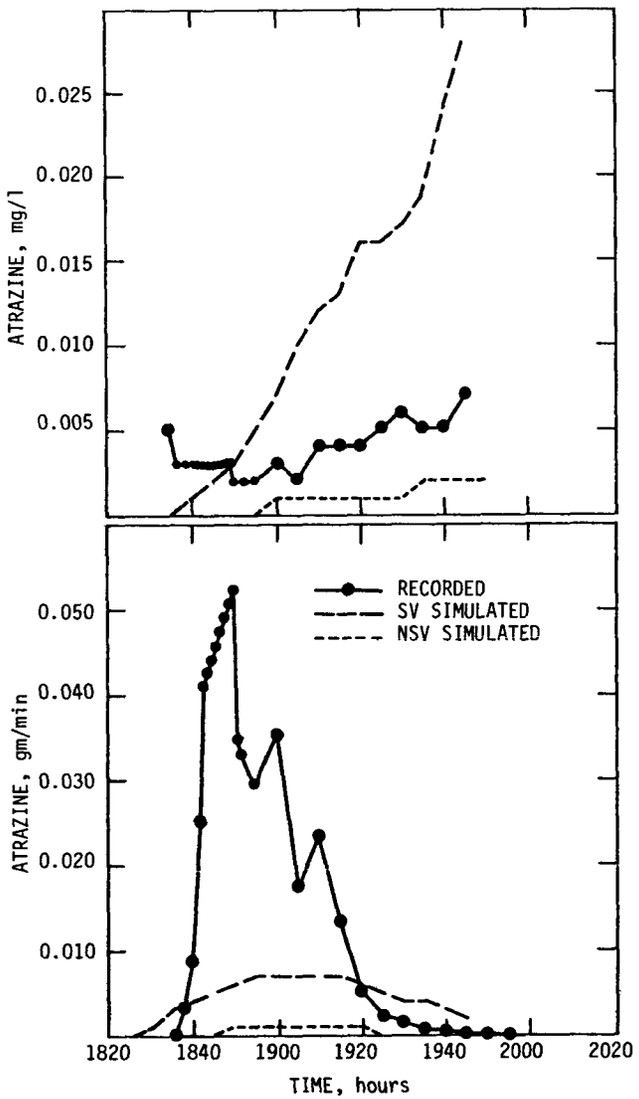

Figure B3 Atrazine removal in solution from the P2 watershed for the storm of June 27, 1974

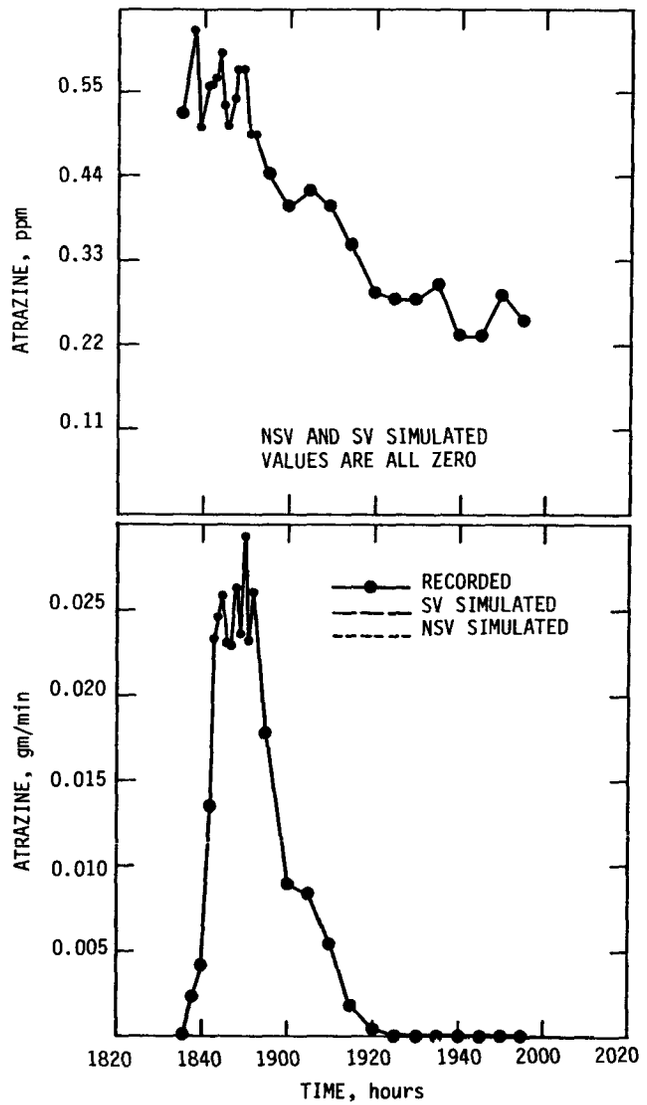

Figure B4 Atrazine removal on sediment from the P2 watershed for the storm of June 27, 1974

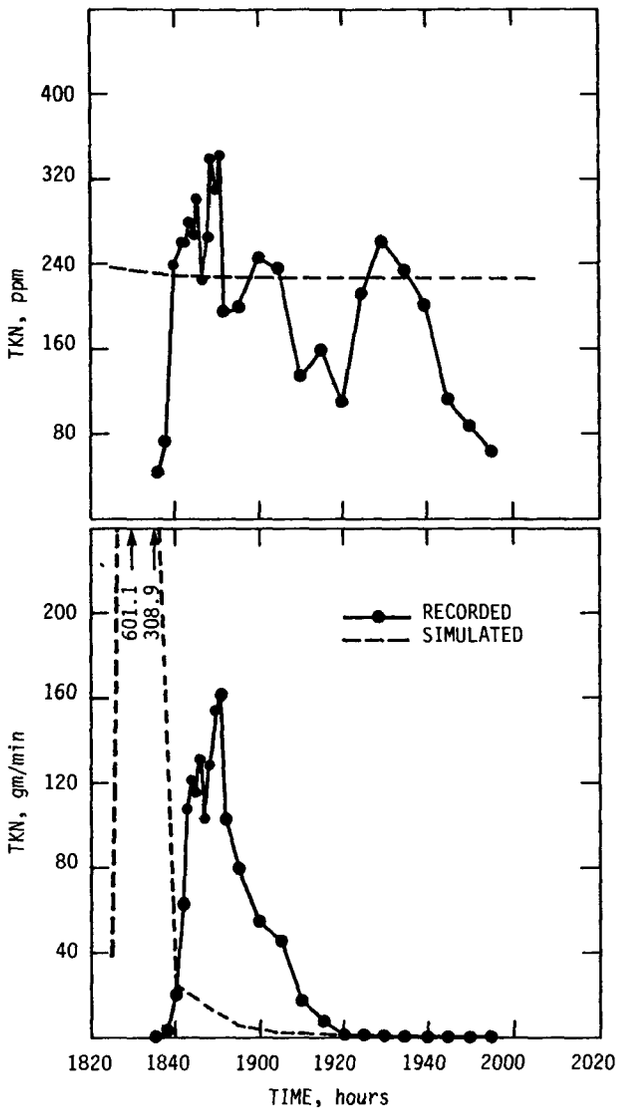

Figure B5 TKN removal on sediment from the P2 watershed for the storm of June 27, 1974

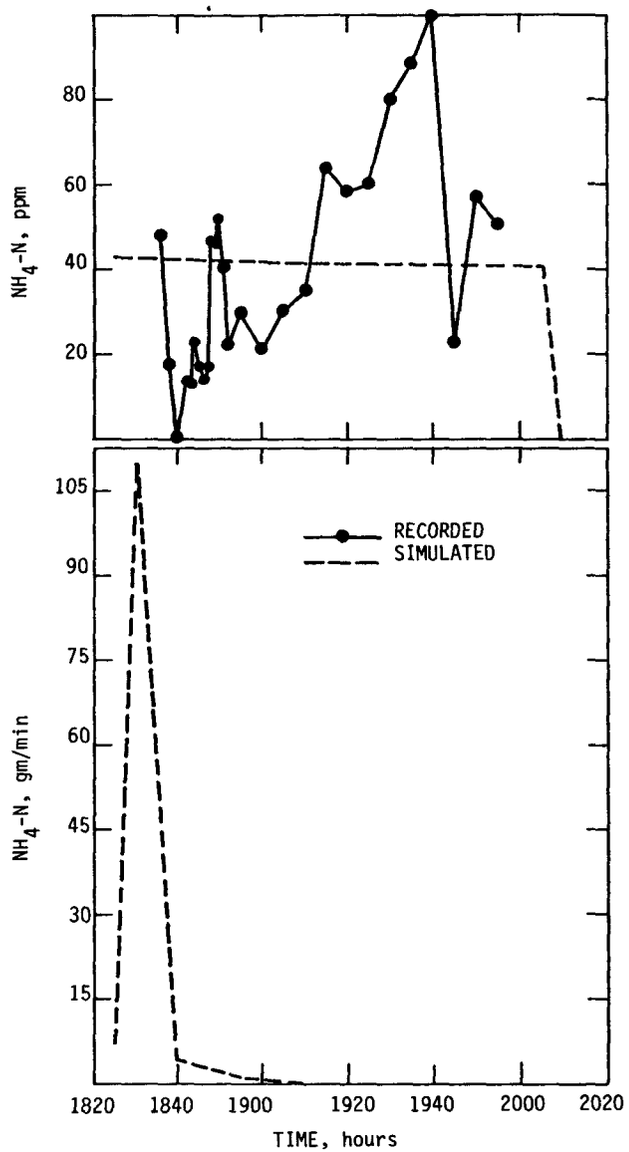

Figure B6 NH_4 removal on sediment from the P2 watershed for the storm of June 27, 1974

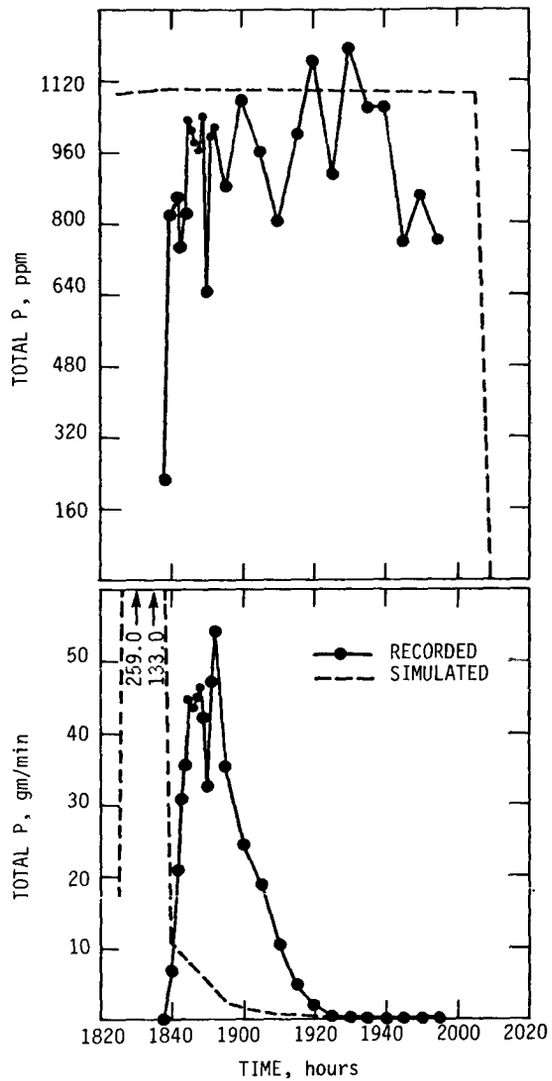

Figure B7 Total P removal on sediment from the P2 watershed for the storm of June 27, 1974

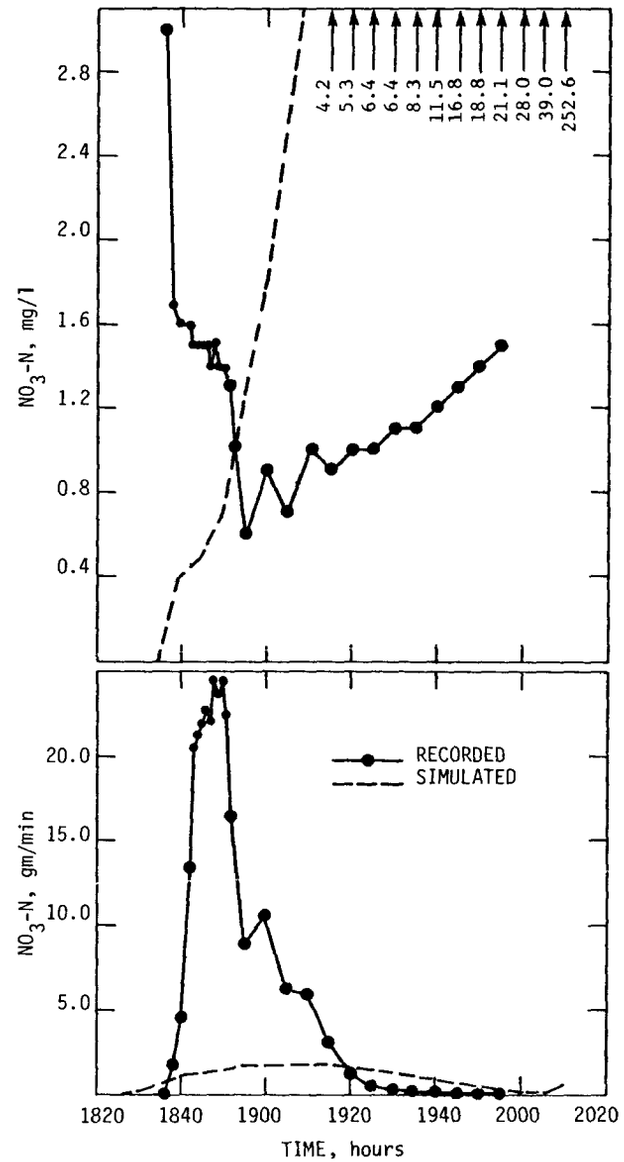

Figure B8 NO_3 removal in solution from the P2 watershed for the storm of June 27, 1974

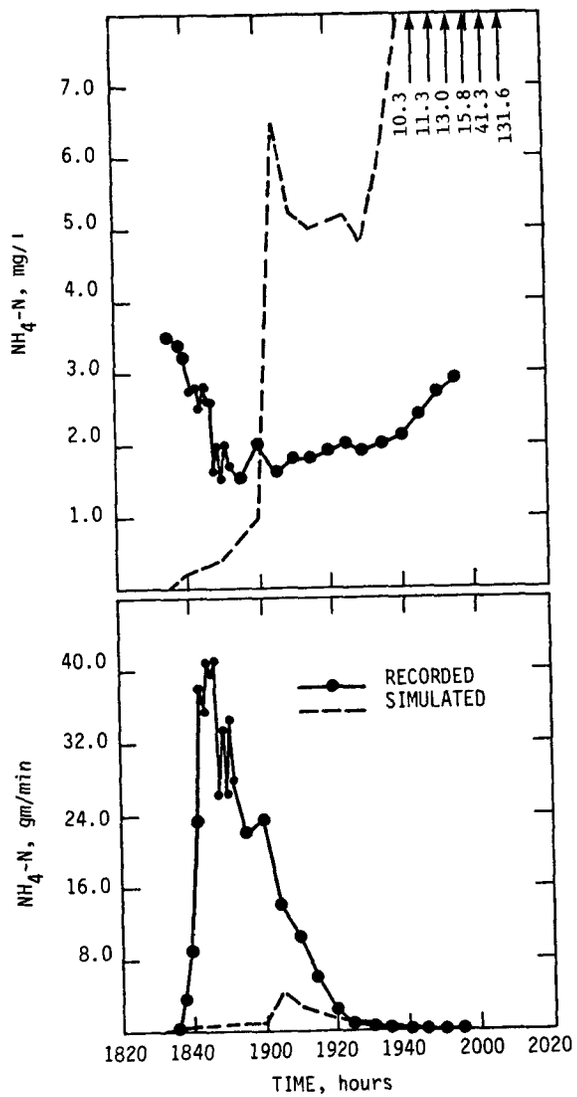

Figure B9 NH_4 removal in solution from the P2 watershed for the storm of June 27, 1974

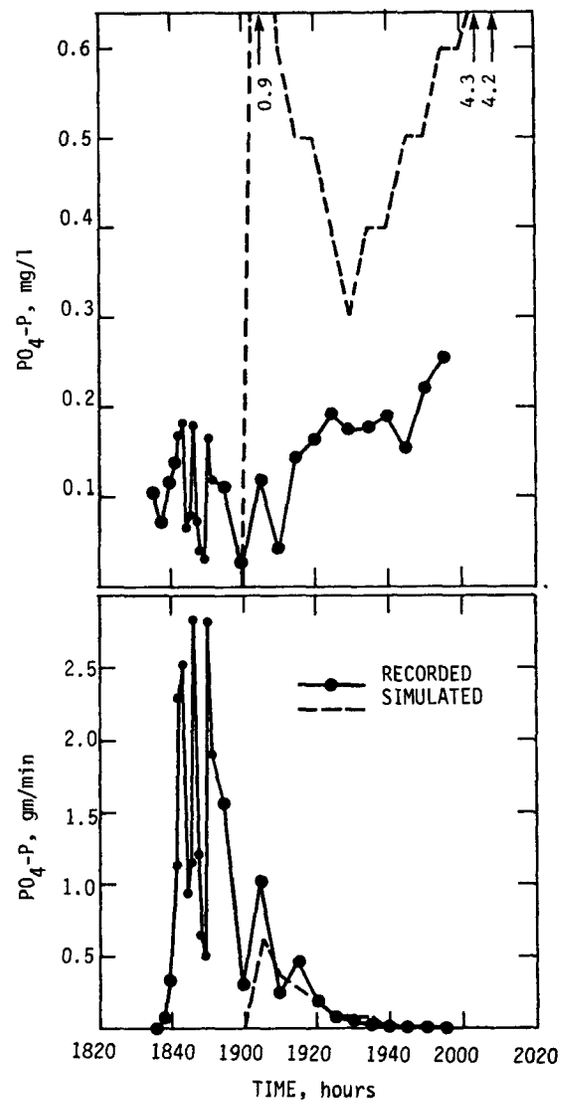

Figure B10 PO_4 removal in solution from the P2 watershed for the storm of June 27, 1974

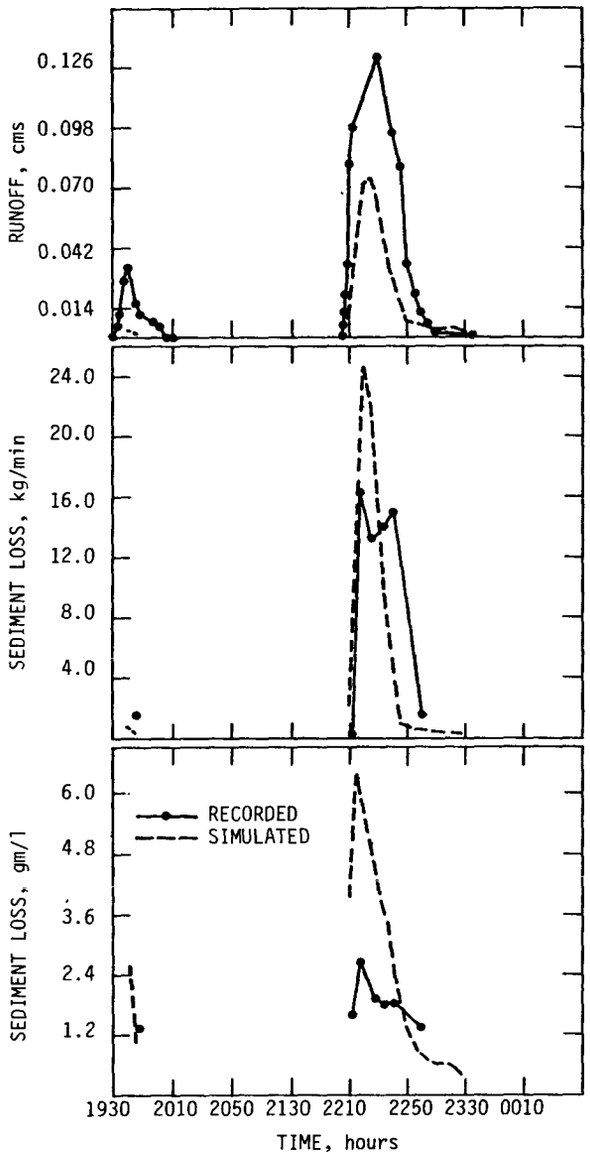

Figure B11 Runoff and sediment loss from the P2 watershed for the storm of July 24, 1975

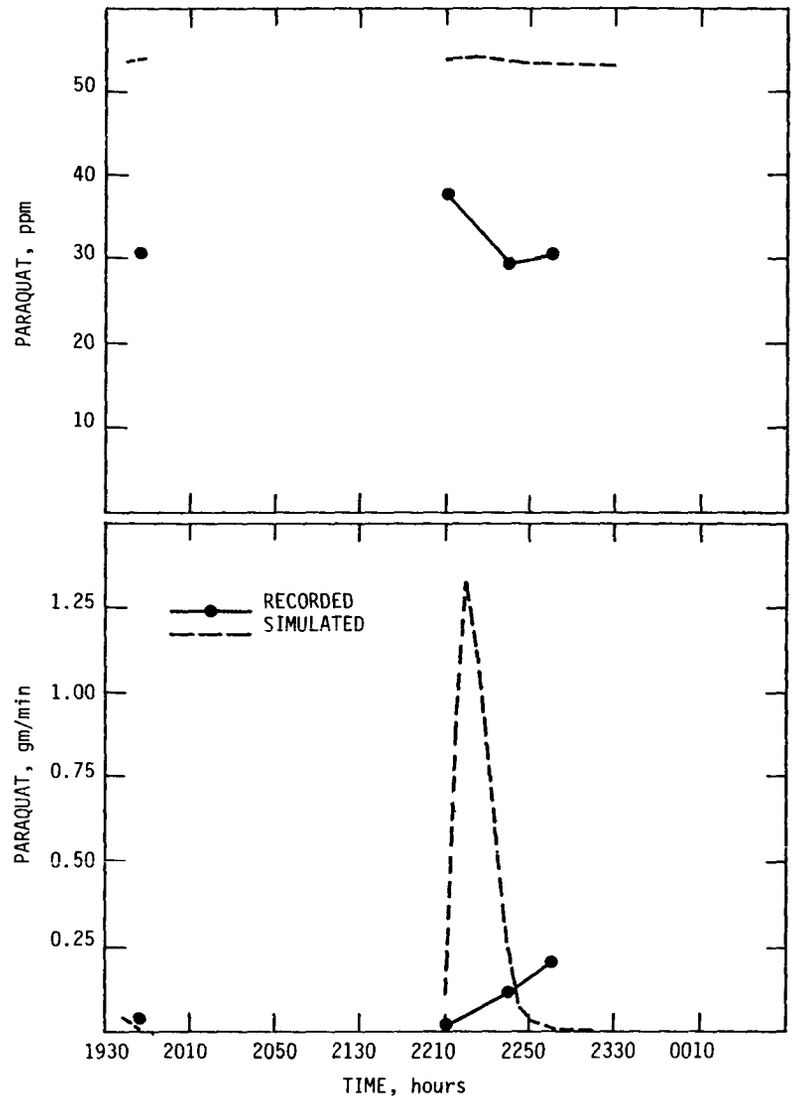

Figure B12 Paraquat removal on sediment from the P2 watershed for the storm of July 24, 1975

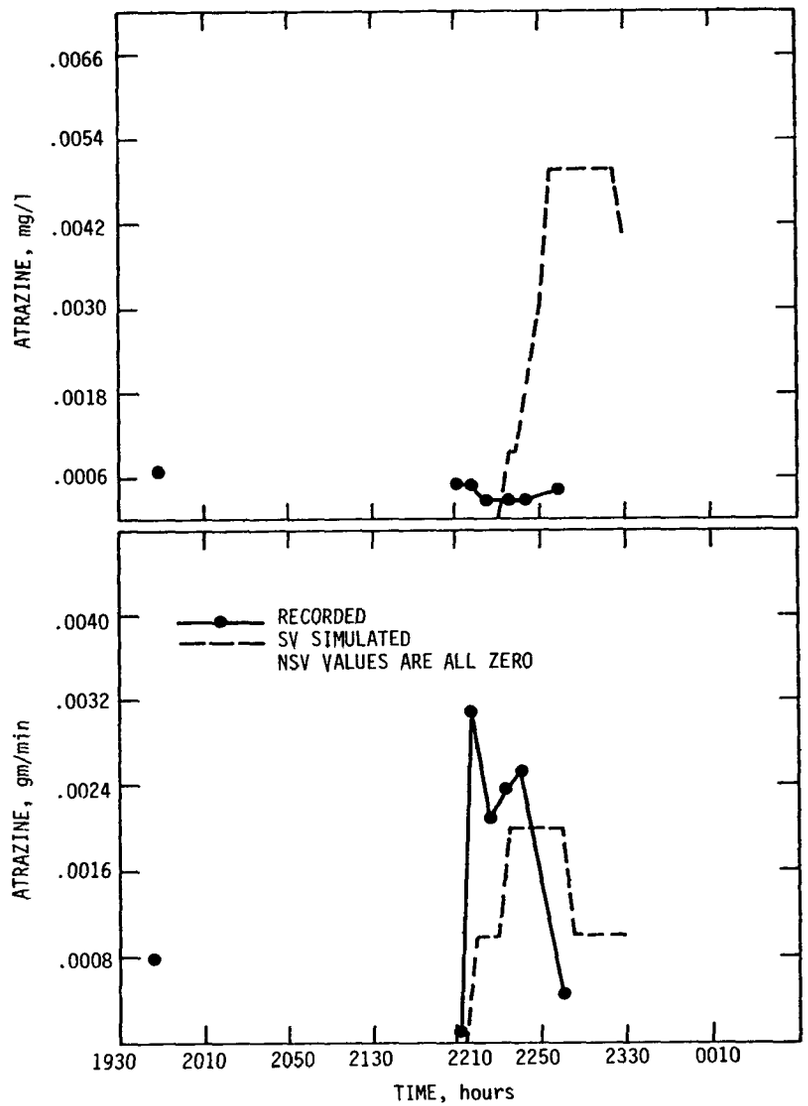

Figure B13 Atrazine removal in solution from the P2 watershed for the storm of July 24, 1975

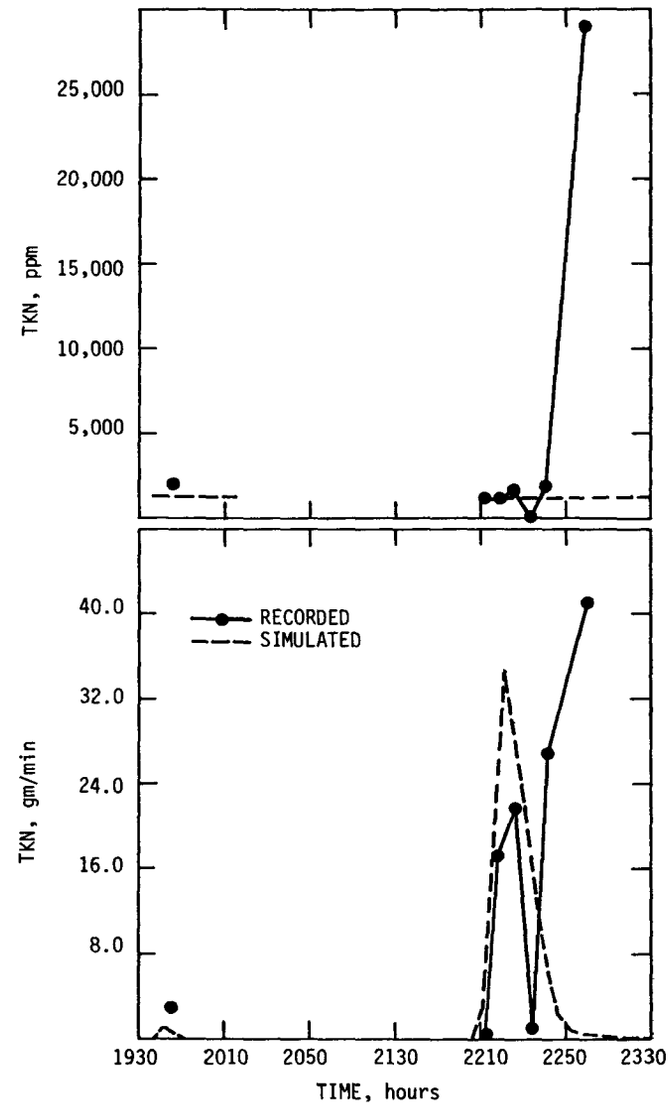

Figure B14 TKN removal on sediment from the P2 watershed for the storm of July 24, 1975

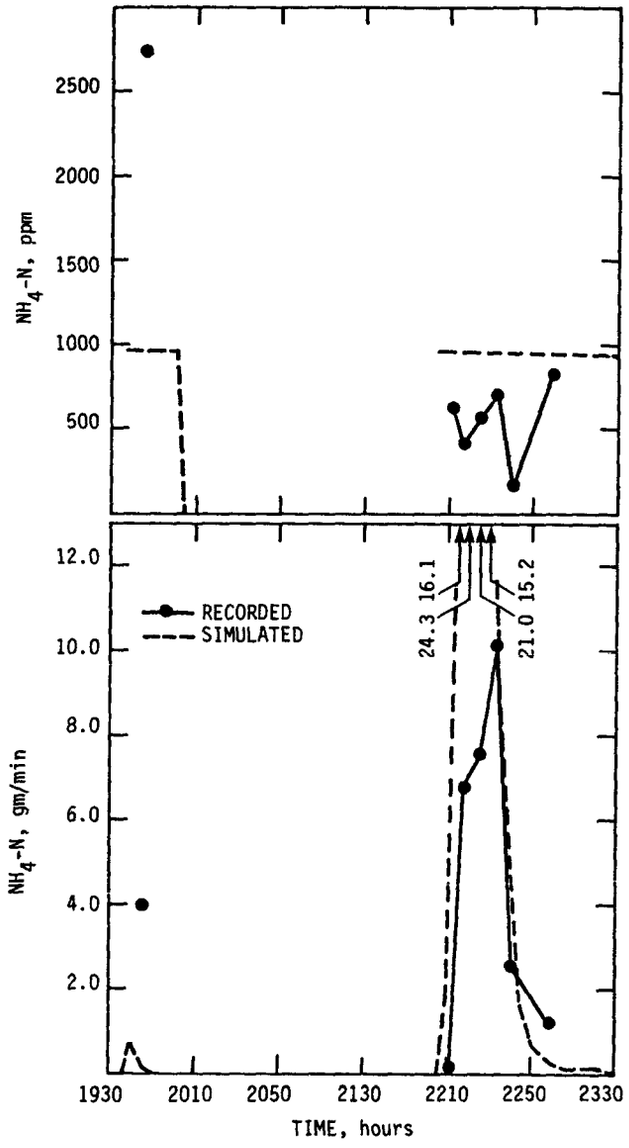

Figure B15 NH_4 removal on sediment from the P2 watershed for the storm of July 24, 1975

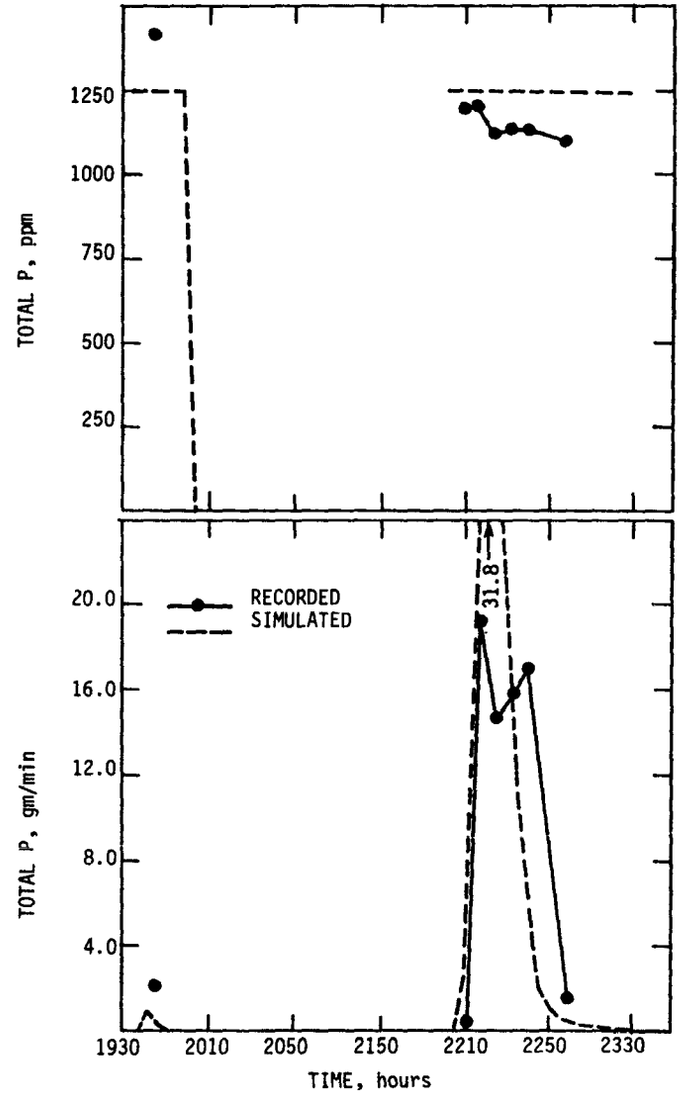

Figure B16 Total P removal on sediment from the P2 watershed for the storm of July 24, 1975

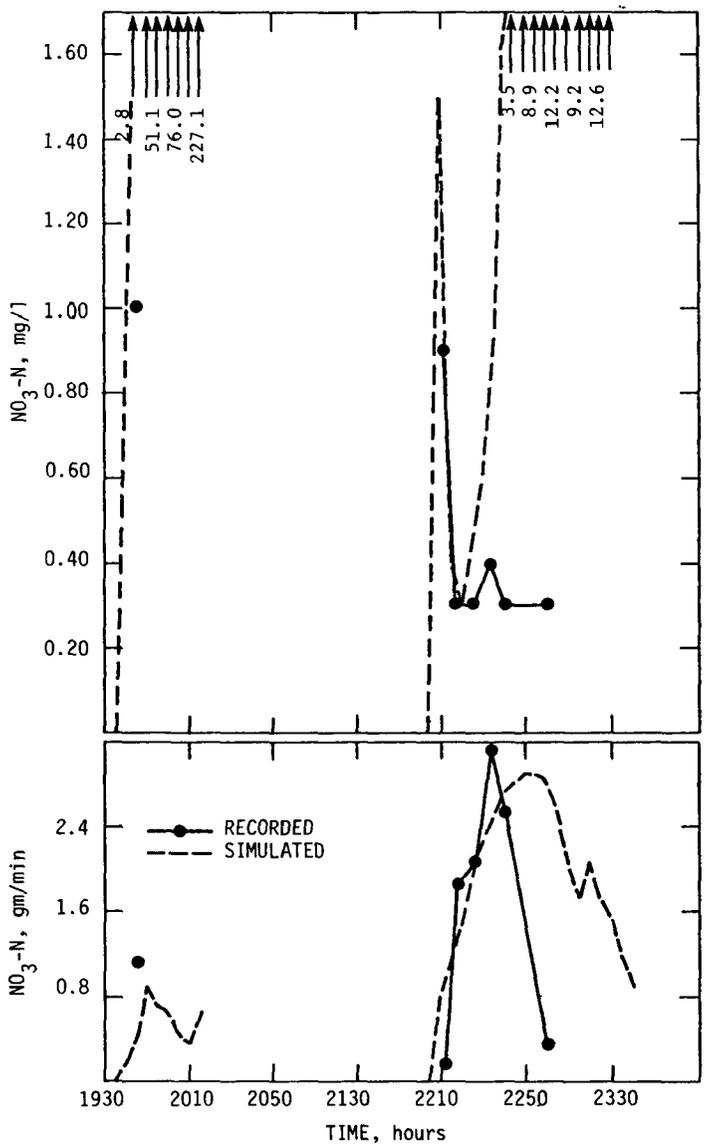

Figure B17 NO_3 removal in solution from the P2 watershed for the storm of July 24, 1975

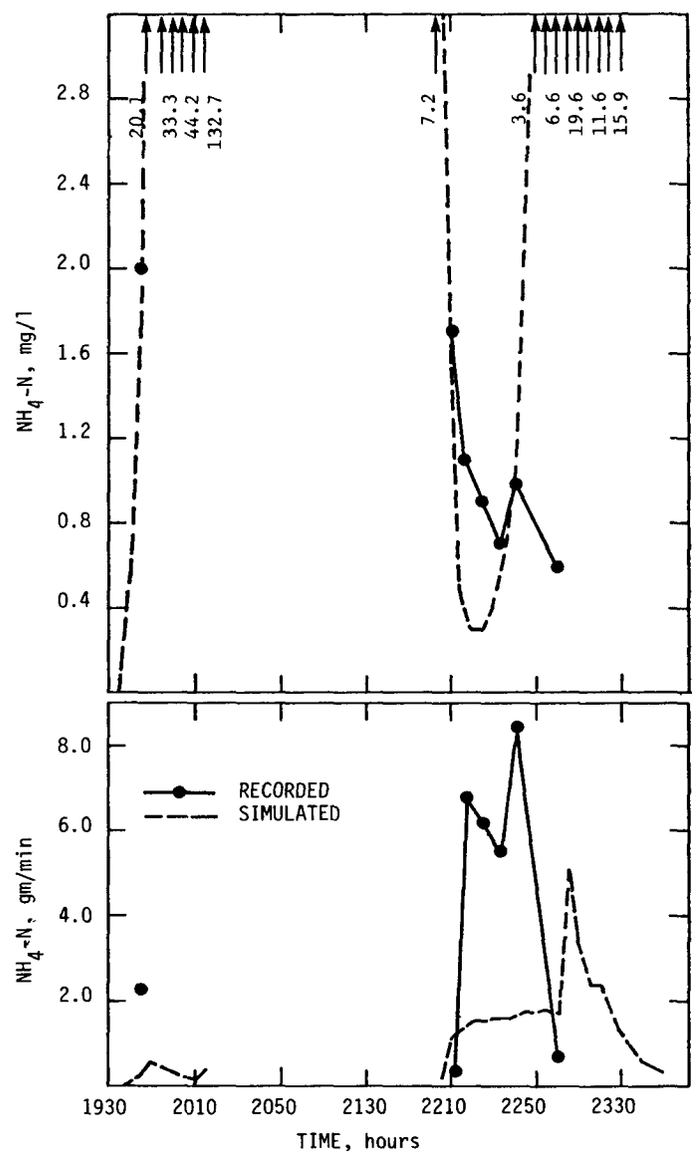

Figure B18 NH_4 removal in solution from the P2 watershed for the storm of July 24, 1975

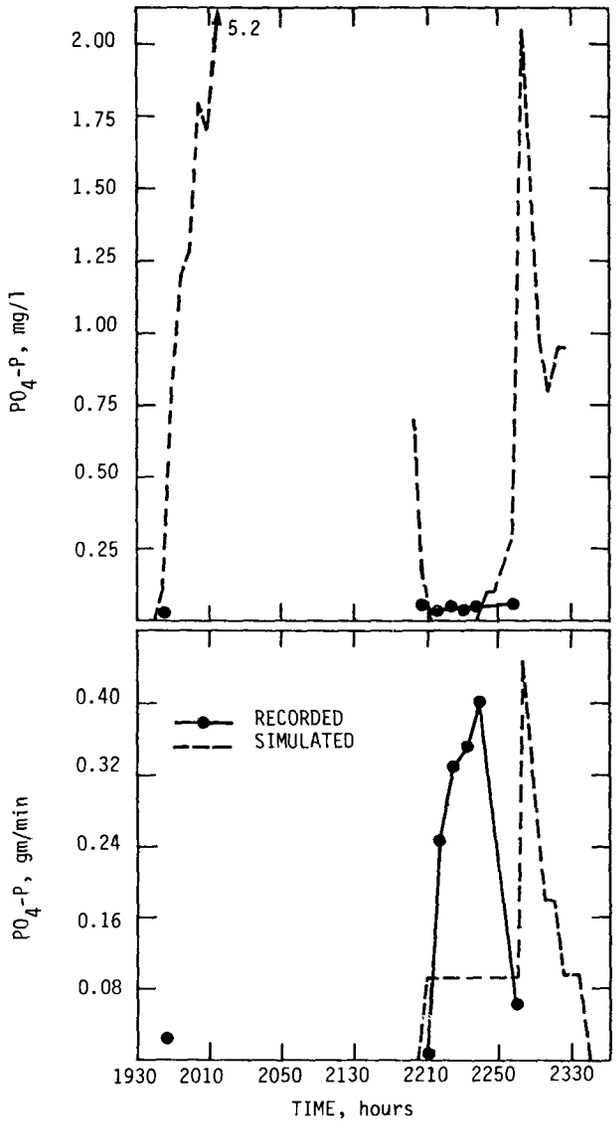

Figure B19 PO_4 removal in solution from the P2 watershed for the storm of July 24, 1975

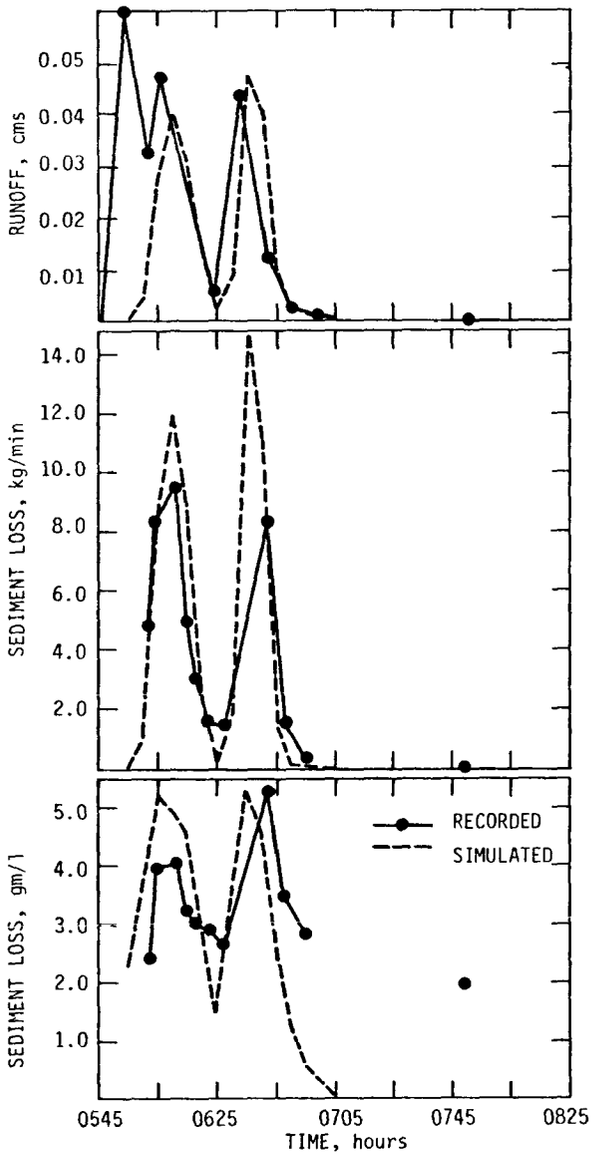

Figure C1 Runoff and sediment loss from the P6 watershed for the storm of August 27, 1974

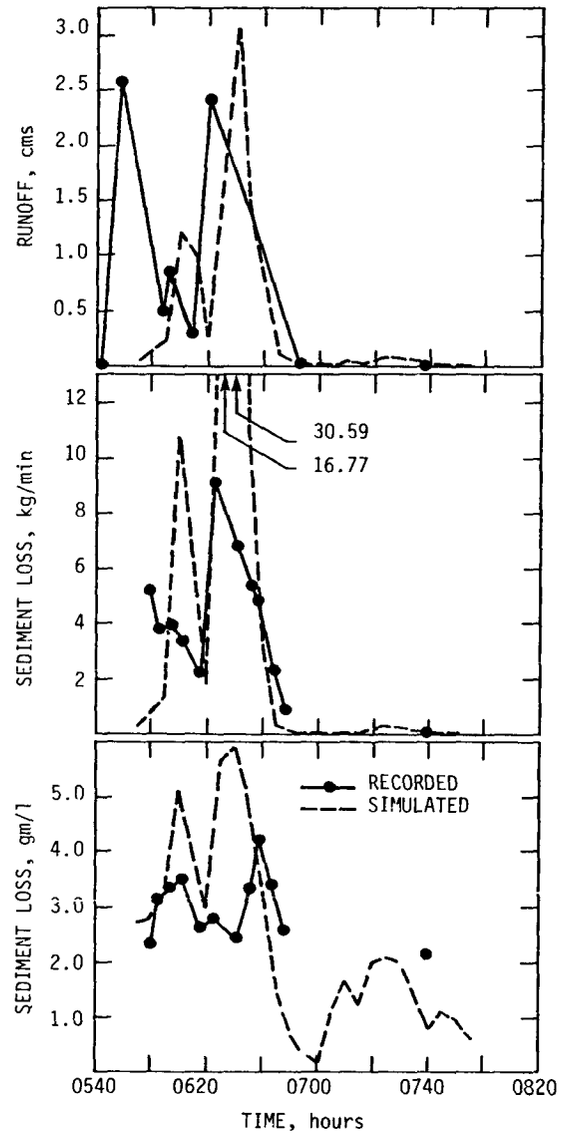

Figure C2 Runoff and sediment loss from the P6 watershed for the storm of August 13, 1974

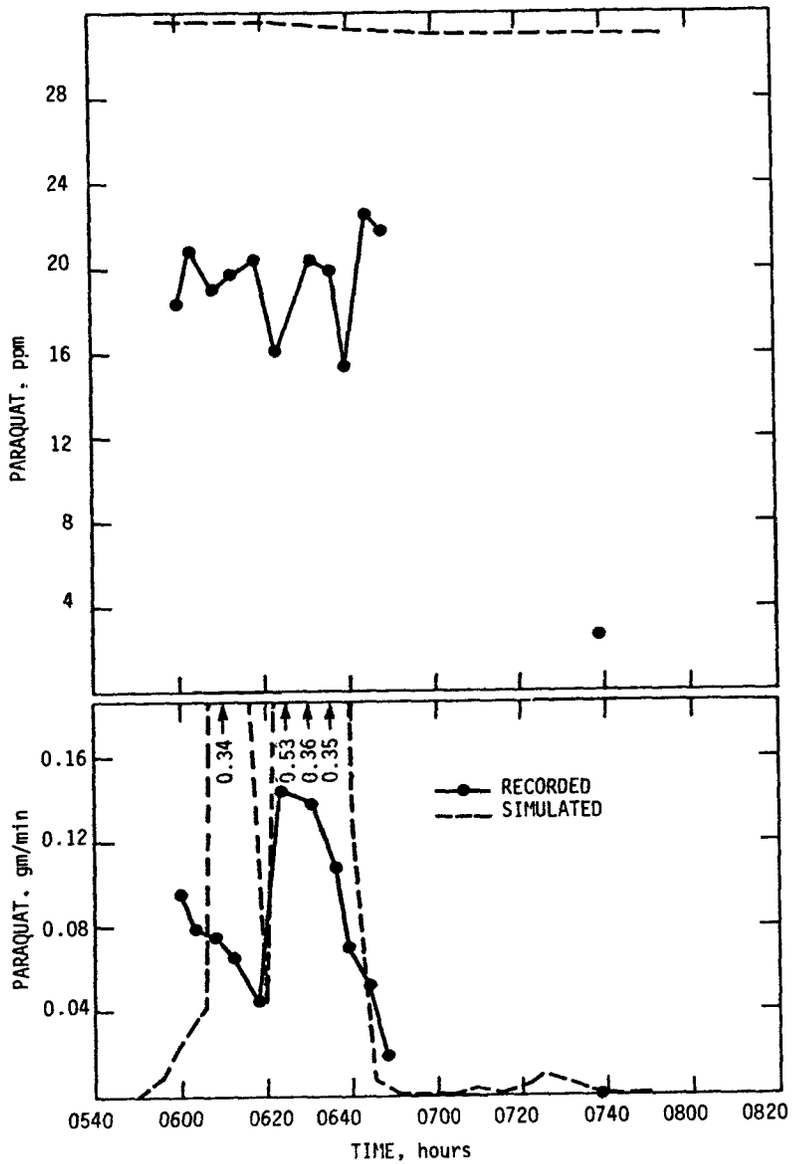

Figure C3 Paraquat removal on sediment from the P6 watershed for the storm of August 13, 1974

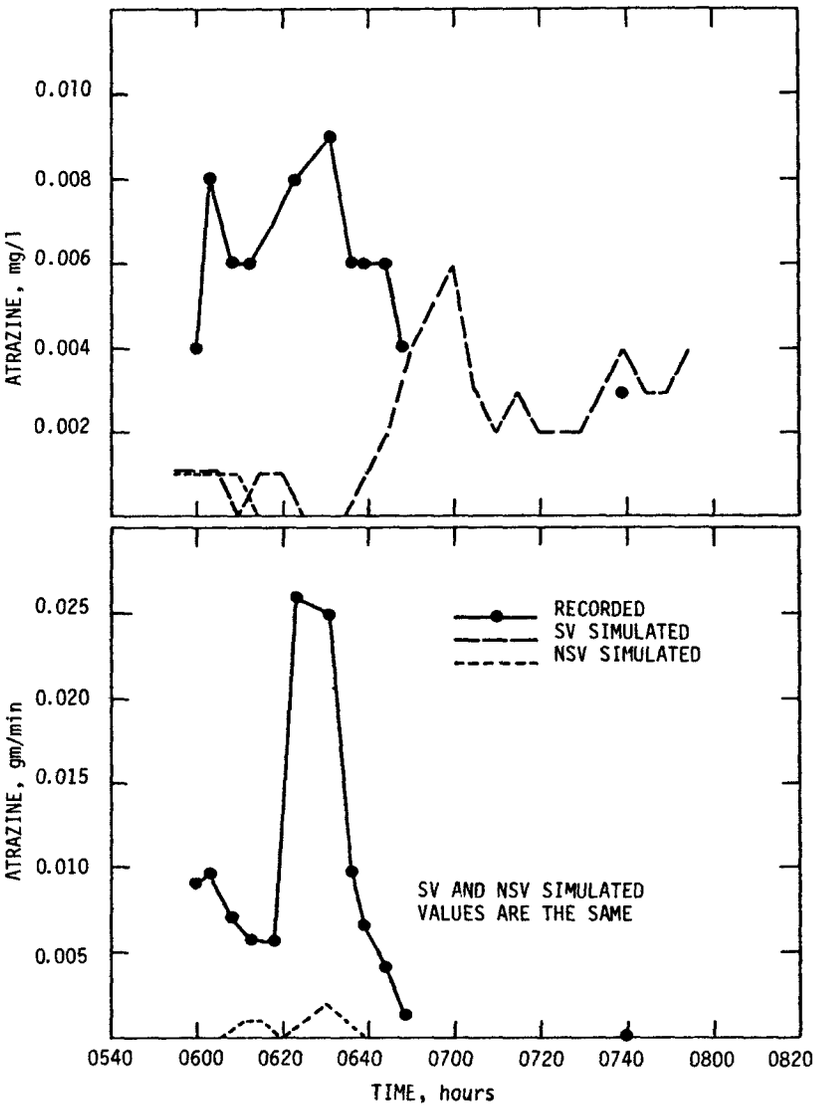

Figure C4 Atrazine removal in solution from the P6 watershed for the storm of August 13, 1974

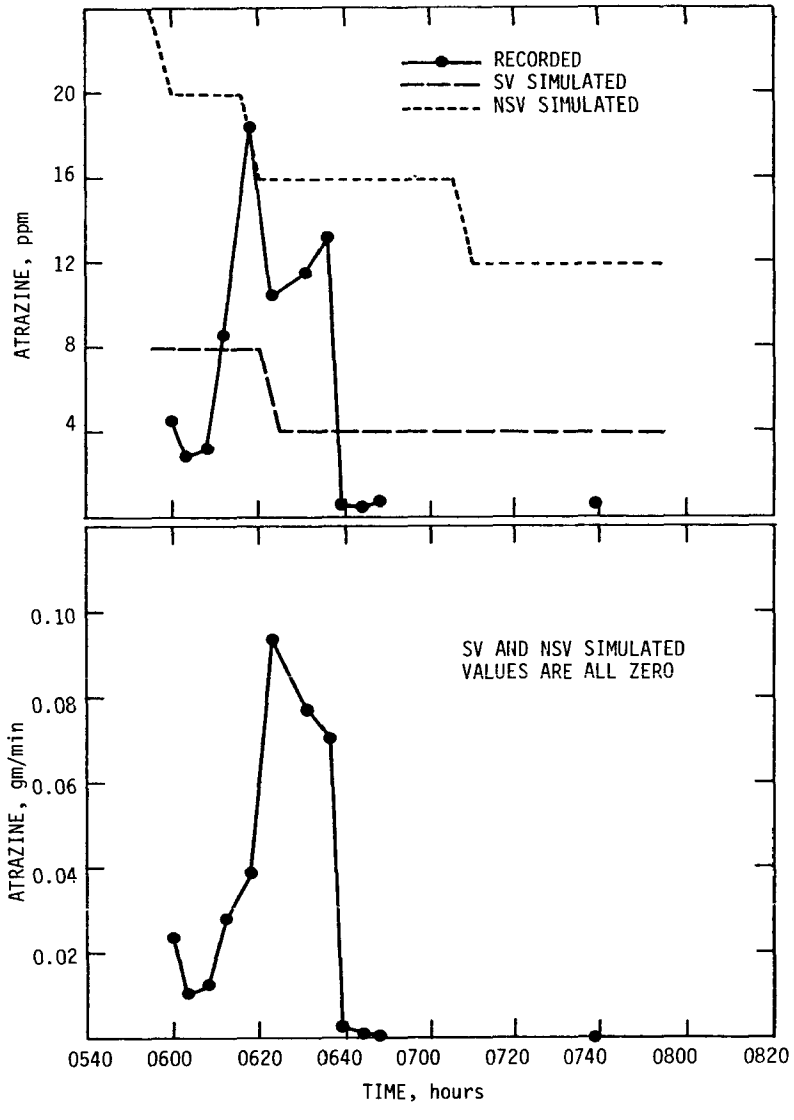

Figure C5 Atrazine removal on sediment from the P6 watershed for the storm of August 13, 1974

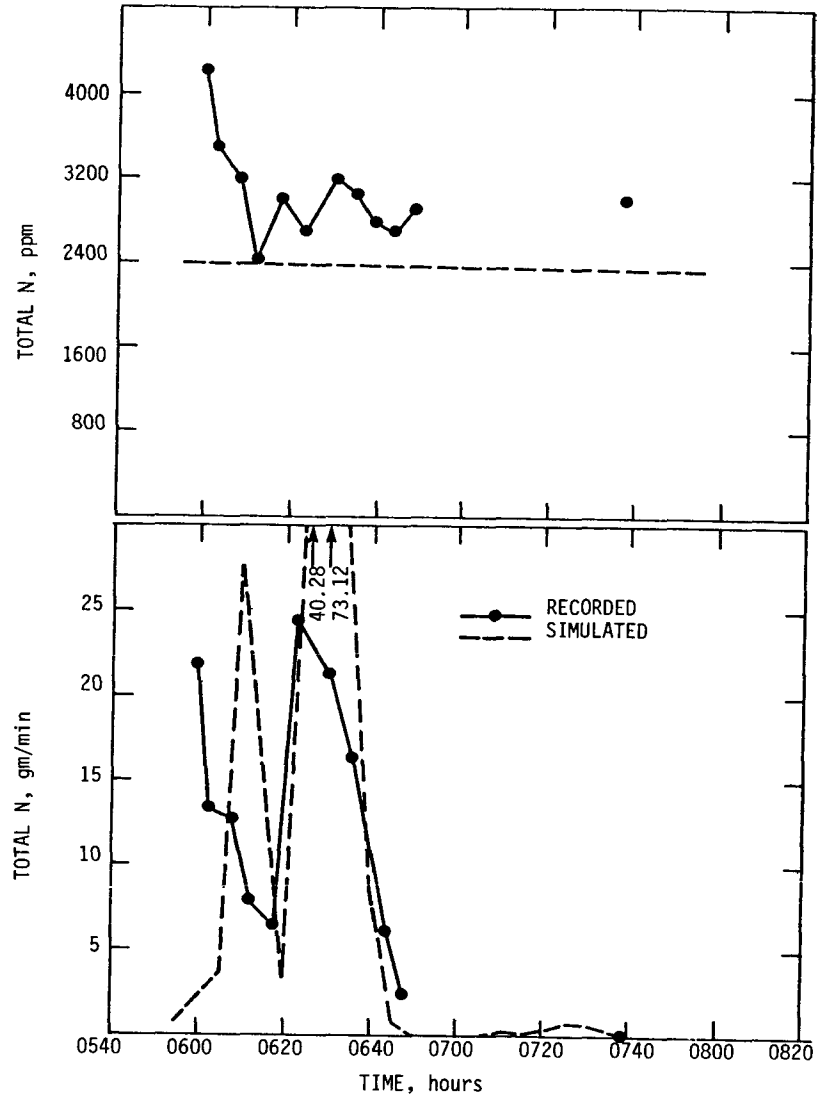

Figure C6 Total N removal on sediment from the P6 watershed for the storm of August 13, 1974

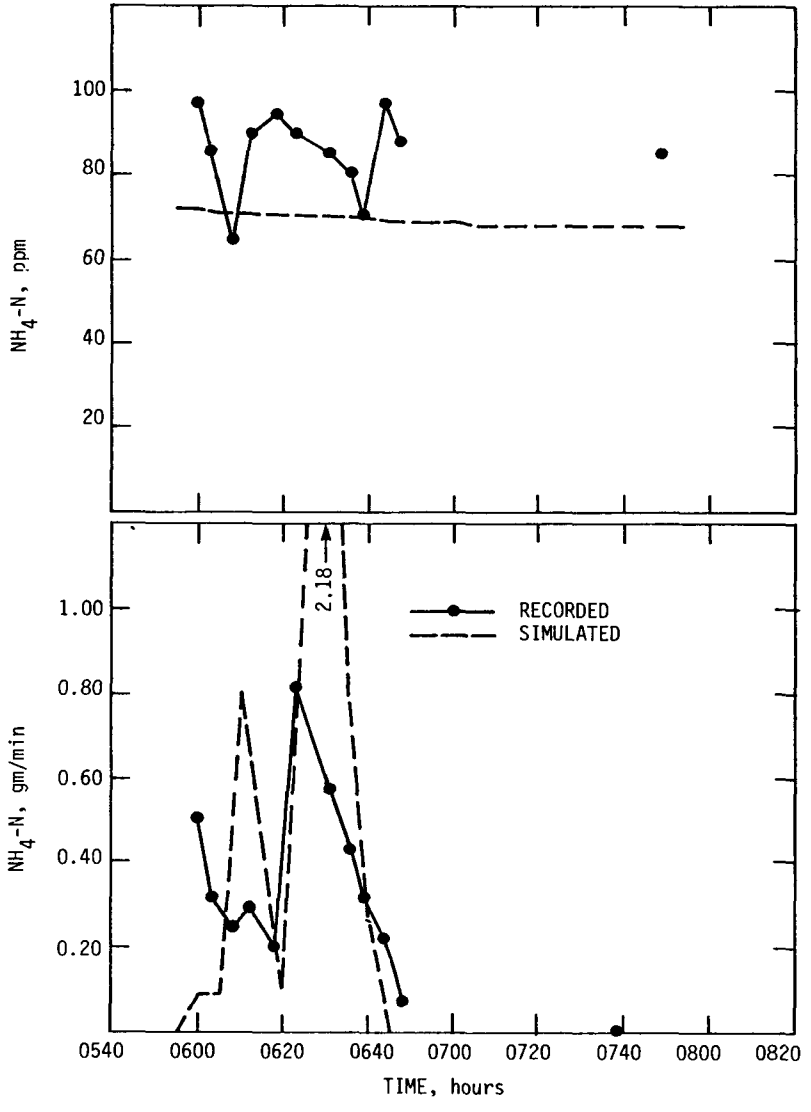

Figure C7 NH_4 removal on sediment from the P6 watershed for the storm of August 13, 1974

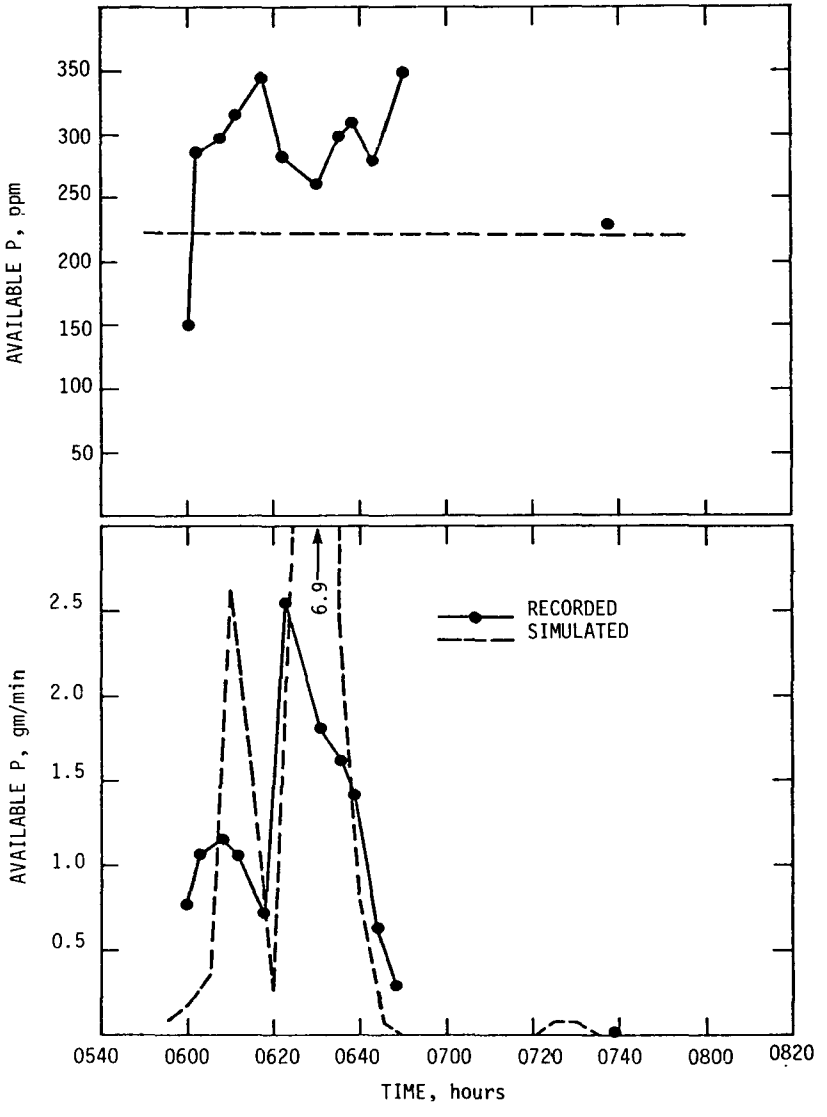

Figure C8 Available P removal on sediment from the P6 watershed for the storm of August 13, 1974

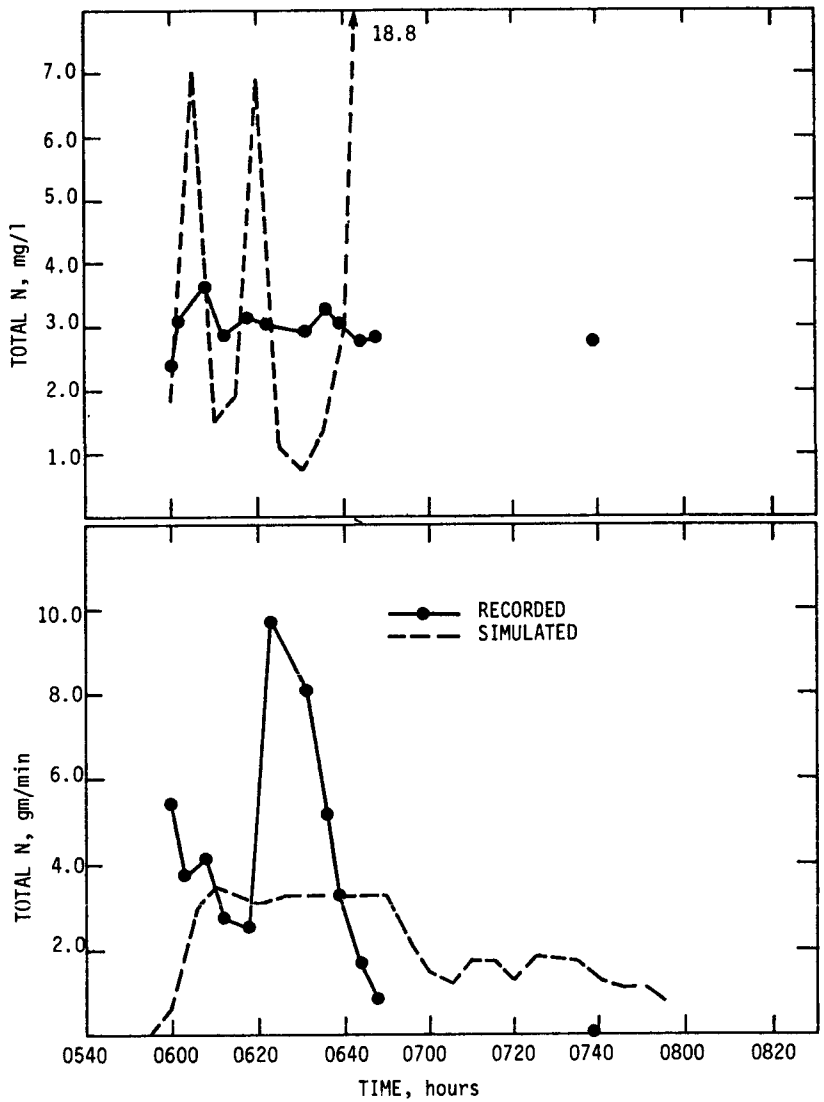

Figure C9 Total N removal in solution from the P6 watershed for the storm of August 13, 1974

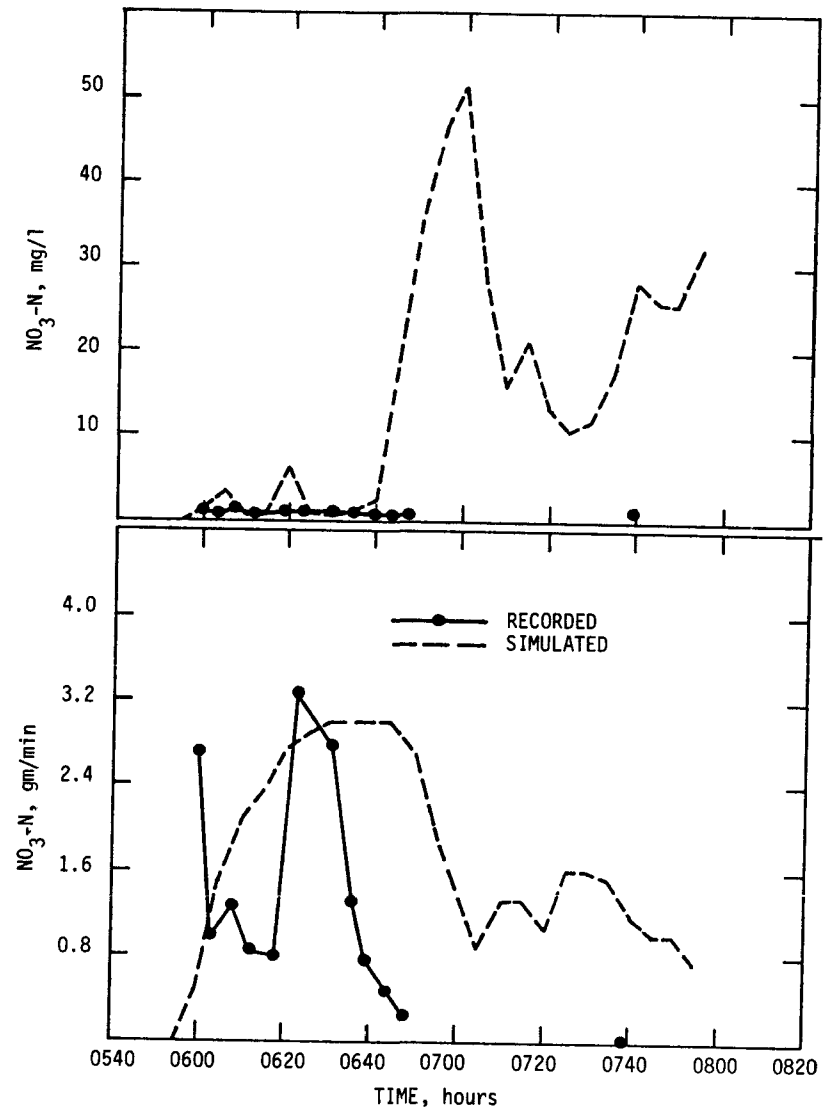

Figure C10 NO_3 removal in solution from the P6 watershed for the storm of August 13, 1974

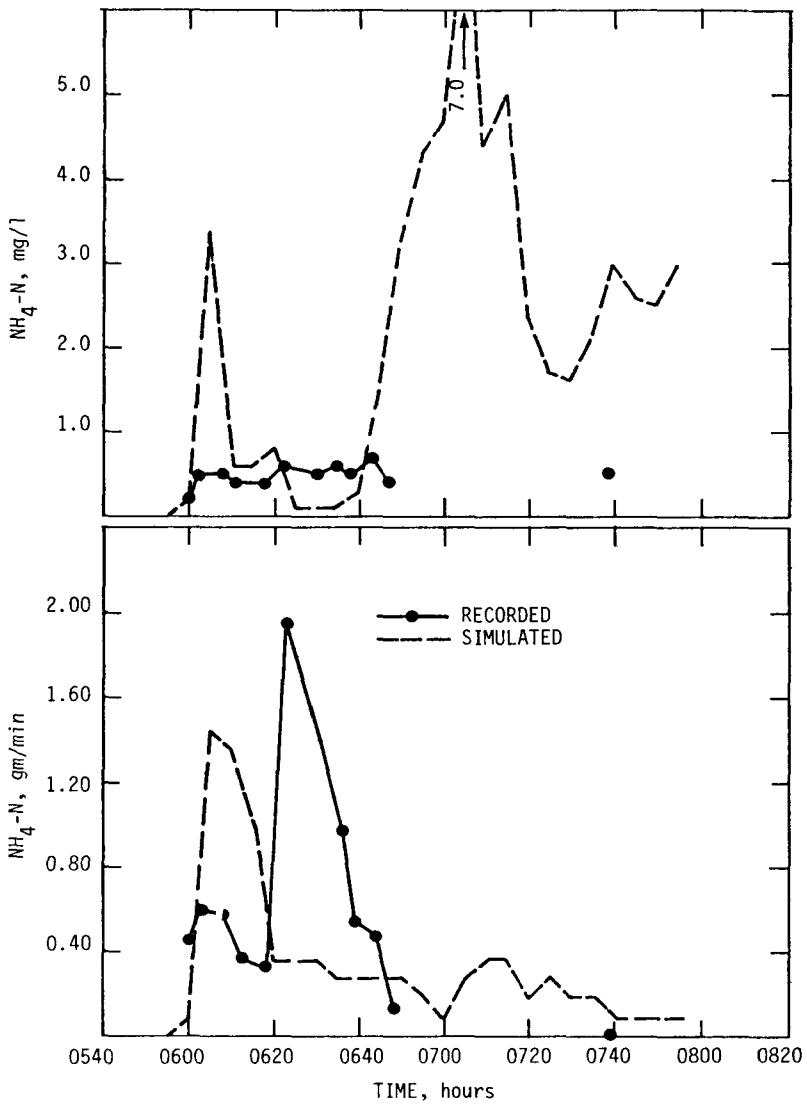

Figure C11 NH_4 removal in solution from the P6 watershed for the storm of August 13, 1974

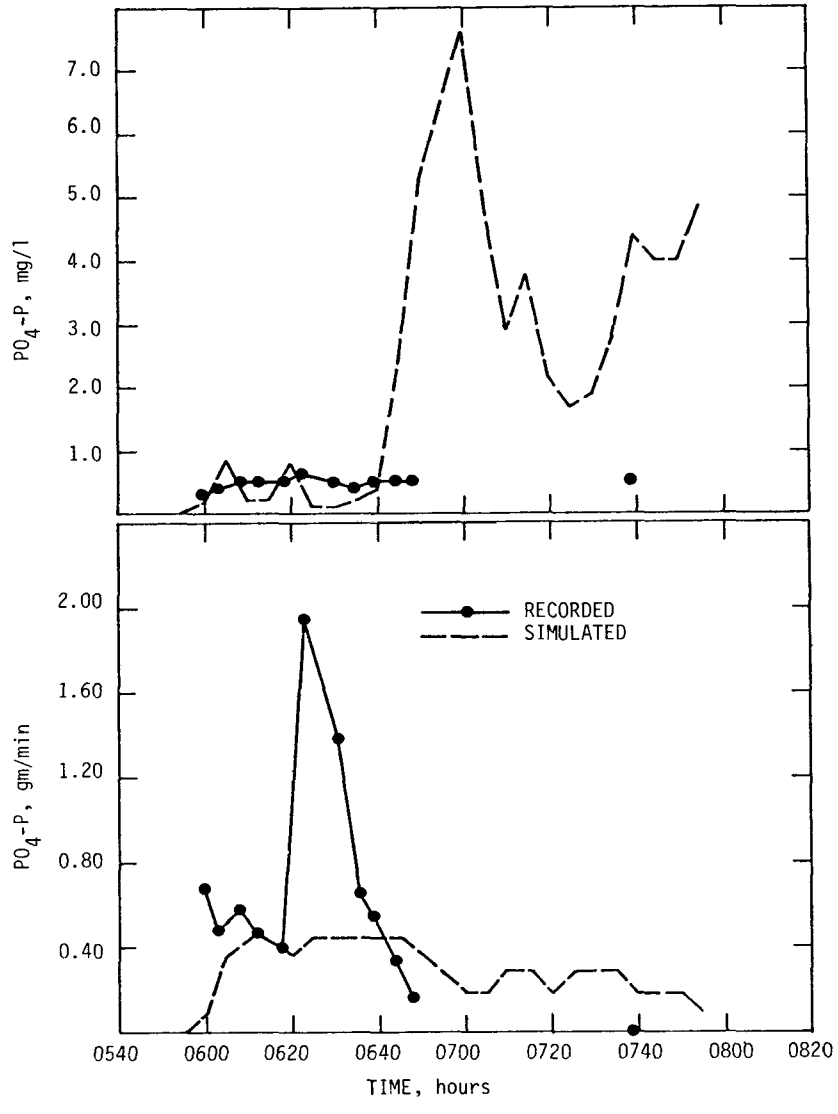

Figure C12 PO_4 removal in solution from the P6 watershed for the storm of August 13, 1974

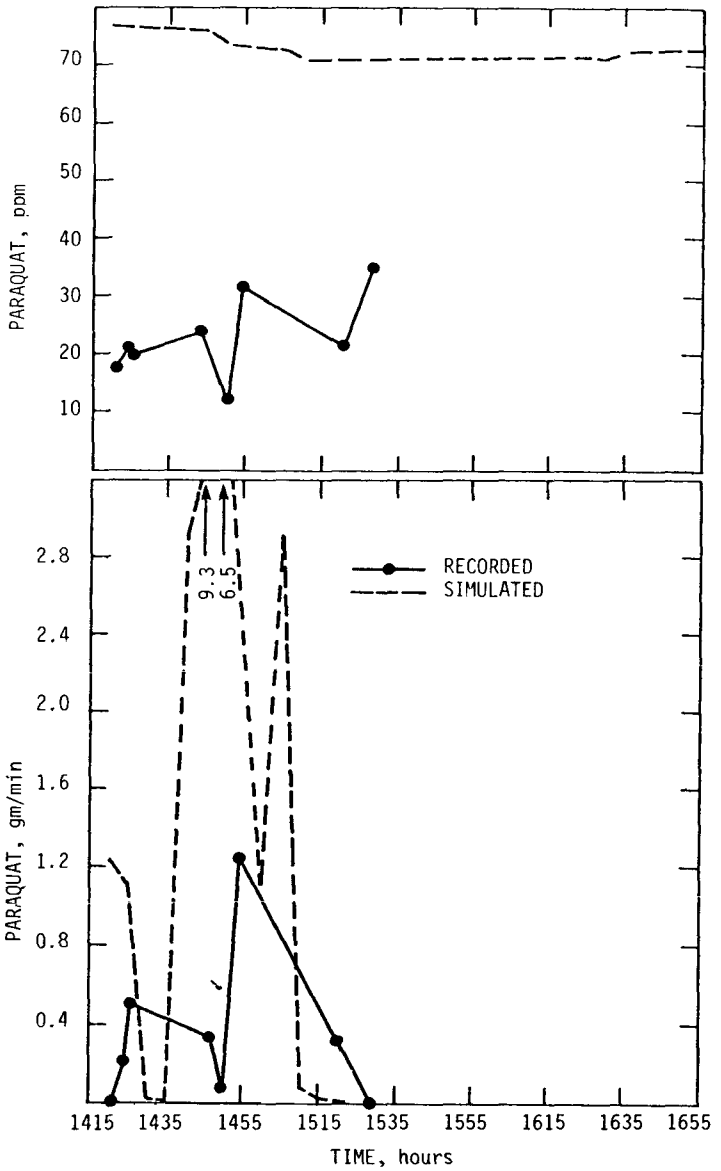

Figure C13 Paraquat removal on sediment from the P6 watershed for the storm of August 20, 1975

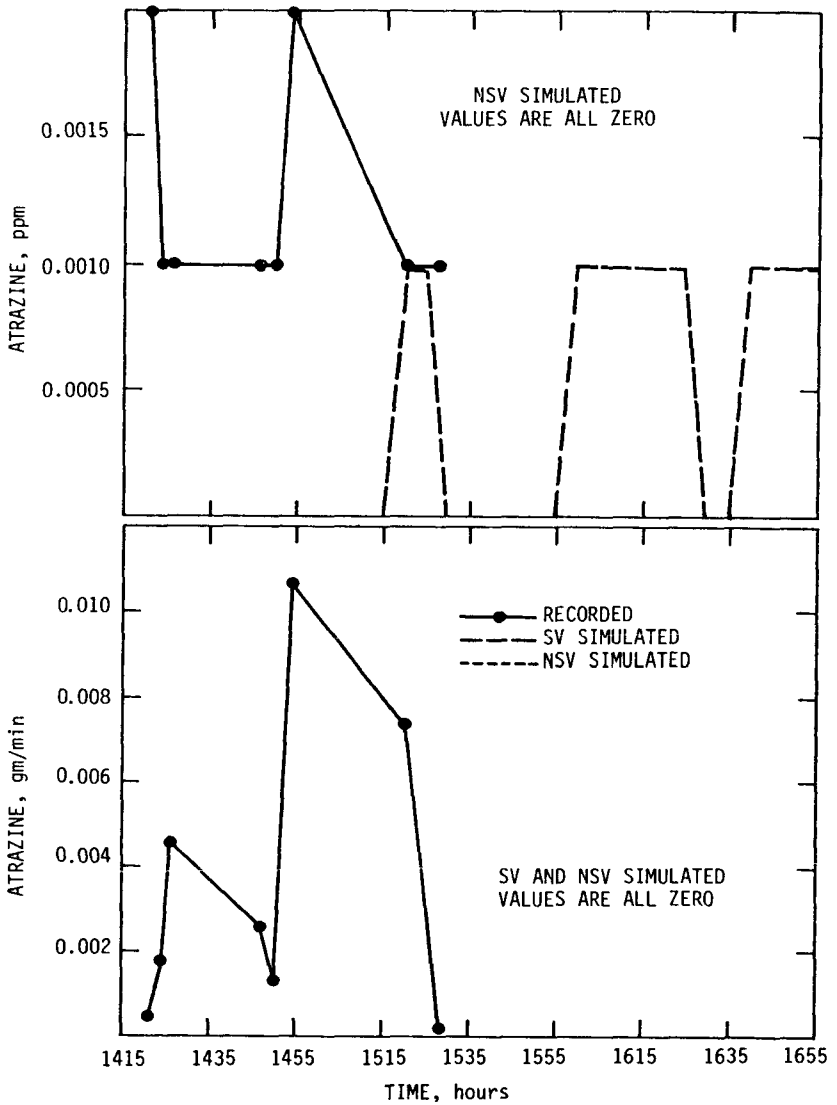

Figure C14 Atrazine removal in solution from the P6 watershed for the storm of August 20, 1975

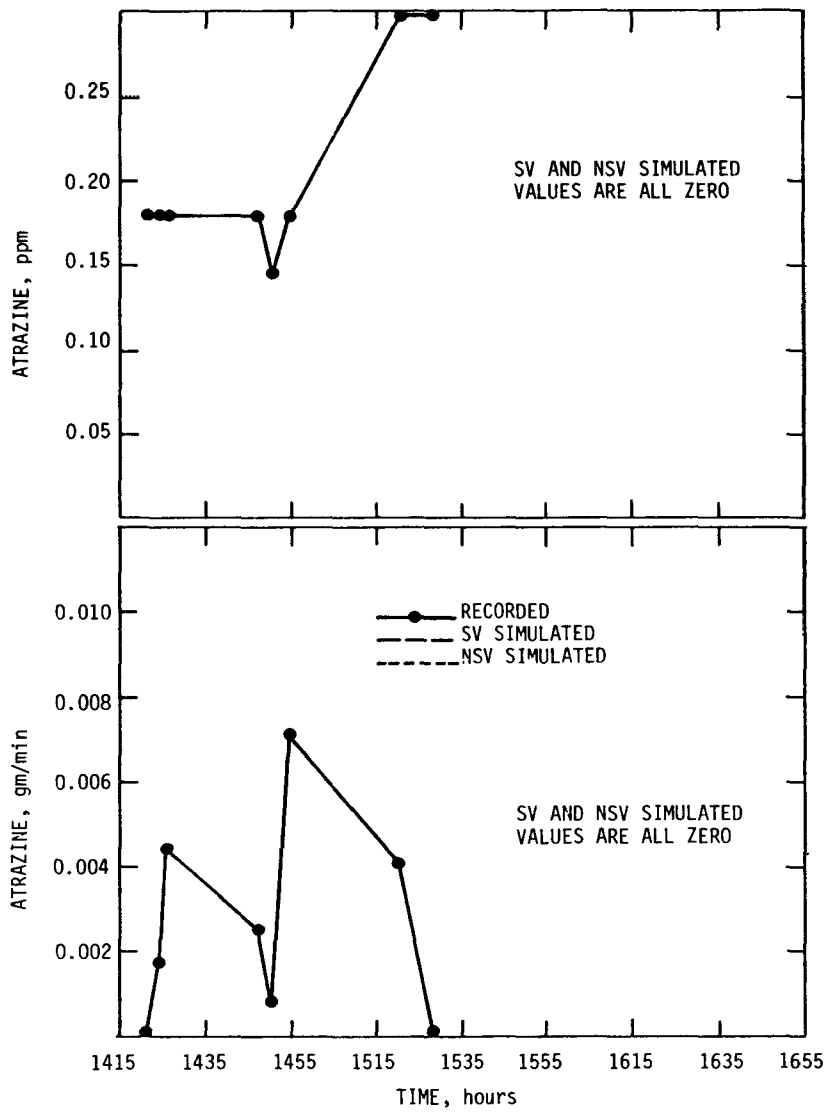

Figure C15 Atrazine removal on sediment from the P6 watershed for the storm of August 20, 1975

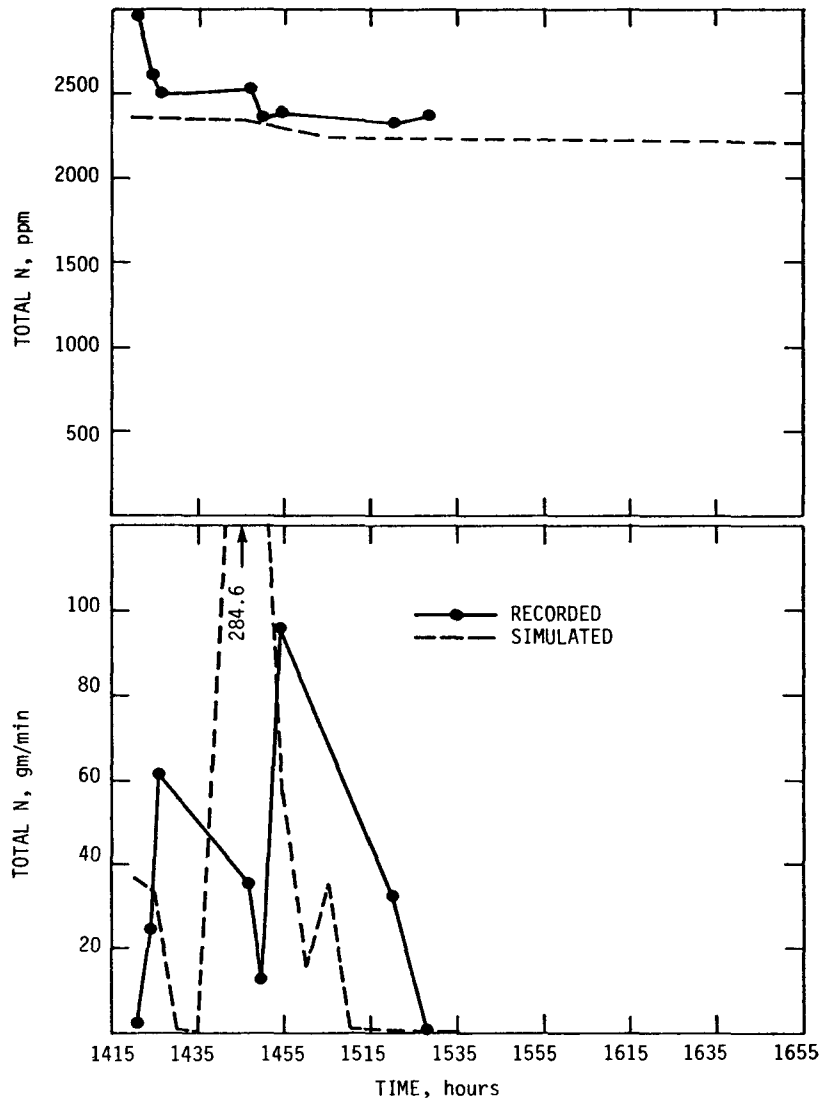

Figure C16 Total N removal in sediment from the P6 watershed for the storm of August 20, 1975

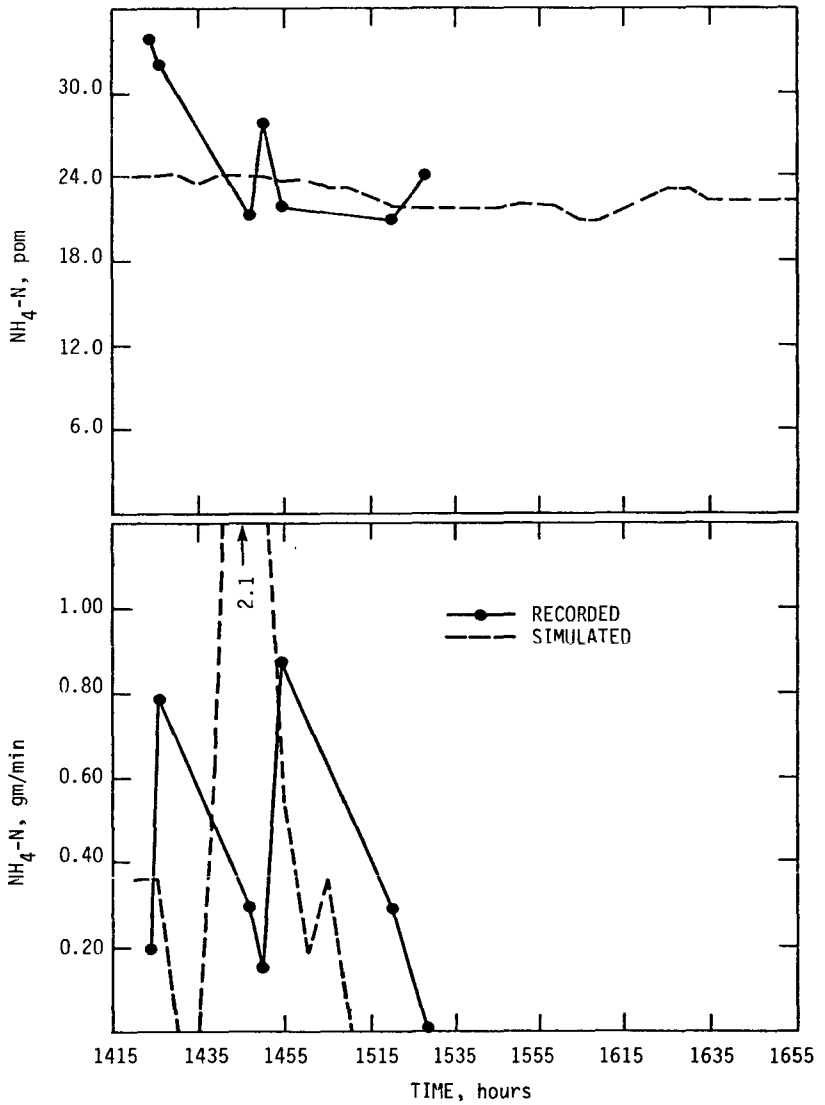

Figure C17 NH_4 removal on sediment from the P6 watershed for the storm of August 20, 1975

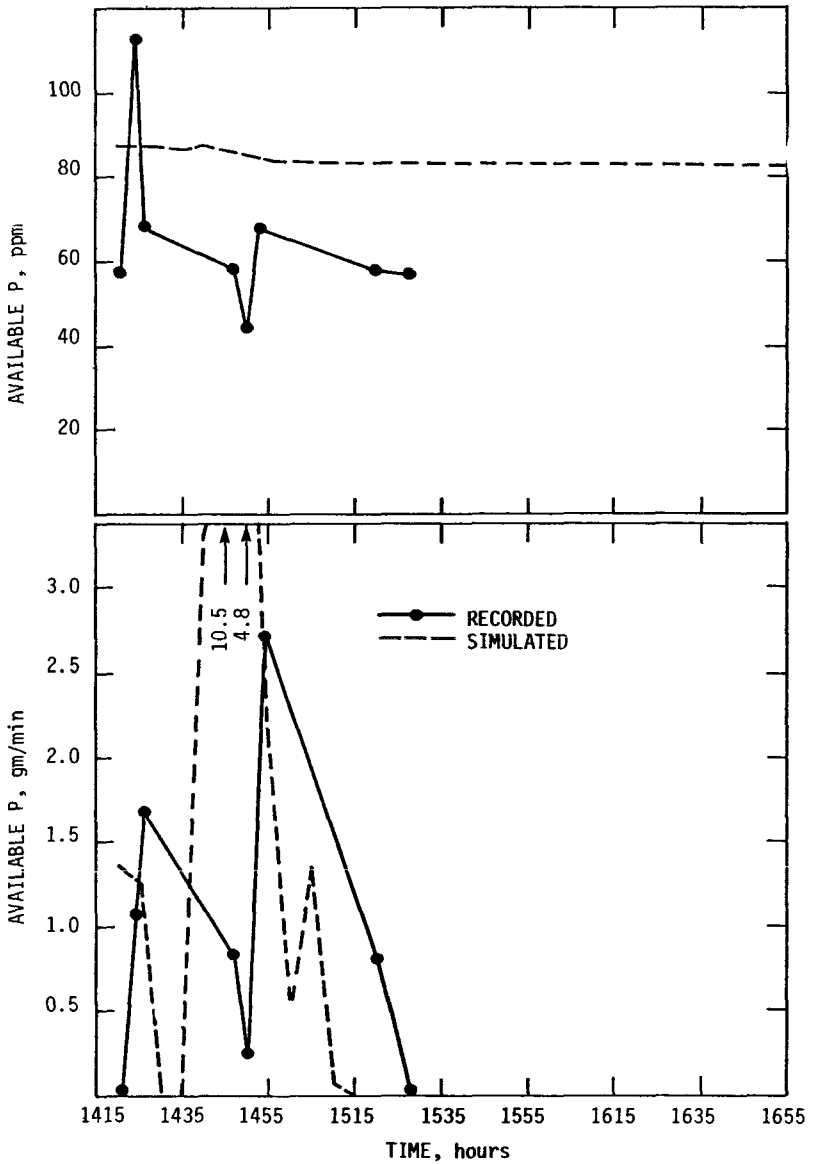

Figure C18 Available P removal on sediment from the P6 watershed for the storm of August 20, 1975

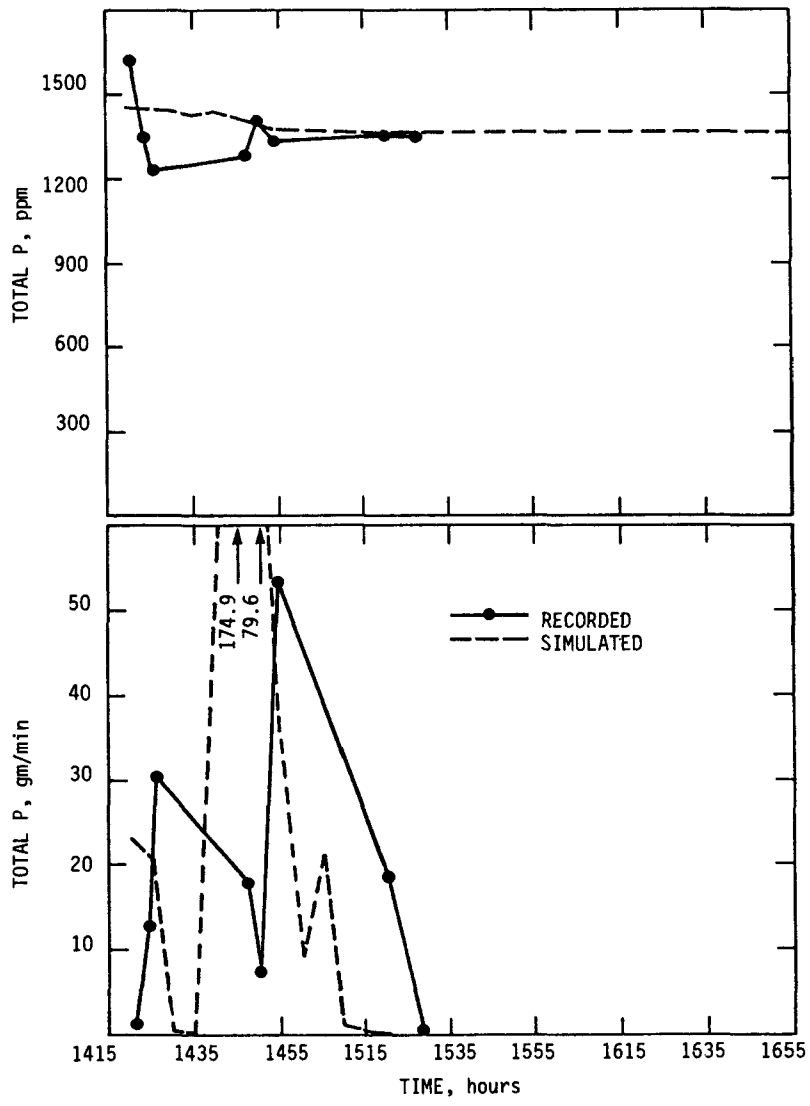

Figure C19 Total P removal on sediment from the P6 watershed for the storm of August 20, 1975

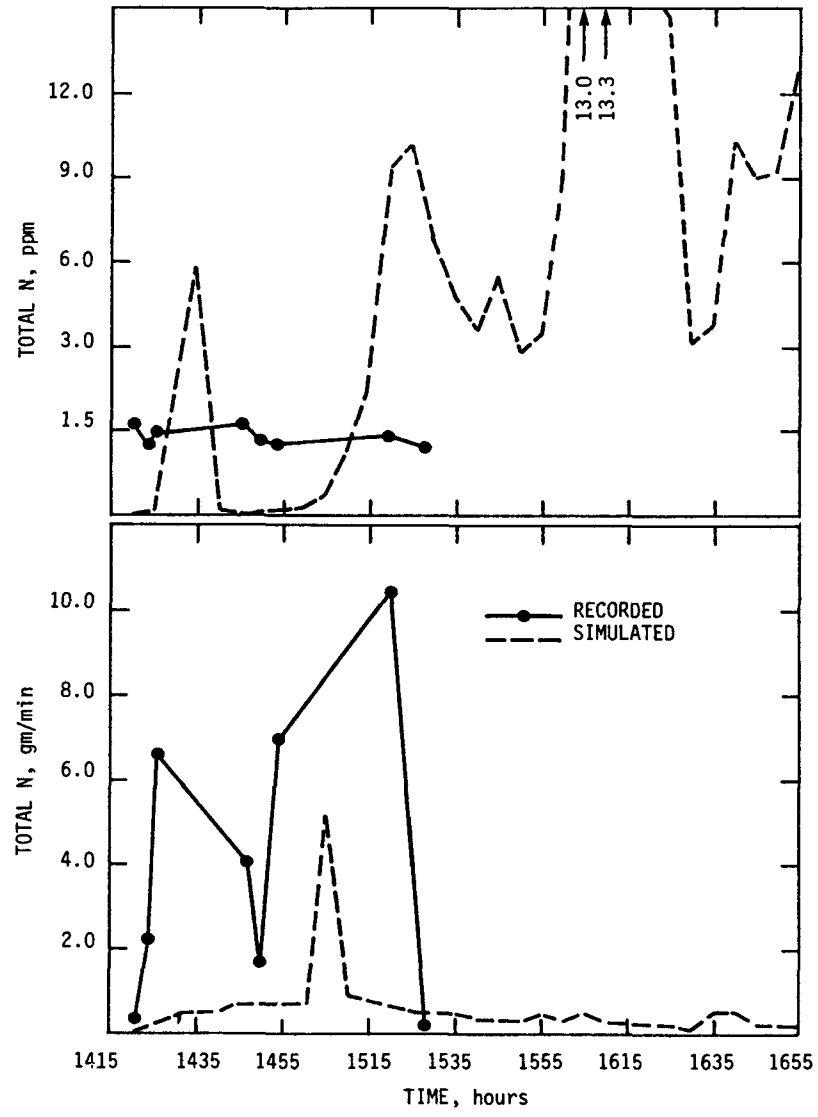

Figure C20 Total N removal in solution from the P6 watershed for the storm of August 20, 1975

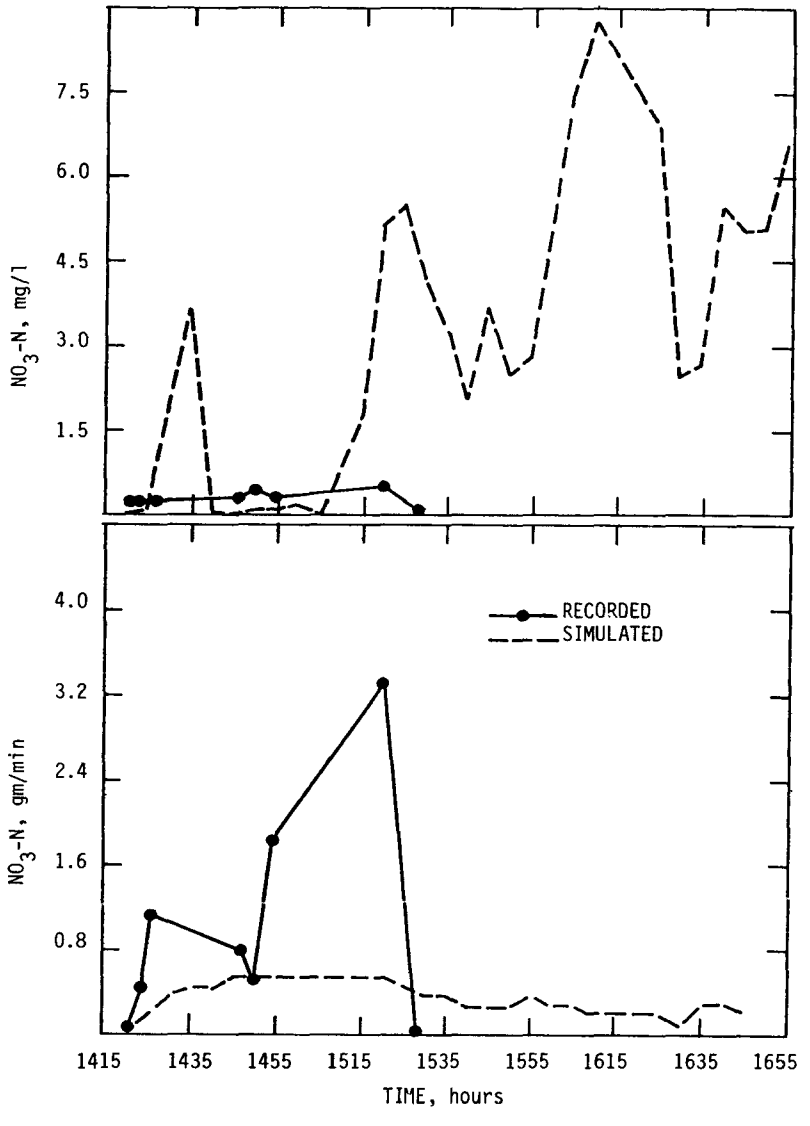

Figure C21 NO_3 removal in solution from the P6 watershed for the storm of August 20, 1975

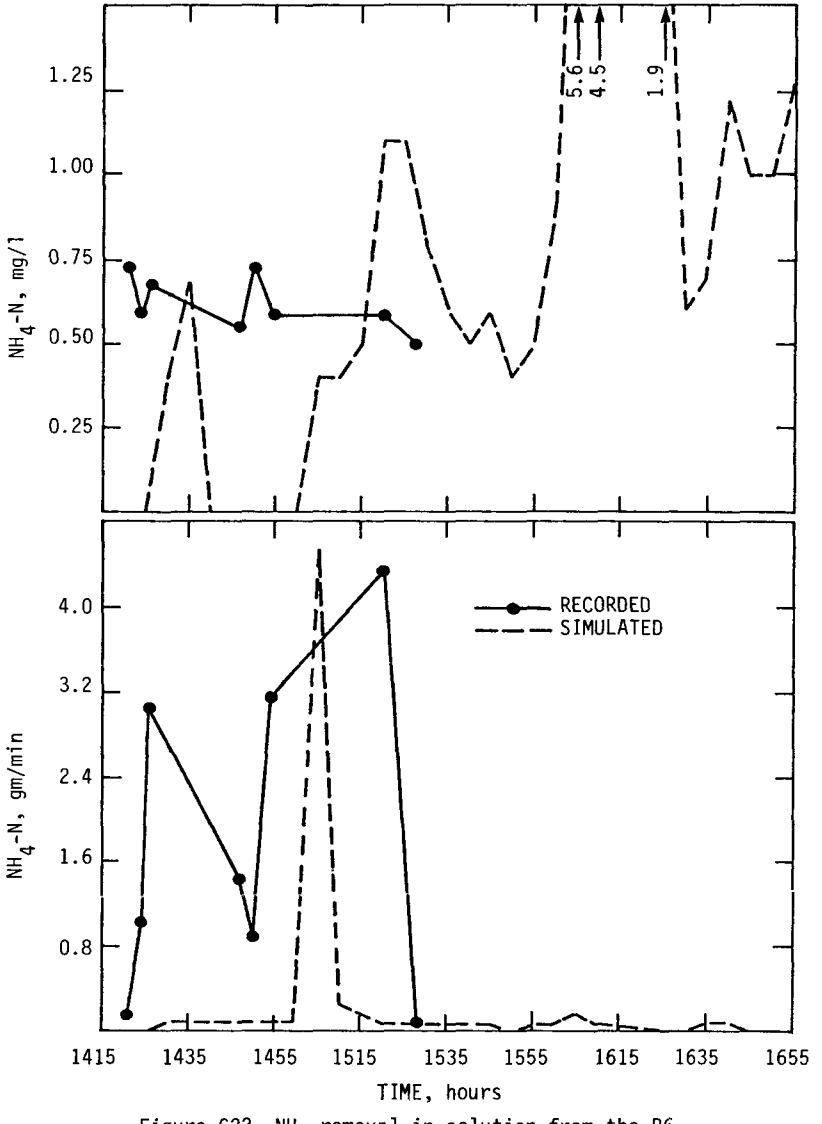

Figure C22 NH_4 removal in solution from the P6 watershed for the storm of August 20, 1975

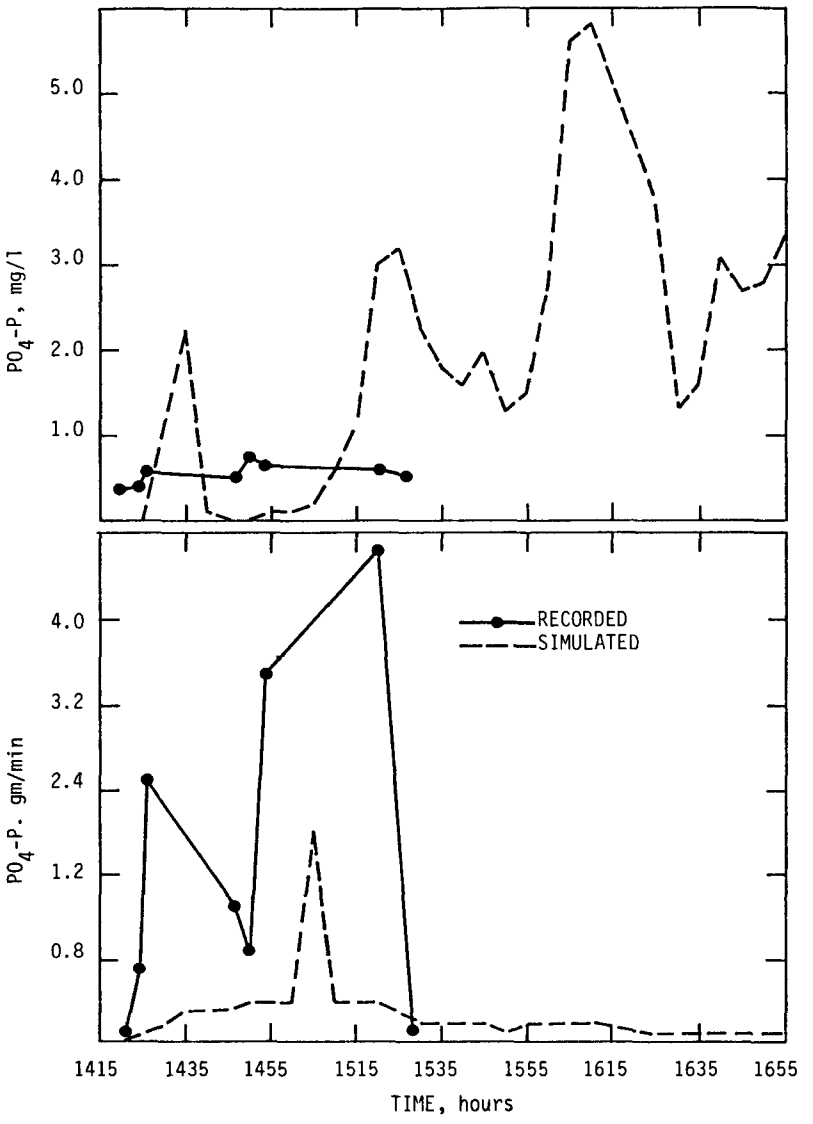

Figure C23 PO_4 removal in solution from the P6 watershed for the storm of August 20, 1975

```
//HARL7508 JOB 'A19$X2,444,2,35','J7508 DAVIS ',CLASS=E,REGION=512K
// EXEC FORTCL,PARM.FORT='OPT=1,MAP,XREF',REGION.FORT=512K
//FORT.SYSPRINT DD SYSOUT=A
//FORT.SYSIN DD *
C
C
C
C        ***********************************************************
C        *                                                         *
C        *   AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL - VERSION II   *
C        *                                                         *
C        ***********************************************************
C
C                                  DEVELOPED BY:  HYDROCOMP, INCORPORATED
C                                                 1502 PAGE MILL ROAD
C                                                 PALO ALTO, CA.  94304
C                                                   415-493-5522
C
C                                            FOR:  U.S. ENVIRONMENTAL
C                                                   PROTECTION AGENCY
C                                                 OFFICE OF RESEARCH
C                                                  AND DEVELOPMENT
C                                                 SOUTHEAST ENVIRONMENTAL
C                                                  RESEARCH LABORATORY
C                                                 ATHENS, GA.  30601
C                                                   404-546-3581
C
C
C                                                 VERSION: 10 JUNE 1977
C
C
C                                  MAIN PROGRAM
C
      IMPLICIT  REAL(L)
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSE(5),APERCB(5),RIB(5),ERSN(5),K3(12)
      DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
     1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
     2 TEMPX(24),WINDX(24),RAIN(288),SRERMT(5),ERSNMT(5)
      DIMENSION IRAIN(288),IRAD(12,31),
     1 IWIND(12,31),ITEMP(12,31,2),GRAD(24),RADDIS(24),WINDIS(24),
     2 IEVAP(12,31),IDEW(12,31)
      DIMENSION WSNAME(20),CHNAME(20),COVPMO(12),DPM(12),TITLE(4,20)
      DIMENSION TIMTIL(12),YRTIL(12),SRERTL(12)
      DIMENSION LSRO(128),EROS(128),RROS(128),IDSN(4),ITYPE(4)
      DIMENSION SMOIST(24,5),JMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24),LZTEMP(12)
C
      COMMON /ALL/ RL,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,PB,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,JTEMP,LTEMP,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 ROTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,ROTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGA,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SKERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVKMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
```

```
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNRGM,JN,JNT,JNI,JNIT,
     1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2              SNRSY,SNRGY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      COMMON /PESTD/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
      REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
     1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
     2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C   COMMON LAND DECLARATIONS FOR I*2 & R*4
      INTEGER  DAY,MONTH,DSNROS,DSNFLD,DSNERS,TMBLSZ,NEROS,
     1         NILSRC,NRROS
      REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,
     1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
     2      RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
     3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CDRMEM,CRAINM,
     4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
     5      NEPTOM,RCSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
     6      RUSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
     8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
     9      SCEP1,SRGXT,SRGXT1,JREK,KKER,JSER,KSER,SRERT,MMPIN,
     *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
     1      TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SREK,
     2      TEMPX,RAC,WINDX,RAIN,LSRO,EROS,RROS
C
      INTEGER  BGNDAY, BGNMON, BGNYR, ENDDAY, ENDMON, ENDYR
      INTEGER  YEAR, DYSTRT, DYEND, H, TIME
C
      INTEGER  IERROR, YR, MO, DY, CN, DA
      INTEGER  TIMPPT
      INTEGER  DSN
      INTEGER  DPM
C
      INTEGER*4  BCTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  APMCDE,DESORP,SURF,SOIL
C
      INTEGER*4  LOOP
      INTEGER*4  ICHECK
C
      INTEGER*4  BLANK1,BLANK2,CHNAME,DISK,WSNAME,SNOPRT
C
C
      INTEGER  TIMTIL, SFLAG ,YRTIL
C
      DOUBLE PRECISION  MNAM,PESTIC,ENDDIS,RUNOFF,SEDIME,OVERLA,CHAR
C
      REAL  UZDPTH,BDSZ,BDUZ,BDLZ,SZDPTH,COVPMO,RADCON
      REAL  PETMUL,WMUL,RMUL
      REAL  ICS
      REAL  N, MU, ML
      REAL  SRRTMT, ERSNMT, NP
      REAL  KUGI
C
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
```

```
22.9          2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
23.           3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
23.1          4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
23.2          5 UPRITT,UPRIS(5),SSTR(12)
23.3     C
23.4           INTEGER TIMAP(12),YEARAP(12),KFLAG,DDG(12),YDG(12)
23.5     C
23.6           REAL     K,NI,FPLZ,TOTPAP,PSSZ,PSUZ,PSLZ,PSGZ,
23.7          2         KGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
23.8          3         GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
23.9          4         NIP,CEGLOM,DEGLOT,NCOM,UIST,SULG,KDG(12)
24.      C
24.1     C     NUTRIENT VARIABLES -- DECLARED,DIMENSIONED,INITIALIZED
24.2     C
24.3     C
24.4           INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
24.5     C
24.6           REAL  DELT,
24.7          1         SNT(20),SNRSM(20,5),SNROM(20,5),
24.8          2         UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
24.9          3         NRSM(20,5),LNRPM(20),
25.           4         SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
25.1          5         SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
25.2          6         LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
25.3          7         TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
25.4          8         KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
25.5           DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
25.6     C
25.7           REAL  SNAPL(20,5,5),UNAPL(20,5,5),KNI(8,4),KPI(5,4),UZF,LZF
25.71          REAL  ULUPF(12),LZUPF(12)
25.8     C
25.9           INTEGER  APDAY(5),APLCNT,JHOUR,NAPPL,J,IBLK,TIMHAR,
26.           1            SELHV(20),IOERR,INTRVL
26.1           INTEGER DPMM1(12)
132.     C
133.           DATA  TIMTIL/12*0/,YRTIL/12*0/,SRERTL/12*0.0/
134.           DATA  COVPMO/12*0.0/,BDSZ/103./,SZDPTH/.0625/,UZDPTH/6.0625/
135.           DATA  ICS, OFS/2*0.0/,BDUZ/103./,BDLZ/103./
136.     C
137.1          DATA BLANK1/'    '/,BLANK2/'    '/
138.     C
138.2          DATA K,NI,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
138.3         2 TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
138.4         3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,SULG/25*0.0/
138.6          DATA TIMAP/12*999/,YEARAP/12*0/,SSTR/12*0.0/
138.91         DATA KGPLB/0.4530/, SURF/'SURF'/, SOIL/'SOIL'/
138.95   C
139.           DATA GRAD/0.04,0.04,0.03,0.02,
140.          *0.02,0.02,0.02,0.06,0.14,0.18,0.20,0.17,0.13,0.06,0.03,0.01,0.05,
141.          *0.07,0.10,0.13,0.15,0.13,0.12,0.08/
142.           DATA RADDIS/6*0.0,0.019,
143.          *0.041,0.067,0.088,0.102,0.110,0.110,0.110,0.105,0.095,0.081,0.055,
144.          *0.017,5*0.0/
145.           DATA WINDIS/7*0.034,0.035,
146.          *0.037,0.041,0.046,0.050,0.053,0.054,0.058,0.057,0.056,0.050,0.043,
147.          *0.040,0.038,0.036,0.036,0.035/
148.           DATA DPM/31,28,31,30,31,30,31,31,30,31,30,31/
149.           DATA PETMUL,WMUL,RMUL/3*1.0/
149.1          DATA PESTIC/'PESTICID'/,ENDDIS/'ENDDISK'/,RUNOFF/'RUNOFF  '/,
149.2         1SEDIME/'SEDIMENT'/,OVERLA/'OVERLAND'/
149.3           DATA APLCNT/1/
149.4           DATA SELHV/0,0,0,0,0,0,1,0,0,0,0,0,0,1,0,0,0,0,0,0/
149.5          DATA DPMM1/0,31,28,31,30,31,30,31,31,30,31,30/
149.6          DATA KFLAG/0/,ARODL/0.0/
149.7          DATA SFLAG/0/
149.9          DATA KDG/12*0.0/
150.     C
151.     C                    DATA INPUT -- NAMELIST VARIABLES
```

```
151.1     C
151.2     C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
151.3     C      NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
151.4     C      LIST AND IN THE NAMELIST READ STATEMENTS.  ADD C TO COLUMN
151.5     C      1 IN THE FORMATTED READ STATEMENTS TO DEACTIVATE THAT
151.6     C      SECTION OF CODE.
151.7     C
152.      C
153.            NAMELIST /CNTL/  INTRVL,HYMIN,AREA
154.            NAMELIST /STRT/  BGNDAY,BGNMON,BGNYR
155.            NAMELIST /ENDD/  ENDDAY,ENDMON,ENDYR
156.            NAMELIST /LND1/  UZSN,UZS,LZSN,LZS
157.            NAMELIST /LND2/  L,SS,NN,A,EPXM,PETMUL
158.            NAMELIST /LND3/  K3
159.            NAMELIST /LND4/  INFIL,INTER,IRC,K24L,KK24,K24EL
160.            NAMELIST /LND5/  SGW,GWS,KV,ICS,DFS,IFS
161.            NAMELIST /SND1/  RADCON,CCFAC,SCF,ELDIF,IDNS,F
162.            NAMELIST /SND2/  DGM,WC,MPACK,EVAPSN,MELEV,TSNOW
163.            NAMELIST /SND3/  PACK,DEPTH
164.            NAMELIST /SND4/  PETMIN,PETMAX,WMUL,RMUL,KUGI
165.            NAMELIST /CROP/  COVPMO
166.            NAMELIST /MUD1/  TIMTIL
167.            NAMELIST /MUD2/  YRTIL
168.            NAMELIST /MUD3/  SRERTL
169.            NAMELIST /SMDL/  JRER,KRER,JSER,KSER,SRERI,SCMPAC
169.1           NAMELIST /PSTR/  PSSZ,PSUZ,PSLZ,PSGZ
169.2           NAMELIST /PST1/  TIMAP
169.3           NAMELIST /PST2/  YEARAP
169.4           NAMELIST /PST3/  SSTR
169.5           NAMELIST /AMDL/  CMAX,DD,K,N,NP
169.51          NAMELIST /DEGD/  DDG
169.52          NAMELIST /DEGY/  YDG
169.53          NAMELIST /DEGR/  KDG
169.6           NAMELIST /LZTP/  LZTEMP
169.7           NAMELIST /RETP/  ASZT,BSZT,AUZT,BUZT
169.8           NAMELIST /DPTH/  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
170.      C
171.      C         INPUT PARAMETER DESCRIPTION
172.      C   WSNAME: WATERSHED NAME (72 CHARACTERS)
173.      C   CHNAME: CHEMICAL NAME (80 CHARACTERS)
174.      C   HYCAL : INDICATES WHAT FACTORS ARE TO BE SIMULATED
175.      C         = PROD  PRODUCTION RUN
176.      C         = CALB  CALIBRATION RUN
177.      C   INPUT : INPUT UNITS; ENGLISH(ENGL), METRIC(METR)
178.      C   OUTPUT: OUTPUT UNITS; ENGLISH(ENGL), METRIC(METR), BOTH(BOTH)
179.      C   PRINT : DENOTES FREQUENCY OF OUTPUT; EACH INTERVAL(INTR),
180.      C           EACH HOUR(HOUR), OR EACH DAY(DAYS),OR EACH MONTH(MNTH)
181.      C   SNOW  : (NO) SNOWMELT NOT PERFORMED, (YES) SNOWMELT CALC'S PERFORMED
182.      C   PEST  : (NO) PESTICIDES NOT PERFORMED, (YES) PESTICIDE CALC'S PERFORM
183.      C   NUTR  : (NO) NUTRIENTS NOT PERFORMED, (YES) NUTRIENT CALC'S PERFORMED
184.      C   ICHECK: CHECKS MOST OF THE INPUT IF SET EQUAL TO ON, OTHERWISE SET
185.      C           TO OFF
185.01    C
185.012   C     DISK: (NO) NO INFORMATION WRITTEN TO DISK
185.013   C         : (YES) LSRC AND/OR EROS WRITTEN TO DISK
185.014   C
185.015   C   ONLY IF DISK=YES SHOULD PARAMETERS IDEBUG THROUGH DSNERS BE INPUTTED
185.016   C
185.02    C   IDEBUG: DEBUGGING OPTION FOR WRITING TO DISK
185.03    C         : (OFF)  NO DEBUG OUTPUT
185.04    C         : (ON)  PRINT ECHO OF INFO. WRITTEN TO DISK
185.07    C     CHAR: (RUNOFF) LSRO WRITTEN TO DISK
185.08    C         : (SEDIMENT) EROS WRITTEN TO DISK
185.085   C         : (OVERLAND) RROS WRITTEN TO DISK
185.09    C         : (ENDDISK) END OF DISK WRITING INFORMATION
185.1     C    TITLE: TITLE FOR DATA SET ON DISK (80 CHARS)
185.11    C   DSNFLO: DATA SET NUMBER FOR LSRO FILE
185.12    C   DSNERS: DATA SET NUMBER FOR EROS FILE
185.125   C   DSNROS: DATA SET NUMBER FOR RROS FILE
```

```
185.13   C
186.     C  INTRVL: TIME INTERVAL OF PRECIPITATION( 5 , 15 OR 60 MINUTES )
187.     C  HYMIN : MINIMUM FLOW FOR OUTPUT DURING A TIME INTERVAL (CFS, CMS)
188.     C  AREA  : WATERSHED AREA (AC, HA)
189.     C  BGNDAY, BGNMON, BGNYR : DATE SIMULATION BEGINS
190.     C  ENDDAY, ENDMON, ENDYR : DATE SIMULATION ENDS
191.     C  UZSN  : NOMIMAL UPPER ZONE STORAGE (IN, MM)
192.     C  UZS   : INITIAL UPPER ZONE STORAGE (IN, MM)
193.     C  LZSN  : NOMINAL LOWER ZONE STORAGE (IN, MM)
194.     C  LZS   : INITIAL LOWER ZONE STORAGE (IN, MM)
195.     C  L     : LENGTH OF OVERLAND FLOW TO CHANNEL (FT, M)
196.     C  SS    : AVERAGE OVERLAND FLOW SLOPE
197.     C  NN    : MANNING'S N FOR OVERLAND FLOW
198.     C  A     : FRACTION OF AREA THAT IS IMPERVIOUS
199.     C  K3    : INDEX TO ACTUAL EVAPORATION (12 MONTHLY VALUES)
200.     C  EPXM  : MAXIMUM INTERCEPTION STORAGE (IN, MM)
201.     C  INFIL : INFILTRATION RATE (IN/HR, MM/HR)
202.     C  INTER : INTERFLOW PARAMETER, ALTERS RUNOFF TIMING
203.     C  IRC   : INTERFLOW RECESSION RATE
204.     C  K24L  : FRACTION OF GROUNDWATER RECHARGE PERCOLATING TO DEEP
205.     C          GROUNDWATER
206.     C  KK24  : GROUNDWATER RECESSION RATE
207.     C  K24EL : FRACTION OF WATERSHED AREA WHERE GROUNDWATER IS WITHIN
208.     C          REACH OF VEGETATION
209.     C  SGW   : INITIAL GROUNDWATER STORAGE (IN, MM)
210.     C  GWS   : GROUNDWATER SLOPE
211.     C  KV    : PARAMETER TO ALLOW VARIABLE RECESSION RATE FOR GROUNDWATER
212.     C          DISCHARGE
213.     C  ICS   : INITIAL INTERCEPTION STORAGE (IN, MM)
214.     C  OFS   : INITIAL OVERLAND FLOW STORAGE (IN, MM)
215.     C  IFS   : INITIAL INTERFLOW STORAGE (IN, MM)
216.     C
217.     C  ONLY IF SNOW=YES SHOULD PARAMETERS SNOWPRINT THROUGH KUGI BE INPUTTED
218.     C
218.1    C  SNOWPRINT: (NO) HOURLY SNOW TABLES NOT PRINTED DURING PERIODS
218.2    C                     OF SNOWPACK
218.3    C              (YES) HOURLY SNOW TABLES PRINTED
219.     C  RADCON: CORRECTION FACTOR FOR RADIATION
220.     C  CCFAC : CORRECTION FACTOR FOR CONDENSATION AND CONVECTION
221.     C  SCF   : SNOW CORRECTION FACTOR FOR RAINGAGE CATCH DEFICIENCY
222.     C  ELDIF : ELEVATION DIFFERENCE FROM TEMP. STATION TO MEAN SEGMENT ELEVA
223.     C          (1000 FT, KM)
224.     C  IDNS  : DENSITY OF NEW SNOW AT 0 DEGREES F.
225.     C  F     : FRACTION OF SEGMENT WITH COMPLETE FOREST COVER
226.     C  DGM   : DAILY GROUNDMELT (IN/DAY, MM/DAY)
227.     C  WC    : MAXIMUM WATER CONTENT OF SNOWPACK BY WEIGHT
228.     C  MPACK : ESTIMATED WATER EQUIVALENT OF SNOWPACK FOR COMPLETE COVERAGE
229.     C  EVAPSN: CORRECTION FACTOR FOR SNOW EVAPORATION
230.     C  MELEV : MEAN ELEVATION OF WATERSHED (FT, M)
231.     C  TSNOW : TEMPERATURE BELOW WHICH SNOW FALLS (F, C)
232.     C  PACK  : INITIAL WATER EQUIVALENT OF SNOWPACK (IN, MM)
233.     C  DEPTH : INITIAL DEPTH OF SNOWPACK (IN, MM)
234.     C  PETMIN: TEMPERATURE AT WHICH ZERO PET OCCURS (F, C)
235.     C  PETMAX: TEMPERATURE AT WHICH PET IS REDUCED BY 50% (F, C)
236.     C  PETMUL: POTENTIAL EVAPOTRANSPIRATION MULTIPLICATION FACTOR
237.     C  WMUL  : WIND MULTIPLICATION FACTOR
238.     C  RMUL  : RADIATION MULTIPLICATION FACTOR
239.     C  KUGI  : INDEX TO FOREST DENSITY AND UNDERGROWTH (0.0-10.0)
239.1    C
240.     C  COVPMO: PERCENTAGE CROP COVER ON MONTHLY BASIS
241.     C  TIMTIL: TIME (IN JULIAN DAYS) WHEN SOIL IS TILLED
242.     C  YRTIL : THE CORRESPONDING YEAR IN WHICH TIMTIL APPLIES
243.     C  SRERTL: FINE DEPOSITS PRODUCED BY TILLAGE (TONS/ACRE, TONNES/HECTARE)
247.     C  JRER  : EXPONENT OF RAINFALL INTENSITY  IN SOIL SPLASH EQUATION
248.     C  KRER  : COEFFICIENT IN SOIL SPLASH EQUATION
249.     C  JSER  : EXPONENT OF OVERLAND FLOW IN SURFACE SCOUR EQUATION
250.     C  KSER  : COEFFICIENT IN SURFACE SCOUR EQUATION
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251.      C  SPERI : INITIAL FINES DEPOSIT (TONS/ACRE, TONNES/HECTARE)
251.1     C  SCMPAC: RATE BY WHICH SOIL FINES ARE DECREASED PER DAY (ONLY ON
251.2     C           NON-RAIN DAYS)
252.      C
253.      C  ONLY IF PEST=YES SHOULD TITLE PESTICIDE AND PARAMETERS APMODE
254.      C  THROUGH BK BE INPUTTED
255.      C
256.      C  TITLE WORD PESTICIDE MUST BE INCLUDED IN THE INPUT SEQUENCE
257.      C  PRIOR TO ANY PESTICIDE INPUT PARAMETERS
258.      C
259.      C  APMODE: APPLICATION MODE; SURFACE APPLIED (SURF),
260.      C                              SOIL INCORPORATED (SOIL)
261.      C  DESORP: (NO) ONLY ADSORPTION ALGORITHM USED, (YES) BOTH ADSORPTION
262.      C           AND DESORPTION USED
262.1     C  PSSZ  : INITIAL PESTICIDE STORAGE IN SURFACE ZONE (LB/AC, KG/HA)
262.2     C  PSUZ  : INITIAL PESTICIDE STORAGE IN UPPER ZONE (LB/AC, KG/HA)
262.3     C  PSLZ  : INITIAL PESTICIDE STORAGE IN LOWER ZONE (LB/AC, KG/HA)
262.4     C  PSGZ  : INITIAL PESTICIDE STORAGE IN GROUNDWATER ZONE (LB/AC, KG/HA)
263.      C  SSTR  : PESTICIDE APPLICATION FOR ENTIRE WATERSHED (LB/AC, KG/HA)
264.      C  TIMAP : TIME OF PESTICIDE APPLICATION (JULIAN DAY)
265.      C  YEAPAP: THE CORRESPONDING YEAR IN WHICH TIMAP APPLIES
266.      C  CMAX  : MAXIMUM SOLUBILITY OF PESTICIDE IN WATER (LB/LB)
267.      C  DD    : PERMANENTLY FIXED CAPACITY (LB PESTICIDE/LB SOIL)
268.      C  K     : COEFICIENT IN FREUNDLICH ADSORPTION CURVE
269.      C  N     : EXPONENT IN FREUNDLICH ADSORPTION CURVE
270.      C  NP    : DESORPTION EXPONENT IN FREUNDLICH CURVE
270.1     C  DDG   : JULIAN DAY WHEN KDG(I) BEGINS (MAX. OF 12 VALUES)
270.2     C  YDG   : CORRESPONDING YEAR IN WHICH DDG APPLIES
270.3     C  KDG   : PESTICIDE DECAY RATE (PER DAY) (MAX. 12 VALUES)
272.05    C
272.06    C           FOLLOWING ARE TO INPUTTED FOR NUTR=YES OR PEST=YES
272.07    C
272.1     C  SZDPTH: SURFACE LAYER SOIL DEPTH (IN THE RANGE OF 1/8 INCH) (IN, MM)
272.2     C  UZDPTH: DEPTH OF SOIL INCORPORATION AND UPPER ZONE (IN, MM)
272.3     C  BDSZ  : BULK DENSITY OF SURFACE LAYER SOIL (LB/FT(3)), (G/CM(3))
272.4     C  BDUZ  : BULK DENSITY OF UPPER ZONE SOIL (LB/FT(3), (G/CM(3))
272.5     C  BDLZ  : BULK DENSITY OF LOWER ZONE SOIL (LB/FT(3), (G/CM(3))
272.6     C  ASZT  : SLOPE OF SURFACE ZONE SOIL TEMPERATURE REGRESSION EQN.
272.7     C  BSZT  : Y-INTERCEPT OF SURFACE ZONE SOIL TEMPERATURE REGRESSION EQN.
272.8     C  AUZT  : SLOPE OF UPPER ZONE SOIL TEMPERATURE REGRESSION EQN.
272.85    C  BUZT  : Y-INTERCEPT OF UPPER ZONE TEMPERATURE REGRESSION EQN.
272.86    C  UZF   : UPPER ZONE CHEMICAL PERCOLATION  FACTOR
272.87    C  LZF   : LOWER ZONE CHEMICAL PERCOLATION FACTOR
272.9     C
272.91    C TURN OFF UNDERFLOW ABORT ON HP3000
272.92    C
272.93    C      ON REAL UNDERFLOW CALL ERRSET
272.94    C
273.            READ (5,1096) (WSNAME(I),I=1,20)
273.1     C
273.2     C   CHECK FOR RUNNING NUMBERED ON WYLBUR
273.3     C
273.4           IF(WSNAME(19).EQ.BLANK1.AND.WSNAME(20).EQ.BLANK2) GO TO 10
273.5           WRITE(6,1079) WSNAME(19),WSNAME(20)
273.6           STOP
273.7     C
274.       10   READ (5,1096) (CHNAME(I),I=1,20)
275.            READ (5,1097)  HYCAL
276.            READ (5,1097)  INPUT
277.            READ (5,1098)  OUTPUT
278.            READ (5,1097)  PRINT
279.            READ (5,1099)  SHOW
280.            READ (5,1099)  PEST
281.            READ (5,1099)  NUTR
282.            READ (5,1098)  ICHECK
282.01
282.02    C                    READ DISK INFORMATION
282.03    C
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282.04          IDKCNT = 0
282.05          READ (5,1099) DISK
282.06          IF (DISK .EQ. NO) GO TO 20
282.07    C
282.08          READ (5,1097) IDEBUG
282.09       12 READ (5,1100) CHAR
282.1           IF (CHAR .EQ. ENDDIS)  GO TO 20
282.11          IF (CHAR .NE. RUNOFF)  GO TO 14
282.12          IDKCNT = IDKCNT + 1
282.13    C
282.14          READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
282.15          READ (5,1083) DSNFLO
282.16          IDSN(IDKCNT) = DSNFLO
282.165         ITYPE(IDKCNT) = 1
282.17          GO TO 12
282.18    C
282.19       14 IF (CHAR .NE. SEDIME)  GO TO 16
282.2           IDKCNT = IDKCNT + 1
282.21          READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
282.22          READ (5,1083) DSNERS
282.23          IDSN(IDKCNT) = DSNERS
282.235         ITYPE(IDKCNT) = 2
282.24          GO TO 12
282.41    C
282.42       16 IF (CHAR .NE. OVERLA)  GO TO 18
282.43          IDKCNT = IDKCNT + 1
282.44          READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
282.45          READ (5,1083) DSNROS
282.46          IDSN(IDKCNT) = DSNROS
282.465         ITYPE(IDKCNT) = 2
282.47          GO TO 12
282.48    C
282.49       18 WRITE (6,1084) CHAR
282.5           STOP
282.51    C
282.52    C
282.53    C                    DATA INPUT -- NAMELIST VARIABLES
282.54    C
282.55    C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
282.56    C      NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
282.57    C      READ STATEMENTS.  ADD C TO COLUMN 1 IN THE FORMATTED READ
282.58    C      STATEMENTS (DIRECTLY BELOW) TO DEACTIVATE THAT SECTION
282.59    C      OF CODE.
282.6     C
282.61    C
283.      C
283.01       20 READ (5,CNTL)
283.02          READ (5,STRT)
283.03          READ (5,ENDD)
283.04          READ (5,LND1)
283.05          READ (5,LND2)
283.06          READ (5,LND3)
283.07          READ (5,LND4)
283.08          READ (5,LND5)
283.09    C
283.1           IF (SNOW .EQ. NO)  GO TO 400
283.102         READ (5,5013)  SNOPRT
283.11          READ (5,SNO1)
283.12          READ (5,SNO2)
283.13          READ (5,SNO3)
283.14          READ (5,SNO4)
283.15    C
283.16      400 READ (5,CROP)
283.17          READ (5,MUD1)
283.18          READ (5,MUD2)
283.19          READ (5,MUD3)
283.2           READ (5,SMDL)
283.21    C
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283.22          IF (PEST .EQ. NO)  GO TO 402
283.23          READ (5,1100)  CHAR
283.24          IF (CHAR .EQ. PESTIC)  GO TO 401
283.25              WRITE (6,1122)
283.26              GO TO 1080
283.27    C
283.28      401 READ (5,1098)  APMODE
283.29          READ (5,1098)  DESORP
283.3           READ (5,PSTR)
283.31          READ (5,PST1)
283.32          READ (5,PST2)
283.33          READ (5,PST3)
283.34          READ (5,AMDL)
283.35          READ (5,DEGD)
283.36          READ (5,DEGY)
283.37          READ (5,DEGR)
283.38    C
283.39    C
284.      C  20 READ (5,5000) INTRVL,HYMIN,AREA
285.      C     READ (5,5001) BGNDAY,BGNMON,BGNYR
286.      C     READ (5,5001) ENDDAY,ENDMON,ENDYR
287.      C     READ (5,5002) UZSN,UZS,LZSN,LZS
288.      C     READ (5,5003) L,SS,NN,A,EPXM,PETMUL
289.      C     READ (5,5004) (KB(I),I=1,12)
290.      C     READ (5,5003) INFIL,INTER,IRC,K24L,KK24,K24EL
290.1     C     READ (5,5003) SGW,GWS,KV,ICS,DFS,IFS
291.      C
292.      C     IF (SNOW .EQ. NO)  GO TO 400
292.1     C     READ (5,5013) SNOPRT
293.      C     READ (5,5003) RADCCN,CCFAC,SCF,ELDIF,IDNS,F
294.      C     READ (5,5003) DGM,WC,MPACK,EVAPSN,MELEV,TSNOW
295.      C     READ (5,5005) PACK,DEPTH
296.      C     READ (5,5006) PETMIN,PETMAX,WMUL,KMUL,KUGI
297.      C
298.      C 400 READ (5,5004) (COVPMO(I),I=1,12)
299.      C     READ (5,5009) (TIMTIL(I),I=1,12)
299.1     C     READ (5,5009) (YRTIL(I),I=1,12)
299.2     C     READ (5,5004) (SRERTL(I),I=1,12)
301.      C     READ (5,5003) JRER,KRER,JSER,KSER,SRERI,SCMPAC
302.      C
303.      C     IF (PEST .EQ. NO)  GO TO 402
304.      C     READ (5,1100)  CHAR
305.      C     IF (CHAR.EQ.PESTIC)  GO TO 401
306.      C         WRITE (6,1122)
307.      C         GO TO 1080
308.      C
309.      C 401 READ (5,1098)  APMODE
310.      C     READ (5,1098)  DESORP
310.1     C     READ (5,5002) PSSZ,PSUZ,PSLZ,PSGZ
310.3     C     READ (5,5009) (TIMAP(I),I=1,12)
310.4     C     READ (5,5009) (YEARAP(I),I=1,12)
310.5     C     READ (5,5004) (SSTR(I),I=1,12)
311.1     C     READ (5,5006) CMAX,DD,K,N,NP
312.      C     READ (5,5009) (DDG(I),I=1,12)
312.1     C     READ (5,5009) (YDG(I),I=1,12)
312.2     C     READ (5,5004) (KDG(I),I=1,12)
313.      C
314.      C
315.      C                    PRINTING OF INPUT PARAMETERS
316.      C
317.        402 IF (HYCAL.EQ.CALB)  GO TO 1002
318.            WRITE (6,1091)
319.            IF (PEST.EQ.YES.AND.NUTR.EQ.NO)  WRITE (6,1123)
320.            IF (PEST.EQ.NO .AND.NUTR.EQ.YES) WRITE (6,1124)
321.            IF (PEST.EQ.NO .AND.NUTR.EQ.NO)  WRITE (6,1125)
322.            IF (PEST.EQ.YES.AND.NUTR.EQ.YES) WRITE (6,1126)
323.            WRITE (6,1092)
324.            GO TO 1003
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325.      C
326.       1002 WRITE (6,1093)
327.                IF (PEST.EQ.YES.AND.NUTR.EQ.NO)  WRITE (6,1123)
328.                IF (PEST.EQ.NO .AND.NUTR.EQ.YES) WRITE (6,1124)
329.                IF (PEST.EQ.NO .AND.NUTR.EQ.NO)  WRITE (6,1125)
330.                WRITE (6,1092)
331.                IF (PEST.EQ.NO .OR. NUTR.EQ.NO)  GO TO 1003
332.                WRITE (6,1121)
333.                GO TO 1080
334.      C
335.       1003 WRITE (6,1107) (WSNAME(I),I=1,20)
336.            WRITE (6,1106) (CHNAME(I),I=1,20)
337.            IF (INPUT .EQ. ENGL)  WRITE (6,1108)
338.            IF (INPUT .EQ. METR)  WRITE (6,1109)
339.            IF (OUTPUT .EQ. ENGL) WRITE (6,1110)
340.            IF (OUTPUT .EQ. METR) WRITE (6,1111)
341.            IF (OUTPUT .EQ. BOTH) WRITE (6,1112)
342.            IF (PRINT .EQ. INTR)  WRITE (6,1113)
343.            IF (PRINT .EQ. HOUR)  WRITE (6,1114)
344.            IF (PRINT .EQ. DAYS)  WRITE (6,1115)
345.            IF (PRINT .EQ. MNTH)  WRITE (6,1128)
346.            IF (SNOW .EQ. YES)    WRITE (6,1116)
347.            IF (SNOW .EQ. NO)     WRITE (6,1117)
348.            IF (PEST .EQ. NO)  GO TO 1010
349.            IF (DESORP .EQ. YES)  WRITE (6,1118)
350.            IF (DESORP .EQ. NO)   WRITE (6,1119)
351.            IF (APMODE .EQ. SOIL)  WRITE (6,1105)
352.            IF (APMODE .EQ. SURF)  WRITE (6,1104)
353.       1010 WRITE (6,1092)
353.01    C
353.02          IF (DISK .EQ. NO)  WRITE (6,1088)
353.03          IF (IDKCNT .EQ. 0)  GO TO 40
353.04          IF (IDEBUG .EQ. ON)  WRITE (6,9996)
353.05          WRITE (6,1085)
353.06          DO 34 JDISK=1,IDKCNT
353.07             WRITE (6,1086) IDSN(JDISK)
353.08             WRITE (6,1089) (TITLE(JDISK,I),I=1,20)
353.09             DO 32 I=1,20
353.1        32       LSRO(I) = TITLE(JDISK,I)
353.105            LSRO(21) = 0
353.11             LSRO(22) = BGNDAY
353.115            LSRO(23) = BGNMON
353.12             LSRO(24) = BGNYR
353.125            LSRO(25) = 23
353.13             LSRO(26) = ENDDAY
353.135            LSRO(27) = ENDMON
353.14             LSRO(28) = ENDYR
353.145            LSRO(29) = INTRVL*60.
353.15             IF (INTRVL.EQ.60) LSRO(29) = 900.
353.155            LSRO(30) = ITYPE(JDISK)
353.19    C
353.2              DSN = IDSN(JDISK)
353.21             WRITE(DSN) LSRO
353.22       34 CONTINUE
353.23    C
354.      C
355.         40 WRITE (6,1164) INTRVL,HYMIN,AREA
356.            WRITE (6,1165) BGNDAY,BGNMON,BGNYR
357.            WRITE (6,1166) ENDDAY,ENDMON,ENDYR
358.            WRITE (6,1167) UZSN,UZS,LZSN,LZS
359.            WRITE (6,1168) L,SS,NN,A,BPX4,PETMUL
359.1           WRITE (6,1162) (KS(I),I=1,12)
360.            WRITE (6,1169) INFIL,INTER,IRC,K24L,KK24,K24EL
361.            WRITE (6,1170) SGW,GWS,KV,ICS,OFS,IFS
362.            IF (SNOW .EQ. NO) GO TO 1011
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363.          WRITE (6,1171) RADCON,CCFAC,SCF,ELDIF,IDNS,F
364.          WRITE (6,1172) DGM,WC,MPACK,EVAPSN,MELEV,TSNOW
365.          WRITE (6,1173) PACK,DEPTH
366.          WRITE (6,1174) PETMIN,PETMAX,WMUL,RMUL,KUGI
367.     1011 WRITE (6,1175) (COVPMO(I),I=1,12)
368.          WRITE (6,1183)(TIMTIL(I),I=1,12),(YRTIL(I),I=1,12),
368.1       1       (SRERTL(I),I=1,12)
370.          WRITE (6,1177) JRER,KRER,JSER,KSER,SRERI,SCMPAC
371.          IF (PEST .EQ. NO) GO TO 1012
371.1         WRITE (6,1180) PSSZ,PSUZ,PSLZ,PSGZ
371.2         WRITE (6,1178) (TIMAP(I),I=1,12),(YEARAP(I),I=1,12),
371.3       1                (SSTR(I),I=1,12)
373.          WRITE (6,1179) CMAX,DD,K,N,NP
374.          WRITE (6,1182) (DDG(I),I=1,12),(YDG(I),I=1,12),(KDG(I),I=1,12)
375.     1012 WRITE (6,1120) HYCAL,INPUT,OUTPUT,PRINT,SNOW,PEST,NUTR,ICHECK
375.1         IF (SNOW.EQ.YES)  WRITE (6,5014) SNOPRT
376.          IF (PEST.EQ.YES)  WRITE (6,1127) APMODE,DESORP
377.          WRITE (6,1092)
377.01   C
377.1         IF (NUTR .EQ. NO)  GO TO 460
377.2            CALL NUTRIO  (IOERR,INTRVL,NAPPL,SNAPL,UNAPL,TIMHAR,
377.3       1                  INPUT,OUTPUT,APDAY,KNI,KPI,ULUPF,LZUPF)
377.4            IF (IOERR .EQ. 1)  GO TO 1080
377.5    C
377.61     460 IF (NUTR .EQ. NO)  GO TO 464
377.62           READ (5,LZTP)
377.63           READ (5,RETP)
377.64   C       READ (5,5004)  (LZTEMP(I),I=1,12)
377.65   C       READ (5,5002)  ASZT,BSZT,AUZT,BUZT
377.66           WRITE (6,1130)  (LZTEMP(I),I=1,12)
377.67           WRITE (6,1131)  ASZT,BSZT,AUZT,BUZT
377.68     464 IF (PEST.EQ.NO .AND. NUTR.EQ.NO)  GO TO 465
377.69           READ (5,DPTH)
377.7    C       READ (5,5010)  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
377.71             IF (UZF.EQ.0.0)  UZF = 1.0
377.72             IF (LZF.EQ.0.0)  LZF = 1.0
377.73           WRITE (6,1176)  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
377.735          WRITE (6,1181)
377.74   C
378.       465 IF (INPUT .EQ. METR) GO TO 559
379.          GO TO 449
380.     C
381.     C  CONVERSION OF METRIC INPUT DATA TO ENGLISH UNITS
382.     C
383.       559 HYMIN= HYMIN*35.3
384.          UZSN = UZSN/MMPIN
385.          LZSN = LZSN/MMPIN
386.          INFIL= INFIL/MMPIN
387.          L    = L*3.281
388.          UZS  = UZS/MMPIN
389.          LZS  = LZS/MMPIN
390.          SGW  = SGW/MMPIN
391.          ICS  = ICS/MMPIN
392.          OFS  = OFS/MMPIN
393.          IFS  = IFS/MMPIN
394.          EPXM = EPXM/MMPIN
399.          SRERI= SRERI/(METOPT*2.471)
400.          AREA = AREA*2.471
401.          DO 451 I=1,12
402.       451    SRERTL(I) = SRERTL(I)/(METOPT*2.471)
403.     C
404.          IF (SNOW .EQ. NO)  GO TO 403
405.          ELDIF = ELDIF*3.281
406.          DGM   = DGM/MMPIN
407.          MELEV = MELEV*3.281
408.          TSNOW = 1.8*TSNOW + 32.0
409.          PACK  = PACK/MMPIN
410.          DEPTH = DEPTH/MMPIN
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411.          PETMAX= 1.8*PETMAX + 32.0
412.          PETMIN= 1.8*PETMIN + 32.0
413.     C
414.       403 IF (PEST .EQ. NO)  GO TO 448
415.          DO 501 I=1,12
416.       501     SSTR(I) = SSTR(I)*0.89
416.1         PSSZ = PSSZ*0.89
416.2         PSUZ = PSUZ*0.89
416.3         PSLZ = PSLZ*0.89
416.4         PSGZ = PSGZ*0.89
416.5         ARUDL = ARUDL*25.4
417.     C
417.1      448 IF (NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 449
417.31        UZDPTH= UZDPTH/MMPIN
417.32        SZDPTH= SZDPTH/MMPIN
417.33   C      28328. = UNIT CONVERSION, CM(3)/FT(3)
417.34        BDSZ = BDSZ*28328./454.
417.35        BDUZ = BDUZ*28328./454.
417.36        BDLZ = BDLZ*28328./454.
417.4    C
418.       449 IERROR = 0
419.          IF (ICHECK .EQ. OFF) GO TO 452
420.     C
421.          CALL CHECKR (SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,
423.         1              CMAX,AREA,HYCAL,INPUT,OUTPUT,PRINT,PEST,
424.         2              APMODE,DESORP,ENDYR,ENDMON,ENDDAY,
425.         3              BGNYR,BGNMON,BGNDAY,IERROR,CALB,PROD,
426.         4              ENGL,METR,BOTH,INTR,HOUR,DAYS,MNTH,YES,NO,
427.         5              SURF,SOIL,SZDPTH,COVPMO,TIMTIL,TIMAP,
430.         6              YEARAP,NUTR,LZTEMP)
431.     C
431.1         CALL CHECKS (HYMIN,INTRVL,UZSN,LZSN,IRC,NN,L,SS,A,UZS,LZS,
431.2        1              K24L,KK24,K24EL,K3,SNOW,ICHECK,IERROR,
431.3        2              YES,NO,ON,OFF,RADCON,CCFAC,SCF,ELDIF,
431.4        3              ICNS,F,DGM,WC,EVAPSN,MELEV,TSNOW,
431.5        4              PETMIN,PETMAX,PETMUL,WMUL,RMUL,KUGI)
431.6    C
432.          IF (IERROR .GT. 0) GO TO 1080
433.     C
439.     C                    ADJUSTMENT OF CONSTANTS
440.     C
441.       452 H = 60/INTRVL
442.          TIMFAC = INTRVL
443.          INTRVL = 24*H
443.1         TIMPPT = TIMFAC
443.2         IF (TIMFAC.NE.60) GO TO 4000
443.3         INTRVL = 96
443.4         TIMFAC = 15
443.5         H = 4
444.     C
445.      4000 KRER = KRER*H**(JRER-1.)
446.          KSER = KSER*H**(JSER-1.)
447.     C
448.          M = BDSZ*(SZDPTH/12.0)*43560.*AREA*0.2
448.2         MU = BDUZ*((UZDPTH-SZDPTH)/12.0)
448.3         ML = BDLZ*6.0
448.4         MUZ = MU*43560.*AREA*0.2
448.5         MLZ = ML*43560.*AREA
448.6    C
449.     C                                   INITIALIZE TEMP DIST VARIABLES
450.          TEMPI = 35.
451.          CHANGE = -12.
452.          GRAD(1) = 0.04
453.          GRAD(2) = 0.04
454.     C
455.          IPACK=0.01
456.     C
457.          JCOUNT = BGNDAY
```

```
458.          DO 601 I=1,BGNMON
459.               JCOUNT = JCOUNT + DPMM1(I)
460.      601 CONTINUE
461.          IF (MOD(BGNYR,4).EQ.0 .AND. BGNMON.GT.2)  JCOUNT=JCOUNT+1
462.    C
463.          DO 1005  I=1,5
464.             SREF(I) = SRERI
465.             UZSB(I) = UZS
466.             RESB(I) = DFS
467.             SRGX(I) = IFS
468.     1005 CONTINUE
469.    C
470.          RESS1 = DFS
471.          RESS = UFS
472.          SCEP = ICS
473.          SCEP1 = ICS
474.          SRGXT = IFS
475.          SRGXT1 = IFS
476.          SGW1 = SGW
478.          COVRMX = 0.0
479.          DO 1006 I=1,12
480.     1006     IF (COVRMX.LT.COVPMO(I))  COVRMX=COVPMO(I)
481.    C
482.          IF (PEST .EQ. NO) GO TO 1007
483.    C
486.          NI = 1.0/N
487.          NIP = 1.0/NP
488.          NCOM = NIP/NI
494.    C
498.          FP = DD*M
499.          FPUZ = DD*MUZ
500.          FPLZ = DD*MLZ
501.    C
501.1   C                INITIAL PESTICIDE STORAGES
501.2   C
501.3         DO 999 I=1,5
501.4            SSTR1(I) = PSSZ*AREA*0.2
501.5            USTR(I)  = PSUZ*AREA*0.2
501.6     999 CONTINUE
501.7   C
501.8         LSTR = PSLZ*AREA
501.9         GSTR = PSGZ*AREA
502.          SULG = (PSSZ+PSUZ)*AREA + LSTR
502.02        TOTPAP = (PSSZ+PSUZ)*AREA + LSTR + GSTR
502.1   C
509.    C                              PROGRAM EXECUTION
510.    C                                                  BEGIN YEARLY LOOP
511.     1007 DO 1070  YEAR=BGNYR,ENDYR
512.             IF (YEAR .EQ. BGNYR) JCOUNT = JCOUNT - 1
513.             MNSTRT = 1
514.             MNEND = 12
515.             IF (YEAR .EQ. BGNYR)  MNSTRT = BGNMON
516.             IF (YEAR .EQ. ENDYR)  MNEND = ENDMON
517.    C
518.    C
519.    C  EVAP, TEMP(MAX-MIN), RAD, AND WIND  DATA INPUT
520.    C
521.           DO  1008  DA = 1,31
522.     1008   READ (5,1264) (IEVAP(MN,DA), MN =1,12)
523.    C
524.    C
525.           IF (SNOW.EQ.NO .AND. NUTR.EQ.NO)  GO TO 610
526.            DO  1013 DA = 1,31
527.     1013   READ(5,1265) ((ITEMP(MN,DA,IT), IT=1,2),MN=1,12)
528.    C
529.          IF (SNOW .EQ. NO)  GO TO 610
530.            DO  1014 DA = 1,31
531.     1014   READ(5,1264) (IWIND(MN,DA), MN=1,12)
```

```
532.      C
533.                DO 600 DA =1,31
534.        600     READ (5,1264) (IRAD(MN,DA), MN=1,12)
535.      C
536.                DO 605 DA=1,31
537.        605     READ (5,1264) (IDEW(MN,DA), MN=1,12)
538.      C
539.        610     IF (INPUT .EQ. ENGL) GO TO 625
540.                DO 700 DA=1,31
541.                   DO 650 MN=1,12
542.                      IEVAP(MN,DA) = IEVAP(MN,DA)*3.937
543.                      IF (SNOW.EQ.YES) IWIND(MN,DA) = IWIND(MN,DA)*0.6214
544.                      IF (SNOW.EQ.YES) IDEW(MN,DA) = 1.8*IDEW(MN,DA) + 32.5
545.                        DO 640 IT=1,2
546.        640             IF (SNOW.EQ.YES .OR. NUTR.EQ.YES)
547.           1                ITEMP(MN,DA,IT) = 1.8*ITEMP(MN,DA,IT) + 32.5
548.        650           CONTINUE
549.        700        CONTINUE
550.      C                                        SAV TMIN OF JAN 1 ON 11/31
551.        625 IF (SNOW.EQ.YES .OR. NUTR.EQ.YES) ITEMP(11,31,2) = ITEMP(1,1,2)
552.      C
553.      C
554.      C
555.      C                                                    BEGIN MONTHLY LOOP
556.                 DO 1060  MONTH=MNSTRT,MNEND
557.      C
558.                    COVER1 = COVPMO(MONTH)
559.                    IF (MONTH.LT.12)  COVER2 = COVPMO(MONTH+1)
560.                    IF (MONTH.EQ.12)  COVER2 = COVPMO(1)
560.1                   XK31 = K3(MONTH)
560.2                   IF (MONTH.LT.12)  XK32 = K3(MONTH+1)
560.3                   IF (MONTH.EQ.12)  XK32 = K3(1)
560.4                   LTEMP1 = LZTEMP(MONTH)
560.5                   LTEMP2 = LZTEMP(1)
560.6                   IF (MONTH.NE.12)  LTEMP2=LZTEMP(MONTH+1)
561.      C
562.                    IF (HYCAL .EQ. PROD)  GO TO 1009
563.                    IF (NUTR.EQ.YES)  GO TO 1009
564.      C
565.                    WRITE (6,1265)
566.                    WRITE (6,382)
567.                    WRITE (6,1092)
576.      C
577.       1009         DYSTRT = 1
578.      C
579.                    DYEND = DPM(MONTH)
580.                    IF (MOD(YEAR,4).EQ.0.AND.MONTH.EQ.2)  DYEND=29
581.      C
582.                    IMDEND=DYEND
583.                    IF (YEAR.EQ.BGNYR .AND. MONTH.EQ.BGNMON)  DYSTRT = BGNDAY
584.                    IF (YEAR.EQ.ENDYR .AND. MONTH.EQ.ENDMON)  DYEND  = ENDDAY
585.      C
586.      C                                                    BEGIN DAILY LOOP
587.                    DO 1050  DAY=DYSTRT,DYEND
588.                       IF ((MONTH .EQ. 1) .AND. (DAY .EQ. 1)) JCOUNT = 0
588.1                      IPFLAG = 0
589.                       TIME = 0
590.                       RAINT = 0.0
591.                       EP = PETMUL*IEVAP(MONTH,DAY)/1000.
592.      C
599.                       DO 1019  I=1,INTRVL
600.                          IRAIN(I) = 0
601.                          RAIN(I) = 0.0
602.       1019            CONTINUE
603.      C
603.1     C              CALCULATION OF HOURLY TEMPERATURE FOR SNOW AND/OR NUTRIENTS
603.2     C
604.            IF (SNOW.EQ.NO .AND. NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 949
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626.1     C
626.12          TMIN = ITEMP(MONTH,DAY,2)
626.14          IF (PACK.LE.0.0 .AND. TMIN.GT.PETMAX .AND. NUTR.EQ.NO
626.15         1 .AND. PEST.EQ.NO)  GO TO 949
626.16    C
626.2           IF (YEAR.NE.BGNYR .OR. MONTH.NE.BGNMON .OR.
626.3          1          DAY.NE.BGNDAY) GO TO 899
626.4           CHANGE = (ITEMP(MONTH,DAY,2) - TEMPI)/0.17
627.       899  TGRAD = 0.0
629.            DO 948 I=1,24
630.              IF (I-7)  940, 900, 910
631.        900   CHANGE = ITEMP(MONTH,DAY,1) - TEMPI
632.        910   IF (I.NE.17) GO TO 940
633.      C                          IMDEND IS LAST DAY OF PRESENT MONTH
634.              IF (DAY .NE. IMDEND)  CHANGE =ITEMP(MONTH,DAY+1,2) - TEMPI
635.              IF (MONTH.NE.12) GO TO 925
636.              IF (DAY .EQ. IMDEND)  CHANGE = ITEMP(11,31,2) - TEMPI
637.              GO TO 940
638.        925   IF (DAY .EQ. IMDEND)  CHANGE = ITEMP(MONTH+1,1,2) - TEMPI
639.      C
640.        940   IF (ABS(CHANGE).GT.0.001)  GO TO 945
641.              TGRAD = 0.0
642.              GO TO 947
643.        945   TGRAD = GRAD(I)*CHANGE
644.        947   TEMPX(I) = TEMPI + TGRAD
647.              TEMPI = TEMPI + TGRAD
648.        948 CONTINUE
649.      C
649.01    C
649.03    C            CALCULATE CONTINUOUS WIND AND RAD AND APPLY CORRES MULT
649.04    C            FACTORS FOR SNOWMELT CALCULATIONS
649.05    C
649.06          IF (SNOW .EQ. NO)  GO TO 949
649.07                   WIND = IWIND(MONTH,DAY)
649.08                   DEWX = IDEW(MONTH,DAY)
649.09          WINF=(1.0-F) + F*(.35-.03*KUGI)
649.1     C                                    WINF REDUCES WIND FOR FORESTED AREAS
649.11    C
649.12    C              KUGI IS INDEX TO UNDERGROWTH AND FOREST DENSITY,
649.13    C              WITH VALUES 0 TO 10 - WIND IN FOREST IS 35% OF
649.14    C              WIND IN OPEN WHEN KUGI=0, AND 5% WHEN KUGI=10 -
649.15    C              WIND IS ASSUMED MEASURED AT 1-5 FT ABOVE GROUND
649.16    C              OR SNOW SURFACE
649.17    C
649.19          DEWX = DEWX - 1.0*ELDIF
649.2     C                    DEWPT USES A LAPSE RATE OF 1 DEGREE/1000 FT
649.21    C
649.22          IF ((PACK .LE. 0.0).AND.(TMIN .GT. PETMAX))  GO TO 949
649.23    C
649.24    C     CALCULATE HOURLY WIND AND RADIATION
649.26          R = IRAD(MONTH,DAY)
649.265         DO 952 I=1,24
649.27            WINDX(I)  = WMUL*WIND*WINF*WINDIS(I)
649.28            RAD(I)    = RMUL*R*RADCON*RADDIS(I)
649.29      952 CONTINUE
649.3     C
649.31    C
650.      C       CHECK OF TILLAGE TIME
651.        949           JCOUNT = JCOUNT + 1
652.                      DO 951 I=1,12
653.                         IF (JCOUNT.NE.TIMTIL(I) .OR. YEAR.NE.(YRTIL(I)+1900))
654.           1                 GO TO 951
655.                         WRITE (6,1082)  MNAM(MONTH), DAY, TIMTIL(I), SRERTL(I)
656.                         DO 950 J=1,5
657.                            SREK(J) = SRERTL(I)
658.        950              CONTINUE
659.        951           CONTINUE
660.      C
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661.      C  CROP CANOPY EFFECTS - ASSUMES LINEAR CHANGE BETWEEN MONTHLY VALUES
662.      C
663.            COVER = COVER1 + (1.0 - (FLOAT(DPM(MONTH)+1-DAY)/FLOAT(DPM
664.           1          (MONTH))))*(COVER2-COVER1)
664.1           XK3 = XK31 + (1.0 - (FLOAT(DPM(MONTH)+1-DAY)/FLOAT(DPM(MONTH))))*
664.2          1          (XK32 - XK31)
665.      C
666.            IF (NUTR.EQ.NO)  GO TO 1017
667.      C
670.      C                          CALCULATION OF HOURLY SOIL TEMPERATURE
671.      C
671.1           IF (INPUT.EQ.ENGL) GO TO 805
671.2           DO 802 JHOUR = 1,24
671.3             TEMPX(JHOUR) = 5./9.*(TEMPX(JHOUR)-31.5)
671.4         802 CONTINUE
671.5     C
672.          805 DO 810  JHOUR=1,24
672.1               STEMP(JHOUR) = ASZT + BSZT*TEMPX(JHOUR)
672.2               UTEMP(JHOUR) =  AUZT + BUZT*STEMP(JHOUR)
672.3         810 CONTINUE
672.4           LTEMP = LTEMP1 + (1.0 - (FLOAT(DPM(MONTH)+1-DAY)/FLOAT(DPM
672.5          1                    (MONTH))))*(LTEMP2-LTEMP1)
672.51    C
672.52    C     CONVERSION OF SOIL TEMP FROM F TO C FOR NUTRNT AND DEGRAD
672.53    C
672.54          IF (INPUT .EQ. METR) GO TO 815
672.55          DO 812 JHOUR=1,24
672.56              STEMP(JHOUR) = (STEMP(JHOUR)-32.0)*5./9.
672.57              UTEMP(JHOUR) = (UTEMP(JHOUR)-32.0)*5./9.
672.58        812 CONTINUE
672.59          LTEMP = (LTEMP-32.0)*5./9.
677.      C
677.1     C                          NUTRIENT DAILY CALCULATIONS
677.2     C
678.      C                          TEST FOR APPLICATION OF FERTILIZERS
679.      C
680.      815   IF (APLCNT .GT. NAPPL)  GO TO 860
681.            IF (APDAY(APLCNT) .GE. JCOUNT)  GO TO 820
682.               APLCNT = APLCNT + 1
683.               GO TO 815
684.      820   IF (JCOUNT .NE. APDAY(APLCNT))  GO TO 860
685.      C
686.      C                          ADD NUTRIENT APPLICATIONS TO STORAGES
687.      C                          AND INCREMENT MASS TOTALS IN SYSTEM
688.      C
689.            DO 830  IBLK=1,5
690.               DO 825  J=1,20
691.                  SN(J,IBLK) = SN(J,IBLK) + SNAPL(J,IBLK,APLCNT)
692.                  UN(J,IBLK) = UN(J,IBLK) + UNAPL(J,IBLK,APLCNT)
693.      825      CONTINUE
694.      830   CONTINUE
695.      C
696.            DO 840  J=1,6
697.               SUM = 0.0
698.               DO 835  IBLK=1,5
699.                  SUM = SUM + SNAPL(J,IBLK,APLCNT) + UNAPL(J,IBLK,APLCNT)
700.      835      CONTINUE
701.               TNA = TNA + SUM/5.
702.      840   CONTINUE
703.            DO 850  J=11,14
704.               SUM = 0.0
705.               DO 845  IBLK=1,5
706.                  SUM = SUM + SNAPL(J,IBLK,APLCNT) + UNAPL(J,IBLK,APLCNT)
707.      845      CONTINUE
708.               TPA = TPA + SUM/5.
709.      850   CONTINUE
710.            SUM = 0.0
711.            DO 855  IBLK=1,5
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712.              SUM = SUM + SNAPL(20,IBLK,APLCNT) + UNAPL(20,IBLK,APLCNT)
713.      855   CONTINUE
714.            TCLA = TCLA + SUM/5.
715.      C
716.            WRITE (6,4005)  APLCNT, MNAM(MONTH), DAY, JCOUNT
717.            APLCNT = APLCNT + 1
718.      C
719.      860   IF (JCOUNT .NE. TIMHAR)  GO TO 881
720.      C
721.      C                              COMPUTE AMOUNT HARVESTED AND DECREASE STORAGES
722.      C
723.            DO 870  J=1,20
724.               TNRHV(J) = 0.0
725.               IF (SELHV(J) .EQ. 0)  GO TO 870
726.               SUM = 0.0
727.               DO 865  IBLK=1,5
728.                  SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
729.                  SN(J,IBLK) = 0.0
730.                  UN(J,IBLK) = 0.0
731.      865      CONTINUE
732.               TNRHV(J) = SUM/5. + LN(J) + GN(J)
733.               LN(J) = 0.0
734.               GN(J) = 0.0
735.               TNRHVM(J) = TNRHVM(J) + TNRHV(J)
736.      870   CONTINUE
737.            WRITE (6,4006)  MNAM(MONTH), DAY
738.      C
739.      C                              TRANSFER INPUT REACTION RATES (KNI,KPI) INTO
740.      C                              REACTION RATES IN COMMON /NUT/  (KN,KP)
741.      C                              PLANT UPTAKE RATES ARE THE FRACTION OF THE
742.      C                              MAXIMUN MONTHLY UPTAKE PER UPPER
742.1     C                              LAYERS,SURFACE AND UPPER ZONE, (ULUPF)
742.2     C                              AND LOWER ZONE (LZUPF).
743.      C
744.      881   DO 884  IZONE=1,4
745.               DO 882  J=1,8
746.                  KN(J,IZONE) = KNI(J,IZONE)
747.      882      CONTINUE
748.               DO 883  J=1,5
749.                  KP(J,IZONE) = KPI(J,IZONE)
750.      883      CONTINUE
751.      884   CONTINUE
752.      C
753.            DO 885  IZONE=1,2
754.               KN(3,IZONE) = KN(3,IZONE)*ULUPF(MONTH)
755.               KP(3,IZONE) = KP(3,IZONE)*ULUPF(MONTH)
756.      885   CONTINUE
756.1             KN(3,3) = KN(3,3)*LZUPF(MONTH)
756.2             KP(3,3) = KP(3,3)*LZUPF(MONTH)
757.      C
757.01    C                CHECK FOR PESTICIDE APPLICATION DATE
757.02    C
757.03     1017 IF (PEST .EQ. NO)  GO TO 1018
757.04          DO 896 I=1,12
757.05             IF (JCOUNT.NE.TIMAP(I) .OR. YEAR.NE.(YEARAP(I)+1900)) GO TO 896
757.06             WRITE (6,1076) MNAM(MONTH),DAY,TIMAP(I),SSTR(I)
757.065            KFLAG = 0
757.07             TOTPAP = TOTPAP + SSTR(I)*AREA
757.08             SULG = SULG + SSTR(I)*AREA
757.09    C
757.1              IF (APMCDE .EQ. SURF)  GO TO 888
757.11             DO 886 J=1,5
757.12                SSTR1(J) = SSTR1(J) + SSTR(I)*AREA*0.2*(SZDPTH/UZDPTH)
757.13                USTR(J)  = USTR(J) + SSTR(I)*AREA*0.2 - SSTR1(J)
757.14      886    CONTINUE
757.15             GO TO 896
757.16    C
757.17      888    DO 890 J=1,5
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757.18                SSTR1(J) = SSTR1(J) + SSTR(I)*AREA*0.2
757.19      890    CONTINUE
757.2       896 CONTINUE
757.21    C
757.22          IF (SULG .GT. 0.001)  IPFLAG = 1
757.23    C
757.24    C        CHECK PESTICIDE DEGRADATION RATE
757.241   C
757.25          DO 902 I=1,12
757.26             IF (JCOUNT.NE.DDG(I) .OR. YEAR.NE.(YDG(I)+1900)) GO TO 902
757.27             WRITE (6,1077) MNAM(MONTH),DAY,DDG(I),KDG(I)
757.28             DEGCON = KDG(I)
757.29      902 CONTINUE
757.3     C
758.      C
759.      C                                    PRECIP READ LOOP
760.      C
760.01    C
760.02    C        CHECK FOR AND READ HOURLY PRECIPITATION
760.03    C
760.04     1018 IF (TIMPPT.EQ.5.OR.TIMPPT.EQ.15) GO TO 1020
760.05     2020 DO 2000 J=1,2
760.06             JK = J*720/TIMPPT
760.07             JJ = JK - 720/TIMPPT + 1
760.08             READ(5,2010) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
760.082            IF((YR+1900).LT.BGNYR) GO TO 2020
760.084            IF(MO.LT.MNSTRT) GO TO 2020
760.086            IF(DY.LT.DYSTRT) GO TO 2020
760.11             IF (INPUT.EQ.ENGL) GO TO 2030
760.12             DO 2040 I=JJ,JK
760.13     2040       IRAIN(I) = IRAIN(I)*3.937 + 0.5
760.14     2030    JJJ = J
760.15             YR = YR + 1900
760.16             IF (CN.EQ.9) JJJ=CN
760.17             IT = (YEAR-YR) + (MONTH-MO) + (DAY-DY) + (JJJ-CN)
760.18             IF (IT.NE.0) GO TO 1022
760.19             IF (CN.EQ.9) GO TO 1025
760.2      2000 CONTINUE
760.21    C
760.22    C   HOURLY DATA SPLIT INTO 4 EQUAL 15 MIN DATA ITEMS
760.23    C
760.24          DO 2050 J=1,24
760.25             JK= 96 - J*4 + 4
760.26             JJ = 24 - J + 1
760.27             DO 2050 I=1,4
760.28     2050       IRAIN(JK-I+1) = IRAIN(JJ)
760.29          DIV = 400.
760.3           GO TO 1023
760.31    C
760.32    C        GET 5 OR 15 MINUTE PRECIPITATION DATA
760.33    C
761.       1020 DO 1021 J=1,8
762.             JK = J*180/TIMFAC
763.             JJ = JK - 180/TIMFAC + 1
764.             IF (TIMFAC.EQ.5)  READ (5,1095) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
765.             IF (TIMFAC.EQ.15) READ (5,1094) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
765.5            IF((YR+1900).LT.BGNYR) GO TO 1020
766.             IF(MO.LT.MNSTRT) GO TO 1020
766.5            IF(DY.LT.DYSTRT) GO TO 1020
768.             IF (INPUT.EQ.ENGL) GO TO 708
769.             DO 706 I=JJ,JK
770.                IRAIN(I) = IRAIN(I)*3.937 + 0.5
771.        706  CONTINUE
772.        708  JJJ = J
773.             YR = YR + 1900
774.             IF (CN.EQ.9) JJJ = 9
775.             IT = (YEAR-YR) + (MONTH-MO) + (DAY-DY) + (JJJ-CN)
776.             IF (IT.NE.0) GO TO 1022
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777.              IF (CN.EQ.9) GO TO 1025
778.       1021 CONTINUE
778.1           DIV = 100.
779.            GO TO 1023
780.       1022 WRITE (6,1090) JJJ,MONTH,DAY,YEAR,CN,MO,DY,YR
781.            GO TO 1080
782.       C
783.       C
784.       1023          DO 1024  I=1,INTRVL
785.                        RAIN(I) = IRAIN(I)/DIV
786.                        RAINT = RAINT + RAIN(I)
787.       1024             CONTINUE
788.       C
789.                     IF (RAINT.GT.0.0) GO TO 1026
790.       C
791.       C
792.       C  USE RAIN LOOP IF MOISTURE STORAGES ARE NOT EMPTY
793.       C
794.       1025  IF ((RESS.LT.0.001).AND.(SRGXT.LT.0.001)) GO TO 1040
795.       C
796.       C
797.       C                  RAIN LOOP
798.       C
799.       1026          DO 1036  I=1,INTRVL
800.                        TIME = TIME + 1
801.                        TF = 1
802.                        PR = RAIN(I)
803.       C
804.                        IMIN = MOD(TIME,H)
805.                        IHR = (TIME - IMIN)/H
806.                        IMIN = TIMFAC*IMIN
807.                        PRNTKE = 0
808.                        IF (PRINT.EQ.HOUR) GO TO 1028
809.                        IF (PRINT.EQ.DAYS) GO TO 1029
810.                        IF (PRINT.EQ.MNTH) PRNTKE = 2
811.                        IF (PRINT.EQ.INTR) PRNTKE = 1
812.                           GO TO 1030
813.       1028                IF (IMIN .LT. 1)  PRNTKE = 1
814.                           GO TO 1030
815.       1029                IF (IHR .EQ. 24)  PRNTKE = 1
816.       C
817.       1030             IF (PRNTKE .NE. 1)  GO TO 1031
818.       C
819.                        IF (HYCAL .EQ. CALB)  GO TO 1031
820.       C
821.                        WRITE (6,1101)  IHR, IMIN, DAY,MNAM(MONTH),YEAR
822.                        WRITE (6,1102)
823.                        WRITE (6,1103)
824.       C
825.       1031             CALL LANDS(SFLAG,SNOPRT)
826.                        IF ((RESS .GE. 0.001).OR.(PR .GT. 0.001))  GO TO 1034
827.                        DO 1033  J=1,5
828.                           ERSN(J) = 0.0
829.       1033                CONTINUE
830.                        IF (PRNTKE .EQ. 0)  GO TO 1035
831.       1034             CALL SEDT(SFLAG)
832.       C
833.       1035            IF (IPFLAG .EQ. 0)  GO TO 971
840.                       CALL ADSRB(UZSN,UZF,LZSN,LZF,
840.1          1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
840.2          2 APMODE,TPBAL,DEGSUM,DEGSUT,DEGUOM,DEGUOT,DEGU,DEGS,
840.3          3 DEGLOM,DEGLOT,NIP,NCOM,DIST,TOTPAP,TIMAP,YEARAP,
840.4          4 DESORP,SORF,SOIL,SOLG)
842.                        IF (IHR .EQ. 24)  GO TO 1038
843.                         DEGS = 0.0
844.                         DEGU = 0.0
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845.                          GO TO 971
846.      1038                CALL DEGRAD(
846.1         1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
846.2         2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
846.3         3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
846.4         4 DESORP,SURF,SOIL,SULG,DEGCON)
847.       971            IF (NUTR .EQ. NO)  GO TO 1036
848.     C
849.     C
850.                       CALL NUTRNT(UZSN,UZF,LZSN,LZF)
851.     C
852.      1036             CONTINUE
853.     C
854.                     GO TO 1050
855.     C
856.     C                    NO RAIN LOOP
857.     C
858.     C
859.      1040           TF = INTRVL
860.                     PR = 0.0
861.                     P3 = 0.0
862.                     DO  1042  I=1,5
863.      1042              RESBI(I) = 0.0
864.                     PRNTKE = 1
865.                     IF (PRINT.EQ.MNTH)  PRNTKE = 2
866.                     IMIN = 00
867.                     IHR = 24
868.                     IF (HYCAL.EQ.CALB .OR. PRNTKE.EQ.2)  GO TO 1043
869.                     WRITE (6,1101)  IHR, IMIN, DAY, MNAM(MONTH), YEAR
870.                     WRITE (6,1102)
871.                     WRITE (6,1103)
872.     C
873.      1043           CALL LANDS(SFLAG,SNOPRT)
874.                     SRERT = 0.0
875.                     ERSNT = 0.0
875.3    C
876.                     DO 1041  J=1,5
876.1    C                    SOIL COMPACTION -- ONLY ON NON-RAIN DAYS
876.2                        SRER(J) = SRER(J)*(1.0 - SCMPAC)
876.3    C
877.                         SRERT = SRERT + SRER(J)*0.2
878.                         ERSN(J) = 0.0
879.      1041           CONTINUE
880.                     IF (HYCAL.EQ.CALB .OR. PRNTKE.EQ.2)  GO TO 1044
881.                   IF (OUTPUT.EQ. METR) GO TO 1081
882.                     WRITE (6,1209)
883.                     WRITE (6,1210) ERSN, ERSNT
884.                     WRITE (6,1211)  SRER, SRERT
885.      1081           IF (OUTPUT.EQ. ENGL) GO TO 1044
886.     C  METRIC CONVERSIONS FOR OUTPUT
887.                     ERSNTT=ERSNT*METOPT*2.471
888.                     SRRTMT=SRERT*METOPT*2.471
889.                     DO 1163 I=1,5
890.                       ERSNMT(I)=ERSN(I)*METOPT*2.471
891.                       SRERMT(I)=SRER(I)*METOPT*2.471
892.      1163           CONTINUE
893.                     WRITE (6,1208)
894.                     WRITE (6,1210) ERSNMT, ERSNTT
895.                     WRITE (6,1211) SRERMT, SRRTMT
896.     C
897.      1044          IF (IPFLAG .EQ. 0)  GO TO 972
903.                       CALL ADSRB(UZSN,UZF,LZSN,LZF,
903.1         1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
903.2         2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
903.3         3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
903.4         4 DESORP,SURF,SOIL,SULG)
905.                     CALL DEGRAD(
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905.1          1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
905.2          2 APMODE,TPBAL,DEGSCM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
905.3          3 DEGLOM,DEGLOT,NIP,NCCM,UIST,TOTPAP,TIMAP,YEARAP,
905.4          4 DESORP,SURF,SCIL,SJLG,DEGCON)
906.        972       IF (NUTR .EQ. NO)  GO TO 1050
907.                        CALL NUTRNT(UZSN,UZF,LZSN,LZF)
908.      C                                                END DAILY LOOP
909.       1050          CONTINUE
910.      C
911.      C                     MONTHLY SUMMARY
912.      C
913.                    CALL CUTMON (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,
913.1          1        GDS,TPBAL,DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP,TIMAP,YEARAP)
914.      C
915.      C
916.      C                                                END MONTHLY LOOP
917.       1060       CONTINUE
918.      C
919.      C                     YEARLY SUMMARY
920.                 CALL OUTYR (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
920.1          1     TPBAL,DEGSOT,DEGUOT,DEGLOT,UIST,TIMAP,YEARAP)
921.      C
922.                 APLCNT = 1
923.      C                                                END YEARLY LOOP
924.       1070    CONTINUE
925.      C
925.01    C        WRITE REMAINDER OF ARRAYS TO DISK
925.02    C
925.021         IF (DISK .EQ. NO)  GO TO 1080
925.022   C
925.03          IF(DSNFLO.EQ.0 .OR. NILSRO.EQ.1) GO TO 9990
925.031         IF (OUTPUT .EQ. ENGL)  GO TO 9011
925.032         DO 9010 I=1,TMBLSZ
925.033    9010    LSRO(I) = LSRO(I)*MMPIN
925.04     9011 WRITE(DSNFLO) (LSRO(I),I=1,TMBLSZ)
925.05          IF(IDEBUG .EQ. OFF) GO TO 9990
925.06          WRITE(6,9991) LOOP
925.07     9991 FORMAT('0','DEBUG - - LOOP = ',I5)
925.08          WRITE(6,9992) (LSRO(I),I=1,TMBLSZ)
925.09     9992 FORMAT('0','WRITE TO DISK - LSRO',/,(1X,10(E10.3,2X),/))
925.099   C
925.1      9990 IF(DSNERS.EQ.0 .OR. NERDS.EQ.1) GO TO 9080
925.101         IF (OUTPUT .EQ. ENGL)  GO TO 9021
925.102         DO 9020 I=1,TMBLSZ
925.103    9020    ERDS(I) = ERDS(I)*METOPT*2.471
925.11     9021 WRITE(DSNERS) (ERDS(I),I=1,TMBLSZ)
925.12          IF(IDEBUG .EQ. OFF) GO TO 9080
925.13          WRITE(6,9991) LOOP
925.14          CALL EPDBUG(ERDS,TMBLSZ)
925.21    C
925.22     9080 IF (DSNRDS.EQ.0 .OR. NRRDS.EQ.1) GO TO 1080
925.221         IF (OUTPUT .EQ. ENGL)  GO TO 9031
925.222         DO 9030 I=1,TMBLSZ
925.223    9030    RRDS(I) = RRDS(I)*MMPIN
925.23     9031 WRITE(DSNRDS) (RRDS(I),I=1,TMBLSZ)
925.24          IF (IDEBUG .EQ. OFF)  GO TO 1080
925.25          WRITE (6,9991) LOOP
925.26          CALL EPDBUG(RRDS,TMBLSZ)
925.27    C
926.       1080 WRITE (6,1260)
927.      C
928.      C                     FORMAT STATEMENTS
929.      C
929.1      1079 FORMAT ('1','*****ERROR*****  COLS 73-80 SHOULD BE BLANK.',/,1X,
929.2          1      'USER IS ATTEMPTING TO RUN NUMBERED OR WSNAME >72 CHAR',
929.3          2      /,1X,'COLS  73-80 READ',4X,2A4)
930.       1090 FORMAT ('1','*****ERROR*****  INCORRECT INPUT DATA!   DESIRED ',
931.          *   'CARD ',I1,' FOR ',I2,'/',I2,'/',I4,'; READ CARD ',I1,' FOR ',
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932.          *   I2,'/',I2,'/',I4)
932.05     1077 FORMAT ('0','BEGINNING ON',1X,A8,1X,I2,2X,'(DDG=',I3,') THE ',
932.06          1                'PESTICIDE DEGRADATION RATE (KDG) EQUALS',F9.3)
932.1      1078 FORMAT ('0','PESTICIDE APPLICATION OCCURS ON',1X,A8,1X,I2,2X,
932.2           1              '(TIMAP=',I3,') WITH AN APPLICATION OF',F6.3,
932.3           2              ' LBS/AC')
933.       1082 FORMAT ('0','TILLAGE OF THE SOIL OCCURS ON',1X,A8,1X,I2,2X,
934.            1          '(TIMTIL=',I3,'), RESULTING IN A NEW FINES DEPOSIT ',
935.            1          'STORAGE OF',F6.3,' TONS/ACRE')
935.1      1083 FORMAT(4X,I2)
935.2      1084 FORMAT('0','***ERROR*** INCORRECT INFORMATION FOR WRITING TO ',
935.3           1        'DISK.',/,1X,'OPTIONS ARE : RUNOFF , SEDIMENT , OVERLAND FL
935.4           2W .',/,1X,'INPUT WAS    ',A8)
935.5      1088 FORMAT('0',/,'0','LINE PRINTER OUTPUT ONLY')
935.6      1085 FORMAT('0',/,'0','DATA TO BE WRITTEN TO DISK AS FOLLOWS: ')
935.7      1086 FORMAT('0','LAND SURFACE RUNOFF/EROSION WRITTEN TO DISK DATASET NO
935.8           1. ',I2)
935.9      1089 FORMAT(1X,'TITLE  -  ',20A4)
936.       1091 FORMAT ('1',25X,'THIS IS A PRODUCTION RUN')
937.       1092 FORMAT ('0')
938.       1093 FORMAT ('1',24X,'THIS IS A CALIBRATION RUN')
939.       1094 FORMAT (1X,3I2,I1,12I6)
940.       1095 FORMAT (1X,3I2,I1,36I2)
940.1      2010 FORMAT(10X,3(I2,1X),I1,12I5)
941.       1096 FORMAT (20A4)
942.       1097 FORMAT (6X,A4)
943.       1098 FORMAT (7X,A4)
944.       1099 FORMAT (5X,A4)
945.       1100 FORMAT (A8)
946.       1101 FORMAT ('1',25X,I2,':',I2,'  ON  ',I2,1X,A8,1X,I4)
947.       1102 FORMAT ('+',25X,'_____________________________' )
948.       1103 FORMAT ('0',34X,'BLOCK 1    BLOCK 2    BLOCK 3    BLOCK 4    BLOCK 5',
949.            C  5X,'TOTAL')
950.       1104 FORMAT ('0',32X,'PESTICIDE APPLICATION:  SURFACE-APPLIED')
951.       1105 FORMAT ('0',32X,'PESTICIDE APPLICATION:  SOIL-INCORPORATED')
952.       1106 FORMAT ('0',32X,'CHEMICAL:          ',20A4)
953.       1107 FORMAT ('0',32X,'WATERSHED:         ',20A4)
954.       1108 FORMAT ('0',32X,'INPUT UNITS:     ENGLISH')
955.       1109 FORMAT ('0',32X,'INPUT UNITS:     METRIC')
956.       1110 FORMAT ('0',32X,'OUTPUT UNITS:    ENGLISH')
957.       1111 FORMAT ('0',32X,'OUTPUT UNITS:    METRIC')
958.       1112 FORMAT ('0',32X,'OUTPUT UNITS:    BOTH ENGLISH AND METRIC')
959.       1113 FORMAT ('0',32X,'PRINT INTERVAL: EACH INTERVAL')
960.       1114 FORMAT ('0',32X,'PRINT INTERVAL: EACH HOUR')
961.       1115 FORMAT ('0',32X,'PRINT INTERVAL: EACH DAY')
962.       1128 FORMAT ('0',32X,'PRINT INTERVAL: EACH MONTH')
963.       1116 FORMAT ('0',32X,'SNOWMELT CALCULATIONS PERFORMED')
964.       1117 FORMAT ('0',32X,'SNOWMELT NOT PERFORMED')
965.       1118 FORMAT ('0',32X,'ADSORPTION AND DESORPTION ALGORITHMS USED')
966.       1119 FORMAT ('0',32X,'ADSORPTION CALCULATED ONLY, NO DESORPTION')
967.       1120 FORMAT ('0',/'0','HYCAL=',A4,2X,'INPUT=',A4,2X,'OUTPUT=',A4,2X,
968.            1'PRINT=',A4,2X,'SNOW=',A4,2X,'PEST=',A4,2X,'NUTR=',A4,2X,
969.            2'ICHECK=',A4)
970.       1121 FORMAT ('0','INPUT ERROR: IT IS NOT POSSIBLE TO MAKE CALIBRATION R
971.            1UN WITH BOTH PESTICIDES AND NUTRIENTS TOGETHER',/,' ','CHANGE HYCA
972.            2L TO PROD, OR EITHER PEST OR NUTR FROM YES TO NO')
973.       1122 FORMAT ('0','INPUT ERROR: THE FIRST LINE OF THE PESTICIDE INPUT SE
974.            1QUENCE MUST BE THE WORD PESTICIDE, CORRECT AND RUN AGAIN')
975.       1123 FORMAT ('+',50X,'FOR PESTICIDES')
976.       1124 FORMAT ('+',50X,'FOR NUTRIENTS')
977.       1125 FORMAT ('+',50X,'FOR HYDROLOGY AND SEDIMENT ONLY')
978.       1126 FORMAT ('+',50X,'FOR PESTICIDES AND NUTRIENTS')
979.       1127 FORMAT ('0','APMODE=',A4,2X,'DESORP=',A4)
979.1      1130 FORMAT ('0','LOWER ZONE MONTHLY SOIL TEMPERATURES =  ', 12F6.1)
979.2      1131 FORMAT ('0','SOIL TEMPERATURE REGRESSION EQUATION CONSTANTS',
979.3           1/,' ','SURFACE ZONE:  ASZT = ',F8.3,4X,'BSZT= ',F8.3,
979.4           2/,' ','UPPER ZONE:    AUZT = ',F8.3,4X,'BUZT= ',F8.3)
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980.      1164  FORMAT ('0','INTRVL= ',I2,13X,'HYMIN= ',F8.4,8X,'AREA= ',F10.4)
981.      1165  FORMAT ('0','BGNDAY= ',I2,13X,'BGNMON= ',I2,13X,'BGNYR= ',I4)
982.      1166  FORMAT ('0','ENDDAY= ',I2,13X,'ENDMON= ',I2,13X,'ENDYR= ',I4)
983.      1167  FORMAT ('0',/'0','UZSN= ',F8.4,9X,'UZS= ',F8.4,10X,'LZSN= ',F8.4,
984.           19X,'LZS= ',F8.4)
985.      1168  FORMAT ('0','L= ',F8.4,12X,'SS= ',F8.4,11X,'NN= ',F8.4,11X,'A= ',
986.           1F8.4,12X,'EPXM= ',F8.4,9X,'PETMUL=',F8.4)
986.1      1162 FORMAT('0','K3 = ',12(F4.2,2X))
987.      1169  FORMAT ('0','INFIL= ',F8.4,8X,'INTER= ',F8.4,8X,'IRC= ',F8.4,10X,
988.           1'K24L= ',F8.4,9X,'KK24= ',F8.4,9X,'K24EL= ',F8.4)
989.      1170  FORMAT ('0','SGW= ',F8.4,10X,'GWS= ',F8.4,10X,'KV= ',F8.4,11X,
990.           1'ICS= ',F8.4,10X,'CFS= ',F8.4,10X,'IFS= ',F8.4)
991.      1171  FORMAT ('0',/'0','RADCON= ',F8.4,7X,'CCFAC= ',F8.4,8X,'SCF= ',
992.           1F8.4,10X,'ELDIF= ',F8.4,8X,'IDNS= ',F8.4,9X,'F= ',F8.4)
993.      1172  FORMAT ('0','DGM= ',F8.4,10X,'WC= ',F8.4,11X,'MPACK= ',F8.4,8X,
994.           1'EVAPSN= ',F8.4,7X,'MELEV= ',F8.0,8X,'TSNOW= ',F8.4)
995.      1173  FORMAT ('0','PACK= ',F8.4,9X,'DEPTH= ',F8.4)
996.      1174  FORMAT ('0','PETMIN= ',F8.4,7X,'PETMAX= ',F8.4,
997.           17X,'WMUL= ',F8.4,9X,'RMUL= ',F8.4,9X,'KUGI= ',F8.4)
998.      1175  FORMAT ('0',/'0','COVPMO= ', 12(F4.2,2X) )
999.      1176  FORMAT ('0','SOIL ZONES DEPTHS AND BULK DENSITIES',/,' ',
999.1          1'SZDPTH= ',F8.4,7X,'UZDPTH= ',F8.4,7X,'BDSZ= ',F8.4,7X,
999.2          2'BDUZ= ',F8.4,7X,'BDLZ= ',F8.4,/,'0','LEACHING FACTORS',
999.3          3/,' ','UZF = ',F6.3,7X,'LZF = ',F6.3)
1000.     1177  FORMAT ('0','JRER= ',F6.4,9X,'KRER= ',F6.4,9X,'JSER= ',F6.4,9X,
1001.          1'KSER= ',F6.4,9X,'SRERI= ',F6.4,9X,'SCMPAC= ',F6.4)
1002.1    1178  FORMAT ('0','TIMAP=  ',12(I3,2X),/,1X,
1002.2          1                    'YEARAP= ',12(I3,2X),/,1X,
1002.3          2                    'SSTR=   ',12(F6.3,2X))
1002.5    1180  FORMAT ('0',/'0','PSSZ= ',F8.4,9X,'PSUZ=',F8.4,9X,'PSLZ=',F8.4,9X,
1002.6          1              'PSGZ= ',F8.4)
1004.     1179  FORMAT ('0','CMAX= ',F8.6,9X,'DD= ',F8.6,11X,
1005.          1'K= ',F8.4,12X,'N= ',F8.4,12X,'NP= ',F8.4)
1005.5    1181     FORMAT('1')
1005.1    1182  FORMAT ('0','DDG= ',12(I3,2X),/,1X,'YDG= ',12(I3,2X),/,1X,'KDG= ',
1006.2          1                          12(F5.3,2X))
1007.     1183  FORMAT ('0','TIMTIL= ',12(I3,2X),/,1X,
1007.1          1              'YRTIL = ',12(I2,3X),/,1X,
1008.           1              'SRERTL= ',12(F6.3,2X))
1009.       382 FORMAT (' ',87X,'WATER',24X,'SEDIMENT')
1010.      1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
1011.      1209 FORMAT ('0',8X,'SEDIMENT, TONS/ACRE')
1012.      1210 FORMAT (' ',11X,'ERODED SEDIMENT    ',5(3X,F7.3),4X,F7.3)
1013.      1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
1014.      1260 FORMAT ('1','END OF SIMULATION')
1015.      1263 FORMAT ('1',5X,'DATE',4X,'TIME',4X,'FLOW(CFS-CMS)',6X,
1016.          X          'SEDIMENT (LBS-KG-KG/MIN-GM/L)',23X,
1017.          X          'PESTICIDE (GM-GM/MIN-PPM)')
1018.      1265 FORMAT (8X,24I3)
1019.      1264 FORMAT (8X,12I6)
1031.     4005  FORMAT  ('0','NUTRIENT APPLICATION NO. ',I2,' OCCURS ON ',
1032.          1          A8,2X,I2,'  (DAY = ',I3,')' )
1033.     4006  FORMAT  ('0','PLANT HARVESTING OCCURS ON ',A8,1X,I2)
1033.01   5000  FORMAT (8X,I2,2(8X,F6.0))
1033.02   5001  FORMAT (2(8X,I2),8X,I4)
1033.03   5002  FORMAT (4(8X,F6.0))
1033.04   5003  FORMAT (6(8X,F6.0))
1033.05   5004  FORMAT (8X,12F6.0)
1033.06   5005  FORMAT (2(8X,F6.0))
1033.07   5006  FORMAT (5(8X,F6.0))
1033.091  5009  FORMAT (8X,12I4)
1033.092  5010  FORMAT (2(8X,F6.0),3(6X,F6.0),2(4X,F4.0))
1033.097  5012  FORMAT (3(8X,F6.0))
1033.1     9996 FORMAT ('0','DEBUG OPTION IS ON')
1033.2     5013 FORMAT (10X,A4)
1033.3     5014 FORMAT ('0','SNOWPRINT=',A4)
1034.     C
1035.           STOP
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1036.          END
1037.          SUBROUTINE ERRSET(RESULT)
1038.          REAL RESULT
1039.          RESULT=0.0
1040.          RETURN
1041.          END
1200.     C
1201.     C
1202.     C
1203.     C
1204.          SUBROUTINE CHECKR (SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,
1205.         1                   CMAX,AREA,HYCAL,INPUT,OUTPUT,PRINT,PEST,
1206.         2                   APMODE,DESORP,ENDYR,ENDMON,ENDDAY,
1207.         3                   BGNYR,BGNMON,BGNDAY,IERROR,CALB,PROD,
1208.         4                   ENGL,METR,BOTH,INTR,HOUR,DAYS,MNTH,YES,NO,
1209.         5                   SURF,SOIL,SZDPTH,COVPMO,TIMTIL,TIMAP,
1210.         6                   YEARAP,NUTR,LZTEMP)
1211.     C
1212.          DIMENSION  SSTR(12),COVPMO(12),TIMTIL(12),LZTEMP(12)
1213.     C
1214.          REAL  LZTEMP
1214.1         REAL  SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,CMAX,AREA,SZDPTH,COVPMO
1215.     C
1215.1         INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
1215.2        1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
1215.3    C
1215.4         INTEGER*4  APMODE,DESORP,SURF,SOIL
1216.          INTEGER  ENDYR,ENDMON,ENDDAY,BGNYR,BGNMON,BGNDAY
1217.     C
1218.          INTEGER  TIMTIL,TIMAP(12),YEARAP(12)
1219.     C
1220.     1513 IF (UZDPTH .GT. SZDPTH) GO TO 1514
1221.               WRITE (6,1613)
1222.               IERROR = IERROR + 1
1223.     1514 IF (SZDPTH .LT. 1.0) GO TO 1515
1224.               WRITE (6,1614) SZDPTH
1225.               IERROR= IERROR + 1
1226.     1515 DO 1516 I=1,12
1227.          IF (COVPMO(I) .LE. 1.0) GO TO 1516
1228.               WRITE (6,1615) COVPMO(I)
1229.               IERROR= IERROR + 1
1230.     1516 CONTINUE
1231.          DO 1526 I=1,12
1232.          IF (TIMTIL(I) .GE. 0 .AND. TIMTIL(I) .LT. 367) GO TO 1526
1233.               WRITE (6,1617) TIMTIL(I)
1234.               IERROR= IERROR + 1
1235.     1526 CONTINUE
1236.     1518 IF (BDSZ.GT.31.2 .OR. BDUZ.GT.31.2 .OR. BDLZ.GT.31.2) GO TO 1519
1237.               WRITE (6,1618)  BDSZ,BDUZ,BDLZ
1238.               IERROR = IERROR + 1
1239.     1519 IF (AREA .GT. 0.01) GO TO 1520
1240.               WRITE (6,1619)  AREA
1241.               IERROR = IERROR + 1
1242.     1520 IF (HYCAL .EQ. CALB .OR. HYCAL .EQ. PROD)  GO TO 1521
1243.               WRITE (6,1620)  HYCAL
1244.               IERROR = IERROR + 1
1245.     1521 IF (INPUT .EQ. ENGL .OR. INPUT .EQ. METR) GO TO 1522
1246.               WRITE (6,1621)  INPUT
1247.               IERROR = IERROR + 1
1248.     1522 IF (OUTPUT .EQ. ENGL .OR. OUTPUT .EQ. METR .OR. OUTPUT .EQ. BOTH)
1249.         1     GO TO 1523
1250.               WRITE (6,1622)  OUTPUT
1251.               IERROR = IERROR + 1
1252.     1523 IF (PRINT .EQ. INTR .OR. PRINT .EQ. HOUR .OR. PRINT .EQ. DAYS
1253.         1     .OR. PRINT .EQ. MNTH) GO TO 1550
1254.               WRITE (6,1623)  PRINT
1255.               IERROR = IERROR + 1
1256.     1550 IF (PEST .EQ. YES .OR. PEST .EQ. NO) GO TO 1551
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1257.                 WRITE (6,1650) PEST
1258.                 IERROR= IERROR + 1
1259.       1551 IF (PEST .EQ. NO)  GO TO 1565
1260.            IF (APMODE .EQ. SURF .OR. APMODE .EQ. SOIL) GO TO 1553
1261.                 WRITE (6,1652)  APMODE
1262.                 IERROR = IERROR + 1
1263.       1553 IF (DESORP .EQ. YES .OR. DESORP .EQ. NO) GO TO 1554
1264.                 WRITE (6,1653)  DESORP
1265.                 IERROR = IERROR + 1
1266.       1554 DO 1555 I=1,12
1267.            IF (SSTR(I) .GE. 0.0) GO TO 1555
1268.                 WRITE (6,1654)
1269.                 IERROR = IERROR + 1
1270.       1555 CONTINUE
1271.            IF (CMAX .LE. 1.0) GO TO 1556
1272.                 WRITE (6,1656)  CMAX
1273.                 IERROR = IERROR + 1
1274.1      1556 DO 1558 I=1,12
1274.2               IF (TIMAP(I).GE.0 .AND. TIMAP(I).LT.367)  GO TO 1557
1274.3               WRITE (6,1657) TIMAP(I)
1274.4               IERROR = IERROR + 1
1274.5      1557     IF ((YEARAP(I)+1900).GE.BGNYR .AND. (YEARAP(I)+1900).LE.
1274.6          1        ENDYR)  GO TO 1558
1274.7               WRITE (6,1658)
1274.8               IERROR = IERROR + 1
1274.9      1558 CONTINUE
1293.       1565 IF (NUTR .EQ. YES .OR. NUTR .EQ. NO) GO TO 1570
1294.                 WRITE (6,1660) NUTR
1295.                 IERROR= IERROR + 1
1296.       1570 IF (NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 1581
1297.            DO 1572 I=1,12
1298.               IF (LZTEMP(I).GT.-10.0 .AND. LZTEMP(I).LT.120.0) GO TO 1572
1299.               WRITE (6,1670) LZTEMP(I)
1300.               IERROR = IERROR + 1
1301.       1572 CONTINUE
1302.       1581 IF (ENDYR .GT. BGNYR) GO TO 1582
1303.            IF (ENDYR .EQ. BGNYR .AND. ENDMON .GT. BGNMON) GO TO 1582
1304.            IF (ENDYR .EQ. BGNYR .AND. ENDMON .EQ. BGNMON .AND. ENDDAY
1305.          1          .GE. BGNDAY) GO TO 1582
1306.                 WRITE (6,1681)
1307.                 IERROR = IERROR + 1
1308.       1582 CONTINUE
1309.      C
1310.      C CHECKR ERROR STATEMENTS
1311.      C
1312.       1613 FORMAT ('0','ERROR: UZDPTH HAS BEEN INPUTTED LESS THAN OR EQUAL TO
1313.           1 SZDPTH; THIS IS NOT REALISTIC')
1314.       1614 FORMAT ('0','ERROR: SZDPTH HAS BEEN INPUTTED AS ',F8.4,'; IT MUST
1315.           1BE LESS THAN 1.0 INCHES')
1316.       1615 FORMAT ('0','ERROR: ONE OF THE VALUES FOR COVPMO HAS BEEN INPUTTED
1317.           1 AS ',F8.4,'; COVPMO MUST BE LESS THAN 1.0')
1318.       1617 FORMAT ('0','ERROR: ONE OF THE VALUES FOR TIMTIL HAS BEEN INPUTTED
1319.           1 AS ',I8,'; TIMTIL MUST BE A POSITIVE INTEGER LESS THAN 367')
1320.       1618 FORMAT ('0','ERROR: BDSZ, BDUZ, AND BDLZ  HAS BEEN INPUTTED AS ',
1321.           13F8.4,'; THEY MUST BE GREATER THAN 31.2 LB/FT(3)')
1322.       1619 FORMAT ('0','ERROR: AREA HAS BEEN INPUTTED AS ',F8.6,'; IT SHOULD
1323.           1BE INPUTTED IN ACRES, HOWEVER IF THIS IS ACTUALLY THE CASE THEN SE
1324.           2T ICHECK=OFF',/,' ','AND RUN AGAIN')
1325.       1620 FORMAT ('0','ERROR: HYCAL HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
1326.           1SET EQUAL TO CALB OR PROD')
1327.       1621 FORMAT ('0','ERROR: INPUT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
1328.           1SET EQUAL TO ENGL OR METR')
1329.       1622 FORMAT ('0','ERROR: OUTPUT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
1330.           1 SET EQUAL TO EITHER ENGL, METR, OR BOTH')
1331.       1623 FORMAT ('0','ERROR: PRINT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
1332.           1SET EQUAL TO EITHER INTR, HOUR, DAYS, OR MNTH')
1333.       1650 FORMAT ('0','ERROR: PEST HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
1334.           1ET EQUAL TO YES OR NO')
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 1652 FORMAT ('0','ERROR: APMODE HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1 SET EQUAL TO SURF OR SOIL')
 1653 FORMAT ('0','ERROR: DESOPP HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1 SET EQUAL TO YES OR NO')
 1654 FORMAT ('0','ERROR: SOME OF THE 12 SSTR VALUES INPUTTED ARE LESS T
     1HAN 0.0; THEY MUST BE POSITIVE')
 1656 FORMAT ('0','ERROR: CMAX HAS BEEN INPUTTED AS ',F8.4,'; IT SHOULD
     1BE SET LESS THAN OR EQUAL TO 1.0')
 1657 FORMAT ('0','ERROR: TIMAP HAS BEEN INPUTTED AS ',I4,'; TIMAP MUST
     1BE A POSITIVE INTEGER LESS THAN 367')
 1658 FORMAT ('0','ERROR: THE INPUTTED YEAR OF APPLICATION DOES NOT OCCU
     1R WITHIN THE PERIOD OF SIMULATION')
 1665 FORMAT ('0','ERROR: NUTR HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
     1ET EQUAL TO YES OR NO')
 1670 FORMAT ('0','ERROR: ONE OF THE VALUES OF LZTEMP HAS BEEN INPUTTED
     1AS ',F8.4,'; THIS IS NOT REALISTIC, CHECK INPUT UNIT CONSISTENCY')
 1681 FORMAT ('0','ERROR: THE INPUTTED END DATE (ENDDAY,ENDMON,ENDYR) OC
     1CURS BEFORE THE BEGIN DATE (BGNDAY,BGNMON,BGNYR)')
C
      RETURN
      END
C
C
C
C
      SUBROUTINE CHECKS (HYMIN,INTRVL,UZSN,LZSN,IRC,NN,L,SS,A,UZS,LZS,
     1                   K24L,KK24,K24EL,K3,SNOW,ICHECK,IERROR,
     2                   YES,NO,ON,OFF,RADCON,CCFAC,SCF,ELDIF,
     3                   IDNS,F,DGM,WC,EVAPSN,MELEV,TSNOW,
     4                   PETMIN,PETMAX,PETMUL,WMUL,RMUL,KUGI)
C
      DIMENSION  K3(12)
C
      REAL LZSN,IRC,NN,L,LZS,K24L,KK24,K24EL,K3
      REAL  IDNS,MELEV,KUGI
      REAL  HYMIN,UZSN,SS,A,UZS,RADCON,CCFAC,SCF,ELDIF,F,DGM,WC,
     1      EVAPSN,TSNOW,PETMIN,PETMAX,PETMUL,WMUL,RMUL
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
C
      INTEGER*4  ICHECK
C
      IF (HYMIN .GT. 0.0) GO TO 1501
          WRITE (6,1600)  HYMIN
          IERROR = IERROR + 1
 1501 IF (INTRVL.EQ.5 .OR. INTRVL.EQ.15 .OR. INTRVL.EQ.60) GO TO 1502
          WRITE (6,1601)  INTRVL
          IERROR = IERROR + 1
 1502 IF (UZSN .LT. LZSN) GO TO 1503
          WRITE (6,1602)
          IERROR = IERROR + 1
 1503 IF (IRC .LE. 1.0) GO TO 1504
          WRITE (6,1603)  IRC
          IERROR = IERROR + 1
 1504 IF (NN .LE. 1.0) GO TO 1505
          WRITE (6,1604)  NN
          IERROR = IERROR + 1
 1505 IF (L .GT. 1.0) GO TO 1506
          WRITE (6,1605)  L
          IERROR = IERROR + 1
 1506 IF (SS .LT. 1.0) GO TO 1507
          WRITE (6,1606)  SS
          IERROR = IERROR + 1
 1507 IF (A .LE. 0.0) GO TO 1508
          WRITE (6,1607)  A
          IERROR = IERROR + 1
 1508 IF (UZS .LT. LZS) GO TO 1509
          WRITE (6,1608)
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                IERROR = IERROR + 1
 1509 IF (K24L .LE. 1.0) GO TO 1510
                WRITE (6,1609)  K24L
                IERROR = IERROR + 1
 1510 IF (KK24 .LE. 1.0) GO TO 1511
                WRITE (6,1610)  KK24
                IERROR = IERROR + 1
 1511 IF (K24EL .LE. 1.0) GO TO 1512
                WRITE (6,1611)  K24EL
                IERROR = IERROR + 1
 1512 DO 1527 I=1,12
      IF (K3(I) .LE. 1.0) GO TO 1527
                WRITE (6,1612)  K3(I)
                IERROR = IERROR + 1
 1527 CONTINUE
 1524 IF (SNOW .EQ. YES .OR. SNOW .EQ. NO) GO TO 1525
                WRITE (6,1624)  SNOW
                IERROR = IERROR + 1
 1525 IF (SNOW .EQ. NO) GO TO 1550
      IF (RADCON .GT. 0.0) GO TO 1529
                WRITE (6,1628) RADCON
                IERROR= IERROR + 1
 1529 IF (CCFAC .GT. 0.0) GO TO 1530
                WRITE (6,1629) CCFAC
                IERROR= IERROR + 1
 1530 IF (SCF .GT. 0.0) GO TO 1531
                WRITE (6,1630) SCF
                IERROR= IERROR + 1
 1531 IF (ELDIF .LT. 30.0) GO TO 1532
                WRITE (6,1631) ELDIF
                IERROR= IERROR + 1
 1532 IF (IDNS .LT. 1.0) GO TO 1533
                WRITE (6,1632) IDNS
                IERROR= IERROR + 1
 1533 IF (F .LE.  1.0) GO TO 1534
                WRITE (6,1633) F
                IERROR= IERROR + 1
 1534 IF (DGM .LT. 1.0) GO TO 1535
                WRITE (6,1634) DGM
                IERROR= IERROR + 1
 1535 IF (WC .LT. 1.0) GO TO 1536
                WRITE (6,1635) WC
                IERROR= IERROR + 1
 1536 IF (EVAPSN .GT. 0.0) GO TO 1537
                WRITE (6,1636) EVAPSN
                IERROR= IERROR + 1
 1537 IF (MELEV .LT. 30000.0) GO TO 1538
                WRITE (6,1637) MELEV
                IERROR= IERROR + 1
 1538 IF (TSNOW .GT. 20.0 .AND. TSNOW .LT. 40.0) GO TO 1539
                WRITE (6,1638) TSNOW
                IERROR= IERROR + 1
 1539 IF (PETMIN .GT. 30.0) GO TO 1540
                WRITE (6,1639) PETMIN
                IERROR= IERROR + 1
 1540 IF (PETMAX .LT. 60.0) GO TO 1542
                WRITE (6,1640) PETMAX
                IERROR= IERROR + 1
 1542 IF (WMUL .GT. 0.0) GO TO 1543
                WRITE (6,1642) WMUL
                IERROR= IERROR + 1
 1543 IF (RMUL .GT. 0.0) GO TO 1544
                WRITE (6,1643) RMUL
                IERROR= IERROR + 1
 1544 IF (KUGI .GE. 0.0 .AND. KUGI .LE. 10.0) GO TO 1550
                WRITE (6,1644) KUGI
                IERROR= IERROR + 1
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1509.      1550 IF (PETMUL .GT. 0.0) GO TO 1580
1510.                WRITE (6,1641) PETMUL
1511.                IERROR= IERROR + 1
1512.      1580 IF (ICHECK .EQ. ON) GO TO 1582
1513.                WRITE (6,1680)  ICHECK
1514.                IERROR = IERROR + 1
1515.      1582 IF (IERROR .GT. 0) WRITE (6,1682) IERROR
1516.      C
1517.      C CHECKS ERROR STATEMENTS
1518.      C
1519.      1600 FORMAT ('0','ERROR: HYMIN HAS BEEN INPUTTED AS ',F8.4,'; IT MUST B
1520.          1E SET GREATER THAN 0.0')
1521.      1601 FORMAT ('0','ERROR: INTRVL HAS BEEN INPUTTED AS ',I4,'; IT MUST BE
1522.          1 SET EQUAL TO EITHER 5, 15 OR 60 MINUTES')
1523.      1602 FORMAT ('0','ERROR: UZSN HAS BEEN INPUTTED GREATER THAN OR EQUAL T
1524.          1O LZSN, THIS IS NOT REALISTIC')
1525.      1603 FORMAT ('0','ERROR: IRC HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
1526.          1SET LESS THAN OR EQUAL TO 1.0')
1527.      1604 FORMAT ('0','ERROR: NN HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE S
1528.          1ET LESS THAN 1.0')
1529.      1605 FORMAT ('0','ERROR: L HAS BEEN INPUTTED AS ',F8.4,'; THIS LOOKS RA
1530.          1THER STRANGE - REMEMBER THE UNITS ARE IN FEET OR METERS')
1531.      1606 FORMAT ('0','WARNING: SS HAS BEEN INPUTTED AS ',F8.4,'; A LAND SLO
1532.          1PE OF 45 DEGREES OR GREATER IS QUESTIONABLE, HOWEVER IF THIS ACTUA
1533.          2LLY IS TRUE',/,' ','SET ICHECK=OFF AND RUN AGAIN')
1534.      1607 FORMAT ('0','WARNING: A HAS BEEN INPUTTED AS ',F8.4,'; IMPERVIOUS
1535.          1AREA IS NOT CONSIDERED IN SEDIMENT REMOVAL AS THE MODEL IS BASICAL
1536.          2LY FOR ',/,' ','AGRICULTURAL AREAS, HOWEVER IF IMPERVIOUS AREA IS
1537.          3DESIRED SET ICHECK=OFF AND RUN AGAIN')
1538.      1608 FORMAT ('0','ERROR: UZS HAS BEEN INPUTTED GREATER THAN OR EQUAL TO
1539.          1 LZS, THIS IS NOT REALISTIC')
1540.      1609 FORMAT ('0','ERROR: K24L HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
1541.          1 SET LESS THAN OR EQUAL TO 1.0')
1542.      1610 FORMAT ('0','ERROR: KK24 HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
1543.          1 SET LESS THAN OR EQUAL TO 1.0')
1544.      1611 FORMAT ('0','ERROR: K24EL HAS BEEN INPUTTED AS ',F8.4,'; IT MUST B
1545.          1E SET LESS THAN OR EQUAL TO 1.0')
1546.      1612 FORMAT ('0','ERROR: K3 HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE S
1547.          1ET LESS THAN OR EQUAL TO 1.0')
1547.1     1624 FORMAT ('0','ERROR: SNOW HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
1547.2          1ET EQUAL TO YES OR NO')
1548.      1628 FORMAT ('0','ERROR: RADCON HAS BEEN INPUTTED AS ',F8.4,'; RADCON M
1549.          1UST BE GREATER THAN 1.0')
1550.      1629 FORMAT ('0','ERROR: CCFAC HAS BEEN INPUTTED AS ',F8.4,'; CCFAC MUS
1551.          1T BE GREATER THAN 0.0')
1552.      1630 FORMAT ('0','ERROR: SCF HAS BEEN INPUTTED AS ',F8.4,'; SCF MUST BE
1553.          1 GREATER THAN 0.0')
1554.      1631 FORMAT ('0','ERROR: ELDIF HAS BEEN INPUTTED AS ',F8.4,'; ELDIF SHO
1555.          1ULD BE INPUT IN THOUSANDS OF FEET AND CANNOT EXCEED 30.0')
1556.      1632 FORMAT ('0','ERROR: IDNS HAS BEEN INPUTTED AS ',F8.4,'; IDNS MUST
1557.          1BE LESS THAN 1.0')
1558.      1633 FORMAT ('0','ERROR: F HAS BEEN INPUTTED AS ',F8.4,'; F MUST BE LES
1559.          1S THAN OR EQUAL TO 1.0')
1560.      1634 FORMAT ('0','WARNING: DGM HAS BEEN INPUTTED AS ',F8.4,'; VALUES GR
1561.          1EATER THAN 1.0 INCHES FOR DGM ARE QUESTIONABLE')
1562.      1635 FORMAT ('0','ERROR: WC HAS BEEN INPUTTED AS ',F8.4,'; WC MUST BE L
1563.          1ESS THAN 1.0')
1564.      1636 FORMAT ('0','ERROR: EVAPSN HAS BEEN INPUTTED AS ',F8.4,'; EVAPSN C
1565.          1ANNOT BE A NEGATIVE NUMBER')
1566.      1637 FORMAT ('0','ERROR: MELEV HAS BEEN INPUTTED AS ',F9.1,'; MELEV CAN
1567.          1NOT HAVE A VALUE GREATER THAN 30000.0')
1568.      1638 FORMAT ('0', 'ERROR: TSNOW HAS BEEN INPUTTED AS ',F8.4,'; TSNOW MU
1569.          1ST HAVE A VALUE GREATER THAN 20.0 AND LESS THAN 40.0')
1570.      1639 FORMAT ('0','ERROR: PETMIN HAS BEEN INPUTTED AS ',F8.4,'; PETMIN M
1571.          1UST BE GREATER THAN 30.0')
1572.      1640 FORMAT ('0','ERROR: PETMAX HAS BEEN INPUTTED AS ',F8.4,'; PETMAX M
1573.          1UST BE LESS THAN 60.0')
1574.      1641 FORMAT ('0','ERROR: PETMUL HAS BEEN INPUTTED AS ',F8.4,'; PETMUL M
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1575.          1UST BE GREATER THAN 0.0')
1576.     1642 FORMAT ('0','ERROR: WMUL HAS BEEN INPUTTED AS ',F8.4,'; WMUL MUST
1577.          1BE GREATER THAN 0.0')
1578.     1643 FORMAT ('0','ERROR: RMUL HAS BEEN INPUTTED AS ',F8.4,'; RMUL MUST
1579.          1BE GREATER THAN 0.0')
1580.     1644 FORMAT ('0','ERROR: KUGI HAS BEEN INPUTTED AS ',F8.4,'; KUGI MUST
1581.          1BE A POSITIVE NUMBER LESS THAN 10.0')
1582.     1680 FORMAT ('0','ERROR: ICHECK HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
1583.          1 SET EQUAL TO ON OR OFF')
1584.     1682 FORMAT ('0','THE TOTAL NUMBER OF DETECTED ERRORS IN THE INPUT SEQU
1585.          1ENCE EQUALS',I3,', PLEASE CORRECT AND TRY AGAIN OR CONTACT EPA')
1587.     C
1588.          RETURN
1589.          END
1600.     C
1601.     C
1602.     C
1603.     C
1604.          BLOCK DATA
1605.     C
1606.     C
1607.     C                    BLOCK DATA TO INITIALIZE VARIABLES
1608.     C
1609.     C
1610.          IMPLICIT  REAL(L)
1611.     C
1612.          DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
1613.         1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
1614.          DIMENSION SRER(5),ROBTOM(5),RGBTOT(5),INFTOM(5),INFTOT(5),
1615.         1 ROITOM(5),RCITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
1616.         2 TEMPX(24),WINDX(24),RAIN(288)
1619.1         DIMENSION LSRO(128),EROS(128),RROS(128)
1619.2         DIMENSION SMCIST(24,5),JMOIST(24,5),LMOIST(24),
1619.3        1          STEMP(24),UTEMP(24)
1620.     C
1621.          COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
1622.         1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
1623.         2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
1624.         3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
1624.1        4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
1625.     C
1626.          COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
1627.         1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
1628.         2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
1629.         3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
1630.         4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
1631.         5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
1632.         6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
1633.         7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
1634.         8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
1635.         9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
1636.         * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
1637.         1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
1637.1        2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
1638.     C
1640.          COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
1650.         1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
1651.         2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
1652.         3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
1653.         4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
1654.         5              TSTEP,NSTEP,SFLG,JFLG,LFLG,GFLG
1655.     C
1655.1         COMMON /PESTD/
1655.2        1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
1655.3        2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
1655.4        3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
1655.5        4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
1656.     C
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1656.01   C   COMMON ALL DECLARATIONS FOR I*2 & R*4
1656.02         INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
1656.03         REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
1656.04        1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
1656.05        2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
1656.06   C
1656.07   C   COMMON LAND DECLARATIONS FOR I*2 & R*4
1656.08         INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
1656.09        1         NILSRC,NKROS
1656.1          REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
1656.11        1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
1656.12        2      RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
1656.13        3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,
1656.14        4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
1656.15        5      NEPTOM,RCSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
1656.16        6      ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
1656.17        7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
1656.18        8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
1656.19        9      SCEP1,SRGXT,SRGXTL,JRER,KRER,JSER,KSER,SRERT,MMPIN,
1656.2         *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
1656.21        1      TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
1656.22        2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
1656.23   C
1656.29   C
1659.2          INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
1659.3    C
1659.31         INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
1659.32        1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
1659.4    C
1659.5          INTEGER*4  LOOP
1660.            DOUBLE PRECISION  MNAM
1667.           REAL  NP
1669.     C
1670.           REAL  DELT,
1671.          1        SNT(20),SNRSM(20,5),SNROM(20,5),
1672.          2        UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
1673.          3        NRSM(20,5),LNRPM(20),
1674.          4        SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
1675.          5        SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
1676.          6        LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
1677.          7        TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
1678.          8        KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
1678.1          DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
1678.2          REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
1678.3         2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
1678.4         3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
1678.5         4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
1678.6         5 UPRITT,UPRIS(5)
1680.           DATA  PRTOT, ERSNTT/2*0.0/
1681.           DATA  PRTOM, ERSNTM/2*0.0/
1682.           DATA  RUTOM, RCSTOM, RITOM, RINTOM, NEPTOM/5*0.0/
1683.           DATA  RUTOT, ROSTOT, RITOT, RINTOT, NEPTOT/5*0.0/
1684.           DATA  ROBTOM, ROBTOT, INFTOM, INFTOT, ROITOM, ROITOT/30*0.0/
1685.           DATA  TWBAL, RESB, SRGX, INTF, ERSTOM, ERSTOT/25*0.0/
1687.           DATA  RESB1, BASTOM, RCHTOM, BASTOT, RCHTOT/9*0.0/
1688.           DATA  EPTOM, EPTOT/2*0.0/, PRNTKE/0/
1690.           DATA  PR, P3, RXB, RGX, INFL, UZSB, APERCB, DPST/28*0.0/
1691.           DATA  TIMFAC/0/, UZSN, LZSN, INFIL, INTER, IRC, NN, L, SS/8*0.0/
1692.           DATA  A, UZS, LZS, SGW, GWS, KV, K24L, KK24/8*0.0/
1693.           DATA  IFS, K24EL, K3, EPXM, COVER, COVRMX/17*0.0/
1694.           DATA  ERSN/5*0.0/, SRER/5*0.0/, SRERT/0.0/
1695.           DATA  AREA, M/2*0.0/
1698.           DATA  MUZ, MLZ/2*0.0/
1702.           DATA  MNAM/' JANUARY','FEBRUARY','  MARCH ','  APRIL ',
1703.          *            '  MAY  ','  JUNE  ','  JULY  ',' AUGUST ',
1704.          *            'SEPTMBER',' OCTOBER','NOVEMBER','DECEMBER'/
1705.           DATA  MMPIN/25.4/, METOPT/0.9072/
1708.1          DATA  SMOIST/120*0.0/,UMOIST/120*0.0/,LMOIST/24*0.0/
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1708.2          DATA  STEMP/24*0.0/,UTEMP/24*0.0/,LTEMP/0.0/
1709.           DATA SUMSNM, PXSNM, MELRAM, RADMEM, CORMEM, CRAINM,
1710.          *       CONMEM, SGMM, SNEGMM, SEVAPM, SUMSNY, PXSNY, MELRAY,
1711.          *       RADMEY, CORMEY, CONMEY, CRAINY, SGMY, SNEGMY, SEVAPY,
1712.          *       TSNBAL/21*0.0/,PACK/0.0/,SDEN/0.0/,PETMAX/0.0/
1713.           DATA CALB/'CALB'/,PROD/'PROD'/
1714.           DATA ENGL/'ENGL'/,METR/'METR'/,BOTH/'BOTH'/
1715.           DATA NO/'NO'/,YES/'YES'/
1716.           DATA  JCOUNT/0/
1717.           DATA  HOUR/'HOUR'/,DAYS/'DAYS'/,MNTH/'MNTH'/,INTR/'INTR'/
1717.1          DATA ON/'ON'/,OFF/'OFF'/
1718.     C
1718.1          DATA  LN/20*0.0/,UN/100*0.0/,UNI/100*0.0/
1718.3          DATA  SN/100*0.0/,SNT/20*0.0/,UNIT/20*0.0/,KN/32*0.0/
1718.4          DATA  THKN/8*0.0/,KP/20*0.0/,THKP/5*0.0/,UNT/20*0.0/
1718.5          DATA  DELT,NBAL,PHBAL,CLBAL/4*0.0/
1718.6          DATA  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG/6*0/
1719.           DATA  SNRSM/100*0.0/,SNROM/100*0.0/,UNRIM/100*0.0/,NRSM/100*0.0/,
1720.          1      LNRPM/20*0.0/,SNRBM/100*0.0/,UNRBM/100*0.0/,LNRBM/20*0.0/,
1721.          2      GNRBM/20*0.0/,TNRBM/20*0.0/,SNRSY/100*0.0/,SNROY/100*0.0/,
1722.          3      UNRIY/100*0.0/,NRSY/100*0.0/,LNRPY/20*0.0/,SNRBY/100*0.0/,
1723.          4      UNRBY/100*0.0/,LNRBY/20*0.0/,GNRBY/20*0.0/,TNRBY/20*0.0/,
1724.          5      TNRHV/20*0.0/,TNRHVM/20*0.0/,TNRHVY/20*0.0/,
1725.          6      TNA/0.0/,TPA/0.0/,TCLA/0.0/
1725.05   C
1725.1          DATA STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
1725.2         2 SCST,UPITOM,SDST,UPITOT,JTST,STS,UAST,UTS,UCST,SAS,
1725.3         3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
1725.4         4 FPUZ,UDS,UPRITM,JSTR,UPRITT,UPRIS/102*0.0/
1726.     C
1726.01   C         INITIALIZE DATA FOR DISK WRITING
1726.02   C
1726.03         DATA DSNFLO,DSNERS,TMBLSZ/2*0,128/,DSNROS/0/
1726.04         DATA LSRO,ERDS/256*0./,RRDS/128*0.0/
1726.05         DATA LOOP/0/,NERDS/1/,NILSRO/1/,NRRDS/1/
1727.           END
2000.     C
2001.     C
2002.     C
2003.     C
2004.           SUBROUTINE LANDS(SFLAG,SNOPRT)
2005.     C
2006.     C
2007.     C                                HSP LANDS
2008.     C
2009.     C
2010.           IMPLICIT  REAL(L,K)
2011.     C
2012.           DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),RUZB(5),
2013.          1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
2014.           DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
2015.          1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
2016.          2 TEMPX(24),WINDX(24),RAIN(288),UZSBMT(5),RESBMT(5),SRGXMT(5)
2018.           DIMENSION SHRD(5),RXX(5),DEEPL(5),UZRA(5),PRE(5),INFL(5),UZI(5),
2019.          1 EVDIST(24),ROSINT(5),PERCB(5),
2020.          2 AROSP(5),AINTF(5),AROSIT(5),LAPSE(24),SVP(40),SNOUT(24,16)
2020.1          DIMENSION LSRO(128),ERDS(128),RRDS(128)
2020.2          DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
2020.3         1          STEMP(24),UTEMP(24)
2021.     C
2022.           COMMON /ALL/ KC,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
2023.          1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
2024.          2 CALB,PROD,PEST,NJTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
2025.          3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,ICEBUG,ON,OFF,
2025.1         4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
2026.     C
2027.           COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
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2028.          1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
2029.          2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
2030.          3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
2031.          4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
2032.          5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
2033.          6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
2034.          7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
2035.          8 MELRAM,RADMEM,CDRMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
2036.          9 PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
2037.          * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
2038.          1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
2038.1         2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
2039.     C
2039.01   C    COMMON ALL DECLARATIONS FOR I*2 & R*4
2039.02          INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
2039.03          REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
2039.04         1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,JMOIST,
2039.05         2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
2039.06   C
2039.07   C    COMMON LAND DECLARATIONS FOR I*2 & R*4
2039.08          INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
2039.09         1         NILSRO,NRROS
2039.1           REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,
2039.11         1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
2039.12         2      RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
2039.13         3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CDRMEM,CRAINM,
2039.14         4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
2039.15         5      NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
2039.16         6      ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
2039.17         7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
2039.18         8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
2039.19         9      SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
2039.2          *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
2039.21         1      TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
2039.22         2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
2039.23   C
2040.            INTEGER  HRFLAG,H,SFLAG
2042.1           INTEGER  LASTLP,LASTRO
2042.2           INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
2042.3          1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
2042.4           INTEGER*4  LOOP,SNOPRT
2043.     C
2044.             DOUBLE PRECISION  MNAM
2045.     C
2047.            REAL  IRC4, INFLT, QMETRC
2050.            REAL  UZSMET, LZSMET, SGWMET, SCEPMT, RESSMT
2051.            REAL  TWBLMT, SRGXTM, RESBMT, SRGXMT
2052.            REAL KUGI, NEGMLT, NEGMM, PRJ
2053.            REAL MELT, INDT, KCLD, MELRAD
2053.1    C
2053.2           INTEGER*2 TFI,III
2054.     C
2055.            DATA  IHKR, HRFLAG/2*0/
2056.            DATA  PERC, INFLT/0.0,0.0/
2057.            DATA  SBAS/0.0/
2058.            DATA  SNET1, SNET, SRCH/3*0.0/, NUMI/0/
2059.            DATA  ROSINT/5*0.0/, AETR, KF/2*0.0/
2059.1           DATA  PEPIN, EPIN, EPIN1, EPHR/4*0.0/
2060.            DATA  EVDIST/6*0.0,0.019,0.041,0.067,0.088,0.102,3*0.11,0.105,
2061.           C      0.095,0.081,0.055,0.017,5*0.0/
2062.            DATA SVP/10*1.005,1.01,1.01,1.015,1.02,
2063.           *1.03,1.04,1.06,1.08,1.1,1.29,1.66,2.13,2.74,3.49,4.40,5.55,6.87,
2064.           *8.36,10.09,12.19,14.63,17.51,20.86,24.79,29.32,34.61,40.67,47.68,
2065.           *55.71,64.88/
2066.            DATA LAPSE/6*3.5,3.7,4.0,4.1,
2067.           *4.3,4.6,4.7,4.8,4.9,5.0,5.0,4.8,4.6,4.4,4.2,4.0,3.8,3.7,3.6/
2068.            DATA  APR, AEPIN/2*0.0/
2069.            DATA  AROSB, AINTF, AROSIT/15*0.0/
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2070.          DATA  ARU, ARUI, AROS, ARGXT, ASNET, ASBAS, ASRCH/7*0.0/
2071.          DATA  SUMSN, INDT, KCLD, PXONSN, SEVAPT, RADME, CDRME, LIQw1,
2072.         *      CONME, CRAIN, NEGMLT, SNEGM, NEGMM, LIQS,  LIQW, XICE,
2073.         *      XLNMLT,SGM, SPX, WBAL, SEVAP/21*0.0/
2073.1         DATA RA,LW,PX,MELT,CONV,RAINM,CONDS /7*0./
2074.          DATA  SNOUT/384*0.0/,CLDF/-1.0/,ALBEDO/0.85/
2075.          DATA  SUMSND,PXSND,MELRAD,RADMED,CDRMED,CONMED,CRAIND,SGMD,
2076.         1      SNEGMD,SEVAPD/10*0.0/
2076.8         DATA IEND/0/, LASTRD/0/, PRU/0.0/
2077.     C
2078.     C                    ZEROING OF VARIABLES
2079.     C
2080.          LZS1 = LZS
2081.          UZS1 = UZS
2082.          NUMI = 0
2083.          DPST = 0.0
2084.          PACK1 = PACK
2085.          LIQW1 = LIQW
2086.          PRR = PR
2087.     C
2088.          DO 184 I=1,5
2089.      184    APERCB(I) = 0.0
2090.     C
2091.           PA=1.0-A
2092.           IRC4=IRC**(1.0/96.0)
2093.           LIRC4=1.0-IRC4
2094.           KK4=KK24**(1.0/96.0)
2095.           LKK4= 1.0 - KK4
2096.     C
2097.          IF ((1440./TIMFAC).LE.100.) GO TO 187
2098.          LIRC4 = LIRC4/3.0
2099.          LKK4 = LKK4/3.0
2100.     C
2101.      187 DEC= 0.00982*((NN*L/SQRT(SS))**0.6)
2102.          SPC= 1020.*SQRT(SS)/(NN*L)
2103.     C
2104.          RESS = 0.0
2105.          LNRAT=LZS/LZSN
2106.          D3FV=(2.0*INFIL)/(LNRAT*LNRAT)
2107.          D4F= (TIMFAC/60.)*D3FV
2108.     C                                    REDUCE INFILTRATION IF ICE EXISTS
2109.     C                                    AT THE BOTTOM OF THE PACK -
2110.     C                                   ATTEMPT TO CORRECT FOR FROZEN LAND
2111.          IF (SNOW .EQ. NO)  GO TO 188
2112.          D4FX = (1.0 -XICE)
2113.          IF (D4FX .LT. 0.1)  D4FX = 0.1
2114.          D4F = D4F*D4FX
2114.1         SUMSNH = 0.0
2114.11        PXSNH = 0.0
2114.12        RADMEH = 0.0
2114.13        CDRMEH = 0.0
2114.14        CONMEH = 0.0
2114.15        CRAINH = 0.0
2114.16        SGMH = 0.0
2114.17        SNEGMH = 0.0
2114.18        SEVAPH = 0.0
2114.19        SPXH = 0.0
2115.     C
2116.      188 RATIO= INTER*EXP(0.693147*LNRAT)
2117.          IF ((RATIO).LT.(1.0)) RATIO=1.0
2118.          D4RA= D4F*RATIO
2119.          H = TF/24
2120.     C
2121.     C                                  TF IS 1 FOR RAIN DAYS, AND 96
2122.     C                                  OR 288 FOR NON-RAIN DAYS
2123.     C
2124.          IF (TF .GT. 2)  IHRR=0
2125.     C
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      TFI=TF
      DO 155  III=1,TFI
C
      LOOP = LOOP + 1
      LNRAT = LZS/LZSN
      IF (TF .LT. 2)  GO TO 4
      NUMI =NUMI + 1
      IF (NUMI .NE. H)  GO TO 4
      NUMI = 0
C
    4 SBAS = 0.0
      SRCH = 0.0
      ROS = 0.0
      RU = 0.0
      GWF = 0.0
      RGXT = 0.0
      PERC = 0.0
      INFLT = 0.0
C
C   TIMFAC - TIME INTERVAL IN MINUTES
C   L      - LENGTH OF OVERLAND SLOPE
C   NN     - MANNING'S N FOR OVERLAND SLOPE
C   A      - IMPERVIOUS AREA
C   PA     - PERVIOUS AREA
C
C
C
C
C PR IS INCOMING RAINFALL
C P3 IS RAIN REACHING SURFACE(.00'S INCHES)
C P4 IS TOTAL MOISTURE AVAILABLE( IN.)
C RESS  IS OVERLAND FLOW STORAGE( IN.)
C D4F IS 'B' IN OP. MANUAL
C RATIO IS 'C' IN OP. MANUAL
C EP -  DAILY EVAP ( IN.)
C EPHR - HOURLY EVAP
C EPIN - INTERVAL EVAP
C EPXX - FACTOR FOR REDUCING EVAP FOR SNOW AND TEMP
C
C
C
C
C     DETERMINE IF SNOWMELT IS TO BE DONE
C
      HRFLAG=0
      ITEST = IMIN/TIMFAC
      IF (NUMI .EQ. 1)  HRFLAG = 1
      IF (ITEST.EQ.1)  HRFLAG = 1
C
C     HRFLAG=1 INDICATES BEGINNING OF THE HOUR
C
      IF (HRFLAG.EQ.0) GO TO 999
      IEND = 0
      IF (IHR.EQ.24) GO TO 202
      IHRR = IHR + 1
      GO TO 501
  202 IHRR = IHRR + 1
  501 EPHR = EVDIST(IHRR)*EP
      IF (EPHR.LE.(0.0001))  EPHR=0.0
      EPIN = EPHR
      EPIN1 = EPIN
      IF (SNOW .EQ. NO) GO TO 999
      IF ((PACK .LE. 0.0).AND.(TMIN .GT. PETMAX))  GO TO 999
C                                 ***********************************
C                                            BEGIN SNOWMELT
C                                 ***********************************
      TSNOW1 = TSNOW + 1.
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      SEVAP = 0.0
      SFLAG = 0
      PRHR = 0.0
      IKEND = 60./(TIMFAC)
      IPT = (IHRR-1)*IKEND
C                                   SUM PRECIP FOR THE HOUR
      PX = 0.0
      DO 502 II = 1,IKEND
  502 PRHR = PRHR + RAIN(IPT+II)
C                                       CORRECT TEMP FOR ELEVATION DIFF
C                                       USING LAPSE RATE OF 3.5 DURING RAIN
C                                       PERIODS, AND AN HOURLY VARIATION IN
C                                       LAPSE RATE (LAPSE(I)) FOR DRY PERIOD
C
      LAPS = LAPSE(IHRR)
      IF (PRHR .GT. 0.05)  LAPS = 3.5
      TX = TEMPX(IHRR) - LAPS*ELDIF
C
C
C                                     REDUCE REG EVAP FOR SNOWMELT
C                                     CONDITIONS BASED ON PETMIN AND
C                                     PETMAX VALUES
C
      IF (PACK.LE.IPACK) GO TO 504
      E1E = 0.0
      PACKRA = 1.0
      GO TO 505
  504 PACKRA = PACK/IPACK
      E1E = 1.0 - PACKRA
  505 EPXX = (1.0-F)*E1E + F
      IF (TX.GE.PETMAX) GO TO 512
      IF (EPXX .GT. 0.5)  EPXX = 0.5
C
C                                    REDUCE EVAP BY 50% IF TX IS BETWEEN
C                                    PETMIN AND PETMAX
      IF (TX.LT.PETMIN) EPXX = 0.0
C
C
  512 EPHR = EPHR*EPXX
      EPIN = EPIN*EPXX
      IEND = 0
      SNBAL = 0.0
      IF ((TX .GT. TSNOW) .AND. (PRHR .GT. .02)) DEWX = TX
C
C     SET DEWPT TEMP EQUAL TO AIR TEMP WHEN RAINING
C     ON SNOW TO INCREASE SNOWMELT
C
      IF (DEWX .GT. TX) DEWX = TX
      SNTEMP = TSNOW + (TX-DEWX)*(0.12 + 0.008*TX)
C
C     RAIN/SNOW TEMP. DIVISION - SEE ANDERSON, WRR, VOL. 4, NO. 1,
C     FEB. 1968, P. 27, EQ. 28
C
      IF (SNTEMP .GT. TSNOW1) SNTEMP = TSNOW1
      IF (TX.LT.SNTEMP) GO TO 521
      IF  (PACK) 997, 997, 525
  521 SFLAG = 1
      IF ((PACK.LE.0.0) .AND. (PRHR.LE.0.0))  GO TO 997
C
C     SKIP SNOWMELT IF BOTH PACK AND PRECIP ARE ZERO
C     FOR THE HOUR
C
  525 IEND = 1
C
C     SNOWMELT CALCULATIONS ARE DONE IF IT IS SNOWING, OR,
C     IF A SNOWPACK EXISTS
C
      PX = PRHR
```

```
2261.          IF (PX.LE.0.0) GO TO 550
2262.    C                                  KCLD IS INDEX TO CLOUD COVER
2263.          KCLD = 35.
2264.          IF (SFLAG.LE.0) GO TO 555
2265.    C                                 SNOW IS FALLING
2266.          PX = PX*SCF
2267.          APR = APR + (SCF-1.0)*PRHR
2268.          PRHR = PRHR*SCF
2269.          SUMSN = SUMSN + PX
2270.          DNS = IDNS
2271.          IF (TX .GT. 0.0)  DNS = DNS + ((TX/100.)**2)
2272.    C
2273.    C     SNOW DENSITY WITH TEMP. - APPROX TO FIG. 4, PLATE B-1
2274.    C     SNOW HYDROLOGY  SEE ALSO ANDERSON, TR 36, P. 21
2275.    C
2276.          PACK = PACK + PX
2277.    C
2278.          IF (PACK.LE.IPACK) GO TO 548
2279.          IPACK = PACK
2280.          IF (IPACK .GT. MPACK)  IPACK = MPACK
2281.    C
2282.      548 DEPTH = DEPTH + (PX/DNS)
2283.          IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
2284.          INDT = INDT - 1000*PX
2285.          IF (INDT .LT. 0.0) INDT = 0.0
2286.          PX = 0.0
2287.          GO TO 555
2288.      550 KCLD = KCLD - 1.
2289.      555 IF (KCLD .LT. 0.0) KCLD = 0.0
2290.          PACKRA = PACK/IPACK
2291.          IF (PACK .GT. IPACK)  PACKRA = 1.0
2292.    C
2293.          IF (PACK.GE.0.005) GO TO 580
2294.    C
2295.    C     IPACK IS AN INDEX TO AREAL COVERAGE OF THE SNOWPACK
2296.    C     FOR INITIAL STORMS IPACK = .1*MPACK SO THAT COMPLETE
2297.    C     AREAL COVERAGE RESULTS.  IF EXISTING PACK > .1 *MPACK THEN
2298.    C     IPACK IS SET EQUAL TO MPACK WHICH IS THE WATER EQUI. FOR
2299.    C     COMPLETE AREAL COVERAGE PACKRA IS THE FRACTION AREAL COVERAGE
2300.    C     AT ANY TIME.
2301.    C
2302.          IPACK = 0.1*MPACK
2303.          XICE = 0.0
2304.          XLNMLT = 0.0
2305.          NEGMLT = 0.0
2306.          PX = PX + PACK + LIQW
2307.          PACK = 0.0
2308.          LIQW = 0.0
2308.9   C
2309.    C     ZERO SNOWMELT OUTPUT ARRAY
2309.1   C
2310.          DO 570 I=1,24
2311.            DO 570 MM=1,16
2312.      570     SNOUT(I,MM) = 0.0
2313.          GO TO 997
2314.    C
2315.    C
2316.      580 PXONSN = PXONSN + PX
2317.          IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
2318.          IF (INDT .LT. 800.) INDT = INDT + 1.
2319.    C                                INDT IS INDEX TO ALBEDO
2320.          MELT = 0.0
2321.          IF (SDEN .LT. 0.55) DEPTH=DEPTH*(1.0 - 0.00002*(DEPTH*(.55-SDEN)))
2322.    C
2323.    C     EMPIRICAL RELATIONSHIP FOR SNOW COMPACTION
2324.    C
2325.          IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
2326.          WIN = WINDX(IHRR)
```

```
C
C     HOURLY WIND VALUE
C
      LREF = (TX + 100.)/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      ITX = IFIX(TX)
      SATVAP = SVPP +(MOD(ITX,5)/5)*(SVP(LREF + 1) - SVPP)
      LREF = (DEWX + 100.)/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      IDEWX = IFIX(DEWX)
      VAPP = SVPP + (MOD(IDEWX,5)/5)*(SVP(LREF + 1) - SVPP)
C                        CALCULATION OF VAPOR PRESSURE AT AIRTEMP
C                        AND DEWPOINT
      SEVAP = 0.0
      IF (VAPP.LE.6.108) GO TO 610
      CNM = 8.59*(VAPP - 6.108)
      GO TO 620
  610 CNM = 0.0
      DUMMY=(VAPP-SATVAP)*PACKRA
      IF (VAPP .LT. SATVAP) SEVAP = EVAPSN*0.0002*WIN*DUMMY
      PACK = PACK + SEVAP
      SEVAPT = SEVAPT - SEVAP
C
C     CONDENSATION - CONVECTION MELT, EQ. T-29B, P.176, SNOW HYDROLOGY
C     CONV - CONVECTION, CONDS - CONDENSATION
C     SEVAP - EVAP FROM SNOW (NEGATIVE VALUE)
C
  620 CNV = 0.0
      IF (TX .GT. 32.) CNV = (TX-32.)*(1.0 - 0.3*(MELEV/10000.))
      CCXC = CCFAC*.00026*WIN
C
C     .00026 = .00629/24, I.E. .00026 IS THE DAILY COEFFICIENT
C     (FROM SNOW HYDROLOGY) REDUCED TO HOURLY VALUES.
C
      CONV = CNV*CCXC
      CONDS = CNM*CCXC
C                           CLOUD COVER
C                           CLDF IS FRACTION OPEN SKY - MINIMUM VALUE 0.15
      IF (IHRR.EQ.1 .OR. CLDF.LT.0.0) CLDF = (1.0 - 0.085*(KCLD/3.5))
C                           ALBEDO
      IF (MONTH.GT.9) GO TO 640
      IF (MONTH.LT.4) GO TO 640
      ALBEDO = 0.8 - 0.1*(SQRT(INDT/24.))
      IF (ALBEDO .LT. 0.45)  ALBEDO = 0.45
      GO TO 650
  640 ALBEDO = 0.85 - 0.07*(SQRT(INDT/24.0))
      IF (ALBEDO .LT. 0.6)  ALBEDO = 0.6
C                           SHORT WAVE RADIATION-RA - POSITIVE INCOMING
  650 RA = RAD(IHRR)*(1.0 -ALBEDO)*(1.0-F)
C                           LONG WAVE RADIATION - LW - POSITIVE INCOMING
      DEGHR = TX - 32.0
      IF (DEGHR.LE.0.0) GO TO 660
      LW = F* 0.26*DEGHR + (1.0 - F)*(0.2*DEGHR - 6.6)
      GO TO 665
  660 LW = F*0.2*DEGHR + (1.0 - F)*(0.17*DEGHR - 6.6)
C
C                              LW IS A LINEAR APPROX. TO CURVES IN
C                              FIG. 6, PL 5-3, IN SNOW HYDROLOGY.  6.6
C                              IS AVE BACK RADIATION LOST FROM THE SNOWPACK
C                              IN OPEN AREAS, IN LANGLEYS/HR.
C
C                              CLOUD COVER CORRECTION
  665 IF (LW .LT. 0.0)  LW = LW*CLDF
C
C                              RAIN MELT
      RAINM = 0.0
```

```
2395.      C
2396.      C                                    RAINMELT IS OPERATIVE IF IT IS
2397.      C                                    RAINING AND TEMP IS ABOVE 32 F
2398.      C
2399.            IF ((SFLAG .LT. 1).AND.(TX .GT. 32.))  RAINM = DEGHR*PX/144.
2400.      C                              TOTAL MELT
2401.            RM = (LW + RA)/203.2
2402.      C                              203.2 LANGLEYS REQUIRED TO PRODUCE I INCH
2403.      C                              RUNOFF FROM SNOW AT 32 DEGREES F
2404.            IF (PACK.GE.IPACK) GO TO 680
2405.            RM = RM*PACKRA
2406.            CONV = CONV*PACKRA
2407.            CONDS = CONDS*PACKRA
2408.            RAINM = RAINM*PACKRA
2409.            IF (IHRK.NE.6) GO TO 680
2410.            XLNEM = 0.01*(32.0 - TX)
2411.            IF (XLNEM .GT. XLNMLT) XLNMLT = XLNEM
2412.        680 RADME = RADME + RM
2413.            CDRME = CDRME + CONDS
2414.            CONME = CONME + CONV
2415.            CRAIN = CRAIN + RAINM
2416.            MELT = RM + CONV + CONDS + RAINM
2416.1     C
2416.2           TP = 32.0 - (NEGMLT/(0.00695*PACK))
2416.3     C
2416.4     C     TP IS TEMP OF THE SNOWPACK
2416.5     C     0.00695 IS IN. MELT/IN. SNOW/DEGREE F
2416.6     C
2417.            IF (MELT.GE.0.0) GO TO 700
2418.            NEGMM = 0.0
2419.            IF (TX .LT. 32.) NEGMM = 0.00695*(PACK/2.0)*(32.0 - TX)
2420.      C
2421.      C                                    HALF OF PACK IS USED TO CALCULATE
2422.      C                                    MAXIMUM NEGATIVE MELT
2428.      C
2429.            IF (TP.LE.TX) GO TO 695
2430.            GM = 0.0007*(TP - TX)
2431.            NEGMLT = NEGMLT + GM
2432.            SNEGM = SNEGM + GM
2433.        695 IF (NEGMLT .GT. NEGMM)  NEGMLT = NEGMM
2434.            MELT = 0.0
2435.      C
2436.      C                              MELTING PROCESS BALANCE
2437.      C
2438.        700 PXBY = (1.0 - PACKRA)*PX
2439.            PX = PACKRA*PX
2440.      C
2441.      C     PXBY IS FRACTION OF PRECIP FALLING ON BARE GROUND
2442.      C
2443.            IF ((MELT + PX).LE.0.0) GO TO 795
2444.      C
2445.      C     SATISFY NEGMLT FROM PRECIP(RAIN) AND SNOWMELT
2446.      C
2447.            IF (MELT.GE.NEGMLT) GO TO 720
2448.            NEGMLT = NEGMLT - MELT
2449.            MELT = 0.0
2450.            GO TO 725
2451.        720 MELT = MELT - NEGMLT
2452.            NEGMLT = 0.0
2453.      C
2454.        725 IF (PX.GE.NEGMLT) GO TO 735
2455.            NEGMLT = NEGMLT - PX
2456.            PACK = PACK + PX
2457.            PX = 0.0
2458.            GO TO 740
2459.        735 PX = PX - NEGMLT
2460.            PACK = PACK + NEGMLT
2461.            NEGMLT = 0.0
```

```
C
  740 IF ((PX + MELT) .EQ. 0.0) GO TO  800
C
C     COMPARE SNOWMELT TO EXISTING SNOWPACK AND WATER CONTENT OF
C     THE PACK
C
      IF (MELT.LE.PACK) GO TO 750
      MELT = PACK + LIQW
      DEPTH = 0.0
      PACK = 0.0
      LIQW = 0.0
      INDT = 0.0
      GO TO 765
  750 PACK = PACK - MELT
      IF (SDEN .GT. 0.0)  DEPTH = DEPTH - (MELT/SDEN)
      IF (PACK .GE. (0.9*DEPTH))  DEPTH = 1.11*PACK
      IF (PACK.GE.0.001) GO TO 760
      LIQW = LIQW + PACK
      PACK = 0.0
  760 LIQS = WC*PACK
      IF (SDEN .GT. 0.0) LIQS = WC*(3.0 - (3.33)*SDEN)*PACK
      IF (LIQS .LT. 0.0) LIQS = 0.0
C
C     COMPARE AVAILABLE MOISTURE WITH AVAILABLE STORAGE IN SNOWPACK
C     -LIQS
C
  765 IF ((LIQW + MELT + PX).LE.LIQS) GO TO 775
      PX = MELT + PX + LIQW - LIQS
      LIQW = LIQS
      GO TO 780
  775 LIQW = LIQW + MELT + PX
      PX = 0.0
  780 IF (PX.LE.XLNMLT) GO TO 790
      PX = PX - XLNMLT
      PACK = PACK + XLNMLT
      XICE = XICE + XLNMLT
      XLNMLT = 0.0
      GO TO 795
  790 PACK = PACK + PX
      XICE = XICE + PX
      XLNMLT = XLNMLT - PX
      PX = 0.0
  795 IF (XICE .GT. PACK) XICE = PACK
C
C
C                                 END MELTING PROCESS BALANCE
C
  800 IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
      IF (SDEN .LT. 0.1) SDEN = 0.1
C                                    GROUNDMELT
      IF (IHRR.NE.12) GO TO 830
      DGMM = DGM
      IF (TP .LT. 5.0)  TP = 5.0
      IF (TP .LT. 32.)  DGMM = DGMM - DGM*.03*(32.0 - TP)
      IF (PACK.LE.DGMM) GO TO 825
      PX = PX + DGMM
      PACK = PACK - DGMM
      DEPTH = DEPTH - (DGMM/SDEN)
      SGM = SGM + DGMM
      GO TO 830
  825 PX = PACK + PX + LIQW
      SGM = SGM + PACK
      PACK = 0.0
      DEPTH = 0.0
      LIQW = 0.0
      NEGMLT = 0.0
  830 CONTINUE
      PX = PX + PXBY
```

```
      SPX = SPX + PX
C
C                                        HOUR VALUE ASSIGNMENT
  997 SUMSNH = SUMSN
      PXSNH = PXONSN
      SPXH = SPX
      RADMEH = RADME
      CDRMEH = CDRME
      CONMEH = CONME
      CRAINH = CRAIN
      SGMH = SGM
      SNEGMH = SNEGM
      SEVAPH = SEVAPT
C
C                                        DAILY SUMS
      IF (PRINT.NE.DAYS)  GO TO 996
      SUMSND = SUMSND + SUMSN
      PXSND  = PXSND  + PXONSN
      MELRAD = MELRAD + SPX
      RADMED = RADMED + RADME
      CDRMED = CDRMED + CDRME
      CONMED = CONMED + CONME
      CRAIND = CRAIND + CRAIN
      SGMD   = SGMD   + SGM
      SNEGMD = SNEGMD + SNEGM
      SEVAPD = SEVAPD + SEVAPT
C
C                                        MONTHLY SUMS
  996 SUMSNM = SUMSNM + SUMSN
      PXSNM  = PXSNM  + PXONSN
      MELRAM = MELRAM + SPX
      RADMEM = RADMEM + RADME
      CDRMEM = CDRMEM + CDRME
      CONMEM = CONMEM + CONME
      CRAINM = CRAINM + CRAIN
      SGMM   = SGMM   + SGM
      SNEGMM = SNEGMM + SNEGM
      SEVAPM = SEVAPM + SEVAPT
C
C                                        YEARLY SUMS
      SUMSNY = SUMSNY + SUMSN
      PXSNY  = PXSNY  + PXONSN
      MELRAY = MELRAY + SPX
      RADMEY = RADMEY + RADME
      CDRMEY = CDRMEY + CDRME
      CONMEY = CONMEY + CONME
      CRAINY = CRAINY + CRAIN
      SGMY   = SGMY   + SGM
      SNEGMY = SNEGMY + SNEGM
      SEVAPY = SEVAPY + SEVAPT
C
C                                        ZERO HOURLY VALUES
      SUMSN = 0.0
      PXONSN = 0.0
      SPX = 0.0
      RADME = 0.0
      CDRME = 0.0
      CONME = 0.0
      CRAIN = 0.0
      SGM = 0.0
      SNEGM = 0.0
      SEVAPT = 0.0
C
C                                   SNOWMELT OUTPUT
C
C
C
      SNOUT(IHRR,1) = PACK
```

```
2598.          SNOUT(IHRR,2) = DEPTH
2599.          SNOUT(IHRR,3) = SDEN
2600.          SNOUT(IHRR,4) = ALBEDO
2601.          SNOUT(IHRR,5) = CLDF
2602.          SNOUT(IHRR,6) = NEGMLT
2603.          SNOUT(IHRR,7) = LIQW
2604.          SNOUT(IHRR,8) = TX
2605.          SNOUT(IHRR,9) = RA
2606.          SNOUT(IHRR,10) = LW
2607.          SNOUT(IHRR,11) = PX
2608.          SNOUT(IHRR,12) = MELT
2609.          SNOUT(IHRR,13) = CONV
2610.          SNOUT(IHRR,14) = RAINM
2611.          SNOUT(IHRR,15) = CONDS
2612.          SNOUT(IHRR,16) = XICE
2613.     C
2614.          IF (OUTPUT .EQ. ENGL)  GO TO 845
2615.          IF (OUTPUT .EQ. BOTH .AND. INPUT .EQ. ENGL)  GO TO 845
2616.     C
2617.     C  CONVERSION TO METRIC SNOW OUTPUT
2618.     C
2619.            SNOUT(IHRR,1) = PACK*MMPIN
2620.            SNOUT(IHRR,2) = DEPTH*MMPIN
2621.            SNOUT(IHRR,6) = NEGMLT*MMPIN
2622.            SNOUT(IHRR,7) = LIQW*MMPIN
2623.            SNOUT(IHRR,8) = 0.556*(TX-32.0)
2624.            DO 842 ISNOUT=11,16
2625.               SNOUT(IHRR,ISNOUT) = SNOUT(IHRR,ISNOUT)*MMPIN
2626.      842   CONTINUE
2627.     C
2628.      845 IF (HYCAL.EQ.PROD)  GO TO 998
2628.1         IF (SNOPRT .EQ. NO)  GO TO 998
2629.     C
2630.          IF (IHRR .NE. 24)  GO TO 998
2631.          IF (PACK.LE.0.0)  GO TO 998
2632.          WRITE (6,992) MNAM(MONTH),DAY
2633.          WRITE(6,990)
2634.     C
2635.          DO 880 I=1,24
2636.             WRITE (6,991) I,(SNOUT(I,MM),MM=1,16)
2637.             DO 881 MMM=1,16
2638.                SNOUT(I,MMM) = 0.0
2638.8     881    CONTINUE
2639.      880 CONTINUE
2639.8         IF (NUTR.EQ.YES)  GO TO 998
2640.          WRITE (6,994)
2641.          WRITE (6,995)
2642.     C
2643.     C
2644.      990 FORMAT ('0','HOUR     PACK      DEPTH    SDEN   ALBEDO  CLDF    NEGMELT
2645.         1    LIQW      TX      RA   LW     PX       MELT      CONV      RAINM
2646.         2CONDS      ICE')
2647.      991 FORMAT (' ',I2,2X,2(F8.2,2X),3(F6.3,1X),2(F8.3,1X),
2648.         1         F7.2,1X,2(F4.0,1X),5(F8.3,1X),F6.1)
2649.      992 FORMAT ('0',25X,'SNOWMELT OUTPUT FOR',4X,A8,2X,I2)
2650.      994 FORMAT ('0',5X,'DATE',4X,'TIME',4X,'FLOW(CFS-CMS)',6X,
2651.         X         'SEDIMENT (LBS-KG-KG/MIN-GM/L)',23X,
2652.         X         'PESTICIDE (GM-GM/MIN-PPM)')
2653.      995 FORMAT (' ',87X,'WATER',24X,'SEDIMENT')
2654.     C
2655.     C                              CORRECT WATER BALANCE FOR SNOWMELT
2656.     C                              PACK AND SNOW EVAP
2657.     C
2658.     C                              PRR IS INCOMING PRECIP
2659.     C                              PX  IS MOISTURE TO THE LAND SURFACE
2660.     C                              SEVAP IS SNOW EVAP - NEGATIVE
2661.      998 IF (IEND.EQ.1)  SNBAL = PRHR+SEVAP-PX-PACK+PACK1-LIQW+LIQW1
2662.          IF ((SNBAL.LT.0.0001).AND.(SNBAL.GT.-0.0001))  SNBAL=0.0
```

```
      TSNBAL = TSNBAL + SNBAL
C
C
      PACK1 = PACK
      LIQW1 = LIQW
C                 ********************************
C                            END SNOWMELT
C                 ********************************
C                                        PX IS TOTAL MOISTURE INPUT TO
C                                        THE LAND SURFACE FROM PRECIP
C                                        AND SNOWMELT DURING THE HOUR
C
  999 IF (IEND .GT. C) PR=PX*TIMFAC/60.
C                                      IEND>0 INDICATES SNOWMELT
C                                      OCCURRED DURING THE HOUR
C
C
C
C
C   * * *    INTERCEPTION  FUNC.     * * *
C
C
C EPXM - MAX. INTERCEPTION STORAGE
C SCEP - EXISTING INTER. STORAGE
C EPX  - AVAILABLE INTER. STORAGE
C RUI  - IMPERVIOUS RUNOFF DURING INTERVAL
C
C
C
      IF (COVER.GT.C.0001) GO TO 204
      SNET = SNET + SCEP
      SCEP = 0.0
      EPX = 0.C
      GO TO 203
C
C
  204 EPX = EPXM*(COVER/COVRMX)-SCEP
      IF (EPX.LT.(C.0001))  EPX = 0.0
      IF (PR.LT.EPX) GO TO 205
  203 P3 = PR-EPX
      RU = P3*A
      RUI = RU
      SCEP = SCEP+EPX
      GO TO 206
  205 SCEP = SCEP+PR
      P3 = 0.C
      RU = 0.C
      RUI = 0.0
C
C
C
C   * * *      INTERCEPTION EVAP      * * *
C
C
  206 IF ((NUMI.NE.C).OR.(IMIN.NE.0)) GO TO 221
      IF (SCEP.LE.0.0) GO TO 221
      IF (SCEP.GE.EPIN) GO TO 210
      EPIN = EPIN - SCEP
      SNET = SNET + SCEP
      SCEP = 0.0
      GO TO 221
  210 SCEP = SCEP-EPIN
      SNET = SNET+EPIN
      EPIN = 0.0
C
C
C     ***  INFILTRATION FUNC.  ***
C  P4 IS TOTAL MOISTURE IN STORAGE BLOCK
```

```
C  SHRD(I) = SURFACE DETENTION AND INTERFLOW FROM BLOCK I
C  RXX(I)  = SURFACE DETENTION FROM BLOCK I
C  RGXX(I) = INTERFLOW  COMPONENT FROM BLOCK I
C  RGX(I)  = VOLUME TO INTER. DETEN STOR. FROM BLOCK I
C
C
C      BEGINNING OF BLOCK LOOP
C
C
  221 DO 100 I=1,5
      P4 = P3 + RESB(I)
      RESB1(I) = RESB(I)
      IF ((10.*P4).LE.(((2*I)-1)*D4F)) GO TO 10
      SHRD(I) = (P4-(((2*I)-1)*D4F/10.))
      IF ((10.*P4).LE.(((2*I)-1)*D4RA)) GO TO 25
      RXX(I) = (P4-(((2*I)-1)*D4RA/10.))
      GO TO 31
   10 SHRD(I) = 0.0
   25 RXX(I) = 0.0
   31 RGXX  = SHRD(I)-RXX(I)
C
C
C   ***  UPPER ZONE FUNCTION ***
C
C PRE(I)  - % SURFACE DETENTION TO OVERLAND FLOW
C UZSB(I) -  UPPER ZONE STORAGE IN EACH BLOCK
C UZS     - TOTAL UPPER ZONE STORAGE
C RUZB(I) - ADDITION TO U.Z. STORAGE DURING INTERVAL
C
      IF (UZSB(I).LT.0.0)  UZSB(I)=0.0
      UZRA(I) = UZSB(I)/UZSN
      IF (UZRA(I).GT.6.0) GO TO 7
      IF (UZRA(I).GT.2.0) GO TO 8
      UZI(I) = 2.0*ABS((UZRA(I)/2.0)-1.0) +1.0
      PRE(I) = (UZRA(I)/2.0)*((1.0/(1.0+UZI(I)))**UZI(I))
      GO TO 9
    7 PRE(I) = 1.0
      GO TO 9
    8 UZI(I) = (2.0*ABS(UZRA(I)-2.0))+1.0
      PRE(I) = 1.0-((1.0/(1.0+UZI(I)))**UZI(I))
    9 RXB(I) = RXX(I)* PRE(I)
      RGX(I) = RGXX*PRE(I)
      RGXX = 0.0
      RUZB(I) = SHRD(I)-RGX(I)-RXB(I)
      UZSB(I) = UZSB(I)+RUZB(I)
C
        RIB(I) = P4 - RXB(I)
C
C
C
C   * * *      UPPER ZONE EVAP    * * *
C
C
C REPIN - ACCUM DAILY EVAP POT. FOR L.Z. AND GROWATER, I.E
C         PORTION NOT SATISFIED FROM U.Z.
C
C
        IF ((NUMI.NE.0).OR.(IMIN.NE.0)) GO TO 290
        IF (EPIN.LE.(0.0))  GO TO 290
          IF(UZRA(I).LE.2.0) GO TO 230
          IF (UZSB(I).LE.EPIN) GO TO 270
          UZSB(I) = UZSB(I)-EPIN
          RUZB(I) = RUZB(I)-EPIN
          SNET = SNET+PA*EPIN*0.20
          GO TO 290
  230     EFFECT = 0.5*UZRA(I)
          IF (EFFECT.LT.(0.02))  EFFECT = 0.02
          IF (UZSB(I).LE.EPIN*EFFECT)  GO TO 270
```

```
              UZSB(I) = UZSB(I)-(EPIN*EFFECT)
              RUZB(I) = RUZB(I)-(EPIN*EFFECT)
              EDIFF = (1.0-EFFECT)*EPIN
              REPIN = REPIN + EDIFF*0.20
              SNET = SNET + (PA*EPIN*EFFECT)*0.20
              GO TO 290
      270     EDIFF = EPIN - UZSB(I)
              REPIN = REPIN + EDIFF*0.20
              SNET = SNET + PA*UZSB(I)*0.20
              UZSB(I) = 0.0
              RUZB(I) = 0.0
C
C
C     * * * *     INTERFLOW FUNCTION * * *
C
C       SRGX(I) - INTERFLOW DETENTION STORAGE FROM BLOCK I
C       INTF(I) - INTERFLOW LEAVING STORAGE FROM BLOCK I
C       SRGXT - TOTAL INTERFLOW STORAGE
C       RGXT  - TOTAL INTERFLOW LEAVING STORAGE DURING INTERVAL
C
      290   INTF(I) = LIRC4*SRGX(I)
            SRGX(I) = SRGX(I)+(RGX(I)*PA)-INTF(I)
            RU = RU + INTF(I)*0.20
            SRGXT = SRGXT + (RGX(I)*PA-INTF(I))*0.20
            RGXT = RGXT + INTF(I)*0.20
C
C ***     OVERLAND FLOW ROUTING ***
C
C
C  RXB(I)  = VOLUME TO OVERLAND SURFACE DETENTION FROM BLOCK I
C  ROSB(I) = VOLUME OF OVERLAND FLOW TO STREAM FROM BLOCK I
C  RESB(I) = VOLUME OF OVERLAND Q REMAINING ON SURFACE
C                FROM BLOCK I
C
         F1 = RXB(I)-(RESB(I))
         F3 = (RESB(I))+ RXB(I)
         IF (RXB(I).LE.(RESB(I))) GO TO 34
         DE = DEC*((F1)**0.6)
         GO TO 35
      34 DE = (F3)/2.0
      35 IF (F3.GT.(2.0*DE)) DE = F3/2.0
         IF (F3.LE.0.005) GO TO 40
         DUMV = (1.0+0.6*(F3/(2.0*DE))**3.)**1.67
         ROSB(I) = (TIMFAC/60.)*SRC*((F3/2.)**1.67)*DUMV
         IF (ROSB(I) .GT. 0.95*RXB(I))  ROSB(I) = .95*RXB(I)
         GO TO 43
      40 ROSB(I) = 0.0
      43 RESB(I) = RXB(I)-ROSB(I)
         ROSB(I) = ROSB(I)*PA
         ROSINT(I) = ROSB(I) + INTF(I)
C
C
C
C          * * *  UPPER ZONE DEPLETION * * *
C
C  DEEPL(I) - DIFFERENCE IN UPPER AND LOWER ZONE RATIOS
C  PERCB(I) - UPPER ZONE DEPLETION FROM EACH BLOCK
C  PERC     - TOTAL U.Z. DEPLETION
C  INFLT    - TOTAL INFILTRATION
C  ROS      - TOTAL OVERLAND FLOW TO THE STREAM FROM ALL BLOCKS
C
            IF ((NUMI .EQ. 0).AND.(IMIN .EQ. 0))  GO TO 44
            PERCB(I) = 0.0
            GO TO 47
C
      44    DEEPL(I)= ((UZSB(I)/UZSN)-(LZS/LZSN))
            IF (DEEPL(I).LE.0.01) GO TO 47
            PERCB(I)=0.1*INFIL*UZSN*(DEEPL(I)**3)
```

```
C
      IF (SNOW .EQ. YES) PERCB(I) = PERCB(I)*D4FX
C
            IF (UZSB(I).GT.PERCB(I)) GO TO 48
            PERCB(I) = UZSB(I)*PERCB(I)/(PERCB(I)+UZSB(I))
            GO TO 47
C
   48       UZSB(I)=UZSB(I)-PERCB(I)
            PERC=PERC+PERCB(I)*0.2
            RUZB(I) = RUZB(I) - PERCB(I)
  47        INFL(I)= P4-SHRD(I)
            INFLT=INFLT + INFL(I)*0.20
      RESS = RESS + RESB(I)*0.2
      UZS = UZS + RUZB(I)*0.20
      ROS = ROS + ROSB(I)*0.2
  100 CONTINUE
      IF (UZS .LE. 0.0001) UZS=0.0
C
C END OF BLOCK LOOP
C
         RU=RU + ROS
         IF ((RESS).GE.(0.0001))  GO TO 302
         LZS = LZS + RESS
         RESS = 0.0
         DO 306  IK= 1,5
  306    RESB(IK)= 0.0
  302    IF (SRGXT.GE.(0.0001))  GO TO 305
         LZS = LZS + SRGXT/PA
         SRGXT = 0.0
           DO 304  IK= 1,5
  304      SRGX(IK)= 0.0
C
C
C    * * * LOWER ZONE AND GROUNDWATER  * * *
C
C  SBAS  - BASE STREAMFLOW
C  SRCH  - SUM OF GRDWATER RECHARGE
C  PREL  - % OF INFILTRATION AND U.Z. DEPLETION ENTERING L.Z
C  F1A   - GROUNDWATER RECHARGE - IE. PORTION OF INFIL.
C          AND U.Z. DEPLETION ENTERING GRDWATER
C  K24L  - FRACTION OF F1A LOST TO DEEP GRDWATER
C
  305       LZI=1.5*ABS((LZS/LZSN)-1.0)+1.0
            PREL=(1.0/(1.0+LZI))**LZI
            IF (LZS.LT.LZSN)  PREL=1.0-PREL*LNRAT
            F3= PREL*(INFLT)
            F1A = (1.0-PREL)*INFLT
            IF ((NUMI.NE.0).OR.(IMIN.NE.0)) GO TO 309
            F3 = F3 + PREL*PERC
            F1A = F1A + (1.0-PREL)*PERC
  309       LZS= LZS+F3
         F1= F1A*(1.0 - K24L)*PA
         GWF=SGW*LKK4*(1.0 + KV*GWS)
         RU = RU + GWF
         SBAS= GWF
         SRCH= F1A*K24L*PA
         SGW = SGW - GWF + F1
         GWS = GWS + F1
C
C   * * *       GROUNDWATER EVAP   * * *
C
C
C LOS  - EVAP LOST FROM GROUNDWATER
C
C      NOTE: EVAP FROM GRDWATER AND LZ IS CALCULATED ONLY DAILY
C
         IF ((HRFLAG.EQ.0).OR.(IHRR.NE.21)) GO TO 101
         IF (GWS .GT. 0.0001)  GWS = 0.97*GWS
```

```
2933.              LOS= SGW*K24EL*REPIN*PA
2939.              SGW=SGW - LOS
2940.              GWS=GWS - LOS
2941.              SNET= SNET + LOS
2942.              REPIN= REPIN - LOS
2943.              IF (GWS.LT.(0.0))  GWS=0.0
2944.       C
2945.       C  * * *        LOWER ZONE EVAP  * * *
2946.       C
2947.       C AETR - EVAP LOST FROM L.Z.
2948.       C
2949.       C
2950.             IF (REPIN.LT.(0.0001))  GO TO 351
2951.             LNRAT = LZS/LZSN
2954.              IF (XK3.LT.0.995) GO TO 300
2955.              KF=50.0
2956.              GO TO 320
2957.        300   KF=0.25/(1.0-XK3)
2958.        320   IF (REPIN.GE.(KF*LNRAT))  GO TO 340
2959.              AETR= REPIN*(1.0-(REPIN/(2.0*KF*LNRAT)))
2960.              GO TO 350
2961.        340   AETR= 0.5*(KF*LNRAT)
2962.        350   IF (XK3.LT.(0.50))  AETR=AETR*(2.0*XK3)
2963.              LZS=LZS - AETR
2964.              SNET= SNET + PA*AETR
2965.              ASNET = ASNET + LOS + PA*AETR
2966.        351   REPIN = 0.0
2967.        101   SNETI = SNET - SNET1
2968.       C
2968.01     C         STORE LSRO AND WRITE TO DISK
2968.02     C
2968.03          IF (DSNFLO.EQ.0) GO TO 4010
2968.04          LSRO(NILSRO) = RO
2968.05          IF (NILSRO.LT.TMBLSZ) GO TO 4000
2968.06          IF (OUTPUT.EQ.ENGL) GO TO 4040
2968.07          DO 4030 I = 1,TMBLSZ
2968.08     4030    LSRO(I) = LSRO(I)*MMPIN
2968.085    4040 IF(IDEBUG .EQ. ON) WRITE(6,9996) LOOP
2968.086    9996 FORMAT('0','DEBUG - - LOOP = ',I5)
2968.09          WRITE(DSNFLO)  (LSRO(I),I=1,TMBLSZ)
2968.091         IF(IDEBUG .EQ. ON) WRITE(6,9995) (LSRO(I),I=1,TMBLSZ)
2968.092    9995 FORMAT('0','WRITE TO DISK - LSRO ',/,(1X,10(E10.3,2X),/))
2968.1           DO 4050 I = 1,TMBLSZ
2968.11     4050    LSRO(I) = 0.
2968.12          NILSRO = 0
2968.13     4000 NILSRO = NILSRO + 1
2968.14     C
2969.       C
2969.01     4010 IF (DSNROS .EQ. 0)  GO TO 4011
2969.02          IF (ROS .EQ. 0.0)  GO TO 4011
2969.03          IF (LOOP .EQ. (LASTRD+1))  GO TO 924
2969.04          IHEAD = -LOOP
2969.05          RROS(NRROS) = IHEAD
2969.06          IF (NRROS .LT. TMBLSZ)  GO TO 922
2969.07          IF (OUTPUT .EQ. ENGL)  GO TO 912
2969.08          DO 910 I=1,TMBLSZ
2969.09      910    RROS(I) = RROS(I)*MMPIN
2969.1       912 IF (IDEBUG .EQ. ON)  WRITE (6,9997) LOOP
2969.11     9997 FORMAT('0','DEBUG - - LOOP = ',I5)
2969.12     C
2969.13          IF (IDEBUG .EQ. ON)  CALL ERDBUG(RROS,TMBLSZ)
2969.14          WRITE(DSNROS)  (RROS(I),I=1,TMBLSZ)
2969.15          DO 920 I=1,TMBLSZ
2969.16      920    RROS(I) = 0.0
2969.17          NRROS = 0
2969.18     C
2969.19      922 NRROS = NRROS+1
2969.2       924 RROS(NRROS) = ROS
2969.21          LASTRD = LOOP
```

```
2969.22          IF (NPROS .LT. TMBLSZ)  GO TO 942
2969.23          IF (OUTPUT .EQ. ENGL)  GO TO 932
2969.24          DO 930 I=1,TMBLSZ
2969.25      930    RROS(I) = RROS(I)*MMPIN
2969.26      932 IF (IDEBUG .EQ. ON)  WRITE (6,9997) LOOP
2969.27          IF (IDEBUG .EQ. ON)  CALL ERDBUG(RROS,TMBLSZ)
2969.28          WRITE(DSNROS) (RROS(I),I=1,TMBLSZ)
2969.29          DO 940 I=1,TMBLSZ
2969.3       940    RROS(I) = 0.0
2969.31          NRROS = 0
2969.32     C
2969.33      942 NRROS = NRROS+1
2969.34     C
2969.35     C
2970.       C
2971.       C WBAL - WATER BALANCE IN THE INTERVAL
2972.       C TWBAL - ACCUMULATED WATER BALANCE
2973.       C
2974.       C
2975.        4011 WBAL = (LZS-LZS1+UZS-UZS1+RESS-RESS1)*PA+(SNET-SNET1+SGW-SGW1+
2976.            X        SCEP-SCEP1+SRCH+SRGXT-SRGXT1+RU-PR)
2977.          IF ((WBAL .LE. 0.0001).AND.(WBAL .GE. -0.0001))  WBAL = 0.0
2978.          TWBAL=TWBAL+WBAL
2979.       C
2980.          DPS = F1A*PA
2981.          DPST = DPST + DPS
2982.       C
2983.       C
2984.       C                    RESETTING VARIABLES
2985.       C
2986.          LZS1=LZS
2987.          UZS1=UZS
2988.          RESS1=RESS
2989.          SCEP1=SCEP
2990.          SRGXT1=SRGXT
2991.          SGW1=SGW
2992.          SNET1=SNET
2993.       C
2994.          ASBAS = ASBAS + SBAS
2995.          ASRCH = ASRCH + SRCH
2996.             APR = APR + PRR
2997.             ARU = ARU + RU
2998.             ARUI = ARUI + RUI
2999.             ARGS = ARGS + RGS
3000.             ARGXT = ARGXT + RGXT
3001.             IF ((NUMI.NE.0).OR.(IMIN.NE.0))  GO TO 148
3002.             AEPIN = AEPIN + EPIN1
3003.             ASNET = ASNET + SNETI
3004.        148 DO 150  I=1,5
3005.             APERCB(I) = APERCB(I) + PERCB(I)
3006.             ARGSB(I) = ARGSB(I) + RGSB(I)
3007.             AINTF(I) = AINTF(I) + INTF(I)
3008.             ARGSIT(I) = ARGSIT(I) + RGSINT(I)
3009.        150    CONTINUE
3010.       C
3010.1          IF (IMIN .NE. 0)  GO TO 155
3010.11     C                    CALCULATION OF SOIL MOISTURE
3010.12     C
3010.2          DO 51 I=1,5
3010.3             SMOIST(IHR,I) = 45302.4*AREA*RESB(I)/M
3010.4             UMOIST(IHR,I) = ((UZSB(I)/UZSN)+0.48)/24.0
3010.5             IF (UMOIST(IHR,I) .GT. 0.35)  UMOIST(IHR,I)=0.35
3010.6         51 CONTINUE
3010.7          LMOIST(IHR) = 0.1404*(LZS/LZSN)**2.66
3010.8          IF (LMOIST(IHR) .GT. 0.35)  LMOIST(IHR)=0.35
3010.9      C
3011.        155 CONTINUE
3012.       C
```

```
3013.            IF (PRNTKE .EQ. 0)  GO TO 190
3014.      C
3015.      C                          CUMULATIVE RECORDS
3016.      C
3017.            PRTOM = PRTOM + APR
3018.            EPTOM = EPTOM + AEPIN
3019.            RUTOM = RUTOM + ARU
3020.            ROSTOM = ROSTOM + AROS
3021.            RITOM = RITOM + ARUI
3022.            RINTOM = RINTOM + ARGXT
3023.            NEPTOM = NEPTOM + ASNET
3024.            BASTOM = BASTOM + ASBAS
3025.            RCHTOM = RCHTOM + ASRCH
3026.      C
3027.              DO 157  I=1,5
3028.                 ROBTOM(I) = ROBTOM(I) + AROSB(I)
3029.                 ROBTOT(I) = ROBTOT(I) + AROSB(I)
3030.                 INFTOM(I) = INFTOM(I) + AINTF(I)
3031.                 INFTOT(I) = INFTOT(I) + AINTF(I)
3032.                 ROITOM(I) = ROITOM(I) + AROSIT(I)
3033.        157      ROITOT(I) = ROITOT(I) + AROSIT(I)
3034.      C
3035.            PRTOT = PRTOT + APR
3036.            EPTOT = EPTOT + AEPIN
3037.            RUTOT = RUTOT + ARU
3038.            ROSTOT = ROSTOT + AROS
3039.            RITOT = RITOT + ARUI
3040.            RINTOT =RINTOT + ARGXT
3041.            NEPTOT = NEPTOT + ASNET
3042.            BASTOT = BASTOT + ASBAS
3043.            RCHTOT = RCHTOT + ASRCH
3044.      C
3045.            IF (PRNTKE .EQ. 2)  GO TO 171
3046.            IF (HYCAL.EQ.PROD) GO TO 160
3047.      C
3048.      C                     OUTPUT FOR HSP LANDS CALIBRATION RUN
3049.      C
3050.      C
3052.            RU = (RU*AREA*43560.)/(TIMFAC*720.)
3053.            IF (RU.LT.HYMIN .AND. NUTR.EQ.YES) PRU = RU
3053.5           IF (RU .LT. HYMIN)  GO TO 170
3054.            QMETRC=RU*.0283
3055.            IF (NUTR .EQ. YES)  GO TO 960
3056.            WRITE (6,379) MNAM(MONTH),DAY,IHR,IMIN
3057.            WRITE (6,378) RU,QMETRC
3058.            GO TO 170
3059.      C
3059.2     C
3059.3     C                          WRITE NUTRIENT CALIBRATION OUTPUT
3059.4     C
3059.45    960   IF (PRU .LE. HYMIN) GO TO 970
3059.46          GO TO 980
3059.5     970         WRITE (6,4001)
3059.6                 IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  WRITE (6,4002)
3059.7                 IF (OUTPUT .EQ. METR)  WRITE (6,4003)
3059.8                 WRITE (6,4004)
3060.      980   IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)
3061.           1      WRITE (6,4901)  MNAM(MONTH), DAY, IHR, IMIN, RU
3062.            IF (OUTPUT .EQ. METR)
3063.           1      WRITE (6,4901)  MNAM(MONTH), DAY, IHR, IMIN, QMETRC
3063.5           PRU = RU
3064.            GO TO 170
3065.      C
3066.        160 IF (SNOW.EQ.NO .OR. PRINT.NE.DAYS)  GO TO 169
3067.               SUMSNH = SUMSNO
3068.               PXSNH = PXSNO
3069.               SPXH = MELRAD
3070.               RADMEH = RADMED
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3071.              CDRMEH = CDRMED
3072.              CONMEH = CONMED
3073.              CRAINH = CRAIND
3074.              SGMH = SGMD
3075.              SNEGMH  = SNEGMD
3076.              SEVAPH = SEVAPD
3077.      C
3078.      C                    OUTPUT FOR HSP LANDS PRODUCTION RUN  AND SUMMARIES
3079.      C
3080.        169 IF (OUTPUT.EQ. METR) GO TO 161
3081.            WRITE (6,360)
3082.            WRITE (6,362)
3083.            WRITE (6,363) AROSB,AROS
3084.            WRITE (6,364) AINTF,ARGXT
3085.            WRITE (6,365) ARUI
3086.            WRITE (6,366) AROSIT,ARU
3087.            WRITE (6,380) ASBAS
3088.            WRITE (6,381) ASRCH
3089.            WRITE (6,361) APR,APR,APR,APR,APR,APR
3090.            IF ((SNOW.EQ.NO).OR.(PACK.LE.0.0))  GO TO 181
3091.      C                                 SNOWMELT OUTPUT
3092.            WRITE (6,478) SUMSNH
3093.            WRITE (6,479) FXSNH
3094.            WRITE (6,480) SPXH
3095.            WRITE (6,481)
3096.            WRITE (6,482) RADMEH
3097.            WRITE (6,483) CONMEH
3098.            WRITE (6,484) CDRMEH
3099.            WRITE (6,485) CRAINH
3100.            WRITE (6,486) SGMH
3101.            WRITE (6,487) SNEGMH
3102.            WRITE (6,490) PACK
3103.               COVR = 100.
3104.               IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
3105.               IF (PACK.GT.0.01) GO TO 1078
3106.               COVR=0.0
3107.               SDEN=0.0
3108.       1078 WRITE (6,491) SDEN
3109.            WRITE (6,492) COVR
3110.            WRITE (6,488) SEVAPH
3111.        181 WRITE (6,367)
3112.            WRITE (6,368) AEPIN,AEPIN,AEPIN,AEPIN,AEPIN,AEPIN
3113.            WRITE (6,369) ASNET,ASNET,ASNET,ASNET,ASNET,ASNET
3114.            WRITE (6,383) COVER
3115.            WRITE (6,370)
3116.            WRITE (6,371) UZSB,UZS
3117.            WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
3118.            WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
3119.            WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
3120.            WRITE (6,375) RESB,RESS
3121.            WRITE (6,376) SRGX,SRGXT
3122.            WRITE (6,377) TWBAL
3123.            IF ((SNOW.EQ.YES).AND.(PACK.GT.0.0))  WRITE (6,489) TSNBAL
3124.        161 IF (OUTPUT.EQ. ENGL) GO TO 171
3125.      C
3126.      C  METRIC CONVERSIONS FOR OUTPUT
3127.            APR    =APR*MMPIN
3128.            AROS   =AROS*MMPIN
3129.            ARGXT  =ARGXT*MMPIN
3130.            ARUI   =ARUI*MMPIN
3131.            ARU    =ARU*MMPIN
3132.            ASBAS  =ASBAS*MMPIN
3133.            ASRCH  =ASRCH*MMPIN
3134.            AEPIN  =AEPIN*MMPIN
3135.            ASNET  =ASNET*MMPIN
3136.            UZSMET=UZS*MMPIN
3137.            LZSMET=LZS*MMPIN
3138.            SGWMET=SGW*MMPIN
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3139.          SCEPMT=SCEP*MMPIN
3140.          RESSMT=RESS*MMPIN
3141.          TWBLMT=TWBAL*MMPIN
3142.          SRGXTM=SRGXT*MMPIN
3143.    C  SNOW
3144.          IF (SNOW .EQ. NO)  GO TO 163
3145.          SUMSNH = SUMSNH*MMPIN
3146.          PXSNH = PXSNH*MMPIN
3147.          SPXH = SPXH*MMPIN
3148.          RADMEH = RADMEH*MMPIN
3149.          CONMEH = CONMEH*MMPIN
3150.          CORMEH = CORMEH*MMPIN
3151.          CRAINH = CRAINH*MMPIN
3152.          SGMH = SGMH*MMPIN
3153.          SNEGMH = SNEGMH*MMPIN
3154.          PACKML = PACK*MMPIN
3155.          SEVAPH = SEVAPH*MMPIN
3156.          TSNBML = TSNBAL*MMPIN
3157.      163 DO 162 I=1,5
3158.            AROSB(I) =ARCSB(I)*MMPIN
3159.            AINTF(I) =AINTF(I)*MMPIN
3160.            AROSIT(I)=ARCSIT(I)*MMPIN
3161.            UZSBMT(I)=UZSB(I)*MMPIN
3162.            RESBMT(I)=RESB(I)*MMPIN
3163.            SRGXMT(I)=SRGX(I)*MMPIN
3164.      162 CONTINUE
3165.          WRITE (6,460)
3166.          WRITE (6,362)
3167.          WRITE (6,363) AROSB,AROS
3168.          WRITE (6,364) AINTF,ARGXT
3169.          WRITE (6,365) ARUI
3170.          WRITE (6,366) AROSIT,ARJ
3171.          WRITE (6,380) ASBAS
3172.          WRITE (6,381) ASRCH
3173.          WRITE (6,361) APR,APR,APR,APR,APR,APR
3174.          IF (SNOW.EQ.NO .OR. PACK.LE.0.0)  GO TO 182
3175.          WRITE (6,478)  SUMSNH
3176.          WRITE (6,479)  PXSNH
3177.          WRITE (6,480)  SPXH
3178.          WRITE (6,481)
3179.          WRITE (6,482)  RADMEH
3180.          WRITE (6,483)  CONMEH
3181.          WRITE (6,484)  CORMEH
3182.          WRITE (6,485)  CRAINH
3183.          WRITE (6,486)  SGMH
3184.          WRITE (6,487)  SNEGMH
3185.          WRITE (6,490)  PACKML
3186.             COVR = 100.0
3187.             IF (PACK.LT.IPACK)  COVR = (PACK/IPACK)*100.
3188.             IF (PACK.GT.0.01)  GO TO 1079
3189.             COVR = 0.0
3190.             SDEN = 0.0
3191.     1079 WRITE (6,491)  SDEN
3192.          WRITE (6,492)  COVR
3193.          WRITE (6,488)  SEVAPH
3194.      182 WRITE (6,367)
3195.          WRITE (6,368) AEPIN,AEPIN,AEPIN,AEPIN,AEPIN,AEPIN
3196.          WRITE (6,369) ASNET,ASNET,ASNET,ASNET,ASNET,ASNET
3197.          WRITE (6,383) COVER
3198.          WRITE (6,370)
3199.          WRITE (6,371) UZSBMT, UZSMET
3200.          WRITE (6,372) LZSMET, LZSMET, LZSMET, LZSMET, LZSMET, LZSMET
3201.          WRITE (6,373) SGWMET, SGWMET, SGWMET, SGWMET, SGWMET, SGWMET
3202.          WRITE (6,374) SCEPMT, SCEPMT, SCEPMT, SCEPMT, SCEPMT, SCEPMT
3203.          WRITE (6,375) RESBMT, RESSMT
3204.          WRITE (6,376) SRGXMT, SRGXTM
3205.          WRITE (6,377) TWBLMT
3206.          IF (SNOW.EQ.YES .AND. PACK.GT.0.0)  WRITE (6,489)  TSNBML
```

```
C
  171 IF (PRINT.NE.DAYS)  GO TO 170
        SUMSND = 0.0
        PXSND  = 0.0
        MELRAD = 0.0
        RADMED = 0.0
        CDRMED = 0.0
        CONMED = 0.0
        CRAIND = 0.0
        SGMD   = 0.0
        SNEGMD = 0.0
        SEVAPD = 0.0
C
C                    FORMAT STATEMENTS
C
  378 FORMAT ('+',21X,F6.3,2X,F6.3)
  379 FORMAT (' ',A8,1X,I2,2X,I2,':',I2)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',8X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
  481 FORMAT ('0',11X,'MELT')
  482 FORMAT (' ',14X,'RADIATION',60X,F7.2)
  483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
  484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
  485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
  486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
  487 FORMAT (' ',14X,'CUM NEG HEAT',57X,F7.2)
  490 FORMAT ('0',11X,'SNOW PACK',63X,F7.2)
  491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
  492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
  488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
  367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
  368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
  369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
  383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
  370 FORMAT ('0',11X,'STORAGES')
  371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
  372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
  373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
  374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
  375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
  489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
  460 FORMAT ('0',8X,'WATER, MILLIMETERS')
4001  FORMAT  ('0',40X,'|',10X,'DISSOLVED IN WATER',5X,'|',
     1        6X,'ADSORBED TO SEDIMENT',5X,'|',/,
     2        ' ',4X,'DATE',6X,'TIME',7X,'FLOW   SEDIMENT',
     3        3X,'NO3+NO2',3X,'NH4',5X,'PO4',6X,'CL',
     4        5X,'NH4',3X,'ORG-N',5X,'PO4',3X,'ORG-P',6X,
     5        'TOT-N',3X,'TOT-P')
4002  FORMAT  (' ',24X,'(CFS)',5X,'(LB)',2X,8(4X,'(LB)'),7X,'(LB)',
     1        4X,'(LB)')
4003  FORMAT  (' ',24X,'(CMS)',5X,'(KG)',2X,8(4X,'(KG)'),7X,'(KG)',
     1        4X,'(KG)')
4004  FORMAT  (' ',32X,'(GM/L)',2X,4(2X,'(MG/L)'),4(3X,'(PPM)'),
     1        5X,'(MG/L)',2X,'(MG/L)')
4901  FORMAT ('0',A8,1X,I2,2X,I2,':',I2,3X,F8.3)
C
```

```
3263.        170 APR = 0.0
3264.            AEPIN = 0.0
3265.            ARU = 0.0
3266.            ARUI = 0.0
3267.            AROS = 0.0
3268.            ARGXT = 0.0
3269.            ASNET = 0.0
3270.            ASBAS = 0.0
3271.            ASRCH = 0.0
3272.            DO 172  I=1,5
3273.               AROSB(I) = 0.0
3274.               AINTF(I) = 0.0
3275.               AROSIT(I) = 0.0
3276.        172    CONTINUE
3277.      C
3291.        190 RETURN
3292.            END
4000.      C
4001.      C
4002.      C
4003.      C
4004.            SUBROUTINE SEDT(SFLAG)
4005.      C
4006.      C
4007.      C                                SEDIMENT EROSION MODEL
4008.      C
4009.      C
4010.            DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
4011.           1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
4012.            DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
4013.           1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
4014.           2 TEMPX(24),WINDX(24),RAIN(2883),UZSBMT(5),RESBMT(5),SRGXMT(5),
4015.           3 SRERMT(5)
4016.            DIMENSION AERSN(5),AERSNM(5)
4017.            DIMENSION ISTAR(5)
4017.1           DIMENSION LSRO(128),EROS(128),RROS(128)
4017.2           DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
4017.3          1          STEMP(24),UTEMP(24)
4018.      C
4019.            COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
4020.           1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
4021.           2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
4022.           3 JCOUNT,PRINT,INTK,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
4022.1          4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
4023.      C
4024.            COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
4025.           1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
4026.           2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
4027.           3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
4028.           4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
4029.           5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
4030.           6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
4031.           7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
4032.           8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
4033.           9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
4034.           * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
4035.           1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
4035.1          2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
4036.      C
4036.01    C   COMMON ALL DECLARATIONS FOR I*2 & R*4
4036.02          INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
4036.03          REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
4036.04         1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
4036.05         2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
4036.06    C
4036.07    C   COMMON LAND DECLARATIONS FOR I*2 & R*4
4036.08          INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
4036.09         1         NILSRO,NRROS
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4036.1          REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
4036.11        1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
4036.12        2      RXB,RCITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
4036.13        3      IPACK,TMIN,SUMSNM,PXSNM,XKB,MELRAM,RADMEM,CORMEM,CRAINM,
4036.14        4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
4036.15        5      NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
4036.16        6      ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
4036.17        7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
4036.18        8      KV,K24L,KK24,K24EL,EP,IFS,KB,EPXM,RESS1,RESS,SCEP,
4036.19        9      SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
4036.2         *      METOPT,CCFAC,SCF,IONS,F,DGM,WC,MPACK,EVAPSN,MELEV,
4036.21        1      TSNOW,PETMIN,RCITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
4036.22        2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
4036.23   C
4038.2          INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
4038.3         1           MNTH,NO,NOTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
4038.9          INTEGER*4  LCOP
4039.           DOUBLE PRECISION  MNAM
4039.1          INTEGER SFLAG
4040.     C
4042.           REAL  SRRTMT
4043.           REAL  KGPLB
4044.     C
4045.           DATA  ERSNT/0.0/, AERSN/5*0.0/
4046.           DATA  IASTRK/'*'/, IBLANK/' '/
4046.1          DATA LASTLP/-1/
4047.     C
4048.     C  SER = TRANSPORT CAPACITY OF OVERLAND FLOW IN TONS/ACRE
4049.     C  ERSN = EROSION REACHING STREAM
4050.     C  SRER = FINES DEPOSIT IN TONS/ACRE
4050.1    C  RER = FINES GENERATED IN INTERVAL
4051.     C
4052.     C                    ZEROING OF VARIABLES
4053.     C
4054.           SRERT = 0.0
4055.           DO 4599 I=1,5
4056.     4599  ISTAR(I) = IBLANK
4057.           ERSNT = 0.0
4057.1          RER = 0.0
4057.2          CR = COVER
4058.     C
4059.     C                    SOIL EROSION LOOP
4060.     C
4060.01   C     IF SNOWING (SFLAG=1) NO SOIL FINES GENERATED
4060.1          IF (SFLAG .EQ. 1)  GO TO 4399
4060.2    C
4060.3          IF (SNOW.EQ.NO .OR. PACK.LT.0.01)  GO TO 4389
4060.31   C     INCREASE COVER BY SNOW COVER WHEN RAIN ON SNOW OCCURS
4060.4             SCOVER = PACK/IPACK
4060.5             IF (SCOVER .GT. 1.0)  SCOVER = 1.0
4060.6             CR = COVER + (1.0-COVER)*SCOVER
4060.7    C
4061.      4389    RER = (1.0 - CR)*KRER*PR**JRER
4062.      4399 DO 4452 I=1,5
4063.                SRER(I) = SRER(I) + RER
4064.             IF ((ROSB(I)+RESB(I)).GT.0.0) GO TO 4444
4065.     C
4066.                ERSN(I) = 0.0
4067.                SER = 0.
4068.                GO TO 4446
4069.     C
4070.      4444      SER = KSER*(ROSB(I)+RESB(I))**JSER
4071.                IF (SER .LE. SRER(I)) GO TO 4501
4072.                SER = SRER(I)
4073.                ISTAR(I) = IASTRK
4074.     C
4075.      4501      ERSN(I) = SER*ROSB(I)/(ROSB(I)+RESB(I))
4076.                SRER(I) = SRER(I) - ERSN(I)
```

```
                IF (SRER(I) .LT. 0.) SRER(I) = 0.
C
 4446    AERSN(I) = AERSN(I) + ERSN(I)
 4452    CONTINUE
C
        IF (PRNTKE .EQ. 0)  GO TO 4490
C
           DO 4456  I=1,5
              ERSNT = ERSNT + AERSN(I)*0.2
              SRERT = SRERT + SRER(I)*0.2
              ERSTOM(I) = ERSTOM(I) + AERSN(I)
              ERSTOT(I) = ERSTOT(I) + AERSN(I)
 4456         CONTINUE
C
C                    CUMULATIVE RECORDS
C
        ERSNTM = ERSNTM + ERSNT
        ERSNTT = ERSNTT + ERSNT
C
        IF (PRNTKE .EQ. 2)  GO TO 4487
C
          ERSNTP = 0.0
          ERSNTK = 0.0
          ERSNKM = 0.0
          ERSNCM = 0.0
C
         IF (HYCAL .EQ. PROD)  GO TO 4460
         IF (RU .LT. HYMIN)  GO TO 4487
C
C   CONVERSION OF SEDIMENT LOSS TO LBS., KGS., KGS/MINUTE, AND
C                                        GM/L FOR OUTPUT
C
         ERSNTP = ERSNT*2000.*AREA
         ERSNTK = ERSNTP*.454
         ERSNKM = ERSNTK/TIMFAC
         ERSNCM = ERSNTP*454./(RU*TIMFAC*60.*28.32)
        IF (NUTR .EQ. YES)  GO TO 892
C
         WRITE (6,4484) ERSNTP, ERSNTK, ERSNKM, ERSNCM
        GO TO 893
C
892     IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  WRITE (6,4902)  ERSNTP
        IF (OUTPUT .EQ. METR)  WRITE (6,4902)  ERSNTK
C
893     IF (HYCAL.EQ.CALB .AND. PEST.EQ.NO .AND. NUTR.EQ.NO)
     1                  WRITE (6,4999) (ISTAR(I),I=1,5)
 4999            FORMAT ('+',74X,5A1)
         GO TO 4487
C
C
C                       PRINTING OF OUTPUT
C
 4460 IF (OUTPUT.EQ. METR) GO TO 4462
        WRITE (6,4480)
        WRITE (6,4481)  (AERSN(I), I=1,5), ERSNT
        WRITE (6,4482)  (SRER(I), I=1,5), SRERT
 4462 IF (OUTPUT.EQ. ENGL) GO TO 4487
        ERSNTI=ERSNT*METOPT*2.471
        SRRTMT=SRERT*METOPT*2.471
        DO 4461 I=1,5
          AERSNM(I)=AERSN(I)*METOPT*2.471
          SRERMT(I)=SRER(I)*METOPT*2.471
 4461 CONTINUE
        WRITE (6,4485)
        WRITE (6,4481) AERSNM, ERSNTI
        WRITE (6,4482) SRERMT, SRRTMT
C
```

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4144.      C                          FORMAT STATEMENTS
4145.      C
4146.       4480 FORMAT ('0',8X,'SEDIMENT, TONS/ACRE')
4147.       4481 FORMAT (' ',11X,'ERODED SEDIMENT',4X,5(3X,F7.3),4X,F7.3)
4148.       4482 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
4149.       4484 FORMAT ('+',30X,4(2X,F7.2))
4150.       4485 FORMAT ('0',8X,'SEDIMENT, TONNES/HECTARE')
4151.       4902 FORMAT ('+',30X,F8.2)
4152.      C
4153.       4487 DO 4489  I=1,5
4154.               AERSN(I) = 0.0
4155.       4489    CONTINUE
4156.      C
4157.       4490 CONTINUE
4157.01    C
4157.02    C        STORE EROSION DATA & WRITE TO DISK
4157.03    C
4157.04          IF (DSNERS.EQ.0) GO TO 1010
4157.05          IF (ERSNT.EQ.0.) GO TO 1010
4157.06          IF (LOOP.EQ.(LASTLP+1)) GO TO 1050
4157.07    C
4157.08    C     DATA COMPRESSION PERFORMED - NO ZEROS STORED
4157.09    C
4157.1           IHEAD = -LOOP
4157.11          EROS(NEROS) = IHEAD
4157.12          IF (NEROS.LT.TMBLSZ) GO TO 1090
4157.13          IF (OUTPUT.EQ.ENGL) GO TO 1060
4157.14          DO 1070 I = 1,TMBLSZ
4157.15    1070     EROS(I) = ERCS(I) *METOPT*2.471
4157.16    1060 IF(IDEBUG .EQ. CN) WRITE(6,9996) LOOP
4157.17    9996 FORMAT('0','DEBUG - - LOOP = ',I5)
4157.18          IF(IDEBUG .EQ. CN) CALL ERDBUG(EROS,TMBLSZ)
4157.19          WRITE(DSNERS) (EROS(I),I=1,TMBLSZ)
4157.21          DO 1080 I = 1,TMBLSZ
4157.22    1080     EROS(I) = 0.
4157.23          NEROS = 0
4157.24    1090 NEROS = NEROS + 1
4157.25    1050 EROS(NEROS) = ERSNT
4157.26          LASTLP = LOOP
4157.27          IF (NEROS.LT.TMBLSZ) GO TO 1000
4157.28          IF (OUTPUT.EQ.ENGL) GO TO 1020
4157.29          DO 1030 I = 1,TMBLSZ
4157.3     1030     EROS(I) = ERCS(I) *METOPT*2.471
4157.31    1020 IF(IDEBUG .EQ. CN) WRITE(6,9996) LOOP
4157.32          IF(IDEBUG .EQ. CN) CALL ERDBUG(EROS,TMBLSZ)
4157.33          WRITE(DSNERS) (EROS(I),I=1,TMBLSZ)
4157.34          DO 1040 I = 1,TMBLSZ
4157.35    1040     EROS(I) = 0.
4157.36          NEROS = 0
4157.37    1000 NEROS = NEROS + 1
4158.      C
4158.1      1010 CONTINUE
4159.           RETURN
4160.           END
4200.      C
4201.      C
4202.      C
4203.      C
4203.5          SUBROUTINE ERDBUG(ERCS,TMBLSZ)
4203.6          DIMENSION ERCS(128)
4203.7          INTEGER TMBLSZ
4203.8     C
4203.9     C     THIS PRINTS OUT EROSION FILES
4204.      C
4206.           WRITE(6,100)
4207.           KK = 0
4208.           DO 10 I=1,TMBLSZ
4209.              IF(EROS(I).GT.0.) GO TO 10
```

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4210.                IF(I.EQ.1) GO TO 20
4211.                J = I - 1
4212.                JJ = KK + 1
4213.                IHEAD = EROS(KK)
4214.                WRITE(6,110) IHEAD
4215.                WRITE(6,120) (EROS(L),L=JJ,J)
4216.        20      KK = I
4217.        10    CONTINUE
4217.1             IF(KK.EQ.0) GO TO 30
4217.2             IHEAD = EROS(KK)
4217.3             WRITE(6,110) IHEAD
4217.4       30    KK = KK + 1
4217.5             IF(KK.EQ.TMBLSZ) GO TO 40
4218.              WRITE(6,120) (EROS(L),L=KK,TMBLSZ)
4219.        100   FORMAT('0','WRITE TO DISK - EROS')
4220.        110   FORMAT(1X,I5)
4221.        120   FORMAT(1X,10(E10.3,2X),/)
4222.        40    RETURN
4223.              END
5000.       C
5001.       C
5002.       C
5003.       C
5003.5             SUBROUTINE ADSRB(UZSN,UZF,LZSN,LZF,
5003.6            1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
5003.7            2 APMODE,TPBAL,DEGSCM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
5003.8            3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
5003.9            4 DESOPP,SURF,SOIL,SULG)
5004.       C
5004.1      C
5004.2      C
5004.3             IMPLICIT  REAL(L)
5004.4      C
5005.              DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
5005.5            1 UZSB(5),APERCB(5),RIB(5),ERSN(5)
5006.              DIMENSION SPRP(5),UPRP(5),CT(5),ST(5),JFLAG(5),KD(5),
5006.5            3 CAD(5),CTJ(5),STJ(5),KFLAG(5),KDU(5),CADJ(5),STSMET(5),SASMET(5),
5007.             4 SCSMET(5),SDSMET(5),UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5)
5007.5             DIMENSION SAPS(5),SCPS(5),SPRS(5),SPRO(5),SPR(5),SPS(5),SCSC(5),
5008.             1 SASC(5),SDSC(5),SPOFS(5),ASPR(5),ASPRS(5),ASPRO(5),ASPRP(5)
5008.5             DIMENSION UPRI(5),JNFW(5),UDSC(5),UPR(5),UPS(5),UCSC(5),
5009.             1 UASC(5),AUPR(5),AUPRI(5),AUPRP(5),UPRISM(5)
5009.5             DIMENSION CTL(5),MFLAG(5),CADL(5),STL(5),KDL(5)
5010.              DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
5010.5            1           STEMP(24),UTEMP(24)
5011.       C
5011.5             COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
5012.             1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
5012.5            2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
5013.             3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
5013.5            4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
5014.       C
5014.5             COMMON /PESTC/
5015.             1 STST,PRSTCM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
5015.5            2 SCST,UPITOM,SCST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
5016.             3 UDST,SCS,FP,SCS,CMAX,SSTR1,SPROTT,JAS,SPRSTT,UCS,
5016.5            4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
5017.       C
5017.5      C    COMMON ALL DECLARATIONS FOR I*2 & R*4
5018.              INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
5018.5             REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
5019.             1       UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
5019.5            2       LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
5020.       C
5020.5      C
5021.              INTEGER TIMAP(12),YEARAP(12)
5021.5             INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
5022.             1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
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```
5022.5    C
5023.          INTEGER*4  APMCDE,DESORP,SURF,SOIL
5023.5    C
5024.          REAL   KK, INFW
5024.5         REAL  STSTMT, SASTMT, SCSTMT, SDSTMT
5025.          REAL  STSMET, SASMET, SCSMET, SDSMET
5025.5         REAL  MMPIN, METOPT
5026.          REAL  NP, KD, CT, ST, CAD
5026.5    C
5027.          REAL  UTSTMT, UASTMT, UCSTMT, UDSTMT
5027.5         REAL  UTSMET, UASMET, UCSMET, UDSMET
5028.          REAL  JNFW, KNFW, UZSN, UZF, LZSN, LZF
5028.5         REAL  KDU, CTU, STU, CADU
5029.     C
5029.5         REAL  LSTRMT, LASMET, LCSMET, LDSMET
5030.          REAL  GSTRMT, GASMET, GCSMET, GDSMET
5030.5         REAL  KDL, CTL, STL
5031.     C
5031.5         REAL  CTL,K,PTOT,CADL
5032.          INTEGER  MFLAG, JFLAG, KFLAG
5032.5    C
5033.          REAL     K,NI,FPLZ,TOTPAP,KOPT,MOPT,TOPT,TMAX,AK,BK,
5033.5        2         NGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
5034.         3         GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
5034.5        4         NIP,DEGLOM,DEGLOT,NCOM,UIST,SULG
5035.          REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
5035.5        2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
5036.         3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
5036.5        4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
5037.         5 UPRITT,UPRIS(5)
5037.5    C
5061.          DATA  SPST, SASCT, SCSCT, SPRT, SPRST, SPRTT, SPRPTT/7*0.0/
5062.          DATA  SPRCT, SPRPT/2*0.0/, INFW/0.0/
5063.          DATA  ASPR, ASPRS, ASPRD, ASPRP/20*0.0/
5064.          DATA  SDSC, SPCFS, SDSCT/11*0.0/
5065.     C
5066.          DATA  UPST, UASCT, UCSCT, UPRT/4*0.0/
5067.          DATA  UDSCT, UPRPT/2*0.0/, JNFW/5*0.0/, UPRIT/0.0/
5068.          DATA  AUPR, AUPRI, AUPRP/15*0.0/
5069.          DATA  AUPRP/0.0/
5070.     C
5071.          DATA  CT/5*0.0/,JFLAG/5*0/,CAD/5*0.0/,ST/5*0.0/
5072.          DATA  CTU/5*0.0/,KFLAG/5*0/,CADU/5*0.0/,STU/5*0.0/
5073.          DATA  CTL/5*0.0/,MFLAG/5*0/,CADL/5*0.0/,STL/5*0.0/,KDL/5*0.0/
5073.1         DATA KD,KDU/10*0.0/
5074.     C
5075.     C
5076.     C                    SURFACE SOLUTION ADSORPTION-DESORPTION MODEL
5077.     C
5078.     C                  ZEROING VARIABLES
5079.     C
5080.          STST = 0.0
5081.          SAST = 0.0
5082.          SCST = 0.0
5083.          SDST = 0.0
5084.          ERSNT = 0.0
5085.          ASPTOT = 0.0
5086.     C
5087.     C                  ADSORPTION-DESORPTION SOLUTION LOOP
5088.     C                      WITH REVERSIBLE DESORPTION
5089.     C
5090.          PA = 1.0 - A
5091.          Z = 1000000.**(NI-1)
5092.          KK = M*K*Z
5093.          DO 5320  I=1,5
5094.             INFW = 0.2*AREA*(P3+RESB1(I))*226512.
5095.             PTOT = SAS(I) + SCS(I) + SDS(I) + SSTR1(I)
5096.             ASPTOT = ASPTOT + PTOT
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5097.              IF (PTOT.GT.FP) GO TO 5315
5098.                 SAS(I) = PTOT
5099.                 SCS(I) = 0.0
5100.                 SDS(I) = 0.0
5101.                 JFLAG(I) = 0
5102.                 CT(I) = C
5103.                 GO TO 5320
5104.      5315    X = KK*CMAX**NI + FP
5105.              PSLD = PTOT - X - INFW*CMAX
5106.              IF (PSLD .LT. 0.0)  GO TO 5316
5107.                 SAS(I) = X
5108.                 SCS(I) = PSLD
5109.                 SDS(I) = CMAX*INFW
5110.                 JFLAG(I) = 0
5111.                 CT(I) = C
5112.                 GO TO 5320
5113.     C
5114.      5316       SCS(I) = 0.0
5115.                 IF (INFW.GE.0.001) GO TO 5321
5116.                 SAS(I) = PTOT
5117.                 SDS(I) = 0.0
5118.                 JFLAG(I) = 0
5119.                 CT(I) = C
5120.                 GO TO 5320
5121.     C
5122.     C           COMPUTE C AND X BY THE ADSORPTION EQUATION
5123.     C
5124.      5321       C = CMAX*PTOT/(X + INFW*CMAX)
5125.      5317       X = KK*C**NI + FP
5126.                 Q = (PTOT/(X+INFW*C)) - 1.
5127.                 IF (ABS(Q).LE.0.01) GO TO 5319
5128.                    C = C*PTOT/(X + INFW*C)
5129.                    GO TO 5317
5130.     C
5131.      5319          IF (DESORP .EQ. NO)  GO TO 5324
5132.     C
5133.           CALL DSPTN (I,CT,C,JFLAG,CAD,KD,K,Z,NCOM,
5134.          1            ST,X,M,NIP,FP,PTOT,INFW)
5135.     C
5136.      5324          SDS(I) = (C*INFW)*(PTOT/(X+C*INFW))
5137.                    SAS(I) = X*(PTOT/(X+C*INFW))
5138.     C
5139.      5320    CONTINUE
5140.     C
5141.     C                    PESTICIDE REMOVAL LOOP
5142.     C
5143.           DO 5330  I=1,5
5144.     C
5145.              QS = 400.*AREA*ERSN(I)/M
5146.              IF (QS .GT. 1.0)  QS = 1.0
5147.              SAPS(I) = SAS(I)*QS
5148.              SCPS(I) = SCS(I)*QS
5149.              SPRS(I) = SAPS(I) + SCPS(I)
5150.              SAS(I) = SAS(I) - SAPS(I)
5151.              SCS(I) = SCS(I) - SCPS(I)
5152.     C
5153.                 SPRO(I) = 0.0
5154.                 SPOFS(I) = 0.0
5155.                 SPRP(I) = 0.0
5156.                 SPR(I) = 0.0
5157.              IF (P3 +RESB1(I).LE.0.0) GO TO 5329
5158.                 SPRO(I) = SDS(I)*ROSB(I)/((RESB1(I)+P3)*PA)
5159.     C
5160.              SPOFS(I) = SCS(I)*(RESB(I)/(RESB1(I)+P3))
5161.              SPRP(I) = SCS(I) - SPRO(I) - SPOFS(I)
5162.              SPR(I) = SPRO(I) + SPRS(I) + SPRP(I)
5163.      5329    SDS(I) = SPOFS(I)
5164.     C
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5165.              ASPR(I) = ASPR(I) + SPR(I)
5166.              ASPRS(I) = ASPRS(I) + SPRS(I)
5167.              ASPRO(I) = ASPRO(I) + SPRO(I)
5168.              ASPRP(I) = ASPRP(I) + SPRP(I)
5169.      C
5170.      C
5171.              RESB1(I) = 0.0
5172.      C
5173.       5330   CONTINUE
5174.      C
5175.            IF (PRNTKE .EQ. 0)  GO TO 5390
5176.      C
5177.      C                    PREPARATION OF OUTPUT
5178.      C
5179.              DO 5335  I=1,5
5180.                 SPRT = SPRT +ASPR(I)
5181.                 SPROT = SPROT +ASPRO(I)
5182.                 SPRST = SPRST +ASPRS(I)
5183.                 SPRPT = SPRPT +ASPRP(I)
5184.      C
5185.                 SAST = SAST + SAS(I)
5186.                 SCST = SCST + SCS(I)
5187.                 SDST = SDST + SDS(I)
5188.      C
5189.                 SASC(I) = (SAS(I)/M)*1000000.
5190.                 SASCT = SASCT + SASC(I)*0.2
5191.                 SCSC(I) = (SCS(I)/M)*1000000.
5192.                 SCSCT = SCSCT + SCSC(I)*0.2
5193.                 SDSC(I) = (SDS(I)/M)*1000000.
5194.                 SDSCT = SDSCT + SDSC(I)*0.2
5195.      C
5196.                 STS(I) = SAS(I) + SCS(I) + SDS(I)
5197.                 SPS(I) = SASC(I) + SCSC(I) + SDSC(I)
5198.                 STST = STST + STS(I)
5199.                 SPST = SPST + SPS(I)*0.2
5200.      C
5201.                 LRGNT = LRGNT + LRGN(I)*0.2*AKLA
5202.      C
5203.       5335      CONTINUE
5204.      C
5205.      C                    CUMULATIVE RESULTS
5206.              DO 5337  I= 1,5
5207.                 PRSTOM(I) = PRSTOM(I) + ASPRS(I)
5208.                 PROTOM(I) = PROTOM(I) + ASPRO(I)
5209.                 PROTOT(I) = PROTOT(I) + ASPRO(I)
5210.       5337      PRSTOT(I) = PRSTOT(I) + ASPRS(I)
5211.      C
5212.              SPROTM = SPROTM + SPROT
5213.              SPRSTM = SPRSTM + SPRST
5214.      C
5215.              SPRTT = SPRTT + SPRT
5216.              SPROTT = SPROTT + SPROT
5217.              SPRPTT = SPRPTT + SPRPT
5218.              SPRSTT = SPRSTT + SPRST
5219.      C
5220.            IF (PRNTKE .EQ. 2)  GO TO 5370
5221.              IF (HYCAL .EQ. PROD)  GO TO 5340
5222.              IF (RJ .LT. HYMIN)  GO TO 5370
5223.                 SPRTGW = SPROT*454.
5224.                 SPRTCW = (SPROT/(RU*TIMFAC*60.*62.43))*1000000.
5225.                 SPRTGS = SPRST*454.
5226.                 SPRTCS = 0.0
5227.                 IF (ERSNT.GT.0.0)  SPRTCS = (SPRST/(ERSNT*2000.))*1000000.
5228.                 GO TO 5370
5229.      C                    PRINTING OF OUTPUT
5230.      C
5231.       5340 IF (OUTPUT.EQ. METR) GO TO 5341
5232.            WRITE (6,5350)
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5233.          WRITE (6,5351)  STS, STST
5234.          WRITE (6,5352)  SAS, SAST
5235.          WRITE (6,5353)  SCS, SCST
5236.          WRITE (6,5361) SDS, SDST
5237.          WRITE (6,5354)  SPS, SPST
5238.          WRITE (6,5352)  SASC, SASCT
5239.          WRITE (6,5353)  SCSC, SCSCT
5240.          WRITE (6,5361)  SDSC, SDSCT
5241.          WRITE (6,5355)  ASPR, SPRT
5242.          WRITE (6,5356)  ASPRS, SPRST
5243.          WRITE (6,5357)  ASPRO, SPROT
5244.          WRITE (6,5359)  ASPRP, SPRPT
5245.     5341 IF (OUTPUT.EQ. ENGL) GO TO 5370
5246.     C
5247.     C  METRIC CONVERSIONS FOR OUTPUT
5248.          STSTMT=STST*KGPLB
5249.          SASTMT=SAST*KGPLB
5250.          SCSTMT=SCST*KGPLB
5251.          SDSTMT=SDST*KGPLB
5252.          SPRT  =SPRT*KGPLB
5253.          SPRST =SPRST*KGPLB
5254.          SPROT =SPROT*KGPLB
5255.          SPRPT =SPRPT*KGPLB
5256.          DO 5343 I=1,5
5257.            STSMET(I)=STS(I)*KGPLB
5258.            SASMET(I)=SAS(I)*KGPLB
5259.            SCSMET(I)=SCS(I)*KGPLB
5260.            SDSMET(I)=SDS(I)*KGPLB
5261.            ASPR(I)  =ASPR(I)*KGPLB
5262.            ASPRS(I) =ASPRS(I)*KGPLB
5263.            ASPRO(I) =ASPRO(I)*KGPLB
5264.            ASPRP(I) =ASPRP(I)*KGPLB
5265.     5343 CONTINUE
5266.          WRITE (6,5350)
5267.          WRITE (6,5363) STSMET, STSTMT
5268.          WRITE (6,5352) SASMET, SASTMT
5269.          WRITE (6,5353) SCSMET, SCSTMT
5270.          WRITE (6,5361) SDSMET, SDSTMT
5271.          IF (OUTPUT.EQ. BOTH) GO TO 5345
5272.          WRITE (6,5354)  SPS, SPST
5273.          WRITE (6,5352)  SASC, SASCT
5274.          WRITE (6,5353)  SCSC, SCSCT
5275.          WRITE (6,5361)  SDSC, SDSCT
5276.     5345 WRITE (6,5374) ASPR,SPRT
5277.          WRITE (6,5356)  ASPRS, SPRST
5278.          WRITE (6,5357)  ASPRO, SPROT
5279.          WRITE (6,5359)  ASPRP, SPRPT
5280.     C
5281.     C
5282.     C                    ZEROING VARIABLES
5283.     C
5284.     5370 DO 5380  I=1,5
5285.             ASPR(I) = 0.0
5286.             ASPRO(I) = 0.0
5287.             ASPRS(I) = 0.0
5288.             ASPRP(I) = 0.0
5289.     5380    CONTINUE
5290.     C
5291.     5390 SPST = 0.0
5292.          SASCT = 0.0
5293.          SCSCT = 0.0
5294.          SDSCT = 0.0
5295.          SPRT = 0.0
5296.          SPRST = 0.0
5297.          SPROT = 0.0
5298.          SPRPT = 0.0
5299.     C
5300.          DO 5391  I= 1,5
```

```
5391 SSTR1(I) = 0.0
C
C
C
C                    UPPER ZONE SOLUTION ADSORPTION-DESORPTION MODEL
C
C
C                  ZEROING VARIABLES
C
      UTST = 0.0
      UAST = 0.0
      UCST = 0.0
      UDST = 0.0
      UIST = 0.0
      AUPTOT = 0.0
C
C                  SOLUTION ADSORPTION-DESORPTION LOOP
C
C  45302.4 = 0.2 * 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
C
      KK = MUZ*K*Z
C
      DO 6320  I=1,5
         JNFW(I) = AREA*PA*(UZSB(I)+APERCB(I)+INFL(I)+RGX(I))*45302.4
         PTOT = UAS(I) + UCS(I) + UDS(I) + SPRP(I) + USTR(I)
         AUPTOT = AUPTOT + PTOT
         C5 = 0.0
         IF (JNFW(I) .GT. 0.0)  C5 = UDS(I)/JNFW(I)
C
         IF (PTOT.GT.FPUZ) GO TO 6315
            UAS(I) = PTOT
            UCS(I) = 0.0
            UDS(I) = 0.0
            KFLAG(I) = 0
            CTU(I) = 0
            GO TO 6320
C
 6315    X = KK*CMAX**NI + FPUZ
         PSLD = PTOT - X - JNFW(I)*CMAX
         IF (PSLD .LT. 0.0)  GO TO 6316
            UAS(I) = X
            UCS(I) = PSLD
            UDS(I) = CMAX*JNFW(I)
            KFLAG(I) = 0
            CTU(I) = 0
            GO TO 6320
C
 6316       UCS(I) = 0.0
C
            C = C5
            IF (C .LE. 0.0)  C = 0.001
 6317       X = KK*C**NI + FPUZ
            Q = (PTOT/(X+JNFW(I)*C)) - 1.
            IF (ABS(Q).LE.0.01) GO TO 6319
               C = C*PTOT/(X+JNFW(I)*C)
               GO TO 6317
C
 6319          IF (JNFW(I) .LE. 0.001)  X = PTOT
               IF (DESORP .EQ. NO)  GO TO 6324
                  RJNFW = JNFW(I)
C
      CALL DSPTN (I,CTU,C,KFLAG,CADU,KDU,K,Z,NCOM,
     1            STU,X,MUZ,NIP,FPUZ,PTOT,RJNFW)
C
 6324          UDS(I) = (C*JNFW(I))*(PTOT/(X+C*JNFW(I)))
               UAS(I) = X*(PTOT/(X+C*JNFW(I)))
C
 6320    CONTINUE
```

```
5369.      C
5370.      C                    PESTICIDE REMOVAL LOOP
5370.1     C
5370.2     C  UZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN UZF*UZSN
5371.      C
5372.           DO 6330  I=1,5
5373.      C
5374.              IF (JNFW(I) .LE. 0.0001)  GO TO 6327
5375.              QSP = AREA*PA*(INFL(I)+APERCB(I))*45302.4/JNFW(I)
5375.1             UZFM = UZSB(I)/(UZSN*UZF)
5375.2             IF (UZFM.GE.1.0) UZFM = 1.0
5375.              UPRP(I) = UDS(I)*QSP*UZFM
5377.              IF (SRGX(I)+INTF(I) .LT. 0.0001)  GO TO 6329
5378.              QSI = AREA*PA*45302.4*RGX(I)/JNFW(I)
5379.              UPRII = UDS(I)*QSI
5380.              UPRIS(I) = UPRIS(I) + UPRII
5381.              UPRI(I)  = UPRIS(I)*INTF(I)/(SRGX(I)+INTF(I))
5382.              UPRIS(I) = UPRIS(I) - UPRI(I)
5383.              GO TO 6328
5384.       6327   UPRP(I) = 0.0
5385.       6329   UPRII = 0.0
5386.              UPRI(I) = 0.0
5387.       6328   UDS(I) = UDS(I) - UPRP(I) - UPRII
5388.              UPR(I) = UPRP(I) + UPRI(I)
5389.      C
5390.              AUPR(I) = AUPR(I) + UPR(I)
5391.              AUPRI(I) = AUPRI(I) + UPRI(I)
5392.              AUPRP(I) = AUPRP(I) + UPRP(I)
5393.              UIST = UIST + UPRIS(I)
5394.      C
5395.       6330   CONTINUE
5396.      C
5397.           IF (PRNTKE .EQ. 0)  GO TO 6380
5398.      C
5399.      C                    PREPARATION OF OUTPUT
5400.      C
5401.              DO 6335  I=1,5
5402.                 UPRT = UPRT + AUPR(I)
5403.                 UPRIT = UPRIT + AUPRI(I)
5404.                 UPRPT = UPRPT + AUPRP(I)
5405.      C
5406.                 UAST = UAST + UAS(I)
5407.                 UCST = UCST + UCS(I)
5408.                 UDST = UDST + UDS(I)
5409.      C
5410.                 UASC(I) = (UAS(I)/MUZ)*1000000.
5411.                 UCSC(I) = (UCS(I)/MUZ)*1000000.
5412.                 IF (UZSB(I) .LE. 0.0001)  GO TO 6333
5413.                 UDSC(I) = (UDS(I)/(UZSB(I)*AREA*45302.4))*1000000.
5414.                 GO TO 6334
5415.       6333      UDSC(I) = 0.0
5416.       6334      UPS(I) = UASC(I) + UCSC(I) + UDSC(I)
5417.      C
5418.                 UASCT = UASCT + UASC(I)*0.2
5419.                 UCSCT = UCSCT + UCSC(I)*0.2
5420.                 UDSCT = UDSCT + UDSC(I)*0.2
5421.                 UPST = UPST + UPS(I)*0.2
5422.      C
5423.                 UTS(I) = UAS(I) + UCS(I) + UDS(I) + UPRIS(I)
5424.                 UTST = UTST + UTS(I)
5425.      C
5426.       6335      CONTINUE
5427.      C
5428.      C                    CUMULATIVE RESULTS
5429.      C
5430.              DO 6340  I= 1,5
5431.                 UPITOM(I) = UPITOM(I) + AUPRI(I)
5432.       6340      UPITOT(I) = UPITOT(I) + AUPRI(I)
```

```
      UPRITM = UPRITM + UPRIT
      UPRITT = UPRITT + UPRIT
C
      IF (PRNTNE .EQ. 2)  GO TO 6365
C
      IF (HYCAL .EQ. PROD) GO TO 6341
      IF (RU.LT.HYMIN) GO TO 6365
         UPRTGW = UPRIT*434.
         UPRTCW = 1000000.*UPRIT/(RU*TIMFAC*60.*62.43)
         TPRTGW = UPRTGW + SPRTGW
         TPRTCW = UPRTCW + SPRTCW
         TPRTGM = TPRTGW/TIMFAC
         SPRTGM = SPRTGS/TIMFAC
      WRITE (6,6460) TPRTGW,TPRTGM,TPRTCW,SPRTGS,SPRTGM,SPRTCS
      GO TO 6365
C
C                    PRINTING OF OUTPUT
C
 6341 IF (OUTPUT.EQ. METR) GO TO 6342
      WRITE (6,6350)
      WRITE (6,5351)  UTS, UTST
      WRITE (6,5352)  UAS, UAST
      WRITE (6,5353)  UCS, UCST
      WRITE (6,5361)  UDS, UDST
      WRITE (6,6362)  UPRIS, UIST
      WRITE (6,5354)  UPS, UPST
      WRITE (6,5352)  UASC, UASCT
      WRITE (6,5353)  UCSC, UCSCT
      WRITE (6,5361)  UDSC, UDSCT
      WRITE (6,5355)  AUPR, UPRT
      WRITE (6,6358)  AUPRI, UPRIT
      WRITE (6,5359)  AUPRP, UPRPT
 6342 IF (OUTPUT.EQ. ENGL) GO TO 6365
C
C  METRIC CONVERSIONS FOR OUTPUT
      UTSTMT=UTST*KGPLB
      UASTMT=UAST*KGPLB
      UCSTMT=UCST*KGPLB
      UDSTMT=UDST*KGPLB
      UPRT  =UPRT*KGPLB
      UPRIT =UPRIT*KGPLB
      UPRPT =UPRPT*KGPLB
      UIST = UIST*KGPLB
      DO 6344 I=1,5
        UTSMET(I)=UTS(I)*KGPLB
        UASMET(I)=UAS(I)*KGPLB
        UCSMET(I)=UCS(I)*KGPLB
        UDSMET(I)=UDS(I)*KGPLB
        AUPRI(I)  =AUPR(I)*KGPLB
        AUPRI(I) =AUPRI(I)*KGPLB
        AUPRP(I) =AUPRP(I)*KGPLB
        UPRISM(I)=UPRIS(I)*KGPLB
 6344 CONTINUE
      WRITE (6,6350)
      WRITE (6,5363) UTSMET, UTSTMT
      WRITE (6,5352) UASMET, UASTMT
      WRITE (6,5353) UCSMET, UCSTMT
      WRITE (6,5361) UDSMET, UDSTMT
      WRITE (6,6362) UPRISM, UIST
      IF (OUTPUT.EQ. BOTH) GO TO 6345
      WRITE (6,5354)  UPS, UPST
      WRITE (6,5352)  UASC, UASCT
      WRITE (6,5353)  UCSC, UCSCT
      WRITE (6,5361)  UDSC, UDSCT
 6345 WRITE (6,5374) AUPR, UPRT
      WRITE (6,6358)  AUPRI, UPRIT
      WRITE (6,5359)  AUPRP, UPRPT
```

```
C
C
C                    ZEROING VARIABLES
C
 6365 DO 6370  I=1,5
         AUPR(I) = 0.0
         AUPRI(I) = 0.0
         AUPRP(I) = 0.0
 6370    CONTINUE
C
 6380 UPST = 0.0
      UASCT = 0.0
      UCSCT = 0.0
      UDSCT = 0.0
      UPRT = 0.0
      UPRPT = 0.0
      UPRIT = 0.0
C
      DO  6381  I= 1,5
 6381 USTR(I) = 0.0
C
C
C
C                                LOWER ZONE AND GROUNDWATER
C                                SOLUTION ADSORPTION-DESORPTION MODEL
C
C
C
C
C                    SOLUTION ADSORPTION-DESORPTION LOOP
C
      LCS = 0.0
      LAS = 0.0
      LDS = 0.0
      LPRP = 0.0
      ALPTOT = 0.0
C
      KNFW = AREA*(LZS+DPST)*226512.
      KK = MLZ*K*Z
C
      DO 7305  I=1,5
         LSTR = LSTR + UPRP(I)
         ALPTOT = ALPTOT + LSTR
 7305    CONTINUE
C
         IF (LSTR .LE. 0.0001)  GO TO 7330
C
      I=1
      PTOT = LSTR
      C5 = 0.0
      IF (KNFW .GT. 0.0)  C5 = LAS/KNFW
      IF (PTOT.GT.FPLZ) GO TO 7315
         LAS = PTOT
         LCS = 0
         LDS = 0
         MFLAG(I) = 0
         CTL(I) = 0
         GO TO 7320
C
 7315 X = KK*CMAX**NI + FPLZ
      PSLD = PTOT - X - KNFW*CMAX
      IF (PSLD .LT. 0.0)  GO TO 7316
         LAS = X
         LCS = PSLD
         LDS = CMAX*KNFW
         MFLAG(I) = 0
         CTL(I) = 0
         GO TO 7320
```

```
C
 7316    LCS = C.0
C
         C = C5
         IF (C .LE. C.0)  C = 0.001
 7317    X = KK*C**NI + FPLZ
         Q = (PTOT/(X+KNFW*C)) - 1.
         IF (ABS(Q).LE.0.01) GO TO 7319
            C = C*PTOT/(X+KNFW*C)
            GO TO 7317
C
 7319 IF (KNFW .LE. 0.001)  X = PTOT
      IF (DESORP .EQ. NO) GO TO 7324
C
      CALL DSPTN (I,CTL,C,MFLAG,CADL,KDL,K,Z,NCOM,
     1            STL,X,MLZ,NIP,FPLZ,PTOT,KNFW)
C
 7324   LDS = (C*KNFW)*(PTOT/(X+C*KNFW))
            LAS = X*(PTOT/(X+C*KNFW))
C
 7320    CONTINUE
C
C                    PESTICIDE REMOVAL LOOP
C
C  LZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN LZF*LZSN
C
      LZFM = LZS/(LZSN*LZF)
      IF (LZFM.GE.1.0) LZFM =1.0
      LPRP = LDS*DPST*LZFM/(DPST+LZS)
      LDS = LDS - LPRP
C
      LSTR = LAS + LCS + LDS
C
      ALPRP = ALPRP + LPRP
C
 7330 IF (PRNTKE .EQ. 2)  GO TO 7379
      IF (PRNTKE.NE.1 .OR. HYCAL.EQ.CALB)  GO TO 7380
C
C                    PREPARATION OF OUTPUT
C
C
      LASC = (LAS/MLZ)*1000000.
      LCSC = (LCS/MLZ)*1000000.
      LDSC = (LDS/(LZS*AREA*226512.))*1000000.
C
C                     PRINTING OF OUTPUT
C
      IF (OUTPUT.EQ. METR) GO TO 7340
      WRITE (6,7350)
      WRITE (6,7351)  LSTR
      WRITE (6,7352)  LAS
      WRITE (6,7353)  LCS
      WRITE (6,7354)  LDS
      WRITE (6,7355)
      WRITE (6,7352)  LASC
      WRITE (6,7353)  LCSC
      WRITE (6,7354)  LDSC
      WRITE (6,7357)  ALPRP
      WRITE (6,7359)  ALPRP
 7340 IF (OUTPUT.EQ. ENGL) GO TO 7379
C
C  METRIC CONVERSIONS FOR OUTPUT
      LSTRMT=LSTR*KGPLB
      LASMET=LAS*KGPLB
      LCSMET=LCS*KGPLB
      LDSMET=LDS*KGPLB
      ALPRP =ALPRP*KGPLB
      WRITE (6,7350)
```

```
5632.          WRITE (6,7360) LSTKMI
5633.          WRITE (6,7352) LASMET
5634.          WRITE (6,7353) LCSMET
5635.          WRITE (6,7354) LDSMET
5636.          IF (OUTPUT.EQ. BOTH) GO TO 7345
5637.          WRITE (6,7355)
5638.          WRITE (6,7352)  LASC
5639.          WRITE (6,7353)  LCSC
5640.          WRITE (6,7354)  LDSC
5641.     7345 WRITE (6,7361) ALPRP
5642.          WRITE (6,7359) ALPRP
5643.     C
5644.     C
5645.     C                    ZEROING OF VARIABLES
5646.     C
5647.     7379 ALPRP = 0.0
5648.     C
5649.     7380 CONTINUE
5650.     C
5651.     C  SULG IS THE SUMMATION OF PESTICIDE IN STORAGE IN THE SURFACE,
5652.     C   UPPER, AND LOWER ZONES (IT DOES NOT INCLUDE PESTICIDE IN
5653.     C   GROUNDWATER STORAGE) AND IS USED AS A CHECK IN MAIN TO DECIDE
5654.     C   WHETHER OR NOT TO CONTINUE PESTICIDE CALCULATIONS
5655.     C
5656.          SULG = ASPTOT + AUPTOT + ALPTOT
5657.     C
5658.     C
5659.     C                              GROUNDWATER ADSORPTION-DESORPTION MODEL
5660.     C
5661.     C
5662.          GSTR = GSTR + LPRP
5663.          IF (FPLZ .GT. 0.0)  GO TO 7520
5664.             GAS = 0.0
5665.             GDS = GSTR
5666.             GCS = 0.0
5667.     C
5668.     7520    GAS = GSTR
5669.             GCS = 0.0
5670.             GDS = 0.0
5671.     C
5672.          IF ((PRNTKE .NE. 1).OR.(HYCAL.EQ.CALB))  GO TO 7580
5673.     C
5674.     C                    PRINTING OF OUTPUT
5675.     C
5676.          IF (OUTPUT.EQ. METR) GO TO 7530
5677.          WRITE (6,7550)
5678.          WRITE (6,7351)  GSTR
5679.          WRITE (6,7352)  GAS
5680.          WRITE (6,7353)  GCS
5681.          WRITE (6,7354)  GDS
5682.     7530 IF (OUTPUT.EQ. ENGL) GO TO 7580
5683.     C
5684.     C  METRIC CONVERSIONS FOR OUTPUT
5685.          GSTRMT=GSTR*KGPLB
5686.          GASMET=GAS*KGPLB
5687.          GCSMET=GCS*KGPLB
5688.          GDSMET=GDS*KGPLB
5689.          WRITE (6,7550)
5690.          WRITE (6,7360) GSTRMT
5691.          WRITE (6,7352) GASMET
5692.          WRITE (6,7353) GCSMET
5693.          WRITE (6,7354) GDSMET
5694.     C
5695.     7580 CONTINUE
5696.     C
5697.     C                    FORMAT STATEMENTS
5698.     C
```

```
 5350 FORMAT  ('0', 5X,'SURFACE LAYER PESTICIDE')
 5351 FORMAT  ('0',8X,'PESTICIDE, LBS',8X,5(3X,F7.3),3X,F8.3)
 5352 FORMAT  (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 5353 FORMAT  (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 5354 FORMAT  ('0',8X,'PESTICIDE, PPM',8X,5(3X,F7.3),3X,F8.3)
 5355 FORMAT  ('0',8X,'REMOVAL, LBS',10X,5(3X,F7.3),3X,F8.3)
 5356 FORMAT  (' ',11X,'SEDIMENT',11X,5(3X,F7.3),3X,F8.3)
 5357 FORMAT  (' ',11X,'OVERLAND FLOW',6X,5(3X,F7.3),3X,F8.3)
 5359 FORMAT  (' ',11X,'PERCOLATION',8X,5(3X,F7.3),3X,F8.3)
 5361 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 5363 FORMAT ('0',8X,'PESTICIDE, KGS',8X,5(3X,F7.3),3X,F8.3)
 5374 FORMAT ('0',8X,'REMOVAL, KGS',10X,5(3X,F7.3),3X,F8.3)
C
 6350 FORMAT  ('0', 5X,'UPPER ZONE LAYER PESTICIDE')
 6358 FORMAT  (' ',11X,'INTERFLOW',10X,5(3X,F7.3),3X,F8.3)
 6362 FORMAT  (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 6460 FORMAT  ('+',72X,2(3X,F8.3,2X,F8.3,2X,F7.3))
C
 7350 FORMAT  ('0', 5X,'LOWER ZONE LAYER PESTICIDE')
 7351 FORMAT  ('0',8X,'PESTICIDE, LBS',61X,F8.3)
 7352 FORMAT  (' ',11X,'ADSORBED',64X,F8.3)
 7353 FORMAT  (' ',11X,'CRYSTALLINE',61X,F8.3)
 7354 FORMAT  (' ',11X,'DISSOLVED',63X,F8.3)
 7355 FORMAT  ('0',8X,'PESTICIDE, PPM',61X,F8.3)
 7357 FORMAT  ('0',8X,'REMOVAL, LBS',63X,F8.3)
 7359 FORMAT  (' ',11X,'PERCOLATION',61X,F8.3)
 7360 FORMAT  ('0',8X,'PESTICIDE, KGS',61X,F8.3)
 7361 FORMAT  ('0',8X,'REMOVAL, KGS',63X,F8.3)
C
 7550 FORMAT  ('0',5X,'GROUNDWATER LAYER PESTICIDE')
      RETURN
      END
C
C
C
C
      SUBROUTINE DSPTN (I,CT,C,JFLAG,CAD,KD,K,Z,NCOM,
     1                  ST,X,M,NIP,FP,PTOT,INFW)
C
C
C
      DIMENSION CT(5),JFLAG(5),CAD(5),KD(5),ST(5)
C
      INTEGER I,JFLAG
      REAL CT,C,CAD,KD,K,Z,NCOM,ST,X,M,NIP,FP,PTOT,INFW
C
C  THE DESORPTION ALGORITHM IS BASED ON THE FREUNDLICH EQUATION; THE
C  DIFFERENCE BEING THAT THE CONSTANT (K) AND EXPONENT (N) OF THE
C  DESORPTION EQUATION DIFFER FROM THE ADSORPTION VALUES.  DESORPTION
C  OCCURS WHEN THE CONCENTRATION OF PESTICIDE IN WATER (C) IS LESS THAN
C  THE CONCENTRATION (CT) AT THE LAST TIME STEP.  THE DESORPTION
C  EXPONENT (NP -- INPUTTED BY THE USER) AND THE DESORPTION CONSTANT
C  (KD -- CALCULATED BY SETTING THE DESORPTION EQUATION EQUAL TO THE
C  ADSORPTION EQUATION AND SOLVING FOR KD) THEN DEFINE THE NEW DESORP-
C  TION CURVE.  THE ASSUMPTION OF REVERSIBLE DESORPTION IS MADE.  ONCE
C  DESORPTION STOPS ADSORPTION BEGINS BY MOVING BACK UP THE DESORPTION
C  CURVE UNTIL IT INTERSECTS THE ADSORPTION CURVE (I.E., WHEN C EQUALS
C  CAD -- THE CONCENTRATION OF PESTICIDE IN WATER AT WHICH THE ADSORP-
C  TION AND DESORPTION CURVES INTERSECT).  THEN ADSORPTION CONTINUES UP
C  THE ADSORPTION CURVE UNTIL DESORPTION OCCURS AGAIN.  DEFINITIONS OF
C  THE DESORPTION VARIABLES FOLLOW BELOW.
C
C          CT  :  CONCENTRATION OF PESTICIDE IN WATER (LB/LB)
C                     AT THE LAST TIME INTERVAL
C          CAD  :  CONCENTRATION C AT WHICH THE ADSORPTION AND
C                     DESORPTION EQUATIONS MEET, CAD IS SET
C                     EQUAL TO CT WHEN DESORPTION BEGINS AS A
C                     MARKER TO LATER DETERMINE WHEN THE ADSORP-
```

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C                    TION PROCESS LEAVES THE REVERSIBLE DESORP-
C                    TION CURVE AND RETURNS TO THE NON-REVERSIBLE
C                    ADSORPTION CURVE
C          ST   :  CONCENTRATION OF ADSORBED PESTICIDE IN THE SOIL
C                     (LB/LB) AT THE LAST TIME INTERVAL
C          JFLAG  :  FLAG WHICH NOTES WHETHER C WAS CALCULATED ON THE
C                     ADSORPTION CURVE DURING LAST TIME STEP (JFLAG=0)
C                     OR ON THE DESORPTION CURVE (JFLAG=1)
C          NP   :  DESORPTION EXPONENT, APPROXIMATELY 2.3 TIMES N
C                     (INPUTTED BY USER)
C          NIP  :  INVERSE OF NP
C          KD   :  DESORPTION CONSTANT FOR FREUNDLICH CURVE
C          NCOM  :  RATIO OF NIP TO NI
C
C
      IF (CT(I).LE.C) GO TO 5396
      IF (JFLAG(I).EQ.1) GO TO 5393
C
      CAD(I) = CT(I)
      KD(I) = ((K*Z)**NCOM)*(ST(I)**(1.-NCOM))
 5393 X = M*KD(I)*(C**NIP) + FP
      Q = (PTOT/(X+INFW*C)) - 1.0
      IF (ABS(Q).LE.0.01) GO TO 5395
      C = C*PTOT/(X+INFW*C)
      GO TO 5393
C
 5395 JFLAG(I) = 1
      CT(I) = C
      GO TO 5398
C
 5396 IF (JFLAG(I).EQ.0) GO TO 5397
      IF (C.LT.CAD(I)) GO TO 5393
C
 5397 JFLAG(I) = 0
      CT(I) = C
      ST(I) = X/M
      CAD(I) = C
C
 5398 RETURN
      END
C
C
C
C
                    SUBROUTINE DEGRAD(
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SULG,DEGCON)
C
C
C                         DEGRADATION MODEL
C
C
C
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24)
C
      COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,PJ,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /PESTC/
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```
6026.          1 STST,PRSTCM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
6027.          2 SCST,UPITCM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
6028.          3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
6029.          4 FPUZ,UDS,UPRITM,USTR,JPRITT,UPRIS
6034.     C
6034.01   C   COMMON ALL DECLARATIONS FOR I*2 & R*4
6034.11         INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
6034.21         REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
6034.31        1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
6034.41        2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
6034.51   C
6035.     C
6037.           REAL  MMPIN,METOPT,LMAVG
6038.1          INTEGER*4  BOTH,CALB,DAYS,ENDL,HOUR,HYCAL,INPUT,INTR,METR,
6038.2         1           MNTH,NO,NOTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
6038.3    C
6038.4          INTEGER*4  APMCDE,DESORP,SURF,SOIL
6039.     C
6039.05          INTEGER TIMAP(12),YEARAP(12)
6039.1           REAL   K,NI,FPLZ,TOTPAP,DEGCON,
6039.2         2        KGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
6039.3         3        GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
6039.4         4        NIP,DEGLOM,DEGLOT,NCOM,JIST,SULG
6039.5          REAL  STST,PRSTCM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
6039.6         2 PROTOT(5),SCST,UPITCM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
6039.7         3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
6039.8         4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
6039.9         5 UPRITT,JPRIS(5)
6040.     C
6041.     C
6042.     C                              DEGRADATION OF PESTICIDE FROM ADSORBED (A),
6043.     C                              CRYSTALLINE (C), AND DISSOLVED (D) FORMS
6044.     C                              DEGCON = FIRST ORDER DECAY RATE (PER DAY)
6045.     C
6053.     C
6059.     C                   INITIALIZE PARAMETERS
6060.           DEGS = 0.0
6061.           DEGU = 0.0
6062.           DEGL = 0.0
6088.     C
6089.06   C                                 DEGRADATION OF PESTICIDE
6089.07   C
6089.08   C                          SURFACE ZONE
6089.09   C
6089.1          IF (STST .LE. 0.0)  GO TO 8022
6089.11         STST = 0.0
6089.12         DO 8020 I=1,5
6089.17            DEGSA = DEGCON*SAS(I)
6089.18            SAS(I) = SAS(I) - DEGSA
6089.19            SAST = SAST - DEGSA
6089.2             DEGSC = DEGCON*SCS(I)
6089.21            SCS(I) = SCS(I) - DEGSC
6089.22            SCST = SCST - DEGSC
6089.23            DEGSD = DEGCON*SDS(I)
6089.24            SDS(I) = SDS(I) - DEGSD
6089.25            SDST = SDST - DEGSD
6089.26            DEGS = DEGS + DEGSA + DEGSC + DEGSD
6089.27            STS(I) = SAS(I) + SCS(I) + SDS(I)
6089.28            STST = STST + STS(I)
6089.29     8020 CONTINUE
6089.3    C
6089.31   C                          UPPER ZONE
6089.32   C
6089.33     8022 IF (UTST .LE. 0.0)  GO TO 8026
6089.34         UTST = 0.0
6089.35         DO 8024 I=1,5
6089.4             DEGUA = DEGCON*UAS(I)
6089.41            UAS(I) = UAS(I) - DEGUA
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```
6089.42            UAST = UAST - DEGUA
6089.43            DEGUC = DEGCCN*UCS(I)
6089.44            UCS(I) = UCS(I) - DEGUC
6089.45            UCST = UCST - DEGUC
6089.46            DEGUD = DEGCCN*UDS(I)
6089.47            UDS(I) = UDS(I) - DEGUD
6089.48            UDST = UDST - DEGUD
6089.49            DEGU = DEGU + DEGUA + DEGUC + DEGUD
6089.5             UTS(I) = UAS(I) + UCS(I) + UDS(I) + UPRIS(I)
6089.51            UTST = UTST + UTS(I)
6089.52     8024 CONTINUE
6089.53    C
6089.54    C                        LOWER ZONE
6089.55    C
6089.56     8026 IF (LSTR .LE. 0.0)  GO TO 8090
6090.          DEGLA = DEGCCN*LAS
6091.          LAS = LAS - DEGLA
6092.          DEGLC = DEGCCN*LCS
6093.          LCS = LCS - DEGLC
6094.          DEGLD = DEGCCN*LDS
6095.          LDS = LDS - DEGLD
6096.          DEGL = DEGLA + DEGLC + DEGLD
6097.          LSTR = LAS + LCS + LDS
6098.     C
6099.      8090       CONTINUE
6100.     C
6101.     C
6102.     C
6103.     C                 CUMULATIVE RESULTS
6104.     C
6105.          DEGSCM = DEGSCM + DEGS
6106.          DEGSOT = DEGSOT + DEGS
6107.          DEGUOM = DEGUOM + DEGU
6108.          DEGUOT = DEGUOT + DEGU
6109.          DEGLOM = DEGLOM + DEGL
6110.          DEGLOT = DEGLOT + DEGL
6111.     C
6112.          TDEG = DEGS + DEGU + DEGL
6113.     C
6114.            IF ((PRNTKE .NE. 1).OR.(HYCAL.EQ.CALB))  GO TO 8600
6115.     C
6116.          IF (OUTPUT.EQ. METR) GO TO 8200
6117.             WRITE (6,8505)
6118.             WRITE (6,8501) TDEG
6119.             WRITE (6,8502) DEGS
6120.             WRITE (6,8503) DEGU
6121.             WRITE (6,8507) DEGL
6122.      8200 IF (OUTPUT.EQ. ENGL) GO TO 8600
6123.     C
6124.     C  METRIC CONVERSIONS FOR OUTPUT
6125.          TDEGMT=TDEG*KGPLB
6126.          DEGSMT=DEGS*KGPLB
6127.          DEGUMT=DEGU*KGPLB
6128.          DEGLMT=DEGL*KGPLB
6129.          WRITE (6,8506)
6130.          WRITE (6,8501) TDEGMT
6131.          WRITE (6,8502) DEGSMT
6132.          WRITE (6,8503) DEGUMT
6133.          WRITE (6,8507) DEGLMT
6134.     C
6135.     C
6136.      8501 FORMAT (' ',8X,'TOTAL',71X,F7.3)
6137.      8502 FORMAT (' ',8X,'FROM SURFACE',64X,F7.3)
6138.      8503 FORMAT (' ',8X,'FROM UPPER ZONE',61X,F7.3)
6139.      8505 FORMAT ('0',5X,'PESTICIDE DEGRADATION LOSS, LBS.')
6140.      8506 FORMAT ('0',5X,'PESTICIDE DEGRADATION LOSS, KGS.')
6141.      8507 FORMAT (' ',8X,'FROM LOWER ZONE',61X,F7.3)
6142.     C
```

```
 8600 RETURN
      END
C
C
C
C
C
      SUBROUTINE NUTRIO (IOERR,INTRVL,NAPP,SNAPL,UNAPL,TIMHR,
     1                   INPUT,OUTPUT,APDAY,KNI,KPI,ULUPF,LZUPF)
C
C                          THIS SUBROUTINE READS NUTRIENT INPUT SEQ.
C                          FOR REACTION RATES, INITIAL STORAGES, AND
C                          APPLICATIONS.  INPUT INFORMATION IS SCANNED
C                          FOR ERRORS WHICH ARE FLAGGED BY IOERR=1.
C                          ON RETURN TO MAIN IOERR=1 WILL STOP THE RUN
C
C                          SUBROUTINE ALSO OUTPUTS REACTION RATES,
C                          INITIAL STORAGES, AND APPLICATIONS
C
C                          DECLARATIONS
C
C                          COMMON VARIABLES
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1         SNT(20),SNRSM(20,5),SNRGM(20,5),
     2         UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3         NRSM(20,5),LNRPM(20),
     4         SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5         SNRSY(20,5),SNRGY(20,5),UNRIY(20,5),NRSY(20,5),
     6         LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7         TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8         KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNRGM,UN,UNT,UNI,UNIT,
     1             UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2             SNRSY,SNRGY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3             TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4             KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5             TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
      INTEGER  NAPPL,NAPP,TIMHAR,TIMHR
      INTEGER*4  INPUT,OUTPUT
C
      INTEGER  NSTRT,NENC,APDAY(5),IOERR,ICHK,IZONE,IBLK,J,
     1            IAPPL
C
      REAL  SNAPL(20,5,5),SNAPLT(20),UNAPL(20,5,5),UNAPLT(20),
     1         TNMET,TPMET,TCLMET,KNI(8,4),KPI(5,4),ULUPTK(12),
     2         LZUPTK(12),LZUPF(12),ULUPF(12)
C
      DOUBLE PRECISION  CONC, LBPAC, KGPHA, NTRT, CHAR8, BLANK8
C
C
C                    DATA INPUT -- NAMELIST VARIABLES
C
C         NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C     NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C     READ STATEMENTS.  ADD C TO COLUMN 1 IN THE FORMATTED READ
C     STATEMENTS TO DEACTIVATE THAT SECTION OF CODE.
C
C
      NAMELIST /NUTRIN/ TSTEP,NAPPL,TIMHAR
      NAMELIST /PLANTU/ ULUPTK
      NAMELIST /PLANTL/ LZUPTK
C
```

```
C
C                                CHARACTER STRINGS USED TO COMPARE AND
C                                INTERPRET INPUT SEQUENCE, NAMES OF
C                                REACTION RATES, AND INPUT UNITS OPTION.
C
      INTEGER*4  CHAR,TYPE,BLANK,REAC,NITR,PHOS,CHLO,END,SURF,
     1         UPPE,LOWE,GROU,TEMP,INIT,APPL,METR,ENGL,
     2         KNNAME(8), KPNAME(5)
C
C                                INITIALIZATION OF STORAGES AND FLAGS
C
      DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,NTRT/'NUTRIENT'/
      DATA BLANK8/'        '/, BLANK/'    '/, REAC/'REAC'/
      DATA NITR/'NITR'/,PHOS/'PHOS'/,CHLO/'CHLO'/,END/'END '/
      DATA SURF/'SURF'/,UPPE/'UPPE'/,LOWE/'LOWE'/,GROU/'GROU'/
      DATA TEMP/'TEMP'/,INIT/'INIT'/,APPL/'APPL'/,METR/'METR'/
      DATA ENGL/'ENGL'/
      DATA KNNAME/'  K1', '  KD', ' KPL', ' KAM',
     1            ' KIM', 'KKIM', ' KSA', ' KAS'/
      DATA KPNAME/'  KM', ' KIM', ' KPL', ' KSA', 'KAS'/
      IOERR = 0
      SFLG = 1
      UFLG = 1
      LFLG = 1
      GFLG = 1
      DO 130  J=1,20
         DO 120  IBLK=1,5
            SN(J,IBLK) = 0.0
            UN(J,IBLK) = 0.0
            UNI(J,IBLK) = 0.0
120      CONTINUE
         LN(J) = 0.0
         GN(J) = 0.0
130   CONTINUE
      DO 135  IZONE=1,4
         DO 132  J=1,8
            KNI(J,IZONE) = 0.0
132      CONTINUE
         DO 134  J=1,5
            KPI(J,IZONE) = 0.0
134      CONTINUE
135   CONTINUE
C
C
136   READ (5,3001)  CHAR8
      WRITE (6,7777) CHAR8
7777  FORMAT (' ',A8)
      IF (CHAR8 .EQ. BLANK8)  GO TO 136
      IF (CHAR8 .EQ. NTRT)  GO TO 142
         IOERR = 1
         WRITE (6,4599)  CHAR8
         RETURN
C
C
C                          DATA INPUT -- NAMELIST VARIABLES
C
C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C     NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C     READ STATEMENTS.  ADD C TO COLUMN 1 IN THE THREE FORMATTED
C     READ STATEMENTS (DIRECTLY BELOW) TO DEACTIVATE THAT
C     SECTION OF CODE.
C
C
 142  READ (5,NUTRIN)
      READ (5,PLANTU)
      READ (5,PLANTL)
C
C142  READ (5,5000) TSTEP,NAPPL,TIMHAR
```

```
C     READ (5,5001) (ULUPTK(I),I=1,12)
C     READ (5,5001) (LZUPTK(I),I=1,12)
C
C          THE FOLLOWING ASSIGNMENT IS DUE TO THE NAMELIST LISTS
C      OF JLUPTK AND LZUPTK NOT BEING ABLE TO BE USED IN AN ARGUMENT
C      LIST BEFORE BEING READ IN A NAMELIST.
C
      DO 143 J=1,12
         ULUPF(J) = ULUPTK(J)
         LZUPF(J) = LZUPTK(J)
143   CONTINUE
C
      WRITE (6,4600)
      WRITE (6,4005)
      WRITE (6,4005)
      WRITE (6,4610)  TSTEP,NAPPL,TIMHAR,ULUPTK,LZUPTK
      NAPP=NAPPL
      TIMHR = TIMHAR
C
C                              CHECK TSTEP TO SEE IF AN INTEGER NUMBER ARE
C                              IN A DAY (1440 MIN) AND CHECK THAT TSTEP IS
C                              AN INTEGER MULTIPLE OF THE SIMULATION
C                              INTERVAL (5 OR 15 MIN).
C                              DELT IS THE TIME STEP IN HOURS BECAUSE
C                              REACTION RATES ARE PER HOUR (INTERNALLY).
C
      ICHK = 0
      ITSTEP=TSTEP
      IF ( MOD(1440,ITSTEP) .NE. 0)  ICHK=1
      IF ( MOD(ITSTEP,INTRVL) .NE. 0)  ICHK=1
      IF (ICHK .EQ. 0)  GO TO 145
         WRITE (6,4770) TSTEP
         TSTEP = 60
145   DELT = TSTEP/60.
      NSTEP = 1440/TSTEP
C
C
C                              INPUT REACTION RATES
C
C
150   READ (5,3000)  CHAR
      IF (CHAR .EQ. BLANK)  GO TO 150
      IF (CHAR .EQ. REAC)  GO TO 160
         IOERR = 1
         WRITE (6,4619)
         WRITE (6,4630)  REAC, CHAR
         RETURN
160   READ (5,3000)  TYPE
      IF (TYPE .EQ. BLANK)  GO TO 160
      IF (TYPE .EQ. NITR)  GO TO 170
      IF (TYPE .EQ. PHOS)  GO TO 220
      IF (TYPE .EQ. END)  GO TO 300
         IOERR = 1
         WRITE (6,4619)
         WRITE (6,4640)  TYPE
         RETURN
C
C                              NITROGEN RATES
C
170   READ (5,3000)  CHAR
      IF (CHAR .EQ. SURF)  GO TO 180
         IOERR = 1
         WRITE (6,4620)  TYPE
         WRITE (6,4630)  SURF, CHAR
         RETURN
180   READ (5,3010)  (KNI(J,1),J=1,8)
C
      READ (5,3000)  CHAR
```

```
6363.          IF (CHAR .EQ. UPPE)  GO TO 190
6364.             IOERR = 1
6365.             WRITE (6,4620)  TYPE
6366.             WRITE (6,4630)  UPPE, CHAR
6367.             RETURN
6368.     190  READ (5,3010)  (KNI(J,2),J=1,8)
6369.     C
6370.          READ (5,3000)  CHAR
6371.          IF (CHAR .EQ. LOWE)  GO TO 200
6372.             IOERR = 1
6373.             WRITE (6,4620)  TYPE
6374.             WRITE (6,4630)  LOWE, CHAR
6375.             RETURN
6376.     200  READ (5,3010)  (KNI(J,3),J=1,8)
6377.     C
6378.          READ (5,3000)  CHAR
6379.          IF (CHAR .EQ. GROU)  GO TO 205
6380.             IOERR = 1
6381.             WRITE (6,4620)  TYPE
6382.             WRITE (6,4630)  GROU, CHAR
6383.             RETURN
6384.     205  READ (5,3010)  (KNI(J,4),J=1,8)
6385.     C
6386.          READ (5,3000)  CHAR
6387.          IF (CHAR .EQ. TEMP)  GO TO 210
6388.             IOERR = 1
6389.             WRITE (6,4620)  TYPE
6390.             WRITE (6,4630)  TEMP, CHAR
6391.             RETURN
6392.     210  READ (5,3010)  (THKN(J),J=1,8)
6393.          GO TO 100
6394.     C
6395.     C                              PHOSPHORUS RATES
6396.     C
6397.     220  READ (5,3000)  CHAR
6398.          IF (CHAR .EQ. SURF)  GO TO 230
6399.             IOERR = 1
6400.             WRITE (6,4620)  TYPE
6401.             WRITE (6,4630)  SURF, CHAR
6402.             RETURN
6403.     230  READ (5,3010)  (KPI(J,1),J=1,5)
6404.     C
6405.          READ (5,3000)  CHAR
6406.          IF (CHAR .EQ. UPPE)  GO TO 240
6407.             IOERR = 1
6408.             WRITE (6,4620)  TYPE
6409.             WRITE (6,4630)  UPPE, CHAR
6410.             RETURN
6411.     240  READ (5,3010)  (KPI(J,2),J=1,5)
6412.     C
6413.          READ (5,3000)  CHAR
6414.          IF (CHAR .EQ. LOWE)  GO TO 250
6415.             IOERR = 1
6416.             WRITE (6,4620)  TYPE
6417.             WRITE (6,4630)  LOWE, CHAR
6418.             RETURN
6419.     250  READ (5,3010)  (KPI(J,3),J=1,5)
6420.     C
6421.          READ (5,3000)  CHAR
6422.          IF (CHAR .EQ. GROU)  GO TO 260
6423.             IOERR = 1
6424.             WRITE (6,4620)  TYPE
6425.             WRITE (6,4630)  GROU, CHAR
6426.             RETURN
6427.     260  READ (5,3010)  (KPI(J,4),J=1,5)
6428.     C
6429.          READ (5,3000)  CHAR
6430.          IF (CHAR .EQ. TEMP)  GO TO 270
```

```
6431.                IOERR = 1
6432.                WRITE (6,4620)  TYPE
6433.                WRITE (6,4630)  TEMP, CHAR
6434.                RETURN
6435.      270   READ (5,3010)  (THKP(J),J=1,5)
6436.            GO TO 160
6437.      C
6438.      C                              OUTPUT OF REACTION RATES AND TEMPERATURE
6439.      C                              CORRECTION FACTORS.
6440.      C
6441.      300   WRITE (6,4650)  (KNNAME(J),J=1,8),
6442.           1                 ((KNI(J,IZONE),J=1,8),IZONE=1,4),(THKN(J),J=1,8)
6443.            WRITE (6,4660)  (KPNAME(J),J=1,5),
6444.           1                 ((KPI(J,IZONE),J=1,5),IZONE=1,4),(THKP(J),J=1,5)
6445.      C
6446.      C                              CONVERT RATES FROM PER DAY TO PER HOUR, AND
6447.      C                              CHECK REACTION RATES BY ZONE FOR
6448.      C                              1) REASONABLENESS, I.E. >= 0.0
6449.      C                              2) VALIDITY OF NUMERICAL SOLUTION TECHNIQUE
6450.      C                                 THE EXPRESSION KNI(J,IZONE)*DELT IS THE
6451.      C                                 FRACTION OF THE CONSTITUTENT REMOVED
6452.      C                                 DURING THE TIMESTEP.  THIS NUMBER SHOULD
6453.      C                                 BE MUCH LESS THAN 1. FOR ACCURATE SOLUTION
6454.      C                                 CHECK SET AT 0.5.
6455.      C                              3) ON OR OFF, IF KNI AND KPI ARE ALL ZERO FOR
6456.      C                                 A ZONE, THEN NO TRANSFORMATIONS ARE DONE.
6457.      C                                 S,U,L, AND GFLG ARE FLAGS TO INDICATE
6458.      C                                 IF TRANSFORMATIONS ARE DONE (1) OR NOT(0).
6459.      C
6460.            DO 311  IZONE=1,4
6461.               SUM = 0.0
6462.               DO 303  J=1,8
6463.                  KNI(J,IZONE) = KNI(J,IZONE)/24.
6464.                  IF (KNI(J,IZONE) .GE. 0.0)  GO TO 301
6465.                     IOERR = 1
6466.                     WRITE (6,4780)  KNNAME(J), IZONE, KNI(J,IZONE)
6467.                     RETURN
6468.      301         IF (DELT*KNI(J,IZONE) .LT. 0.5)  GO TO 302
6469.                     WRITE (6,4790)  KNNAME(J), IZONE
6470.      302         SUM = SUM + KNI(J,IZONE)
6471.      303      CONTINUE
6472.               DO 306  J=1,5
6473.                  KPI(J,IZONE) = KPI(J,IZONE)/24.
6474.                  IF (KPI(J,IZONE) .GE. 0.0)  GO TO 304
6475.                     IOERR = 1
6476.                     WRITE (6,4800)  KPNAME(J), IZONE, KPI(J,IZONE)
6477.                     RETURN
6478.      304         IF (DELT*KPI(J,IZONE) .LT. 0.5)  GO TO 305
6479.                     WRITE (6,4810)  KPNAME(J), IZONE
6480.      305         SUM = SUM + KPI(J,IZONE)
6481.      306      CONTINUE
6482.               IF (SUM .LT. 0.00001)  GO TO (307,308,309,310), IZONE
6483.                  GO TO 311
6484.      307      SFLG = 0
6485.                  GO TO 311
6486.      308      UFLG = 0
6487.                  GO TO 311
6488.      309      LFLG = 0
6489.                  GO TO 311
6490.      310      GFLG = 0
6491.      311   CONTINUE
6492.            DO 313  J=1,8
6493.               IF (THKN(J) .GE. 1.0)  GO TO 313
6494.                  WRITE (6,4812)  KNNAME(J)
6495.      313   CONTINUE
6496.            DO 314  J=1,5
6497.               IF (THKP(J) .GE. 1.0)  GO TO 314
6498.                  WRITE (6,4814)  KPNAME(J)
```

```
314   CONTINUE
C
C
C                                INPUT OF INITIAL NUTRIENT STORAGES
C
C
319   READ (5,3000)  CHAR
      IF (CHAR .EQ. BLANK)  GO TO 319
      IF (CHAR .EQ. INIT)  GO TO 320
         IOERR = 1
         WRITE (6,4665)  CHAR
         RETURN
320   READ (5,3000)  TYPE
      IF (TYPE .EQ. BLANK)  GO TO 320
      IF (TYPE .EQ. NITR)  GO TO 330
      IF (TYPE .EQ. PHOS)  GO TO 340
      IF (TYPE .EQ. CHLO)  GO TO 350
      IF (TYPE .EQ. END)  GO TO 560
         IOERR = 1
         WRITE (6,4725)
         WRITE (6,4740)  TYPE
         RETURN
330   NSTRT = 1
      NEND = 6
         GO TO 360
340   NSTRT = 11
      NEND = 14
         GO TO 360
350   NSTRT = 20
      NEND = 20
C
C                                SURFACE
C
360   READ (5,3020)  CHAR, NBLK
      IF (CHAR .EQ. SURF)  GO TO 365
         IOERR = 1
         WRITE (6,4670)  TYPE
         WRITE (6,4630)  SURF, CHAR
         RETURN
365   IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 370
         IOERR = 1
         WRITE (6,4670)  TYPE
         WRITE (6,4650)  SURF, NBLK
         RETURN
370   IF (NBLK .EQ. 5)  GO TO 400
      READ (5,3010)  (SNT(J),J=NSTRT,NEND)
      DO 390  J=NSTRT,NEND
         DO 380  IBLK=1,5
            SN(J,IBLK) = SNT(J)
380      CONTINUE
390   CONTINUE
      GO TO 440
C
400   DO 410  IBLK=1,5
         READ (5,3010)  (SN(J,IBLK),J=NSTRT,NEND)
410   CONTINUE
      DO 430  J=NSTRT,NEND
         SUM = 0.0
         DO 420  IBLK=1,5
            SUM = SUM + SN(J,IBLK)
420      CONTINUE
         SNT(J) = SUM/5.
430   CONTINUE
C
C                                UPPER ZONE
C
440   READ (5,3020)  CHAR, NBLK
      IF (CHAR .EQ. UPPE)  GO TO 450
```

```
6567.                IOERR = 1
6568.                WRITE (6,4670) TYPE
6569.                WRITE (6,4630)  UPPE, CHAR
6570.                RETURN
6571.      450    IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 460
6572.                IOERR = 1
6573.                WRITE (6,4670)  TYPE
6574.                WRITE (6,4690)  UPPE, NBLK
6575.                RETURN
6576.      460    IF (NBLK .EQ. 5)  GO TO 490
6577.             READ (5,3010)  (UNT(J),J=NSTRT,NEND)
6578.             DO 480  J=NSTRT,NEND
6579.                DO 470  IBLK=1,5
6580.                   UN(J,IBLK) = UNT(J)
6581.      470       CONTINUE
6582.      480    CONTINUE
6583.             GO TO 530
6584.      C
6585.      490    DO 500  IBLK=1,5
6586.                READ (5,3010)  (UN(J,IBLK),J=NSTRT,NEND)
6587.      500    CONTINUE
6588.             DO 520  J=NSTRT,NEND
6589.                SUM = 0.0
6590.                DO 510  IBLK=1,5
6591.                   SUM = SUM + UN(J,IBLK)
6592.      510       CONTINUE
6593.                UNT(J) = SUM/5.
6594.      520    CONTINUE
6595.      C
6596.      C                                LOWER ZONE
6597.      C
6598.      530    READ (5,3000)  CHAR
6599.             IF (CHAR .EQ. LOWE)  GO TO 540
6600.                IOERR = 1
6601.                WRITE (6,4670)  TYPE
6602.                WRITE (6,4630)  LOWE, CHAR
6603.                RETURN
6604.      540    READ (5,3010)  (LN(J),J=NSTRT,NEND)
6605.      C
6606.      C                                GROUNDWATER
6607.      C
6608.             READ (5,3000)  CHAR
6609.             IF (CHAR .EQ. GROU)  GO TO 550
6610.                IOERR = 1
6611.                WRITE (6,4670)  TYPE
6612.                WRITE (6,4630)  GROU, CHAR
6613.                RETURN
6614.      550    READ (5,3010)  (GN(J),J=NSTRT,NEND)
6615.      C
6616.             GO TO 320
6617.      C
6618.      C                                OUTPUT OF INITIAL NUTRIENT STORAGES
6619.      C
6620.      560    WRITE (6,4005)
6621.             WRITE (6,4005)
6622.      C
6623.             CONC = LBPAC
6624.             IF (INPUT .EQ. METR)  CONC=KGPHA
6625.             WRITE (6,4000)  CONC
6626.             WRITE (6,4700)
6627.             WRITE (6,4010)
6628.             WRITE (6,4025)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
6629.             WRITE (6,4030)  (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14),
6630.            1                SN(20,IBLK),  IBLK=1,5)
6631.             WRITE (6,4090)
6632.             WRITE (6,4025)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
6633.             WRITE (6,4030)  (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14),
6634.            1                UN(20,IBLK),  IBLK=1,5)
```

```
      WRITE (6,4110)
      WRITE (6,4020)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
      WRITE (6,4120)
      WRITE (6,4020)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
C
C                                CONVERSION OF METRIC INPUT TO ENGLISH (LB/AC)
C
      IF (INPUT .EQ. ENGL)  GO TO 573
      DO 570  J=1,20
         DO 565  IBLK=1,5
            SN(J,IBLK) = SN(J,IBLK)*.8924
            UN(J,IBLK) = UN(J,IBLK)*.8924
565      CONTINUE
         LN(J) = LN(J)*.8924
         GN(J) = GN(J)*.8924
570   CONTINUE
C
C                               COMPUTE TOTAL NITROGEN (TNA), TOTAL PHOSPHORUS
C                               (TPA), AND TOTAL CHLORIDE (TCLA) IN THE SYSTEM
C                                UNITS = LB/AC.
C
573   TNA = 0.0
      DO 575  J=1,6
         SUM = 0.0
         DO 574  IBLK=1,5
            SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
574      CONTINUE
         TNA = TNA + LN(J) + GN(J) + SUM/5.
575   CONTINUE
C
      TPA = 0.0
      DO 585  J=11,14
         SUM = 0.0
         DO 580  IBLK = 1,5
            SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
580      CONTINUE
         TPA = TPA + LN(J) + GN(J) + SUM/5.
585   CONTINUE
C
      TCLA = 0.0
      DO 590  IBLK=1,5
         TCLA = TCLA + SN(20,IBLK) + UN(20,IBLK)
590   CONTINUE
      TCLA = LN(20) + GN(20) + TCLA/5.
C
      IF (INPUT .EQ. METR)  GO TO 595
         CONC = LBPAC
         WRITE (6,4820)  TNA,CONC, TPA,CONC, TCLA,CONC
      GO TO 600
595      CONC = KGPHA
         TNMET = TNA*1.121
         TPMET = TPA*1.121
         TCLMET = TCLA*1.121
         WRITE (6,4820)  TNMET,CONC, TPMET,CONC, TCLMET,CONC
C
C
C                                NUTRIENT APPLICATIONS
C
C
600   IF (NAPPL.GE.0 .AND. NAPPL.LE.5)  GO TO 610
         IDERR = 1
         WRITE (6,4710)  NAPPL
         RETURN
610   IF (NAPPL .EQ. 0)  GO TO 910
C
      CONC = LBPAC
      IF (INPUT .EQ. METR)  CONC=KGPHA
      WRITE (6,4000)  CONC
```

```
C
      DO 900  IAPPL=1,NAPPL
         DO 614  J=1,20
            SNAPLT(J) = 0.0
            UNAPLT(J) = 0.0
            DO  612  IBLK=1,5
               SNAPL(J,IBLK,IAPPL) = 0.0
               UNAPL(J,IBLK,IAPPL) = 0.0
612         CONTINUE
614      CONTINUE
C
620      READ (5,3020)  CHAR, APDAY(IAPPL)
         IF (CHAR .EQ. BLANK)  GO TO 620
         IF (CHAR .EQ. APPL)  GO TO 630
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4630)  APPL, CHAR
            RETURN
630      IF (APDAY(IAPPL).GE.0 .AND. APDAY(IAPPL).LE.366)  GO TO 635
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4730)  IAPPL, APDAY(IAPPL)
            RETURN
635      IF (IAPPL .EQ. 1)  GO TO 640
         IF (APDAY(IAPPL) .GT. APDAY(IAPPL-1))  GO TO 640
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4735)  IAPPL
            RETURN
640      READ (5,3000)  TYPE
         IF (TYPE .EQ. BLANK)  GO TO 640
         IF (TYPE .EQ. NITR)  GO TO 650
         IF (TYPE .EQ. PHOS)  GO TO 660
         IF (TYPE .EQ. CHLO)  GO TO 670
         IF (TYPE .EQ. END)  GO TO 870
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4745)  TYPE, IAPPL
            RETURN
650      NSTRT = 1
         NEND = 6
            GO TO 680
660      NSTRT = 11
         NEND = 14
            GO TO 680
670      NSTRT = 20
         NEND = 20
C
C                              SURFACE
C
680      READ (5,3020)  CHAR, NBLK
         IF (CHAR .EQ. SURF)  GO TO 690
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4750)  IAPPL, TYPE, SURF, CHAR
            RETURN
690      IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 700
            IOERR = 1
            WRITE (6,4720)
            WRITE (6,4690)  SURF, NBLK
            RETURN
700      IF (NBLK .EQ. 5)  GO TO 730
         READ (5,3010)  (SNAPLT(J),J=NSTRT,NEND)
         DO 720  J=NSTRT,NEND
            DO 710  IBLK=1,5
               SNAPL(J,IBLK,IAPPL) = SNAPLT(J)
710         CONTINUE
720      CONTINUE
```

```
6771.                GO TO 770
6772.      C
6773.      730       DO 740  IBLK=1,5
6774.                   READ (5,3010)  (SNAPL(J,IBLK,IAPPL),J=NSTRT,NEND)
6775.      740       CONTINUE
6776.                DO 760  J=NSTRT,NEND
6777.                   SUM = 0.0
6778.                   DO 750  IBLK=1,5
6779.                      SUM = SUM + SNAPL(J,IBLK,IAPPL)
6780.      750          CONTINUE
6781.                   SNAPLT(J) = SUM/5.
6782.      760       CONTINUE
6783.      C
6784.      C                          UPPER ZONE
6785.      C
6786.      770       READ (5,3020)  CHAR, NBLK
6787.                IF (CHAR .EQ. UPPE)  GO TO 780
6788.                   IOERR = 1
6789.                   WRITE (6,4720)
6790.                   WRITE (6,4750)  IAPPL, TYPE, SURF, CHAR
6791.                   RETURN
6792.      780       IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 790
6793.                   IOERR = 1
6794.                   WRITE (6,4720)
6795.                   WRITE (6,4690)  UPPE, NBLK
6796.                   RETURN
6797.      790       IF (NBLK .EQ. 5)  GO TO 820
6798.                READ (5,3010)  (UNAPLT(J),J=NSTRT,NEND)
6799.                DO 810  J=NSTRT,NEND
6800.                   DO 800  IBLK=1,5
6801.                      UNAPL(J,IBLK,IAPPL) = UNAPLT(J)
6802.      800          CONTINUE
6803.      810       CONTINUE
6804.                GO TO 860
6805.      C
6806.      820       DO 830  IBLK=1,5
6807.                   READ (5,3010)  (UNAPL(J,IBLK,IAPPL),J=NSTRT,NEND)
6808.      830       CONTINUE
6809.                DO 850  J=NSTRT,NEND
6810.                   SUM = 0.0
6811.                   DO 840  IBLK=1,5
6812.                      SUM = SUM + UNAPL(J,IBLK,IAPPL)
6813.      840          CONTINUE
6814.                   UNAPLT(J) = SUM/5.
6815.      850       CONTINUE
6816.      860       GO TO 640
6817.      C
6818.      C                          OUTPUT OF NUTRIENT APPLICATIONS
6819.      C
6820.      870       WRITE (6,4760)  APDAY(IAPPL)
6821.                WRITE (6,4010)
6822.                WRITE (6,4025) (SNAPLT(J),J=1,6),(SNAPLT(J),J=11,14),SNAPLT(20)
6823.                WRITE (6,4030)  (IBLK,(SNAPL(J,IBLK,IAPPL),J=1,6),
6824.           1                    (SNAPL(J,IBLK,IAPPL),J=11,14),
6825.           2                    SNAPL(20,IBLK,IAPPL),  IBLK=1,5)
6826.      C
6827.                WRITE (6,4090)
6828.                WRITE (6,4025) (UNAPLT(J),J=1,6),(UNAPLT(J),J=11,14),UNAPLT(20)
6829.                WRITE (6,4030)  (IBLK,(UNAPL(J,IBLK,IAPPL),J=1,6),
6830.           1                    (UNAPL(J,IBLK,IAPPL),J=11,14),
6831.           2                    UNAPL(20,IBLK,IAPPL),  IBLK=1,5)
6832.      C
6833.      C                          CONVERT APPLICATIONS FROM METRIC TO ENGLISH
6834.      C
6835.                IF (INPUT .EQ. ENGL)  GO TO 900
6836.                DO 890  J=1,20
6837.                   DO 880  IBLK=1,5
6838.                      SNAPL(J,IBLK,IAPPL) = SNAPL(J,IBLK,IAPPL)*.8924
```

```
                    UNAPL(J,IBLK,IAPPL) = UNAPL(J,IBLK,IAPPL)*.8924
880           CONTINUE
890        CONTINUE
C
900     CONTINUE
C
C
910     RETURN
C
C
C
3000    FORMAT  (A4)
3001    FORMAT  (A8)
3010    FORMAT  (8F8.0)
3020    FORMAT  (A4,9X,I3)
4000    FORMAT (' 0',/,' C','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH3-S',3X,
       1        'NH3-A',3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',
       2        3X,'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
4005    FORMAT  (' 0')
4010    FORMAT (' C',3X,'SURFACE LAYER')
4020    FORMAT (' C',6X,'STORAGE',12X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
4025    FORMAT (' C',6X,'AVERAGE',12X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
4030    FORMAT (' ',12X,'BLOCK',I2,6X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
4090    FORMAT (' 0',3X,'UPPER ZONE')
4110    FORMAT (' C',3X,'LOWER ZONE')
4120    FORMAT (' 0',3X,'GROUNDWATER')
4599    FORMAT  (' 0','---ERROR---  EXPECTING THE WORD  NUTRIENT  BUT ',
       1         'READ IN ',A8)
4600    FORMAT  ('1',40X,'NUTRIENT SIMULATION INFORMATION')
4610    FORMAT  (' 0',3X,'TIME STEP FOR TRANSFORMATIONS = ',I5,' MIN',
       1         /,' ',3X,'NUMBER OF NUTRIENT APPLICATIONS = ',I2,
       2         /,' ',3X,'DATE OF PLANT HARVESTING = ',I4,
       3         /,' ',3X,'FRACTION OF MAXIMUM MONTHLY UPTAKE ',
       4         /,' ',6X,'UPPER LAYERS = ',12F6.3,
       5         /,' ',6X,'LOWER ZONE =   ',12F6.3)
4619    FORMAT  (' 0','---ERROR---  IN REACTION RATES SECTION OF INPUT')
4620    FORMAT  (' 0','---ERROR--- IN ',A4,' REACTION RATES SECTION OF ',
       1         'INPUT')
4630    FORMAT  (' ',12X,'EXPECTING ',A5,' BUT READ IN  ',A4)
4640    FORMAT  (' ',12X,'EXPECTING NITR, PHOS, OR END, BUT READ ',
       1         'IN  ',A4)
4650    FORMAT  (' 0','NITROGEN REACTION RATES',8(5X,A4)/,
       1         ' ',6X,'SURFACE',12X,8(2X,F7.4)/
       2         ' ',6X,'UPPER ZONE',9X,8(2X,F7.4)/
       3         ' ',6X,'LOWER ZONE',9X,8(2X,F7.4)/
       4         ' ',6X,'GROUNDWATER',8X,8(2X,F7.4)/
       5         ' ',3X,'TEMPERATURE COEF.',4X,8F9.3)
4660    FORMAT  (' 0','PHOSPHORUS REACTION RATES',  5(5X,A4)/
       1         ' ',6X,'SURFACE',12X,5(2X,F7.4)  /
       2         ' ',6X,'UPPER ZONE',9X,5(2X,F7.4)  /
       3         ' ',6X,'LOWER ZONE',9X,5(2X,F7.4)  /
       4         ' ',6X,'GROUNDWATER',8X,5(2X,F7.4)  /
       5         ' ',3X,'TEMPERATURE COEF.',4X,5F9.3)
4665    FORMAT  (' 0','---ERROR---  EXPECTING  INIT  BUT READ IN ',A4)
4670    FORMAT  (' 0','---ERROR--- IN INITIAL ',A5,' STORAGE SECTION OF ',
       1         'INPUT')
4690    FORMAT  (' ',11X,'FOR ',A5,' EXPECTING BLOCKS=0, 1, OR 5',
       1         ' INPUT VALUE = ',I3)
4700    FORMAT  (' ',3X,'INITIAL STORAGES')
4710    FORMAT  (' 0','---ERROR--- NUMBER OF NUTRIENT APPLICATIONS CAN ',
       1         'RANGE FROM 0 TO 5 ONLY, INPUT VALUE = ',I3)
4720    FORMAT  (' 0','---ERROR--- IN NUTRIENT APPLICATION SECTION')
4725    FORMAT  (' 0','---ERROR--- IN INITIAL STORAGE SECTION')
4730    FORMAT  (' ',11X,'IN APPLICATION NO. ',I2,' THE DAY OF ',
       1         'APPLICATION IS NOT IN THE RANGE 1 TO 366, INPUT ',
       2         'VALUE = ',I3)
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 4735  FORMAT  (' ',12X,'THE DAY OF APPLICATION NO. ',I2,
     1          ' DOES NOT EXCEED THE PREVIOUS APPLICATION DAY')
 4740  FORMAT  ('0',11X,'EXPECTING NITR, PHOS, CHLO, OR END, BUT ',
     1          'READ IN ',A5)
 4745  FORMAT  ('0',11X,'EXPECTING NITR, PHOS, CHLO, OR END, BUT ',
     1          'READ IN ',A5,' FOR APPL. NO. ',I2)
 4750  FORMAT  ('0',11X,'IN APPLICATION NO. ',I2,' FOR ',A4,
     1          'EXPECTING ',A5, ' BUT READ IN ',A5)
 4760  FORMAT  ('0','APPLICATION FOR DAY ',I3)
 4770  FORMAT  ('0','INVALID TSTEP SPECIFIED, INPUT WAS ',I4,
     1          ' EXECUTION CONTINUING WITH TSTEP = 60 MIN.')
 4780  FORMAT  ('0','---ERROR---  INVALID NITROGEN REACTION RATE FOR ',
     1          A4,' IN ZONE ',I2,' INPUT VALUE = ',F8.6)
 4790  FORMAT  ('0','---WARNING---  NITROGEN REACTION RATE ',A4,
     1          ' IN ZONE ',I2,/14X,
     2          ' IS TOO LARGE FOR TIME STEP SELECTED, CONSIDER ',
     3          'REDUCING TSTEP FOR MORE ACCURATE SOLUTION')
 4800  FORMAT  ('0','---ERROR---  INVALID PHOSPHORUS REACTION RATE FOR ',
     1          A4,' IN ZONE ',I2,' INPUT VALUE = ',F8.6)
 4810  FORMAT  ('0','---WARNING---  PHOSHORUS REACTION RATE ',A4,
     1          ' IN ZONE ',I2/14X,
     2          ' IS TOO LARGE FOR TIME STEP SELECTED, CONSIDER ',
     3          'REDUCING TSTEP FOR MORE ACCURATE SOLUTION')
 4812  FORMAT  ('0','---WARNING---  TEMPERATURE COEFFICIENT FOR NITROGEN'
     1          ,' REACTION RATE ',A4,' SHOULD BE >= 1.0')
 4814  FORMAT  ('0','---WARNING---  TEMPERATURE COEFFICIENT FOR ',
     1          'PHOSPHORUS REACTION RATE ',A4,' SHOULD BE >= 1.0')
 4820  FORMAT  ('0',3X,'TOTAL NITROGEN IN SYSTEM = ',2X,F10.3,2X,A5/
     1          ' ',3X,'TOTAL PHOSPHORUS IN SYSTEM = ',F10.3,2X,A5/
     2          ' ',3X,'TOTAL CHLORIDE IN SYSTEM = ',2X,F10.3,2X,A5)
 5000  FORMAT (8X,I4,8X,I4,8X,I4)
 5001  FORMAT (8X,12F6.0)
C
C
       END
C
C
C
C
       SUBROUTINE NUTRNT(UZSN,UZF,LZSN,LZF)
C
C                              THIS SUBROUTINE IS CALLED EVERY INTERVAL ON
C                              A RAIN DAY OR ONLY ONCE A DAY ON A NO RAIN
C                              DAY TO COMPUTE NUTRIENT LOSSES AND TRANS-
C                              FORMATIONS.  ADVECTIVE LOSS IS COMPUTED
C                              EVERYTIME SUBROUTINE IS CALLED, WHILE
C                              CHEMICAL AND BIOLOGICAL TRANSFORMATIONS
C                              ARE DONE AT SELECTED INTERVALS AS
C                              SPECIFIED BY INPUT PARAMETER TSTEP.
C
C                              DECLARATIONS
C                              COMMON VARIABLES
C
       REAL UZSN,UZF,LZSN,LZF
       INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
       REAL  DELT,
     1        SNT(20),SNRSM(20,5),SNROM(20,5),
     2        UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3        NRSM(20,5),LNRPM(20),
     4        SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5        SNRSY(20,5),SNRUY(20,5),UNRIY(20,5),NRSY(20,5),
     6        LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7        TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8        KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
       DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
       DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1           STEMP(24),UTEMP(24)
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7029.      C
7030.            COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
7031.           1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
7032.           2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
7033.           3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
7034.           4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
7035.           5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
7036.      C
7037.      C
7038.            INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
7038.5           INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
7039.           1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
7040.      C
7041.            REAL  RU,HYMIN,DPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
7042.           1        RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
7043.           2        M,P3,A,LTEMP,LMOIST,MUZ,MLZ
7044.      C
7045.            COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
7046.           1           RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,
7047.           2           M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
7048.           3           IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
7048.1          4           ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
7049.      C
7050.      C                          DECLARATIONS FOR INTERNAL STORAGE ALLOCATION
7051.      C
7052.            REAL  SNRS(20,5),SNRO(20,5),SNRP(20,5),ASNRS(20,5),
7053.           1        ASNRST(20),ASNRO(20,5),  ASNROT(20),
7054.           2        ASNRP(20,5),ASNRPT(20),UNTI(20,5),UNRI(20,5),
7055.           3        UNRP(20,5),NRS(20,5),AUNRI(20,5),AUNRIT(20),
7056.           4        AUNRP(20,5),AUNRPT(20),ANRS(20,5),
7057.           6        ANRST(20),LNRP(20),ALNRP(20),
7058.           7        ASNRB(20,5),ASNRBT(20),AUNRB(20,5),
7059.           8        AUNRBT(20),ALNRB(20),AGNRB(20),ATNRB(20)
7061.      C
7062.      C                          DECLARATIONS FOR OTHER INTERNAL VARIABLES
7063.      C
7064.            INTEGER ITIME,NCYCLE,IHOUR,IBIO,IZONE,IBLK
7065.      C
7066.            DOUBLE PRECISION  CONC,LBPAC,KGPHA,FAR,CEL,DEG
7067.      C
7068.            REAL  FS,FO,FP,Tw,TWI,FII,FLI,T(4),FT,
7069.           1        DELNB(20,5),DELN(20),
7070.           2        SUM,SUMD,SUMA,NDSM(20),NDSC(20),NASM(20),NASC(20),
7071.           3        ERSNT,CONFC,CONFS,TOTN,TOTP,TOTNC,TOTPC,SEDC,
7072.           4        CONVF,SNMET(20,5),UNMET(20,5),LNMET(20),GNMET(20),
7073.           5        SNTMET(20),UNTMET(20),UNITMT(20),UNIMET(20,5),
7074.           6        PA,DUMV(20),DUMA(20,5),INFW(5),JNFW(5),KNFW
7074.5           REAL    STEMPF(24),UTEMPF(24),LTEMPF
7075.      C
7076.      C                          INITIALIZATION AND DECLARATION OF SELECTORS
7077.      C                          USED FOR ADVECTING AND REMOVING NUTRIENTS
7078.      C                          BY MEANS OF SEDIMENT (SD), OVERLAND FLOW
7079.      C                          (OF), INTERFLOW (IF), PERCOLATION (PC),
7080.      C                          BIOLOGICAL (BL).
7081.      C
7082.            INTEGER  SELSD(20),SELOF(20),SELIF(20),SELPC(20),SELBL(20)
7086.1           DATA ASNRS/100*0.0/, ASNRO/100*0.0/, ASNRP/100*0.0/,
7086.2          1     AUNRI/100*0.0/, AUNRP/100*0.0/, ANRS /100*0.0/,
7086.3          2     ALNRP/ 20*0.0/, ASNRB/100*0.0/, AUNRB/100*0.0/,
7086.4          3     ALNRB/ 20*0.0/, AGNRB/ 20*0.0/, ATNRB/ 20*0.0/
7086.5           DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,FAR/'F'/,CEL/'C'/
7086.6           DATA DELNB/100*0.0/, DELN/20*0.0/, CONVF/1.121/
7086.95          DATA SELSD/1,0,1,0,0,0,0,0,0,0,1,0,1,0,0,0,0,0,0,0/,
7086.96         1     SELOF/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
7086.97         2     SELIF/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
7086.98         3     SELPC/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
7086.99         4     SELBL/0,0,0,0,1,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0/
7087.      C
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7088.      C
7089.      C                    BRIEF DESCRIPTION OF VARIABLE NAMING CONVENTION:
7090.      C                    1) FIRST TWO LETTERS SN,UN,LN,GN STAND FOR SURFACE,
7091.      C                       UPPER ZONE, LOWER ZONE, AND GROUNDWATER NUTRIENTS
7092.      C                       UNI = INTERFLOW STORAGE OF DISSOLVED NUTRIENTS
7093.      C                    2) FIRST LETTER A STANDS FOR AN ACCUMULATION OF A
7094.      C                       NUTRIENT LOSS OVER THE INTERVALS BETWEEN PRINTING
7095.      C                    3) THE THIRD OR FOURTH LETTER 'R' STANDS FOR REMOVAL
7096.      C                    4) FOLLOWING THE 'R' A LETTER INDICATES THE CAUSE OF
7097.      C                       REMOVAL;  'S'=SEDIMENT, 'O'=OVERLAND FLOW,
7098.      C                       'P'=PERCOLATION, 'I'=INTERFLOW, 'B'=BIOLOGICAL
7099.      C                    5) LETTERS 'M' AND 'Y' INDICATE MONTHLY AND YEARLY
7100.      C                       SUMS OF REMOVALS, MONTHLY SUM IS ACCUMULATED IN
7101.      C                       NUTRNT AND PASSED TO MAIN FOR OUTPUT, AND YEARLY
7102.      C                       AMOUNTS ARE CALCULATED AND PRINTED IN MAIN
7103.      C                    6) THE LETTER 'T' APPEARING AT THE VERY END INDICATES
7104.      C                       THE TOTAL OR AVERAGE MASS OF THE 5 BLOCKS IN THE
7105.      C                       SURFACE AND UPPER ZONES
7106.      C
7107.      C                       NUTRIENTS ARE STORED IN VECTORS AND ARRAYS IN THE
7108.      C                       FOLLOWING SEQUENCE OF ELEMENTS:
7109.      C                       1 = ORG-N,  ORGANIC NITROGEN
7110.      C                       2 = NH4-S,  AMMONIUM IN SOLUTION
7111.      C                       3 = NH4-A,  AMMONIUM ADSORBED TO SOIL
7112.      C                       4 = NO3+NO2,   NITRITE PLUS NITRATE
7112.2     C                       5 = N2-GAS, NITROGEN GAS FROM DENITRIFICATION
7112.4     C                       6 = PLNT-N, PLANT NITROGEN
7115.      C                       7 = OPEN
7116.      C                       8 = OPEN
7117.      C                       9 = OPEN
7118.      C                       10 = OPEN
7119.      C                       11 = ORG-P,  ORGANIC PHOSPHORUS
7120.      C                       12 = PO4-S,  PHOSPHATE IN SOLUTION
7121.      C                       13 = PO4-A,  PHOSPHATE ADSORBED TO SOIL
7122.      C                       14 = PLNT-P, PLANT PHOSPHORUS
7123.      C                       15 = OPEN
7124.      C                       16 = OPEN
7125.      C                       17 = OPEN
7126.      C                       18 = OPEN
7127.      C                       19 = OPEN
7128.      C                       20 = CL,     CHLORIDE
7129.      C
7130.            PA = 1.0 - A
7131.      C
7132.      C                             ADVECTIVE LOSSES
7133.      C
7134.      C                             SURFACE ZONE
7135.      C
7136.            DO 120  IBLK=1,5
7137.      C
7138.      C                             SEDIMENT REMOVAL
7139.      C
7140.               IF (ERSN(IBLK) .LE. 0.0)  GO TO 40
7141.               FS = 2000.*AREA*0.2*ERSN(IBLK)/M
7142.               IF (FS .GT. 1.0)  FS=1.0
7143.               DO 20  J=1,20
7144.                  SNRS(J,IBLK) = SELSD(J)*FS*SN(J,IBLK)
7145.      20       CONTINUE
7146.               GO TO 60
7147.      40       DO 50  J=1,20
7148.                  SNRS(J,IBLK) = 0.0
7149.      50       CONTINUE
7150.      C
7151.      C                             OVERLAND FLOW AND PERCOLATION
7152.      C
7152.1     C  45302.4 = 0.2 * 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
7152.2     C
7153.      60       IF ((P3+RESB1(IBLK)) .LE. 0.0)  GO TO 80
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```
7153.1              FT = PA*(P3+RESB1(IBLK))
7153.2              INFW(IBLK) = AREA*FT*45302.4
7154.               FO = RGSB(IBLK)/FT
7155.               FP = RIB(IBLK)/(P3+RESB1(IBLK))
7156.               DO 70  J=1,20
7157.                  SNRO(J,IBLK) = SELOF(J)*FO*SN(J,IBLK)
7158.                  SNRP(J,IBLK) = SELPC(J)*FP*SN(J,IBLK)
7159.       70      CONTINUE
7160.               GO TO 100
7161.       80      DO 90  J=1,20
7162.                  SNRO(J,IBLK) = 0.0
7163.                  SNRP(J,IBLK) = 0.0
7164.       90      CONTINUE
7164.5              INFW(IBLK) = 0.0
7165.       C
7166.       C                          CHANGE SURFACE STORAGES AND ACCUMULATE
7167.       C                          REMOVALS
7168.       C
7169.       100     DO 110  J=1,20
7170.                  SN(J,IBLK) = SN(J,IBLK) - SNRS(J,IBLK) - SNRO(J,IBLK) -
7171.            1                   SNRP(J,IBLK)
7172.                  UN(J,IBLK) = UN(J,IBLK) + SNRP(J,IBLK)
7173.                  ASNRS(J,IBLK) = ASNRS(J,IBLK) + SNRS(J,IBLK)
7174.                  ASNRO(J,IBLK) = ASNRO(J,IBLK) + SNRO(J,IBLK)
7175.                  ASNRP(J,IBLK) = ASNRP(J,IBLK) + SNRP(J,IBLK)
7176.       110     CONTINUE
7177.       120   CONTINUE
7178.       C
7179.       C                          UPPER ZONE
7180.       C
7181.             DO 220  IBLK=1,5
7182.       C
7183.       C                          PERCOLATION AND INTERFLOW
7184.       C                          UNTI = TRANSFER FROM UZ TO INTERFLOW
7184.1      C
7184.2      C  UZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN UZF*UZSN
7185.       C
7186.               TW = UZSB(IBLK) + RGX(IBLK) + APERCB(IBLK) + INFL(IBLK)
7186.5              JNFW(IBLK) = AREA*PA*TW*45302.4
7187.               TWI = SRGX(IBLK) + INTF(IBLK)
7188.               IF (TW .LE. 0.0)  GO TO 140
7189.               FII = RGX(IBLK)/TW
7189.1              UZFM = UZSB(IBLK)/(UZSN*UZF)
7189.2              IF (UZFM.GE.1.0) UZFM = 1.0
7190.               FP = UZFM*(INFL(IBLK) + APERCB(IBLK))/TW
7191.               DO 130  J=1,20
7192.                  UNTI(J,IBLK) = SELIF(J)*FII*UN(J,IBLK)
7193.                  UNI(J,IBLK) = UNI(J,IBLK) + UNTI(J,IBLK)
7194.                  UNRP(J,IBLK) = SELPC(J)*FP*UN(J,IBLK)
7194.1                 IF (TF.EQ.1.OR.UNI(J,IBLK).LE.0.0) GO TO 130
7194.2                 UN(J,IBLK) = UN(J,IBLK) + UNI(J,IBLK)
7194.3                 UNI(J,IBLK) = 0.0
7195.       130     CONTINUE
7196.               GO TO 160
7197.       140     DO 150  J=1,20
7198.                  UNTI(J,IBLK) = 0.0
7199.                  UNRP(J,IBLK) = 0.0
7199.1                 IF (TF.EQ.1.OR.UNI(J,IBLK).LE.0.0) GO TO 150
7199.2                 UN(J,IBLK) = UN(J,IBLK) + UNI(J,IBLK)
7199.3                 UNI(J,IBLK) = 0.0
7200.       150     CONTINUE
7201.       C
7202.       C                          LOSS FROM INTERFLOW STORAGE
7203.       C
7204.       160     IF (TWI .LE. 0.0)  GO TO 180
7205.               FLI = INTF(IBLK)/TWI
7206.               DO 170  J=1,20
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7207.                 UNRI(J,IBLK) = FLI*UNI(J,IBLK)
7208.      170      CONTINUE
7209.               GO TO 200
7210.      180      DO 190  J=1,20
7211.                 UNRI(J,IBLK) = 0.0
7212.      190      CONTINUE
7213.      C
7214.      C                          REMOVE AND ADD STORAGES AND ACCUMULATE
7215.      C
7216.      200      DO 210  J=1,20
7217.                 UN(J,IBLK) = UN(J,IBLK) - UNTI(J,IBLK) - UNRP(J,IBLK)
7218.                 UNI(J,IBLK) = UNI(J,IBLK) - UNRI(J,IBLK)
7219.                 AUNRI(J,IBLK) = AUNRI(J,IBLK) + UNRI(J,IBLK)
7220.                 AUNRP(J,IBLK) = AUNRP(J,IBLK) + UNRP(J,IBLK)
7221.                 LN(J) = LN(J) + UNRP(J,IBLK)*0.2
7222.      210      CONTINUE
7223.      220   CONTINUE
7224.      C
7225.      C                          COMPUTE NUTRIENT REMOVAL TO STREAM (NRS)
7226.      C                          AND ACCUMULATIONS
7227.      C
7228.            DO 240  IBLK=1,5
7229.               DO 230  J=1,20
7230.                 NRS(J,IBLK) = SNRS(J,IBLK) + SNRD(J,IBLK) + UNRI(J,IBLK)
7231.                 ANRS(J,IBLK) = ANRS(J,IBLK) + NRS(J,IBLK)
7232.      230      CONTINUE
7233.      240   CONTINUE
7234.      C
7235.      C                          LOWER ZONE
7236.      C
7236.5     C  226512 = 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
7236.6     C
7236.7     C
7236.8     C  LZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN LZF*LZSN
7237.            TW = LZS + DPST
7237.5           KNFW = AREA*TW*226512.0
7238.            IF (TW .LE. 0.0)  GO TO 260
7238.1           LZFM = LZS/(LZSN*LZF)
7238.2           IF (LZFM.GE.1.0) LZFM =1.0
7239.            FP = LZFM*DPST/TW
7240.            DO 250  J=1,20
7241.               LNRP(J) = SELPC(J)*FP*LN(J)
7242.      250   CONTINUE
7243.            GO TO 280
7244.      260   DO 270  J=1,20
7245.               LNRP(J) = 0.0
7246.      270   CONTINUE
7247.      C
7248.      280   DO 290  J=1,20
7249.               LN(J) = LN(J) - LNRP(J)
7250.               GN(J) = GN(J) + LNRP(J)
7251.               ALNRP(J) = ALNRP(J) + LNRP(J)
7252.      290   CONTINUE
7253.      C
7254.      C                          GROUNDWATER
7255.      C                          NO ADVECTIVE LOSS FROM GROUNDWATER
7256.      C
7257.      C
7258.      C                          CHECK TO SEE IF PHYSICAL AND BIOLOGICAL
7259.      C                          TRANSFORMATIONS ARE TO BE DONE THIS
7260.      C                          INTERVAL ON A RAIN DAY, OR SETUP THE
7261.      C                          NUMBER OF TIMES TO LOOP FOR A NO RAIN
7262.      C                          DAY
7263.      C
7264.            IF (TF .GT. 1)  GO TO 300
7265.            ITIME = IMIN + 60*IHR
7266.            IF ( MOD(ITIME,TSTEP) .NE. 0)  GO TO 810
7267.            NCYCLE = 1
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7268.            GO TO 310
7269.      300   NCYCLE = NSTEP
7270.      C
7271.      310   DO 800  IBIO=1,NCYCLE
7272.      C
7273.      C                          COMPUTE HOUR OF THE DAY TO ACCESS HOURLY
7274.      C                          SOIL TEMP DATA FOR THE 4 SOIL ZONES:
7275.      C                          SURFACE, UPPER, LOWER, GROUNDWATER
7276.      C
7277.                IF (TF .GT. 1)  GO TO 320
7278.                IHOUR = IHR + 1
7279.                GO TO 330
7280.      320       IHOUR = 1 + (IBIO*TSTEP)/60
7281.      330       IF (IHOUR .EQ. 25)  IHOUR=24
7282.1               T(1) = STEMP(IHOUR)
7282.2               T(2) = UTEMP(IHOUR)
7282.3               T(3) = LTEMP
7282.4               T(4) = LTEMP
7285.      C
7285.1     C                 TRANSFORMATIONS BYPASSED AT TEMPERATURES BELOW 4 DEG. C
7285.2     C
7286.      C                          SURFACE ZONE TRANSFORMATIONS
7287.      C
7288.                IF (SFLG .EQ. 0)  GO TO 450
7289.                IZONE = 1
7289.1               IF (T(1) .LE. 4.0) GO TO 450
7290.      C
7291.                CALL TRANS (DELT,IZONE,DUMV,SN,KN,THKN,KP,THKP,T,DUMV,DELNB,
7291.1          1                        AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
7292.      C
7293.      C                          COMPUTE AND ACCUMULATE AMOUNT REMOVED
7294.      C                          BIOLOGICALLY
7295.      C
7296.                DO 440  IBLK=1,5
7297.                   DO 430  J=1,20
7298.                      ASNRB(J,IBLK) = ASNRB(J,IBLK) + SELBL(J)*DELNB(J,IBLK)
7299.      430         CONTINUE
7300.      440       CONTINUE
7301.      C
7302.      C                          UPPER ZONE TRANSFORMATIONS
7303.      C
7304.      450       IF (UFLG .EQ. 0)  GO TO 560
7305.                IZONE = 2
7305.1               IF (T(2) .LE. 4.0) GO TO 560
7306.      C
7307.                CALL TRANS (DELT,IZONE,DUMV,UN,KN,THKN,KP,THKP,T,DUMV,DELNB,
7307.1          1                        AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
7307.2     C
7308.      C
7309.                DO 550  IBLK=1,5
7310.                   DO 540  J=1,20
7311.                      AUNRB(J,IBLK) = AUNRB(J,IBLK) + SELBL(J)*DELNB(J,IBLK)
7312.      540         CONTINUE
7313.      550       CONTINUE
7314.      C
7315.      C                          LOWER ZONE TRANSFORMATIONS
7316.      C
7317.      560       IF (LFLG .EQ. 0)  GO TO 660
7318.                IZONE = 3
7318.1               IF (T(3) .LE. 4.0) GO TO 660
7318.5               IF (KNFW.LE.0.000001) GO TO 660
7319.      C
7320.                CALL TRANS (DELT,IZONE,LN,DUMA,KN,THKN,KP,THKP,T,DELN,DUMA,
7320.2          1                        AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
7321.      C
7322.                DO 650  J=1,20
7323.                   ALNRB(J) = ALNRB(J) + SELBL(J)*DELN(J)
```

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7324.      650      CONTINUE
7325.      C
7326.      C                                GROUNDWATER ZONE
7327.      C
7328.      660      IF (GFLG .EQ. 0)  GO TO 800
7329.               IZONE = 4
7329.1              IF (T(4) .LE. 4.0) GO TO 800
7330.      C
7331.               CALL TRANS (DELT,IZONE,GN,DUMA,KN,THKN,KP,THKP,T,DELN,DUMA,
7331.2          1                            AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
7332.      C
7333.               DO 750  J=1,20
7334.                  AGNRB(J) = AGNRB(J) + SELBL(J)*DELN(J)
7335.      750      CONTINUE
7336.      C
7337.      800   CONTINUE
7338.      C
7339.      C                                END OF NO RAIN INTERVAL LOOP
7340.      C
7341.        810 IF (PRNTKE .EQ. 0)  GO TO 1300
7342.      C
7343.      C                                COMPUTE BIOLOGICAL REMOVALS
7344.      C                                ACCUMULATE MONTHLY VALUES OF ADVECTIVE
7345.      C                                AND BIOLOGICAL REMOVALS
7346.      C                                ATNRB = ACCUM. TOTAL NUTR REMOVAL BIOL.
7347.      C
7348.            DO 920  J=1,20
7349.               SUM = 0.0
7350.               DO 910  IBLK=1,5
7351.                  SUM = SUM + ASNRB(J,IBLK) + AUNRB(J,IBLK)
7352.      910      CONTINUE
7353.               ATNRB(J) = SUM/5. + ALNRB(J) + AGNRB(J)
7354.      920   CONTINUE
7355.      C
7356.            DO 940  J=1,20
7357.               DO 930  IBLK=1,5
7358.                  SNRSM(J,IBLK) = SNRSM(J,IBLK) + ASNRS(J,IBLK)
7359.                  SNRCM(J,IBLK) = SNRCM(J,IBLK) + ASNRC(J,IBLK)
7360.                  UNRIM(J,IBLK) = UNRIM(J,IBLK) + AUNRI(J,IBLK)
7361.                  NRSM(J,IBLK) = NRSM(J,IBLK) + ANRS(J,IBLK)
7362.                  SNRBM(J,IBLK) = SNRBM(J,IBLK) + ASNRB(J,IBLK)
7363.                  UNRBM(J,IBLK) = UNRBM(J,IBLK) + AUNRB(J,IBLK)
7364.      930      CONTINUE
7365.               LNRPM(J) = LNRPM(J) + ALNRP(J)
7366.               LNRBM(J) = LNRBM(J) + ALNRB(J)
7367.               GNRBM(J) = GNRBM(J) + AGNRB(J)
7368.               TNRBM(J) = TNRBM(J) + ATNRB(J)
7369.      940   CONTINUE
7370.      C
7371.            IF (PRNTKE .EQ. 2)  GO TO 1200
7372.      C                                OUTPUT OPTIONS
7373.      C
7374.            IF (HYCAL .EQ. PROD)  GO TO 1100
7375.            IF (TF.GT.1 .OR. RU.LT.HYMIN)  GO TO 1200
7376.      C
7377.      C                                COMPUTE CONCENTRATIONS AND MASSES IN STREAM
7378.      C                                FOR CALIBRATION OUTPUT
7379.      C                                NDSM=NUTRIENTS DISSOLVED IN STREAM,MASS
7380.      C                                NDSC=NUTRIENTS DISSOLVED IN STREAM, CONC.
7381.      C                                NASM=NUTRIENTS ADSORBED IN STREAM, MASS
7382.      C                                NASC=NUTRIENTS ADSORBED IN STREAM, CONC.
7383.      C                                CONFC = CONVERSION FACTOR TO GET MG/L UNITS
7384.      C                                CONFS = CONV. FACTOR TO GET ADSORBED NUTR.
7385.      C                                        CONC. IN PPM OF SEDIMENT
7386.      C
7387.            ERSNT = 0.0
7388.            DO 945  IBLK=1,5
7389.               ERSNT = ERSNT + ERSN(IBLK)
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945   CONTINUE
      ERSNT = ERSNT/5.
      CONFC = 454000./(RU*TIMFAC*60.*28.32)
      IF (ERSNT .GT. 0.0)  CONFS = 1.0E6/(ERSNT*2000.*AREA)
      DO 970  J=1,20
         SUMD = 0.0
         SUMA = 0.0
         DO 950  IBLK=1,5
            SUMD = SUMD + ASNRO(J,IBLK) + AUNRI(J,IBLK)
            SUMA = SUMA + ASNRS(J,IBLK)
950      CONTINUE
         NDSM(J) = SUMD*AREA/5.
         NDSC(J) = NDSM(J)*CONFC
         NASM(J) = SUMA*AREA/5.
         IF (ERSNT .LE. 0.0)  GO TO 960
            NASC(J) = NASM(J)*CONFS
         GO TO 970
960      NASC(J) = 0.0
970   CONTINUE
C
C                    COMPUTE TOTAL MASS OF N (TOTN) AND P (TOTP),CONC.
C                    OF TOTAL N (TOTNC) ,P (TOTPC), AND SEDIMENT(SEDC)
C                    PER WATER PHASE IN STREAM
C
      TOTN = 0.0
      TOTP = 0.0
      DO 971  J=1,6
         TOTN = TOTN +NDSM(J) + NASM(J)
971   CONTINUE
      DO 972  J=11,14
         TOTP = TOTP + NDSM(J) + NASM(J)
972   CONTINUE
C
      TOTNC = TOTN*CONFC
      TOTPC = TOTP*CONFC
      SEDC = (CONFC/CONFS)*1.0E3
C
C
C                         MODIFICATIONS FOR METRIC OUTPUT
C                         CONVERT MASS FROM LB. TO KG. CONC. IN MG/L
C
      IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  GO TO 1000
      DO 980  J=1,20
         NDSM(J) = NDSM(J)/2.205
         NASM(J) = NASM(J)/2.205
980   CONTINUE
      TOTN = TOTN/2.205
      TOTP = TOTP/2.205
C
1000  WRITE (6,4130)  NDSM(4),NDSM(2),NDSM(12),NDSM(20),
     1                NASM(3),NASM(1),NASM(13),NASM(11),TOTN,TOTP
      WRITE (6,4135)  SEDC
      WRITE (6,4140)  NDSC(4),NDSC(2),NDSC(12),NDSC(20),
     1                NASC(3),NASC(1),NASC(13),NASC(11),TOTNC,TOTPC
      GO TO 1200
C
C                         PRODUCTION OUTPUT
C                         COMPUTE WATERSHED AVG. FROM BLOCK STORAGES
C
1100  DO 1120  J=1,20
         SNT(J) = 0.0
         UNT(J) = 0.0
         UNIT(J) = 0.0
         ASNRST(J) = 0.0
         ASNROT(J) = 0.0
         ASNRPT(J) = 0.0
         AUNRIT(J) = 0.0
         AUNRPT(J) = 0.0
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7451.                ANRST(J) = C.0
7452.                ASNRBT(J) = 0.0
7453.                AUNRBT(J) = C.0
7454.                DO 1110  IBLK=1,5
7455.                   SNT(J) = SNT(J) + SN(J,IBLK)*0.2
7456.                   UNT(J) = UNT(J) + UN(J,IBLK)*0.2
7457.                   UNIT(J) = UNIT(J) + UNI(J,IBLK)*0.2
7458.                   ASNRST(J) = ASNRST(J) + ASNRS(J,IBLK)*0.2
7459.                   ASNROT(J) = ASNROT(J) + ASNRO(J,IBLK)*0.2
7460.                   ASNRPT(J) = ASNRPT(J) + ASNRP(J,IBLK)*0.2
7461.                   AUNRIT(J) = AUNRIT(J) + AUNRI(J,IBLK)*0.2
7462.                   AUNRPT(J) = AUNRPT(J) + AUNRP(J,IBLK)*0.2
7463.                   ANRST(J) = ANRST(J) + ANRS(J,IBLK)*0.2
7464.                   ASNRBT(J) = ASNRBT(J) + ASNRB(J,IBLK)*0.2
7465.                   AUNRBT(J) = AUNRBT(J) + AUNRB(J,IBLK)*0.2
7466.      1110      CONTINUE
7467.      1120   CONTINUE
7468.      C
7469.            IF (OUTPUT .EQ. METR)  GO TO 1130
7470.            CONC = LBPAC
7471.            WRITE (6,4005)
7472.            WRITE (6,4000)  CONC
7473.      C
7474.      C                              SURFACE
7475.      C
7476.            WRITE (6,4010)
7477.            WRITE (6,4020)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
7478.            WRITE (6,4030)  (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14),
7479.           1                SN(20,IBLK),  IBLK=1,5)
7480.            WRITE (6,4040)
7481.            WRITE (6,4050)  (ASNRST(J),J=1,6),(ASNRST(J),J=11,14),ASNRST(20)
7482.            WRITE (6,4030) (IBLK,(ASNRS(J,IBLK),J=1,6),(ASNRS(J,IBLK),J=11,14)
7483.           1               ,ASNRS(20,IBLK),  IBLK=1,5)
7484.            WRITE (6,4060)  (ASNROT(J),J=1,6),(ASNROT(J),J=11,14),ASNROT(20)
7485.            WRITE (6,4030) (IBLK,(ASNRO(J,IBLK),J=1,6),(ASNRO(J,IBLK),J=11,14)
7486.           1               ,ASNRO(20,IBLK),  IBLK=1,5)
7487.            WRITE (6,4070)  (ASNRPT(J),J=1,6),(ASNRPT(J),J=11,14),ASNRPT(20)
7488.            WRITE (6,4030) (IBLK,(ASNRP(J,IBLK),J=1,6),(ASNRP(J,IBLK),J=11,14)
7489.           1               ,ASNRP(20,IBLK),  IBLK=1,5)
7490.            WRITE (6,4080)  (ASNRBT(J),J=1,6),(ASNRBT(J),J=11,14),ASNRBT(20)
7491.            WRITE (6,4030) (IBLK,(ASNRB(J,IBLK),J=1,6),(ASNRB(J,IBLK),J=11,14)
7492.           1               ,ASNRB(20,IBLK),  IBLK=1,5)
7493.      C
7494.      C                              UPPER ZONE
7495.      C
7496.            WRITE (6,4090)
7497.            WRITE (6,4020)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
7498.            WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
7499.           1               ,UN(20,IBLK),  IBLK=1,5)
7500.            WRITE (6,4100)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
7501.            WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14)
7502.           1               ,UNI(20,IBLK),  IBLK=1,5)
7503.            WRITE (6,4040)
7504.            WRITE (6,4100)  (AUNRIT(J),J=1,6),(AUNRIT(J),J=11,14),AUNRIT(20)
7505.            WRITE (6,4030) (IBLK,(AUNRI(J,IBLK),J=1,6),(AUNRI(J,IBLK),J=11,14)
7506.           1               ,AUNRI(20,IBLK),  IBLK=1,5)
7507.            WRITE (6,4070)  (AUNRPT(J),J=1,6),(AUNRPT(J),J=11,14),AUNRPT(20)
7508.            WRITE (6,4030) (IBLK,(AUNRP(J,IBLK),J=1,6),(AUNRP(J,IBLK),J=11,14)
7509.           1               ,AUNRP(20,IBLK),  IBLK=1,5)
7510.            WRITE (6,4080)  (AUNRBT(J),J=1,6),(AUNRBT(J),J=11,14),AUNRBT(20)
7511.            WRITE (6,4030) (IBLK,(AUNRB(J,IBLK),J=1,6),(AUNRB(J,IBLK),J=11,14)
7512.           1               ,AUNRB(20,IBLK), IBLK=1,5)
7513.      C
7513.1     C
7513.2     C                              TOTAL TO STREAM
7513.3     C
7513.4           WRITE (6,4015)  (ANRST(J),J=1,6),(ANRST(J),J=11,14),ANRST(20)
7513.5     C
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7514.      C                                LOWER ZONE AND GROUNDWATER
7515.      C
7516.            WRITE (6,4110)
7517.            WRITE (6,4020)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
7518.            WRITE (6,4040)
7519.            WRITE (6,4070)  (ALNRP(J),J=1,6),(ALNRP(J),J=11,14),ALNRP(20)
7520.            WRITE (6,4080)  (ALNRB(J),J=1,6),(ALNRB(J),J=11,14),ALNRB(20)
7521.            WRITE (6,4120)
7522.            WRITE (6,4020)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
7523.            WRITE (6,4040)
7524.            WRITE (6,4080)  (AGNRB(J),J=1,6),(AGNRB(J),J=11,14),AGNRB(20)
7524.01    C
7524.02    C              CONVERT DAILY SOIL TEMPERATURE TO ENGLISH UNITS
7524.03    C
7524.04          DO 1125 I = 6,17,11
7524.05             STEMPF(I) = STEMP(I) * 9./5. + 32.05
7524.06             UTEMPF(I) = UTEMP(I) * 9./5. + 32.05
7524.07    1125  CONTINUE
7524.08          LTEMPF = LTEMP * 9./5. + 32.05
7524.09    C
7524.1     C                                DAILY SOIL TEMPERATURE
7524.11    C
7524.12          DEG = FAR
7524.13          WRITE (6,4124) DEG
7524.14          WRITE (6,4125) STEMPF(17), STEMPF(6)
7524.15          WRITE (6,4126) UTEMPF(17), UTEMP(6)
7524.16          WRITE (6,4127) LTEMPF
7524.17    C
7525.      C
7526.      1130  IF (OUTPUT .EQ. ENGL)  GO TO 1200
7527.      C
7528.      C                                METRIC CONVERSIONS FOR OUTPUT
7529.      C
7530.            CONC = KGPHA
7531.            DO 1150  J=1,20
7532.               SNTMET(J) = SNT(J)*CONVF
7533.               ASNRST(J) = ASNRST(J)*CONVF
7534.               ASNROT(J) = ASNROT(J)*CONVF
7535.               ASNRPT(J) = ASNRPT(J)*CONVF
7536.               ASNRBT(J) = ASNRBT(J)*CONVF
7537.      C
7538.               UNTMET(J) = UNT(J)*CONVF
7539.               UNITMT(J) = UNIT(J)*CONVF
7540.               AUNRIT(J) = AUNRIT(J)*CONVF
7541.               AUNRPT(J) = AUNRPT(J)*CONVF
7542.               AUNRBT(J) = AUNRBT(J)*CONVF
7543.      C
7543.1              ANRST(J) = ANRST(J)*CONVF
7544.               LNMET(J) = LN(J)*CONVF
7545.               ALNRP(J) = ALNRP(J)*CONVF
7546.               ALNRB(J) = ALNRB(J)*CONVF
7547.               GNMET(J) = GN(J)*CONVF
7548.               AGNRB(J) = AGNRB(J)*CONVF
7549.               DO 1140  IBLK=1,5
7550.                  SNMET(J,IBLK) = SN(J,IBLK)*CONVF
7551.                  ASNRS(J,IBLK) = ASNRS(J,IBLK)*CONVF
7552.                  ASNRO(J,IBLK) = ASNRO(J,IBLK)*CONVF
7553.                  ASNRP(J,IBLK) = ASNRP(J,IBLK)*CONVF
7554.                  ASNRB(J,IBLK) = ASNRB(J,IBLK)*CONVF
7555.                  UNMET(J,IBLK) = UN(J,IBLK)*CONVF
7556.                  UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
7557.                  AUNRI(J,IBLK) = AUNRI(J,IBLK)*CONVF
7558.                  AUNRP(J,IBLK) = AUNRP(J,IBLK)*CONVF
7559.                  AUNRB(J,IBLK) = AUNRB(J,IBLK)*CONVF
7560.      1140     CONTINUE
7561.      1150  CONTINUE
7562.            WRITE (6,4005)
7563.            WRITE (6,4000)  CONC
```

```
7564.      C
7565.      C                                SURFACE
7566.      C
7567.            WRITE (6,4010)
7568.            WRITE (6,4020)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
7569.            WRITE (6,4030)  (IBLK,(SNMET(J,IBLK),J=1,6),
7570.           1                (SNMET(J,IBLK),J=11,14),
7571.           2                SNMET(20,IBLK),  IBLK=1,5)
7572.            WRITE (6,4040)
7573.            WRITE (6,4050)  (ASNRST(J),J=1,6),(ASNRST(J),J=11,14),ASNRST(20)
7574.            WRITE (6,4030) (IBLK,(ASNRS(J,IBLK),J=1,6),(ASNRS(J,IBLK),J=11,14)
7575.           1               ,ASNRS(20,IBLK),  IBLK=1,5)
7576.            WRITE (6,4060)  (ASNROT(J),J=1,6),(ASNROT(J),J=11,14),ASNROT(20)
7577.            WRITE (6,4030) (IBLK,(ASNRO(J,IBLK),J=1,6),(ASNRO(J,IBLK),J=11,14)
7578.           1               ,ASNRO(20,IBLK),  IBLK=1,5)
7579.            WRITE (6,4070)  (ASNRPT(J),J=1,6),(ASNRPT(J),J=11,14),ASNRPT(20)
7580.            WRITE (6,4030) (IBLK,(ASNRP(J,IBLK),J=1,6),(ASNRP(J,IBLK),J=11,14)
7581.           1               ,ASNRP(20,IBLK),  IBLK=1,5)
7582.            WRITE (6,4080)  (ASNRBT(J),J=1,6),(ASNRBT(J),J=11,14),ASNRBT(20)
7583.            WRITE (6,4030) (IBLK,(ASNRB(J,IBLK),J=1,6),(ASNRB(J,IBLK),J=11,14)
7584.           1               ,ASNRB(20,IBLK),  IBLK=1,5)
7585.      C
7586.      C                                UPPER ZONE
7587.      C
7588.            WRITE (6,4090)
7589.            WRITE (6,4020)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
7590.            WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),
7591.           1                (UNMET(J,IBLK),J=11,14),
7592.           2                UNMET(20,IBLK),  IBLK=1,5)
7593.            WRITE (6,4100)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
7594.            WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
7595.           1                (UNIMET(J,IBLK),J=11,14),
7596.           2                UNIMET(20,IBLK),  IBLK=1,5)
7597.            WRITE (6,4040)
7598.            WRITE (6,4100)  (AUNRIT(J),J=1,6),(AUNRIT(J),J=11,14),AUNRIT(20)
7599.            WRITE (6,4030) (IBLK,(AUNRI(J,IBLK),J=1,6),(AUNRI(J,IBLK),J=11,14)
7600.           1               ,AUNRI(20,IBLK),  IBLK=1,5)
7601.            WRITE (6,4070)  (AUNRPT(J),J=1,6),(AUNRPT(J),J=11,14),AUNRPT(20)
7602.            WRITE (6,4030) (IBLK,(AUNRP(J,IBLK),J=1,6),(AUNRP(J,IBLK),J=11,14)
7603.           1               ,AUNRP(20,IBLK),  IBLK=1,5)
7604.            WRITE (6,4080)  (AUNRBT(J),J=1,6),(AUNRBT(J),J=11,14),AUNRBT(20)
7605.            WRITE (6,4030) (IBLK,(AUNRB(J,IBLK),J=1,6),(AUNRB(J,IBLK),J=11,14)
7606.           1               ,AUNRB(20,IBLK), IBLK=1,5)
7607.      C
7607.1     C
7607.2     C                                TOTAL TO STREAM
7607.3     C
7607.4           WRITE (6,4015)  (ANRST(J),J=1,6),(ANRST(J),J=11,14),ANRST(20)
7607.5     C
7608.      C                                LOWER ZONE AND GROUNDWATER
7609.      C
7610.            WRITE (6,4110)
7611.            WRITE (6,4020)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
7612.            WRITE (6,4040)
7613.            WRITE (6,4070)  (ALNRP(J),J=1,6),(ALNRP(J),J=11,14),ALNRP(20)
7614.            WRITE (6,4080)  (ALNRB(J),J=1,6),(ALNRB(J),J=11,14),ALNRB(20)
7615.            WRITE (6,4120)
7616.            WRITE (6,4020)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
7617.            WRITE (6,4040)
7618.            WRITE (6,4080)  (AGNRB(J),J=1,6),(AGNRB(J),J=11,14),AGNRB(20)
7618.1     C
7618.2     C                                DAILY SOIL TEMPERATURE
7618.3     C
7618.4           DEG = CEL
7618.5           WRITE (6,4124) DEG
7618.6           WRITE (6,4125) STEMP(17), STEMP(6)
7618.7           WRITE (6,4126) UTEMP(17), UTEMP(6)
7618.8           WRITE (6,4127) LTEMP
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7618.9    C
7619.     C
7620.     C                                ZERO OUT ACCUMULATIONS AFTER PRINTING
7621.     C
7622.     1200  DO 1220  J=1,20
7623.              DO 1210  IBLK=1,5
7624.                 ASNKS(J,IBLK) = 0.0
7625.                 ASNRO(J,IBLK) = 0.0
7626.                 ASNRP(J,IBLK) = 0.0
7627.                 ASNRB(J,IBLK) = 0.0
7628.                 AUNRI(J,IBLK) = 0.0
7629.                 AUNRP(J,IBLK) = 0.0
7630.                 AUNRB(J,IBLK) = 0.0
7631.                 ANRS(J,IBLK) = 0.0
7632.     1210     CONTINUE
7633.              ALNRP(J) = 0.0
7634.              ALNRB(J) = 0.0
7635.              AGNRB(J) = 0.0
7636.     1220  CONTINUE
7637.     C
7638.     C
7639.     1300  RETURN
7640.     C
7641.     C
7642.     C
7643.     4000  FORMAT ('0','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
7644.          1         3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
7645.          2         'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
7646.     4005  FORMAT ('0')
7647.     4010  FORMAT ('0',3X,'SURFACE LAYER')
7647.5    4015  FORMAT ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
7648.     4020  FORMAT ('0',6X,'STORAGE',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7648.1    4124  FORMAT ('0','DAILY SOIL TEMPERATURE IN DEGREE ',A1)
7648.2    4125  FORMAT ('0','   SURFACE ZONE MAX(4PM)  MIN(6AM)',
7648.3         1       /,' ',14X,F5.1,5X,F5.1)
7648.4    4126  FORMAT ('0','   UPPER ZONE   MAX(4PM)  MIN(6AM)',
7648.5         1       /,' ',14X,F5.1,5X,F5.1)
7648.6    4127  FORMAT ('0','   LOWER ZONE DAILY AVERAGE',/,' ',12X,F5.1)
7649.     4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7650.     4040  FORMAT ('0',6X,'REMOVAL')
7651.     4050  FORMAT ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7652.     4060  FORMAT ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7653.     4070  FORMAT ('0',9X,'PERCOLATION',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7654.     4080  FORMAT ('0',9X,'BIOLOGICAL',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7655.     4090  FORMAT ('0',3X,'UPPER ZONE')
7656.     4100  FORMAT ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
7657.     4110  FORMAT ('0',3X,'LOWER ZONE')
7658.     4120  FORMAT ('0',3X,'GROUNDWATER')
7659.     4130  FORMAT ('+',40X,8F8.3,4X,2F8.3)
7659.5    4135  FORMAT (' ',30X,F8.2)
7660.     4140  FORMAT ('+',40X,8F8.1,4X,2F8.1)
7661.     C
7662.           END
7800.     C
7801.     C
7801.1    C
7801.2    C
7802.           SUBROUTINE TRANS (DELT,IZONE,N,NB,KN,THKN,KP,THKP,T,DELN,DELNB,
7802.5         1                  AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
7803.     C
7803.5    C                         THIS SUBROUTINE
7804.     C                         1) CORRECTS REACTION RATES FOR SOIL TEMP
7804.5    C                            LESS THAN 35 DEG C.
7805.     C                            KNC = VECTOR OF NITROGEN REACTION RATES
7805.5    C                               CORRECTED FOR EFFECTS OF ENVIR. FACTORS
7806.     C                            KPC = VECTOR OF PHOSPHORUS RATES, CORRECTED
7806.5    C                         2) DEVELOPS COEFFICIENT ARRAY OF CORRECTED RATES
7807.     C
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7807.5    C                          3) THEN SOLVES A SYSTEM OF FIRST
7808.     C                             ORDER DIFFERENTIAL EQUATIONS FOR THE
7808.5    C                             CONSTITUTENT CONCENTRATIONS AT THE NEXT
7809.     C                             TIME STEP.
7809.5    C
7810.     C                             CALLING VARIABLES ARE:
7810.5    C                             N(20) = VECTOR OF CONCENTRATIONS  (LB/AC)
7811.     C                             DELT = TIME STEP (DELTA T)  (HR)
7811.5    C                             IZONE = SOIL LAYERS 1 TO 4
7812.     C                             KN(8,4) = NITROGEN REACTION RATES AT 35 C
7812.5    C                             THKN(8) = TEMP. CORRECTION COEF FOR KN
7813.     C                             KP(5,4) = PHOSPHORUS RATES AT 35 C
7813.5    C                             THKP(5) = TEMP. COEF. FOR KP
7814.     C                             T(4) = SOIL TEMP AT 4 SOIL LAYERS, DEG C
7814.5    C                             DELN(20) = CHANGE IN CONCENTRATION THIS
7815.     C                                        TIME STEP (LB/AC)
7815.5    C
7816.     C                             NB(20,5) = ARRAY OF CONCENTRATIONS,BY
7816.5    C                                        BLOCK (LB/AC)
7817.     C                             DELNB(20,5) = CHANGE IN NB, BY BLOCK
7817.5    C                                           (LB/AC)
7818.     C
7818.5    C                             AREA = TOTAL WATERSHED AREA (ACRES)
7819.     C                             M = MASS OF SOIL IN SURFACE LAYER PER BLOCK
7819.5    C                             MUZ = MASS OF SOIL IN UPPER ZONE PER BLOCK
7820.     C                             MLZ = MASS OF SOIL IN LOWER ZONE PER BLOCK
7820.5    C                                      ALL MASSES ARE IN LBS
7821.     C
7821.5    C                             INFW(5) = MASS OF WATER IN SURFACE ZONE
7822.     C                                                PER BLOCK
7822.5    C                             JNFW(5) = MASS OF WATER IN UPPER ZONE
7823.     C                                                PER BLOCK
7823.5    C                             KNFW = MASS OF WATER IN LOWER ZONE
7824.     C
7824.5    C                             SOLUTION TECHNIQUE CONSIDERED HERE IS A
7825.     C                             SIMPLE EULER INTEGRATION SCHEME:
7825.5    C                               Y(T+1) = Y(T) + DELT*DY(T)/DT
7826.     C                             WITH
7826.5    C                               DY(T)/DT = C*Y(T)
7827.     C                             SUBROUTINE COMPUTES AND RETURNS
7827.5    C                                DELN = DELT * C * Y
7828.     C                             AND Y(T+1)
7828.5    C
7829.           REAL  DELT,DELN(20),C(20,20),
7829.5         1        KN(8,4),THKN(8),KP(5,4),THKP(5),T(4),
7830.          2        DELNB(20,5),SUM,RELT,FTN(8),FTP(5),
7830.5         3        KNC(8),KPC(5),AREA,M,MUZ,MLZ,INFW(5),JNFW(5),KNFW,
7831.          4        WMMAB(5),WMMA,SMMA,SCT,SWCT,LBA,PPMS(20),PPMSW(20)
7831.2          DOUBLE PRECISION  NB(20,5),N(20)
7831.5    C
7832.           INTEGER  IROW,ICOL,IBLK,IZONE
7832.2          DATA C/400*0.C/
7832.21   C
7832.22   C            DELN AND DELNB ARE ZEROED
7832.23   C
7832.24         DO 10  J=1,20
7832.25            DELN(J) = 0.0
7832.26           DO 20 K=1,5
7832.27              DELNB(J,K) = 0.0
7832.28   20      CONTINUE
7832.29   10    CONTINUE
7832.3    C
7832.5          IF (IZONE.EQ.1 .OR. IZONE.EQ.2)  GO TO 310
7833.     C
7833.5    C                             TEMPERATURE CORRECTION OF REACTION RATES
7834.     C
7834.5          IF (T(IZONE) .GE. 35)  GO TO 37
7835.           RELT = T(IZONE) - 35.
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7835.5          DO 35  J=1,8
7836.              FTN(J) = THKN(J)**RELT
7836.5     35   CONTINUE
7837.           DO 36  J=1,5
7837.5             FTP(J) = THKP(J)**RELT
7838.      36   CONTINUE
7838.5          GO TO 40
7839.      37   DO 38  J=1,8
7839.5             FTN(J) = 1.0
7840.      38   CONTINUE
7840.5          DO 39  J=1,5
7841.              FTP(J) = 1.0
7841.5     39   CONTINUE
7842.      C
7842.5     40   DO 41  J=1,8
7843.              KNC(J) = KN(J,IZONE)*FTN(J)
7843.5     41   CONTINUE
7844.           DO 42  J=1,5
7844.5             KPC(J) = KP(J,IZONE)*FTP(J)
7845.      42   CONTINUE
7845.5     C
7846.      C                        DEVELOP COEFFICIENT ARRAY
7846.5     C
7847.           C(1,1) = -KNC(4)
7847.5          C(1,2) = KNC(5)
7848.           C(1,4) = KNC(6)
7848.5          C(2,1) = KNC(4)
7849.           C(2,2) = -(KNC(7) + KNC(1) + KNC(5))
7849.5          C(2,3) = KNC(8)
7850.           C(3,2) = KNC(7)
7850.5          C(3,3) = -KNC(8)
7851.           C(4,2) = KNC(1)
7851.5          C(4,4) = -(KNC(2) + KNC(3) + KNC(6))
7852.           C(5,4) = KNC(2)
7852.5          C(6,4) = KNC(3)
7853,      C
7853.5          C(11,11) = -KPC(1)
7854.           C(11,12) = KPC(2)
7854.5          C(12,11) = KPC(1)
7855.           C(12,12) = -(KPC(2) + KPC(4) + KPC(3))
7855.5          C(12,13) = KPC(5)
7856.           C(13,12) = KPC(4)
7856.5          C(13,13) = -KPC(5)
7857.           C(14,12) = KPC(3)
7857.5     C
7858.      C                          SOLUTION
7858.5     C
7859.           IF (IZONE.EQ.4) GO TO 95
7859.5     C
7860.      C                                LOWER ZONE
7860.5     C
7861.      C                CALC BOTH MASS PER ACRE OF SOIL AND MASS PER ACRE SOIL
7861.5     C                    WATER INCLUDING A CONVERSION FACTOR TO PPM
7862.      C
7862.1          SMMA = MLZ/(1000000.*AREA)
7862.2          WMMA = KNFW/(1000000.*AREA)
7862.5          DO 90 IROW = 1,20
7863.             SUM = 0.0
7863.5            DO 85 ICOL = 1,20
7864.               GO TO (70,80,70,80,85,85,85,85,85,85,70,80,70,85,85,85,85,85,
7864.4         1                          85,85), ICOL
7864.5     C
7865.      70         PPMS(ICOL) = N(ICOL)/SMMA
7865.5                SCT = C(IROW,ICOL)*PPMS(ICOL)
7866.                 LBA = SCT*SMMA
7866.5                SUM = SUM + LBA
7867.                 GO TO 85
7867.5     C
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7868.      80          PPMSW(ICOL) = N(ICOL)/WMMA
7868.1                 SWCT = C(IROW,ICOL)*PPMSW(ICOL)
7868.5                 LBA = SWCT*WMMA
7869.                  SUM = SUM + LBA
7869.5                 GO TO 85
7870.      85        CONTINUE
7870.5               DELN(IROW) = DELT*SUM
7871.      90      CONTINUE
7871.5             DO 91   J=1,20
7872.                N(J) = N(J) + DELN(J)
7872.5     91      CONTINUE
7873.              RETURN
7873.5     C
7874.      C                GROUNDWATER
7874.5     C
7875.      95      DO 200  IROW=1,20
7875.5               SUM = 0.0
7876.                DO 100  ICOL=1,20
7876.5                  SUM = SUM + C(IROW,ICOL)*N(ICOL)
7877.      100       CONTINUE
7877.5               DELN(IROW) = DELT*SUM
7878.      200     CONTINUE
7878.5             DO 300  J=1,20
7879.                N(J) = N(J) + DELN(J)
7879.5     300     CONTINUE
7880.              RETURN
7880.5     C
7881.      C                          FOLLOWING SECTION IS FOR THE BLOCKS
7881.5     C                          USED IN THE SURFACE AND UPPER ZONE
7882.      C
7882.5     C
7883.      C                          TEMPERATURE CORRECTION OF REACTION RATES
7883.5     C
7884.      310     IF (T(IZONE) .GE. 35)  GO TO 370
7884.5             RELT = T(IZONE) - 35.
7885.              DO 350  J=1,8
7885.5               FTN(J) = THKN(J)**RELT
7886.      350     CONTINUE
7886.5             DO 360  J=1,5
7887.                FTP(J) = THKP(J)**RELT
7887.5     360     CONTINUE
7888.              GO TO 400
7888.5     370     DO 380  J=1,8
7889.                FTN(J) = 1.0
7889.5     380     CONTINUE
7890.              DO 390  J=1,5
7890.5               FTP(J) = 1.0
7891.      390     CONTINUE
7891.5     C
7892.      400     DO 410  J=1,8
7892.5               KNC(J) = KN(J,IZONE)*FTN(J)
7893.      410     CONTINUE
7893.5             DO 420  J=1,5
7894.                KPC(J) = KP(J,IZONE)*FTP(J)
7894.5     420     CONTINUE
7895.      C
7895.5     C                       DEVELOP COEFFICIENT ARRAY
7896.      C
7896.5             C(1,1) = -KNC(4)
7897.              C(1,2) = KNC(5)
7897.5             C(1,4) = KNC(6)
7898.              C(2,1) = KNC(4)
7898.5             C(2,2) = -(KNC(7) + KNC(1) + KNC(5))
7899.              C(2,3) = KNC(8)
7899.5             C(3,2) = KNC(7)
7900.              C(3,3) = -KNC(8)
7900.5             C(4,2) = KNC(1)
7901.              C(4,4) = -(KNC(2) + KNC(3) + KNC(6))
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7901.5          C(5,4) = KNC(2)
7902.           C(6,4) = KNC(3)
7902.5    C
7903.           C(11,11) = -KPC(1)
7903.5          C(11,12) = KPC(2)
7904.           C(12,11) = KPC(1)
7904.5          C(12,12) = -(KPC(2) + KPC(4) + KPC(3))
7905.           C(12,13) = KPC(5)
7905.5          C(13,12) = KPC(4)
7906.           C(13,13) = -KPC(5)
7906.5          C(14,12) = KPC(3)
7907.     C
7907.5    C                          SOLUTION
7908.     C
7908.5          DO 700  IBLK=1,5
7909.              IF(IZONE.EQ.1) GO TO 425
7909.5    C
7910.              IF (JNFW(IBLK) .LE. 0.000001) GO TO 700
7910.5             SMMA = MUZ/(1000000.*AREA)
7911.              WMMAB(IBLK) = JNFW(IBLK)/(1000000.*AREA)
7911.5             GO TO 430
7912.     C
7912.5    425      IF (INFW(IBLK) .LE. 0.000001) GO TO 700
7913.              SMMA = M/(1000000.*AREA)
7913.5             WMMAB(IBLK) = INFW(IBLK)/(1000000.*AREA)
7914.     430        DO 500 IROW = 1,20
7914.5    C
7915.                 SUM = 0.0
7915.5                DO 450 ICOL = 1,20
7916.                   GO TO (435,440,435,440,450,450,450,450,450,450,435,440,
7916.5          1                435,450,450,450,450,450,450,450), ICOL
7917.     435           PPMS(ICOL) = NB(ICOL,IBLK)/SMMA
7917.1                  SCT = C(IROW,ICOL)*PPMS(ICOL)
7917.2                  LBA = SCT*SMMA
7917.3                  SUM = SUM + LBA
7917.5                  GO TO 450
7918.     C
7918.5    440           PPMSW(ICOL) = NB(ICOL,IBLK)/WMMAB(IBLK)
7918.6                  SWCT = C(IROW,ICOL)*PPMSW(ICOL)
7919.                   LBA = SWCT*WMMAB(IBLK)
7919.5                  SUM = SUM + LBA
7920.5    450         CONTINUE
7921.                DELNB(IROW,IBLK) = DELT*SUM
7927.     500        CONTINUE
7927.5             DO 600  J=1,20
7928.                NB(J,IBLK) = NB(J,IBLK) + DELNB(J,IBLK)
7928.3               IF (NB(J,IBLK).LT.0.000001) NB(J,IBLK)=0.0
7928.5    600      CONTINUE
7929.     700   CONTINUE
7929.5    C
7930.           RETURN
7930.5          END
8000.     C
8001.     C
8002.     C
8003.     C
8004.           SUBROUTINE OUTMON (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
8004.1         1 TPBAL,DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP,TIMAP,YEARAP)
8005.     C
8006.     C                          THIS SUBROUTINE OUTPUTS MONTHLY
8007.     C                          TABLES, AND ZEROS ACCUMULATIONS
8008.     C
8009.           INTEGER  YEAR
8010.     C
8011.     C
8011.1          DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
8011.2         1          STEMP(24),UTEMP(24)
8012.           COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
8013.          1            RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,
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     2          M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
     3          IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
     4          ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTP,METR,
     1          MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  LOOP
C
      REAL  RU,HYMIN,DPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
     1        RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
     2        M,P3,A,LTEMP,LMOIST,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 RUTOM,NEPTOM,RCSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CDRMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRC,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
C
      DOUBLE PRECISION  MNAM(12)
C
      REAL  PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,RITOM,RINTOM,BASTOM,
     1        RCHTOM,RUTOT,NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,
     2        TWBAL,EPTOM,EPTOT,UZS,UZSN,LZSN,INFIL,INTER,IRC,
     3        NN,L,SS,SGW1,PR,SGW,GWS,KV,K24L,KK24,K24EL,EP,IFS,
     4      K3(12),EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,SRGXT1,JRER,KRER,
     5        JSER,KSER,SRERT,MMPIN,METOPT,  NEPTOM,ROSTOM,
     6        CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,
     7        PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,IPACK,TMIN,SUMSNM,
     9        PXSNM,XK3,MELRAM,RADMEM,CDRMEM,CRAINM,SGMM,SNEGMM,SEVAPM,
     A        SUMSNY,PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,
     B        CRAINY,SNEGMY,SEVAPY,TSNBAL,CONMEM,
     C        COVER,COVRMX,ROBTOM(5),ROBTOT(5),RXB(5),ROITOM(5),
     D        ROITOT(5),INFTOM(5),INFTOT(5),ERSTOM(5),ERSTOT(5),
     E        SRER(5),TEMPX(24),RAD(24),WINDX(24),RAIN(288),
     F        LSRC(128),EROS(128),RROS(128)
C
      INTEGER  DAY,MONTH
      INTEGER  DSNERS,DSNROS,DSNFLO,TMBLSZ
C
C
      COMMON /PESTC/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5)
C
      REAL     KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,TPBAL,
     1        DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP
C
      INTEGER  TIMAP(12),YEARAP(12)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
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8080.          1            UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
8081.          2            SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
8082.          3            TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
8083.          4            KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
8084.          5            TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
8085.     C
8086.           REAL  DELT,
8087.          1        SNT(20),SNRSM(20,5),SNROM(20,5),
8088.          2        UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
8089.          3        NRSM(20,5),LNRPM(20),
8090.          4        SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
8091.          5        SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
8092.          6        LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
8093.          7        TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
8094.          8        KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
8094.5          DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
8095.     C
8096.     C
8097.           INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
8098.     C
8099.     C
8100.     C                          HYDROLOGY AND PESTICIDE VARIABLES USED
8101.     C                          INTERNALLY
8102.     C
8103.           REAL  PRT,PRTTOM(5),PRTTOT(5),DEGTOM,
8104.          1        DEGT,PBAL,COVR,PACKMM,TSNBMM,
8105.          2        UZSMET,LZSMET,SGWMET,SCEPMT,RESSMT,TWBLMT,SRGXTM,
8106.          3        SRRTMT,STSTMT,SASTMT,SCSTMT,SDSTMT,UTSTMT,
8107.          4        UASTMT,UCSTMT,UDSTMT,LSTRMT,LASMET,LCSMET,LDSMET,
8108.          5        GSTRMT,GASMET,GCSMET,GDSMET,DEGTMT,DEGSMT,DEGUMT,
8109.          6        DEGLMT,TPBALM,UZSBMT(5),RESBMT(5),SRGXMT(5),
8110.          7        SRERMT(5),STSMET(5),SASMET(5),SCSMET(5),SDSMET(5),
8111.          8        UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5),UPRISM(5)
8112.     C
8113.     C                          NUTRIENT INTERNAL VARIABLES
8114.     C
8115.           DOUBLE PRECISION  CONC, LBPAC, KGPHA
8116.     C
8117.           REAL  NBALMT,PHBLMT,CLBLMT,
8118.          1        SNMET(20,5),SNTMET(20),UNMET(20,5),UNTMET(20),
8119.          2        LNMET(20),GNMET(20),SNRSMT(20),SNROMT(20),
8120.          3        UNRIMT(20),SNRBMT(20),UNRBMT(20),NRSMT(20),
8121.          4        NRSYT(20),SNRSYT(20),SNROYT(20),SNRBYT(20),
8122.          5        UNRIYT(20),UNRBYT(20),UNITMT(20),UNIMET(20,5),
8123.          6        TR(20),TNR,TPR,TCLR,TNS,TPS,TCLS,
8124.          7        SUMS,SUMI,SUMB,SUMRS,CONVF
8124.1          DATA PRT/0.0/,DEGT/0.0/,LBPAC/'LB/AC'/,KGPHA/'KG/HA'/
8124.2          DATA TR/20*0.0/,CONVF/1.121/
8125.     C
8126.     C
8127.     C
8128.     C                    MONTHLY SUMMARY
8129.     C
8130.                IF (PEST .EQ. NO)  GO TO 973
8131.     C
8132.                DO 1051  I= 1,5
8133.      1051      PRTTOM(I) = PRSTOM(I) + PROTOM(I) + UPITOM(I)
8134.     C
8135.     C
8136.                DEGTOM = DEGSOM + DEGJOM + DEGLOM
8137.                DEGT = DEGT + DEGTOM
8138.     C
8139.                PRTM = SPRCTM + SPRSTM + UPRITM
8140.                PRT = PRT + PRTM
8141.     C
8142.                PBAL = STST + UTST + LSTR + GSTR + PRT + DEGT - TOTPAP
8143.                IF ((PBAL .LE. 0.0).AND.(PBAL .GE. -0.0020))  PBAL = 0.0
8144.                IF (JCOUNT.LT.TIMAP(1) .AND. YEAR.LE.(YEARAP(1)+1900)) PBAL=0.
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8145.                TPBAL = TPBAL + PBAL
8146.      C
8147.        973     IF (NUTR .EQ. NO)  GO TO 990
8148.      C
8149.      C                            COMPUTE MONTHLY NUTRIENT TOTALS BY ZONE,
8150.      C                            ACCUMULATE YEARLY REMOVALS,
8151.      C                            COMPUTE TOTAL N, P, CL MASS BALANCES
8152.      C
8153.      C                            SURFACE
8154.            DO 991  J=1,20
8155.               SUMS = 0.0
8156.               SUMO = 0.0
8157.               SUMB = 0.0
8158.               SNT(J) = 0.0
8159.               DO 989  IBLK=1,5
8160.                  SUMS = SUMS + SNRSM(J,IBLK)
8161.                  SUMO = SUMO + SNROM(J,IBLK)
8162.                  SUMB = SUMB + SNRBM(J,IBLK)
8163.                  SNT(J) = SNT(J) + SN(J,IBLK)
8164.      989      CONTINUE
8165.               SNRSMT(J) = SUMS/5.
8166.               SNROMT(J) = SUMO/5.
8167.               SNRBMT(J) = SUMB/5.
8168.               SNT(J) = SNT(J)/5.
8169.      991   CONTINUE
8170.      C
8171.      C                            UPPER ZONE
8172.      C
8173.            DO 993  J=1,20
8174.               SUMI = 0.0
8175.               SUMB = 0.0
8176.               UNT(J) = 0.0
8177.               UNIT(J) = 0.0
8178.               DO 992  IBLK=1,5
8179.                  SUMI = SUMI + UNRIM(J,IBLK)
8180.                  SUMB = SUMB + UNRBM(J,IBLK)
8181.                  UNT(J) = UNT(J) + UN(J,IBLK)
8182.                  UNIT(J) = UNIT(J) + UNI(J,IBLK)
8183.      992      CONTINUE
8184.               UNRIMT(J) = SUMI/5.
8185.               UNRBMT(J) = SUMB/5.
8186.               UNT(J) = UNT(J)/5.
8187.               UNIT(J) = UNIT(J)/5.
8188.      993   CONTINUE
8189.      C
8190.      C                            TOTAL REMOVAL TO STREAM
8191.      C
8192.            DO 995 J=1,20
8193.               SUMRS = 0.0
8194.               DO 994  IBLK=1,5
8195.                  SUMRS = SUMRS + NRSM(J,IBLK)
8196.      994      CONTINUE
8197.               NRSMT(J) = SUMRS/5.
8198.      995   CONTINUE
8199.      C
8200.      C                            YEARLY ACCUMULATIONS
8201.      C
8202.            DO 997  J=1,20
8203.               DO 996  IBLK=1,5
8204.                  SNRSY(J,IBLK) = SNRSY(J,IBLK) + SNRSM(J,IBLK)
8205.                  SNROY(J,IBLK) = SNROY(J,IBLK) + SNROM(J,IBLK)
8206.                  SNRBY(J,IBLK) = SNRBY(J,IBLK) + SNRBM(J,IBLK)
8207.      C
8208.                  UNRIY(J,IBLK) = UNRIY(J,IBLK) + UNRIM(J,IBLK)
8209.                  UNRBY(J,IBLK) = UNRBY(J,IBLK) + UNRBM(J,IBLK)
8210.      C
8211.                  NRSY(J,IBLK) = NRSY(J,IBLK) + NRSM(J,IBLK)
8212.      996      CONTINUE
8213.               LNRPY(J) = LNRPY(J) + LNRPM(J)
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8214.              LNRBY(J) = LNRBY(J) + LNRBM(J)
8215.              GNRBY(J) = GNRBY(J) + GNRBM(J)
8216.              TNRHVY(J) = TNRHVY(J) + TNRHVM(J)
8217.      997   CONTINUE
8218.      C
8219.      C                          MASS BALANCES AND TOTAL REMOVALS
8220.      C                          TR(20) = TOTAL REMOVAL OVER SIMULATION PERIOD
8221.      C                          TNR = TOTAL NITROGEN REMOVAL
8222.      C                          TPR = TOTAL PHOSPHORUS REMOVAL
8223.      C                          TCLR = TOTAL CHLORIDE REMOVAL
8224.      C                          TNS = TOTAL NITROGEN IN STORAGE
8225.      C                          TPS = TOTAL PHOSPHORUS IN STORAGE
8226.      C                          TCLS = TOTAL CHLORIDE IN STORAGE
8227.      C                          TNA = TOTAL NITROGEN ADDED, AND INITIAL STRG.
8228.      C                          TPA = TOTAL PHOSPHORUS ADDED
8229.      C                          TCLA = TOTAL CHLORIDE ADDED
8230.      C
8231.            DO 503  J=1,20
8232.              SUMB = 0.0
8233.              DO 502  IBLK=1,5
8234.                SUMB = SUMB + NRSM(J,IBLK)
8235.      502     CONTINUE
8236.              TR(J) = TR(J) + SUMB/5. + TNRHVM(J)
8237.      503   CONTINUE
8238.            TNR = 0.0
8239.            DO 504  J=1,6
8240.              TNR = TNR + TR(J)
8241.      504   CONTINUE
8242.            TPR = 0.0
8243.            DO 505  J=11,14
8244.              TPR = TPR + TR(J)
8245.      505   CONTINUE
8246.            TCLR = TR(20)
8247.      C
8248.            TNS = 0.0
8249.            DO 511  J=1,6
8250.              SUMB = 0.C
8251.              DO 510  IBLK = 1,5
8252.                SUMB = SUMB + SN(J,IBLK) + UN(J,IBLK) + UNI(J,IBLK)
8253.      510     CONTINUE
8254.              TNS = TNS + SUMB/5. + LN(J) + GN(J)
8255.      511   CONTINUE
8256.            NBAL = TNS + TNR - TNA
8257.      C
8258.            TPS = 0.0
8259.            DO 513  J=11,14
8260.              SUMB = 0.C
8261.              DO 512  IBLK=1,5
8262.                SUMB = SUMB + SN(J,IBLK) + UN(J,IBLK) + UNI(J,IBLK)
8263.      512     CONTINUE
8264.              TPS = TPS + SUMB/5. + LN(J) + GN(J)
8265.      513   CONTINUE
8266.            PHBAL = TPS + TPR - TPA
8267.      C
8268.            SUMB = 0.C
8269.            DO 514  IBLK=1,5
8270.              SUMB = SUMB + SN(20,IBLK) + UN(20,IBLK) + UNI(20,IBLK)
8271.      514   CONTINUE
8272.            TCLS = SUMB/5. + LN(20) + GN(20)
8273.            CLBAL = TCLS + TCLR - TCLA
8274.      C
8275.      C
8276.        990       WRITE (6,1200)  MNAM(MONTH), YEAR
8277.                  WRITE (6,1201)
8278.                  WRITE (6,1103)
8279.      C
8280.            IF (OUTPUT.EQ. METR) GO TO 1053
8281.            WRITE (6,360)
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8282.          WRITE (6,362)
8283.          WRITE (6,363) ROBTOM, ROSTOM
8284.          WRITE (6,364) INFTOM, RINTOM
8285.          WRITE (6,365) RITOM
8286.          WRITE (6,366) RCITOM, ROTOM
8287.          WRITE (6,380) BASTOM
8288.          WRITE (6,381) RCHTOM
8289.          WRITE (6,361) PRTOM,PRTOM,PRTOM,PRTOM,PRTOM,PRTOM
8290.          IF (SNOW .EQ. NO)  GO TO 1071
8291.          WRITE (6,478) SUMSNM
8292.          WRITE (6,479) PXSNM
8293.          WRITE (6,480) MELRAM
8294.          WRITE (6,481)
8295.          WRITE (6,482) RADMEM
8296.          WRITE (6,483) CONMEM
8297.          WRITE (6,484) CORMEM
8298.          WRITE (6,485) CRAINM
8299.          WRITE (6,486) SGMM
8300.          WRITE (6,487) SNEGMM
8301.          WRITE (6,490) PACK
8302.             COVR = 100.
8303.             IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
8304.             IF (PACK.GT.0.01) GO TO 1078
8305.             COVR=0.0
8306.             SDEN=0.0
8307.     1078 WRITE (6,491) SDEN
8308.          WRITE (6,492) COVR
8309.          WRITE (6,488) SEVAPM
8310.     1071 WRITE (6,367)
8311.          WRITE (6,368) EPTOM,EPTOM,EPTOM,EPTOM,EPTOM,EPTOM
8312.          WRITE (6,369) NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM
8313.          WRITE (6,383) COVER
8314.          WRITE (6,370)
8315.          WRITE (6,371) LZSB,UZS
8316.          WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
8317.          WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
8318.          WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
8319.          WRITE (6,375) RESB,RESS
8320.          WRITE (6,376) SRGX,SRGXT
8321.          WRITE (6,377) TWBAL
8322.          IF (SNOW.EQ.YES)  WRITE (6,489) TSNBAL
8323.                WRITE (6,1209)
8324.                WRITE (6,1210) ERSTOM,  ERSNTM
8325.                WRITE (6,1211)  SRER, SRERT
8326.     C
8327.                IF (PEST .EQ. NO)  GO TO 974
8328.     C
8329.                WRITE (6,1220)
8330.                WRITE (6,1221)  STS, STST
8331.                WRITE (6,1222)  SAS, SAST
8332.                WRITE (6,1223)  SCS, SCST
8333.                WRITE (6,1227)  SDS, SDST
8334.                WRITE (6,1224)  UTS, UTST
8335.                WRITE (6,1222)  UAS, UAST
8336.                WRITE (6,1223)  UCS, UCST
8337.                WRITE (6,1227)  UDS, UDST
8338.                WRITE (6,1226)  UPRIS, UIST
8339.                WRITE (6,1228)  LSTR
8340.                WRITE (6,1229)  LAS
8341.                WRITE (6,1230)  LCS
8342.                WRITE (6,1231)  LDS
8343.                WRITE (6,1232)  GSTR
8344.                WRITE (6,1229)  GAS
8345.                WRITE (6,1230)  GCS
8346.                WRITE (6,1231)  GDS
8347.                WRITE (6,1240)  PRTTOM, PRTM
8348.                WRITE (6,1241)  PROTOM, SPROTM
8349.                WRITE (6,1242)  PRSTOM, SPRSTM
8350.                WRITE (6,1243)  UPITOM, UPRITM
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8351.                 WRITE (6,1248)
8352.                 WRITE (6,1245) DEGTOM
8353.                 WRITE (6,1246) DEGSOM
8354.                 WRITE (6,1247) DEGUOM
8355.                 WRITE (6,1252) DEGLOM
8356.                 WRITE (6,1266) TPBAL
8357.      C
8358.        974     IF (NUTR .EQ. NO)  GO TO 1053
8359.      C
8360.      C                              MONTHLY NUTRIENT OUTPUT
8361.      C
8362.            CONC = LBPAC
8363.            WRITE (6,1092)
8364.            WRITE (6,4000)  CONC
8365.            WRITE (6,4005)
8366.            WRITE (6,4006)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
8367.            WRITE (6,4030) (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14)
8368.           1                ,SN(20,IBLK),  IBLK=1,5)
8369.            WRITE (6,4007)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
8370.            WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
8371.           1                ,UN(20,IBLK),  IBLK=1,5)
8372.            WRITE (6,4015)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
8373.            WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14),
8374.           1               UNI(20,IBLK),  IBLK=1,5)
8375.            WRITE (6,4008)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
8376.            WRITE (6,4009)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
8377.      C
8378.            WRITE (6,4011)
8379.            WRITE (6,4012)
8380.            WRITE (6,4013)  (SNRSMT(J),J=1,6),(SNRSMT(J),J=11,14),SNRSMT(20)
8381.            WRITE (6,4030) (IBLK,(SNRSM(J,IBLK),J=1,6),
8382.           1               (SNRSM(J,IBLK),J=11,14),
8383.           2               SNRSM(20,IBLK),  IBLK=1,5)
8384.            WRITE (6,4014)  (SNROMT(J),J=1,6),(SNROMT(J),J=11,14),SNROMT(20)
8385.            WRITE (6,4030) (IBLK,(SNROM(J,IBLK),J=1,6),
8386.           1               (SNROM(J,IBLK),J=11,14),
8387.           2               SNROM(20,IBLK),  IBLK=1,5)
8388.            WRITE (6,4015)  (UNRIMT(J),J=1,6),(UNRIMT(J),J=11,14),UNRIMT(20)
8389.            WRITE (6,4030) (IBLK,(UNRIM(J,IBLK),J=1,6),
8390.           1               (UNRIM(J,IBLK),J=11,14),
8391.           2               UNRIM(20,IBLK),  IBLK=1,5)
8392.            WRITE (6,4016)  (NRSMT(J),J=1,6),(NRSMT(J),J=11,14),NRSMT(20)
8393.            WRITE (6,4017)  (LNRPM(J),J=1,6),(LNRPM(J),J=11,14),LNRPM(20)
8394.            WRITE (6,4018)  (TNRBM(J),J=1,6),(TNRBM(J),J=11,14),TNRBM(20),
8395.           1                (SNRBMT(J),J=1,6),(SNRBMT(J),J=11,14),SNRBMT(20),
8396.           2                (UNRBMT(J),J=1,6),(UNRBMT(J),J=11,14),UNRBMT(20),
8397.           3                (LNRBM(J),J=1,6),(LNRBM(J),J=11,14),LNRBM(20),
8398.           4                (GNRBM(J),J=1,6),(GNRBM(J),J=11,14),GNRBM(20)
8399.            WRITE (6,4019)  (TNRHVM(J),J=1,6),(TNRHVM(J),J=11,14),TNRHVM(20)
8400.            WRITE (6,4021)  NBAL, PHBAL, CLBAL
8401.      C
8402.      C
8403.       1053 IF (OUTPUT.EQ. ENGL) GO TO 1055
8404.      C  CONVERSIONS TO METRIC
8405.      C  NEW PARAMETERS DEFINED FOR VARIABLES NOT RESET TO ZERO.
8406.      C
8407.            PRTOM =PRTOM*MMPIN
8408.            ROSTOM=ROSTOM*MMPIN
8409.            RINTOM=RINTOM*MMPIN
8410.            RITOM =RITOM*MMPIN
8411.            RUTOM =RUTOM*MMPIN
8412.            BASTOM =BASTOM*MMPIN
8413.            RCHTOM=RCHTOM*MMPIN
8414.            EPTOM =EPTOM*MMPIN
8415.            NEPTOM =NEPTOM*MMPIN
8416.            UZSMET=UZS*MMPIN
8417.            LZSMET=LZS*MMPIN
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8418.          SGKMET=SGK*MMPIN
8419.          SCEPMT=SCEP*MMPIN
8420.          RESSMT=RESS*MMPIN
8421.          TWBLMT=TWBAL*MMPIN
8422.          SRGXTM=SRGXT*MMPIN
8423.     C  SEDIMENT
8424.          ERSNTM=ERSNTM*METOPT*2.471
8425.          SRRTMT=SRERT*METOPT*2.471
8426.     C  SNOW
8427.          IF (SNOW .EQ. NO)  GO TO 970
8428.          SUMSNM = SUMSNM*MMPIN
8429.          PXSNM = PXSNM*MMPIN
8430.          MELRAM = MELRAM*MMPIN
8431.          RADMEM = RADMEM*MMPIN
8432.          CONMEM = CONMEM*MMPIN
8433.          CORMEM = CORMEM*MMPIN
8434.          CRAINM = CRAINM*MMPIN
8435.          SGMM = SGMM*MMPIN
8436.          SNEGMM = SNEGMM*MMPIN
8437.          PACKMM = PACK*MMPIN
8438.          SEVAPM = SEVAPM*MMPIN
8439.          TSNBMM = TSNBAL*MMPIN
8440.     C  PESTICIDE
8441.       970 IF (PEST .EQ. NO)  GO TO 975
8442.          STSTMT=STST*KGPLB
8443.          SASTMT=SAST*KGPLB
8444.          SCSTMT=SCST*KGPLB
8445.          SDSTMT=SDST*KGPLB
8446.          UTSTMT=UTST*KGPLB
8447.          UASTMT=UAST*KGPLB
8448.          UCSTMT=UCST*KGPLB
8449.          UDSTMT=UDST*KGPLB
8450.          UIST=UIST*KGPLB
8451.          LSTRMT=LSTR*KGPLB
8452.          LASMET=LAS*KGPLB
8453.          LCSMET=LCS*KGPLB
8454.          LDSMET=LDS*KGPLB
8455.          GSTRMT=GSTR*KGPLB
8456.          GASMET=GAS*KGPLB
8457.          GCSMET=GDS*KGPLB
8458.          GDSMET=GDS*KGPLB
8459.          PRTM  =PRTM*KGPLB
8460.          SPROTM=SPROTM*KGPLB
8461.          SPRSTM=SPRSTM*KGPLB
8462.          UPRITM=UPRITM*KGPLB
8463.          DEGTMT=DEGTOM*KGPLB
8464.          DEGSMT=DEGSCM*KGPLB
8465.          DEGUMT=DEGUCM*KGPLB
8466.          DEGLMT=DEGLCM*KGPLB
8467.          TPBALM=TPBAL*KGPLB
8468.     C
8469.     C ARRAY METRIC MODIFICATIONS
8470.       975 DO 1048 I=1,5
8471.            ROBTOM(I)=ROBTOM(I)*MMPIN
8472.            INFTOM(I)=INFTOM(I)*MMPIN
8473.            ROITOM(I)=ROITOM(I)*MMPIN
8474.            UZSBMT(I)=UZSB(I)*MMPIN
8475.            RESBMT(I)=RESB(I)*MMPIN
8476.            SRGXMT(I)=SRGX(I)*MMPIN
8477.            ERSTOM(I)=ERSTOM(I)*METOPT*2.471
8478.            SRERMT(I)=SRER(I)*METOPT*2.471
8479.           IF (PEST .EQ. NO)  GO TO 1048
8480.            STSMET(I)=STS(I)*KGPLB
8481.            SASMET(I)=SAS(I)*KGPLB
8482.            SCSMET(I)=SCS(I)*KGPLB
8483.            SDSMET(I)=SDS(I)*KGPLB
8484.            UTSMET(I)=UTS(I)*KGPLB
8485.            UASMET(I)=UAS(I)*KGPLB
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8486.              UCSMET(I)=UCS(I)*KGPLB
8487.              UDSMET(I)=UDS(I)*KGPLB
8488.              UPRISM(I)=UPRIS(I)*KGPLB
8489.              PRTTOM(I)=PRTTOM(I)*KGPLB
8490.              PROTOM(I)=PROTOM(I)*KGPLB
8491.              PRSTOM(I)=PRSTOM(I)*KGPLB
8492.              UPITOM(I)=UPITOM(I)*KGPLB
8493.       1048 CONTINUE
8494.            WRITE (6,460)
8495.            WRITE (6,362)
8496.            WRITE (6,363) RGBTOM,ROSTOM
8497.            WRITE (6,364) INFTOM,RINTOM
8498.            WRITE (6,365) RITOM
8499.            WRITE (6,366) RCITOM,RUTOM
8500.            WRITE (6,380) BASTOM
8501.            WRITE (6,381) RCHTOM
8502.            WRITE (6,361) PRTOM,PRTOM,PRTOM,PRTOM,PRTOM,PRTOM
8503.            IF (SNOW .EQ. NO)  GO TO 1089
8504.            WRITE (6,478)  SUMSNM
8505.            WRITE (6,479)  PXSNM
8506.            WRITE (6,480)  MELRAM
8507.            WRITE (6,481)
8508.            WRITE (6,482)  RADMEM
8509.            WRITE (6,483)  CONMEM
8510.            WRITE (6,484)  CORMEM
8511.            WRITE (6,485)  CRAINM
8512.            WRITE (6,486)  SGMM
8513.            WRITE (6,487)  SNEGMM
8514.            WRITE (6,490)  PACKMM
8515.               COVR = 100.0
8516.               IF (PACK .LT. IPACK)  COVR = (PACK/IPACK)*100.
8517.               IF (PACK .GT. 0.01)  GO TO 1088
8518.               COVR = 0.0
8519.               SDEN = 0.0
8520.       1088 WRITE (6,491)  SDEN
8521.            WRITE (6,492)  COVR
8522.            WRITE (6,488)  SEVAPM
8523.       1089 WRITE (6,367)
8524.            WRITE (6,368) EPTOM,EPTOM,EPTOM,EPTOM,EPTOM,EPTOM
8525.            WRITE (6,369) NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM
8526.            WRITE (6,383) CCVER
8527.            WRITE (6,370)
8528.            WRITE (6,371) UZSMET,UZSMET
8529.            WRITE (6,372) LZSMET,LZSMET,LZSMET,LZSMET,LZSMET,LZSMET
8530.            WRITE (6,373) SGWMET,SGWMET,SGWMET,SGWMET,SGWMET,SGWMET
8531.            WRITE (6,374) SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT
8532.            WRITE (6,375) RESBMT,RESSMT
8533.            WRITE (6,376) SRGXMT,SRGXTM
8534.            WRITE (6,377) TWBLMT
8535.            IF (SNOW .EQ. YES)  WRITE (6,489)  TSNBMM
8536.            WRITE (6,1208)
8537.            WRITE (6,1210) ERSTOM,ERSNTM
8538.            WRITE (6,1211) SRERMT,SRRTMT
8539.      C
8540.               IF (PEST .EQ. NO)  GO TO 976
8541.      C
8542.            WRITE (6,1207)
8543.            WRITE (6,1221) STSMET,STSTMT
8544.            WRITE (6,1222) SASMET,SASTMT
8545.            WRITE (6,1223) SCSMET,SCSTMT
8546.            WRITE (6,1227) SDSMET,SDSTMT
8547.            WRITE (6,1224) UTSMET,UTSTMT
8548.            WRITE (6,1222) UASMET,UASTMT
8549.            WRITE (6,1223) UCSMET,UCSTMT
8550.            WRITE (6,1227) UDSMET,UDSTMT
8551.            WRITE (6,1226) UPRISM,UIST
8552.            WRITE (6,1228) LSTRMT
8553.            WRITE (6,1229) LASMET
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8554.          WRITE (6,1230) LCSMET
8555.          WRITE (6,1231) LDSMET
8556.          WRITE (6,1232) GSTRMT
8557.          WRITE (6,1229) GASMET
8558.          WRITE (6,1230) CCSMET
8559.          WRITE (6,1231) GDSMET
8560.          WRITE (6,1239) PRTTOM,PRTM
8561.          WRITE (6,1241) PROTOM,SPROTM
8562.          WRITE (6,1242) PRSTOM,SPRSTM
8563.          WRITE (6,1243) CPITOM,JPRITM
8564.          WRITE (6,1249)
8565.          WRITE (6,1245) DEGTMT
8566.          WRITE (6,1246) DEGSMT
8567.          WRITE (6,1247) DEGUMT
8568.          WRITE (6,1252) DEGLMT
8569.          WRITE (6,1266) TPBALM
8570.    C
8571.      976 IF (NUTR .EQ. NC)  GO TO 1055
8572.    C
8573.    C                              CONVF CONVERTS LB/AC TO KG/HA
8574.    C
8575.          DO 520  J=1,20
8576.             SNRSMT(J) = SNRSMT(J)*CONVF
8577.             SNROMT(J) = SNROMT(J)*CONVF
8578.             UNRIMT(J) = UNRIMT(J)*CONVF
8579.             NRSMT(J) = NRSMT(J)*CONVF
8580.             LNRPM(J) = LNRPM(J)*CONVF
8581.             TNRBM(J) = TNRBM(J)*CONVF
8582.             SNRBMT(J) = SNRBMT(J)*CONVF
8583.             UNRBMT(J) = UNRBMT(J)*CONVF
8584.             LNRBM(J) = LNRBM(J)*CONVF
8585.             GNRBM(J) = GNRBM(J)*CONVF
8586.             TNRHVM(J) = TNRHVM(J)*CONVF
8587.    C
8588.              SNTMET(J) = SNT(J)*CONVF
8589.              UNTMET(J) = UNT(J)*CONVF
8590.              UNITMT(J) = UNIT(J)*CONVF
8591.              LNMET(J) = LN(J)*CONVF
8592.              GNMET(J) = GN(J)*CONVF
8593.             DO 519  IBLK=1,5
8594.                SNRSM(J,IBLK) = SNRSM(J,IBLK)*CONVF
8595.                SNROM(J,IBLK) = SNROM(J,IBLK)*CONVF
8596.                UNRIM(J,IBLK) = UNRIM(J,IBLK)*CONVF
8599.                 SNMET(J,IBLK) = SN(J,IBLK)*CONVF
8600.                 UNMET(J,IBLK) = UN(J,IBLK)*CONVF
8601.                 UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
8602.    519      CONTINUE
8603.    520   CONTINUE
8604.          NBALMT = NBAL*CONVF
8605.          PHBLMT = PHBAL*CONVF
8606.          CLBLMT = CLBAL*CONVF
8607.    C
8608.    C
8609.          CONC = KGPHA
8610.          WRITE (6,1092)
8611.          WRITE (6,4000)  CONC
8612.          WRITE (6,4005)
8613.          WRITE (6,4006)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
8614.          WRITE (6,4030) (IBLK,(SNMET(J,IBLK),J=1,6),(SNMET(J,IBLK),J=11,14)
8615.         1                ,SNMET(20,IBLK),  IBLK=1,5)
8616.          WRITE (6,4007)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
8617.          WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),(UNMET(J,IBLK),J=11,14)
8618.         1                ,UNMET(20,IBLK),  IBLK=1,5)
8619.          WRITE (6,4015)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
8620.          WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
8621.         1                (UNIMET(J,IBLK),J=11,14),
8622.         2                UNIMET(20,IBLK),  IBLK=1,5)
8623.          WRITE (6,4008)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
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8624.          WRITE (6,4009)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
8625.     C
8626.          WRITE (6,4011)
8627.          WRITE (6,4012)
8628.          WRITE (6,4013)  (SNRSMT(J),J=1,6),(SNRSMT(J),J=11,14),SNRSMT(20)
8629.          WRITE (6,4030) (IBLK,(SNRSM(J,IBLK),J=1,6),
8630.         1               (SNRSM(J,IBLK),J=11,14),
8631.         2               SNRSM(20,IBLK),  IBLK=1,5)
8632.          WRITE (6,4014)  (SNROMT(J),J=1,6),(SNROMT(J),J=11,14),SNROMT(20)
8633.          WRITE (6,4030) (IBLK,(SNROM(J,IBLK),J=1,6),
8634.         1               (SNROM(J,IBLK),J=11,14),
8635.         2               SNROM(20,IBLK),  IBLK=1,5)
8636.          WRITE (6,4015)  (UNRIMT(J),J=1,6),(UNRIMT(J),J=11,14),UNRIMT(20)
8637.          WRITE (6,4030) (IBLK,(UNRIM(J,IBLK),J=1,6),
8638.         1               (UNRIM(J,IBLK),J=11,14),
8639.         2               UNRIM(20,IBLK),  IBLK=1,5)
8640.          WRITE (6,4016)  (NRSMT(J),J=1,6),(NRSMT(J),J=11,14),NRSMT(20)
8641.          WRITE (6,4017)  (LNRPM(J),J=1,6),(LNRPM(J),J=11,14),LNRPM(20)
8642.          WRITE (6,4018)  (TNRBM(J),J=1,6),(TNRBM(J),J=11,14),TNRBM(20),
8643.         1                (SNRBMT(J),J=1,6),(SNRBMT(J),J=11,14),SNRBMT(20),
8644.         2                (UNRBMT(J),J=1,6),(UNRBMT(J),J=11,14),UNRBMT(20),
8645.         3                (LNRBM(J),J=1,6),(LNRBM(J),J=11,14),LNRBM(20),
8646.         4                (GNRBM(J),J=1,6),(GNRBM(J),J=11,14),GNRBM(20)
8647.          WRITE (6,4019)  (TNRHVM(J),J=1,6),(TNRHVM(J),J=11,14),TNRHVM(20)
8648.          WRITE (6,4021)  NBALMT, PHBLMT, CLBLMT
8649.     C
8650.     C                    ZEROING OF VARIABLES
8651.     C
8652.      1055       PRTOM = 0.0
8653.          RUTOM = 0.0
8654.          NEPTOM = 0.0
8655.          ROSTOM = 0.0
8656.          RITOM = 0.0
8657.          RINTOM = 0.0
8658.          BASTOM = 0.0
8659.          RCHTOM = 0.0
8660.                 EPTOM = 0.0
8661.                 ERSNTM = 0.0
8662.                 PRTM = 0.0
8663.                 SPRCTM = 0.0
8664.                 SPRSTM = 0.0
8665.                 UPRITM = 0.0
8666.                 DEGSOM = 0.0
8667.                 DEGUOM = 0.0
8668.                 DEGLOM = 0.0
8669.          SUMSNM = 0.0
8670.          PXSNM = 0.0
8671.          MELRAM = 0.0
8672.          RADMEM = 0.0
8673.          CORMEM = 0.0
8674.          CONMEM = 0.0
8675.          CRAINM = 0.0
8676.          SGMM = 0.0
8677.          SNEGMM = 0.0
8678.          SEVAPM = 0.0
8679.     C
8680.                 DO 1058  I=1,5
8681.                    ERSTOM(I) = 0.0
8682.                    ROBTOM(I) = 0.0
8683.                    INFTOM(I) = 0.0
8684.                    PRTTOM(I) = 0.0
8685.                    PRUTOM(I) = 0.0
8686.                    PRSTOM(I) = 0.0
8687.                    UPITOM(I) = 0.0
8688.      1058          ROITOM(I)= 0.0
8689.     C
8690.          IF (NUTR .EQ. NO)  GO TO 1060
8691.     C
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C                                   ZERO MONTHLY ACCUMULATIONS
C
      DO 522  J=1,20
         LNRPM(J) = C.0
         LNRBM(J) = C.0
         GNRBM(J) = C.0
         TNRBM(J) = C.0
         TNRHVM(J) = C.0
         DO 521  IBLK=1,5
            SNRSM(J,IBLK) = 0.0
            SNROM(J,IBLK) = 0.0
            UNRIM(J,IBLK) = 0.0
            NRSM(J,IBLK) = 0.0
            SNRBM(J,IBLK) = 0.0
            UNRBM(J,IBLK) = 0.0
521      CONTINUE
522   CONTINUE
C
1060  RETURN
C
C                                   FORMATS
C
 1092 FORMAT ('0')
 1200 FORMAT ('1',25X,'SUMMARY FOR MONTH OF ',A8,1X,I4)
 1201 FORMAT ('+',25X,'_________________________________')
 1103 FORMAT ('0',34X,'BLOCK 1   BLOCK 2   BLOCK 3   BLOCK 4   BLOCK 5',
     C  5X,'TOTAL')
 1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
 1207 FORMAT ('0',5X,'PESTICIDE, KILOGRAMS')
 1209 FORMAT ('0', 8X,'SEDIMENT, TONS/ACRE')
 1210 FORMAT (' ',11X,'ERODED SEDIMENT     ',5(3X,F7.3),4X,F7.3)
 1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
 1220 FORMAT ('0',5X,'PESTICIDE, POUNDS')
 1221 FORMAT ('0', 8X,'SURFACE LAYER',9X,5(3X,F7.3),3X,F8.3)
 1222 FORMAT (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 1223 FORMAT (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 1224 FORMAT ('0', 8X,'UPPER ZONE LAYER',6X,5(3X,F7.3),3X,F8.3)
 1226 FORMAT (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 1227 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 1228 FORMAT ('0', 8X,'LOWER ZONE LAYER',59X,F8.3)
 1229 FORMAT (' ',11X,'ADSORBED',64X,F8.3)
 1230 FORMAT (' ',11X,'CRYSTALLINE',61X,F8.3)
 1231 FORMAT (' ',11X,'DISSOLVED',63X,F8.3)
 1232 FORMAT ('0', 8X,'GROUNDWATER LAYER',58X,F8.3)
 1239 FORMAT ('0',8X,'PESTICIDE REMOVAL, KGS.',2X,5(F7.3,3X),F8.3)
 1240 FORMAT ('0', 8X,'PESTICIDE REMOVAL, LBS.',2X,5(F7.3,3X),F8.3)
 1241 FORMAT (' ',11X,'OVERLAND FLOW REMOVAL',1X,5(F7.3,3X),F8.3)
 1242 FORMAT (' ',11X,'SEDIMENT REMOVAL',6X,5(F7.3,3X),F8.3)
 1243 FORMAT (' ',11X,'INTERFLOW REMOVAL',5X,5(F7.3,3X),F8.3)
 1245 FORMAT (' ',11X,'TOTAL',68X,F7.3)
 1246 FORMAT (' ',11X,'FROM SURFACE',61X,F7.3)
 1247 FORMAT (' ',11X,'FROM UPPER ZONE',58X,F7.3)
 1248 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, LBS.')
 1249 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, KGS.')
 1252 FORMAT (' ',11X,'FROM LOWER ZONE',58X,F7.3)
 1266 FORMAT ('0',11X,'PESTICIDE BALANCE=',F8.4)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',8X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
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      481 FORMAT ('0',11X,'MELT')
      482 FORMAT (' ',14X,'RADIATION',50X,F7.2)
      483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
      484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
      485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
      486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
      487 FORMAT (' ',14X,'COM NEG HEAT',57X,F7.2)
      490 FORMAT ('0',11X,'SNOW PACK',63X,F7.2)
      491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
      492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
      488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
      367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
      368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
      369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
      383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
      370 FORMAT ('0',11X,'STORAGES')
      371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
      372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
      373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
      374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
      375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
      376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
      377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
      489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
      460 FORMAT ('0',8X,'WATER, MILLIMETERS')
C
C                                NUTRIENT FORMATS
C
4000  FORMAT ('0','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
     1        3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
     2        'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
4005  FORMAT  ('0',3X,'STORAGE')
4006  FORMAT  ('0',9X,'SURFACE LAYER',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4007  FORMAT  ('0',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4008  FORMAT  ('0',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4009  FORMAT  ('0',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4011  FORMAT  ('0',3X,'REMOVAL')
4012  FORMAT  ('0',6X,'ADVECTIVE')
4013  FORMAT  ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4014  FORMAT  ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4015  FORMAT  ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4016  FORMAT  ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
4017  FORMAT  ('0',9X,'PERCOLATION TO ',A,' ',12X, 'GROUNDWATER',2X,
     1         F8.2,5F8.3,F8.2,3F8.3,F8.3)
4018  FORMAT  ('0',6X,'BIOLOGICAL - TOTAL ',F8.2,5F8.3,F8.2,3F8.3,F8.3,
     1        /,' ',9X,'SURFACE',9X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     2        /,' ',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     3        /,' ',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     4        /,' ',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4019  FORMAT  ('0',6X,'HARVEST',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4021  FORMAT  ('0',3X,'MASS BALANCE',
     1        /,' ',6X,'NITROGEN   = ',F8.3,
     2        /,' ',6X,'PHOSPHORUS = ',F8.3,
     3        /,' ',6X,'CHLORIDE   = ',F8.3)
4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
      END
C
C
C
C
      SUBROUTINE OUTYR (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     1 TPBAL,DEGSCT,DEGUCT,DEGLOT,JIST,TIMAP,YEARAP)
C
C                                THIS SUBROUTINE OUTPUTS YEARLY
C                                TABLES, AND ZEROS ACCUMULATIONS
C
      INTEGER  YEAR
C
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9011.      C
9011.1          DIMENSION SMCIST(24,5),UMOIST(24,5),LMOIST(24),
9011.2         1          STEMP(24),UTEMP(24)
9012.           COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
9013.          1            RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,
9014.          2            M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
9015.          3            IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
9015.1         4            ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
9016.      C
9017.           INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
9018.1          INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
9018.2         1            MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
9018.3     C
9018.5          INTEGER*4  LOOP
9019.      C
9020.           REAL  RU,HYMIN,DPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
9021.          1        RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
9022.          2        M,P3,A,LTEMP,LMOIST,MUZ,MLZ
9023.      C
9024.           COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
9025.          1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
9026.          2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
9027.          3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
9028.          4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
9029.          5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
9030.          6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
9031.          7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
9032.          8 MELRAM,RADMEM,CDRMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
9033.          9 PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
9034.          * TSNBAL,COVER,COVKMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
9035.          1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
9035.1         2 DSNFLO,DSNERS,LSRC,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
9036.      C
9037.           DOUBLE PRECISION  MNAM(12)
9038.      C
9039.           REAL  PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,RITOM,RINTOM,BASTOM,
9040.          1        RCHTOM,RUTOT,NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,
9041.          2        TWBAL,EPTOM,EPTOT,UZS,UZSN,LZSN,INFIL,INTER,IRC,
9042.          3        NN,L,SS,SGW1,PR,SGW,GWS,KV,K24L,KK24,K24EL,EP,IFS,
9043.          4      K3(12),EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,SRGXT1,JRER,KRER,
9044.          5        JSER,KSER,SRERT,MMPIN,METOPT,  NEPTOM,ROSTOM,
9045.          6        CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,
9046.          7        PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,IPACK,TMIN,SUMSNM,
9047.          9        PXSNM,XK3,MELRAM,RADMEM,CDRMEM,CRAINM,SGMM,SNEGMM,SEVAPM,
9048.          A        SUMSNY,PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,
9049.          B        CRAINY,SNEGMY,SEVAPY,TSNBAL,
9050.          C        COVER,COVKMX,ROBTOM(5),ROBTOT(5),RXB(5),ROITOM(5),
9051.          D        ROITOT(5),INFTOM(5),INFTOT(5),ERSTOM(5),ERSTOT(5),
9052.          E        SRER(5),TEMPX(24),RAD(24),WINDX(24),RAIN(288),
9052.1         F        LSRC(128),EROS(128),RROS(128)
9053.      C
9054.           INTEGER  DAY,MONTH
9054.1          INTEGER  DSNERS,DSNROS,DSNFLO,TMBLSZ
9055.      C
9056.      C
9057.           COMMON /PESTC/
9058.          1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
9059.          2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
9060.          3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
9061.          4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
9066.      C
9066.1          REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
9066.2         2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
9066.3         3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
9066.4         4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
9066.5         5 UPRITT,UPRIS(5)
9067.      C
9068.           REAL    KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,TPBAL,
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     2        DEGSOT,DEGUOT,DEGLOT,UIST
C
      INTEGER  TIMAP(12),YEARAP(12)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
     1            UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2            SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3            TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4            KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5            TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1        SNT(20),SNRSM(20,5),SNROM(20,5),
     2        UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3        NRSM(20,5),LNRPM(20),
     4        SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5        SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
     6        LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7        TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8        KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
C                              HYDROLOGY AND PESTICIDE VARIABLES USED
C                              INTERNALLY
C
      REAL  PRTT,PRTTLM(5),PRTTOT(5),DEGTOT,
     1        COVR,PACKMY,TSNBMY,
     2        UZSMET,LZSMET,SGWMET,SCEPMT,RESSMT,TWBLMT,SRGXTM,
     3        SRRTMT,STSTMT,SASTMT,SCSTMT,SDSTMT,UTSTMT,
     4        UASTMT,UCSTMT,UDSTMT,LSTRMT,LASMET,LCSMET,LDSMET,
     5        GSTRMT,GASMET,GCSMET,GDSMET,DEGTMT,DEGSMT,DEGUMT,
     6        DEGLMT,TPBALM,UZSBMT(5),RESBMT(5),SRGXMT(5),
     7        SKERMT(5),STSMET(5),SASMET(5),SCSMET(5),SDSMET(5),
     8        UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5),UPRISM(5)
C
C                              NUTRIENT INTERNAL VARIABLES
C
      DOUBLE PRECISION  CONC, LBPAC, KGPHA
C
      REAL  NBALMT,PHBLMT,CLBLMT,
     1        SNMET(20,5),SNTMET(20),UNMET(20,5),UNTMET(20),
     2        LNMET(20),GNMET(20),SNRSMT(20),SNROMT(20),
     3        UNRIMT(20),SNRBMT(20),UNRBMT(20),NRSMT(20),
     4        NRSYT(20),SNRSYT(20),SNROYT(20),SNRBYT(20),
     5        UNRIYT(20),UNRBYT(20),UNITMT(20),UNIMET(20,5),
     7        SUMS,SUMI,SUMB,SUMRS,CONVF
      DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,CONVF/1.121/
C
C                              YEARLY OUTPUT
C
      IF (PEST .EQ. NO)  GO TO 981
            DO 1061  I= 1,5
 1061       PRTTOT(I) = PRSTOT(I) + PROTOT(I) + UPITOT(I)
C
            DEGTOT = DEGSOT + DEGUOT + DEGLOT
C
            PRTT = SPROTT + SPRSTT + UPRITT
C
981   IF (NUTR .EQ. NO)  GO TO 977
      DO 526  J=1,20
         SUMS = 0.0
         SUMO = 0.0
         SUMB = 0.0
         DO 523  IBLK=1,5
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9142.                 SUMS = SUMS + SNRSY(J,IBLK)
9143.                 SUMO = SUMO + SNROY(J,IBLK)
9144.                 SUMB = SUMB + SNRBY(J,IBLK)
9145.     523      CONTINUE
9146.              SNRSYT(J) = SUMS/5.
9147.              SNROYT(J) = SUMC/5.
9148.              SNRBYT(J) = SUMB/5.
9149.     C
9150.              SUMI = 0.0
9151.              SUMB = 0.0
9152.              DO 524  IBLK=1,5
9153.                 SUMI = SUMI + UNRIY(J,IBLK)
9154.                 SUMB = SUMB + UNRBY(J,IBLK)
9155.     524      CONTINUE
9156.              UNRIYT(J) = SUMI/5.
9157.              UNRBYT(J) = SUMB/5.
9157.6             TNRBY(J) = SNRBYT(J) + UNRBYT(J) + LNRBY(J) + GNRBY(J)
9158.     C
9159.              SUMRS = 0.0
9160.              DO 525  IBLK=1,5
9161.                 SUMRS = SUMRS + NRSY(J,IBLK)
9162.     525      CONTINUE
9163.              NRSYT(J) = SUMRS/5.
9164.     526   CONTINUE
9165.     C
9166.     C
9167.       977    WRITE (6,1250)  YEAR
9168.              WRITE (6,1251)
9169.              WRITE (6,1103)
9170.     C
9171.           IF (OUTPUT.EQ. METR) GO TO 1066
9172.           WRITE (6,360)
9173.           WRITE (6,362)
9174.           WRITE (6,363) RCBTOT, ROSTOT
9175.           WRITE (6,364) INFTOT, RINTOT
9176.           WRITE (6,365) RITOT
9177.           WRITE (6,366) ROITOT, RUTOT
9178.           WRITE (6,380) BASTOT
9179.           WRITE (6,381) RCHTOT
9180.           WRITE (6,361) PRTOT,PRTOT,PRTOT,PRTOT,PRTOT,PRTOT
9181.     C
9182.           IF (SNOW .EQ. NO)  GO TO 1072
9183.           WRITE (6,478) SUMSNY
9184.           WRITE (6,479) PXSNY
9185.           WRITE (6,480) MELRAY
9186.           WRITE (6,481)
9187.           WRITE (6,482) RADMEY
9188.           WRITE (6,483) CONMEY
9189.           WRITE (6,484) CORMEY
9190.           WRITE (6,485) CRAINY
9191.           WRITE (6,486) SGMY
9192.           WRITE (6,487) SNEGMY
9193.           WRITE (6,490) PACK
9194.              COVR = 100.
9195.              IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
9196.              IF (PACK.GT.0.01) GO TO 1074
9197.              COVR=0.0
9198.              SDEN=0.0
9199.      1074 WRITE (6,491) SDEN
9200.           WRITE (6,492) COVR
9201.           WRITE (6,488) SEVAPY
9202.      1072 WRITE (6,367)
9203.           WRITE (6,368) EPTOT,EPTOT,EPTOT,EPTOT,EPTOT,EPTOT
9204.           WRITE (6,369) NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT
9205.           WRITE (6,383) COVER
9206.           WRITE (6,370)
9207.           WRITE (6,371) UZSB,UZS
9208.           WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
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9209.          WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
9210.          WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
9211.          WRITE (6,375) RESB,RESS
9212.          WRITE (6,376) SRGX,SRGXT
9213.          WRITE (6,377) TWBAL
9214.          IF (SNOW.EQ.YES)  WRITE (6,489) TSNBAL
9215.             WRITE (6,1209)
9216.             WRITE (6,1210) ERSTOT,  ERSNTT
9217.             WRITE (6,1211)  SRER, SRERT
9218.     C
9219.                IF (PEST .EQ. NO)  GO TO 978
9220.     C
9221.             WRITE (6,1220)
9222.             WRITE (6,1221)  STS, STST
9223.             WRITE (6,1222)  SAS, SAST
9224.             WRITE (6,1223)  SCS, SCST
9225.             WRITE (6,1227) SDS, SDST
9226.             WRITE (6,1224)  UTS, UTST
9227.             WRITE (6,1222)  UAS, UAST
9228.             WRITE (6,1223)  UCS, UCST
9229.             WRITE (6,1227)  UDS, UDST
9230.             WRITE (6,1226)  UPRIS, UIST
9231.             WRITE (6,1228)  LSTR
9232.             WRITE (6,1229)  LAS
9233.             WRITE (6,1230)  LCS
9234.             WRITE (6,1231)  LDS
9235.             WRITE (6,1232)  GSTR
9236.             WRITE (6,1229)  GAS
9237.             WRITE (6,1230)  GCS
9238.             WRITE (6,1231)  GDS
9239.             WRITE (6,1240)  PRTTOT, PRTT
9240.             WRITE (6,1241)  PRCTOT, SPROTT
9241.             WRITE (6,1242)  PRSTOT, SPRSTT
9242.             WRITE (6,1243)  UPITOT, UPRITT
9243.             WRITE (6,1248)
9244.             WRITE (6,1245) DEGTOT
9245.             WRITE (6,1246) DEGSOT
9246.             WRITE (6,1247) DEGUOT
9247.             WRITE (6,1252) DEGLOT
9248.             WRITE (6,1266) TPBAL
9249.     C
9250.       978 IF (NUTR .EQ. NO)  GO TO 1066
9251.     C
9252.     C                          YEARLY NUTRIENT OUTPUT
9253.     C
9254.     C
9255.          CONC = LBPAC
9256.          WRITE (6,1092)
9257.          WRITE (6,4000)  CONC
9258.     C
9259.          WRITE (6,4005)
9260.          WRITE (6,4006)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
9261.          WRITE (6,4030) (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14)
9262.         1                ,SN(20,IBLK),  IBLK=1,5)
9263.          WRITE (6,4007)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
9264.          WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
9265.         1                ,UN(20,IBLK),  IBLK=1,5)
9266.          WRITE (6,4015)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
9267.          WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14),
9268.         1                UNI(20,IBLK),  IBLK=1,5)
9269.          WRITE (6,4008)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
9270.          WRITE (6,4009)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
9271.     C
9272.          WRITE (6,4011)
9273.          WRITE (6,4012)
9274.          WRITE (6,4013)  (SNRSYT(J),J=1,6),(SNRSYT(J),J=11,14),SNRSYT(20)
9275.          WRITE (6,4030) (IBLK,(SNRSY(J,IBLK),J=1,6),
9276.         1                (SNRSY(J,IBLK),J=11,14),
```

```
     2                 SNRSY(20,IBLK),  IBLK=1,5)
      WRITE (6,4014)  (SNROYT(J),J=1,6),(SNROYT(J),J=11,14),SNROYT(20)
      WRITE (6,4030) (IBLK,(SNROY(J,IBLK),J=1,6),
     1                (SNROY(J,IBLK),J=11,14),
     2                SNROY(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNRIYT(J),J=1,6),(UNRIYT(J),J=11,14),UNRIYT(20)
      WRITE (6,4030) (IBLK,(UNRIY(J,IBLK),J=1,6),
     1                (UNRIY(J,IBLK),J=11,14),
     2                UNRIY(20,IBLK),  IBLK=1,5)
      WRITE (6,4016)  (NRSYT(J),J=1,6),(NRSYT(J),J=11,14),NRSYT(20)
      WRITE (6,4017)  (LNRPY(J),J=1,6),(LNRPY(J),J=11,14),LNRPY(20)
      WRITE (6,4018)  (TNRBY(J),J=1,6),(TNRBY(J),J=11,14),TNRBY(20),
     1                (SNRBYT(J),J=1,6),(SNRBYT(J),J=11,14),SNRBYT(20),
     2                (UNRBYT(J),J=1,6),(UNRBYT(J),J=11,14),UNRBYT(20),
     3                (LNRBY(J),J=1,6),(LNRBY(J),J=11,14),LNRBY(20),
     4                (GNRBY(J),J=1,6),(GNRBY(J),J=11,14),GNRBY(20)
      WRITE (6,4019)  (TNRHVY(J),J=1,6),(TNRHVY(J),J=11,14),TNRHVY(20)
      WRITE (6,4021)  NBAL, PHBAL, CLBAL
C
C
 1066 IF (OUTPUT .EQ. ENGL) GO TO 1065
C  CONVERSIONS
      PRTOT =PRTOT*MMPIN
      ROSTOT=ROSTOT*MMPIN
      RINTOT=RINTOT*MMPIN
      RITOT =RITOT*MMPIN
      RUTOT =RUTOT*MMPIN
      BASTOT=BASTOT*MMPIN
      RCHTOT=RCHTOT*MMPIN
      EPTOT =EPTOT*MMPIN
      NEPTOT=NEPTOT*MMPIN
      UZSMET=UZS*MMPIN
      LZSMET=LZS*MMPIN
      SGWMET=SGW*MMPIN
      SCEPMT=SCEP*MMPIN
      RESSMT=RESS*MMPIN
      TWBLMT=TWBAL*MMPIN
      SRGXTM=SRGXT*MMPIN
      ERSNTT=ERSNTT*METOPT*2.471
      SRRTMT=SRERT*METOPT*2.471
C  SNOW
      IF (SNOW .EQ. NO)  GO TO 982
      SUMSNY = SUMSNY*MMPIN
      PXSNY = PXSNY*MMPIN
      MELRAY = MELRAY*MMPIN
      RADMEY = RADMEY*MMPIN
      CONMEY = CONMEY*MMPIN
      CORMEY = CORMEY*MMPIN
      CRAINY = CRAINY*MMPIN
      SGMY = SGMY*MMPIN
      SNEGMY = SNEGMY*MMPIN
      PACKMY = PACK*MMPIN
      SEVAPY = SEVAPY*MMPIN
      TSNBMY = TSNBAL*MMPIN
C  PESTICIDE
  982 IF (PEST .EQ. NO)  GO TO 979
      STSTMT=STST*KGPLB
      SASTMT=SAST*KGPLB
      SCSTMT=SCST*KGPLB
      SDSTMT=SDST*KGPLB
      UTSTMT=UTST*KGPLB
      UASTMT=UAST*KGPLB
      UCSTMT=UCST*KGPLB
      UDSTMT=UDST*KGPLB
      UIST=UIST*KGPLB
      LSTRMT=LSTR*KGPLB
      LASMET=LAS*KGPLB
      LCSMET=LCS*KGPLB
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      LDSMET=LDS*KGPLB
      GSTRMT=GSTR*KGPLB
      GASMET=GAS*KGPLB
      GCSMET=GCS*KGPLB
      GDSMET=GDS*KGPLB
      PRTT  =PRTT*KGPLB
      SPROTT=SPROTT*KGPLB
      SPRSTT=SPRSTT*KGPLB
      UPRITT=UPRITT*KGPLB
      DEGTMT=DEGTOT*KGPLB
      DEGSMT=DEGSOT*KGPLB
      DEGUMT=DEGUOT*KGPLB
      DEGLMT=DEGLOT*KGPLB
      TPBALM=TPBAL*KGPLB
C  METRIC MODIFICATION OF ARRAYS
  979 DO 1062 I=1,5
        ROBTOT(I)=ROBTOT(I)*MMPIN
        INFTOT(I)=INFTOT(I)*MMPIN
        ROITOT(I)=ROITOT(I)*MMPIN
        UZSBMT(I)=UZSB(I)*MMPIN
        RESBMT(I)=RESB(I)*MMPIN
        SRGXMT(I)=SRGX(I)*MMPIN
        EPSTOT(I)=ERSTOT(I)*METOPT*2.471
        SRERMT(I)=SRER(I)*METOPT*2.471
          IF (PEST .EQ. NO)  GO TO 1062
        STSMET(I)=STS(I)*KGPLB
        SASMET(I)=SAS(I)*KGPLB
        SCSMET(I)=SCS(I)*KGPLB
        SDSMET(I)=SDS(I)*KGPLB
        UTSMET(I)=UTS(I)*KGPLB
        UASMET(I)=UAS(I)*KGPLB
        UCSMET(I)=UCS(I)*KGPLB
        UDSMET(I)=UDS(I)*KGPLB
        UPRISM(I)=UPRIS(I)*KGPLB
        PRTTOT(I)=PRTTOT(I)*KGPLB
        PROTOT(I)=PROTOT(I)*KGPLB
        PRSTOT(I)=PRSTOT(I)*KGPLB
        UPITOT(I)=UPITOT(I)*KGPLB
 1062 CONTINUE
C
      WRITE (6,460)
      WRITE (6,362)
      WRITE (6,363) ROBTOT,ROSTOT
      WRITE (6,364) INFTOT,RINTOT
      WRITE (6,365) RITOT
      WRITE (6,366) ROITOT,ROTOT
      WRITE (6,380) BASTOT
      WRITE (6,381) RCHTOT
      WRITE (6,361) PRTOT,PRTOT,PRTOT,PRTOT,PRTOT,PRTOT
      IF (SNOW .EQ. NO)  GO TO 1089
      WRITE (6,478)  SUMSNY
      WRITE (6,479)  FXSNY
      WRITE (6,480)  MELRAY
      WRITE (6,481)
      WRITE (6,482)  RADMEY
      WRITE (6,483)  CONMEY
      WRITE (6,484)  CORMEY
      WRITE (6,485)  GRAINY
      WRITE (6,486)  SGMY
      WRITE (6,487)  SNEGMY
      WRITE (6,490)  PACKMY
         COVR = 100.0
         IF (PACK .LT. IPACK)  COVR = (PACK/IPACK)*100.
         IF (PACK .GT. 0.01)  GO TO 1088
         COVR = 0.0
         SDEN = 0.0
 1088 WRITE (6,491)  SDEN
      WRITE (6,492)  COVR
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9413.          WRITE (6,488)  SEVAPY
9414.     1089 WRITE (6,367)
9415.          WRITE (6,368) EPTOT,EPTOT,EPTOT,EPTOT,EPTOT,EPTOT
9416.          WRITE (6,369) NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT
9417.          WRITE (6,383) COVER
9418.          WRITE (6,370)
9419.          WRITE (6,371) UZSBMT,UZSMET
9420.          WRITE (6,372) LZSMET,LZSMET,LZSMET,LZSMET,LZSMET,LZSMET
9421.          WRITE (6,373) SGWMET,SGWMET,SGWMET,SGWMET,SGWMET,SGWMET
9422.          WRITE (6,374) SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT
9423.          WRITE (6,375) RESBMT,RESSMT
9424.          WRITE (6,376) SRGXMT,SRGXTM
9425.          WRITE (6,377) TWBLMT
9426.          IF (SNOW .EQ. YES)  WRITE (6,489)  TSNBMY
9427.          WRITE (6,1208)
9428.          WRITE (6,1210) ERSTOT,ERSNTT
9429.          WRITE (6,1211) SRERMT,SRRTMT
9430.     C
9431.            IF (PEST .EQ. NO)  GO TO 980
9432.     C
9433.          WRITE (6,1207)
9434.          WRITE (6,1221) STSMET,STSTMT
9435.          WRITE (6,1222) SASMET,SASTMT
9436.          WRITE (6,1223) SCSMET,SCSTMT
9437.          WRITE (6,1227) SDSMET,SDSTMT
9438.          WRITE (6,1224) UTSMET,UTSTMT
9439.          WRITE (6,1222) UASMET,UASTMT
9440.          WRITE (6,1223) UCSMET,UCSTMT
9441.          WRITE (6,1227) UDSMET,UDSTMT
9442.          WRITE (6,1226) UPRISM,UIST
9443.          WRITE (6,1228) LSTRMT
9444.          WRITE (6,1229) LASMET
9445.          WRITE (6,1230) LCSMET
9446.          WRITE (6,1231) LDSMET
9447.          WRITE (6,1232) GSTRMT
9448.          WRITE (6,1229) GASMET
9449.          WRITE (6,1230) GCSMET
9450.          WRITE (6,1231) GDSMET
9451.          WRITE (6,1239) PRTTOT,PRTT
9452.          WRITE (6,1241) PROTOT,SPROTT
9453.          WRITE (6,1242) PRSTOT,SPRSTT
9454.          WRITE (6,1243) UPITOT,UPRITT
9455.          WRITE (6,1249)
9456.          WRITE (6,1245) DEGTMT
9457.          WRITE (6,1246) DEGSMT
9458.          WRITE (6,1247) DEGUMT
9459.          WRITE (6,1252) DEGLMT
9460.          WRITE (6,1266) TPBALM
9461.     C
9462.     C
9463.      980 IF (NUTR .EQ. NO)  GO TO 1065
9464.     C
9465.     C                              CONVF CONVERTS LB/AC TO KG/HA
9466.     C
9467.          DO 530  J=1,20
9468.             SNRSYT(J) = SNRSYT(J)*CONVF
9469.             SNROYT(J) = SNRCYT(J)*CONVF
9470.             UNRIYT(J) = UNRIYT(J)*CONVF
9471.             NRSYT(J) = NRSYT(J)*CONVF
9472.             LNRPY(J) = LNRPY(J)*CONVF
9473.             TNRBY(J) = TNRBY(J)*CONVF
9474.             SNRBYT(J) = SNRBYT(J)*CONVF
9475.             UNRBYT(J) = UNRBYT(J)*CONVF
9476.             LNRBY(J) = LNRBY(J)*CONVF
9477.             GNRBY(J) = GNRBY(J)*CONVF
9478.             TNRHVY(J) = TNRHVY(J)*CONVF
9479.     C
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9480.                SNTMET(J) = SNT(J)*CONVF
9481.                UNTMET(J) = UNT(J)*CONVF
9482.                UNITMT(J) = UNIT(J)*CONVF
9483.                LNMET(J) = LN(J)*CONVF
9484.                GNMET(J) = GN(J)*CONVF
9485.               DO 529  IBLK=1,5
9486.                  SNRSY(J,IBLK) = SNRSY(J,IBLK)*CONVF
9487.                  SNROY(J,IBLK) = SNROY(J,IBLK)*CONVF
9488.                  UNRIY(J,IBLK) = UNRIY(J,IBLK)*CONVF
9491.                   SNMET(J,IBLK) = SN(J,IBLK)*CONVF
9492.                   UNMET(J,IBLK) = UN(J,IBLK)*CONVF
9493.                   UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
9494.     529       CONTINUE
9495.     530    CONTINUE
9496.            NBALMT = NBAL*CONVF
9497.            PHBLMT = PHBAL*CONVF
9498.            CLBLMT = CLBAL*CONVF
9499.     C
9500.     C
9501.            CONC = KGPHA
9502.            WRITE (6,1092)
9503.            WRITE (6,4000)  CONC
9504.     C
9505.            WRITE (6,4005)
9506.            WRITE (6,4006)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
9507.            WRITE (6,4030) (IBLK,(SNMET(J,IBLK),J=1,6),(SNMET(J,IBLK),J=11,14)
9508.           1                ,SNMET(20,IBLK),  IBLK=1,5)
9509.            WRITE (6,4007)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
9510.            WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),(UNMET(J,IBLK),J=11,14)
9511.           1                ,UNMET(20,IBLK),  IBLK=1,5)
9512.            WRITE (6,4015)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
9513.            WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
9514.           1                (UNIMET(J,IBLK),J=11,14),
9515.           2                UNIMET(20,IBLK),  IBLK=1,5)
9516.            WRITE (6,4008)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
9517.            WRITE (6,4009)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
9518.     C
9519.            WRITE (6,4011)
9520.            WRITE (6,4012)
9521.            WRITE (6,4013)  (SNRSYT(J),J=1,6),(SNRSYT(J),J=11,14),SNRSYT(20)
9522.            WRITE (6,4030) (IBLK,(SNRSY(J,IBLK),J=1,6),
9523.           1               (SNRSY(J,IBLK),J=11,14),
9524.           2               SNRSY(20,IBLK),  IBLK=1,5)
9525.            WRITE (6,4014)  (SNROYT(J),J=1,6),(SNROYT(J),J=11,14),SNROYT(20)
9526.            WRITE (6,4030) (IBLK,(SNROY(J,IBLK),J=1,6),
9527.           1               (SNROY(J,IBLK),J=11,14),
9528.           2               SNROY(20,IBLK),  IBLK=1,5)
9529.            WRITE (6,4015)  (UNRIYT(J),J=1,6),(UNRIYT(J),J=11,14),UNRIYT(20)
9530.            WRITE (6,4030) (IBLK,(UNRIY(J,IBLK),J=1,6),
9531.           1               (UNRIY(J,IBLK),J=11,14),
9532.           2               UNRIY(20,IBLK),  IBLK=1,5)
9533.            WRITE (6,4016)  (NRSYT(J),J=1,6),(NRSYT(J),J=11,14),NRSYT(20)
9534.            WRITE (6,4017)  (LNRPY(J),J=1,6),(LNRPY(J),J=11,14),LNRPY(20)
9535.            WRITE (6,4018)  (TNRBY(J),J=1,6),(TNRBY(J),J=11,14),TNRBY(20),
9536.           1                (SNRBYT(J),J=1,6),(SNRBYT(J),J=11,14),SNRBYT(20),
9537.           2                (UNRBYT(J),J=1,6),(UNRBYT(J),J=11,14),UNRBYT(20),
9538.           3                (LNRBY(J),J=1,6),(LNRBY(J),J=11,14),LNRBY(20),
9539.           4                (GNRBY(J),J=1,6),(GNRBY(J),J=11,14),GNRBY(20)
9540.            WRITE (6,4019)  (TNRHVY(J),J=1,6),(TNRHVY(J),J=11,14),TNRHVY(20)
9541.            WRITE (6,4021)  NBALMT, PHBLMT, CLBLMT
9542.     C
9543.     C                    ZERUING OF VARIABLES
9544.     C
9545.      1065    PRTOT = 0.0
9546.            RUTOT = 0.0
9547.            NEPTOT = 0.0
9548.            ROSTOT = 0.0
9549.            RITOT = 0.0
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9550.          RINTOT = 0.0
9551.          BASTOT = 0.0
9552.          RCHTOT = 0.0
9553.             EPTOT = 0.0
9554.             ERSNTT = 0.0
9555.             PRTT = 0.0
9556.             SPROTT = 0.0
9557.             SPRSTT = 0.0
9558.             UPRITT = 0.0
9559.             DEGSOT = 0.0
9560.             DEGUOT = 0.0
9561.             DEGLOT = 0.0
9562.          SUMSNY = 0.0
9563.          PXSNY = 0.0
9564.          MELRAY = 0.0
9565.          RADMEY = 0.0
9566.          CDRMEY = 0.0
9567.          CONMEY = 0.0
9568.          CRAINY = 0.0
9569.          SGMY = 0.0
9570.          SNEGMY = 0.0
9571.          SEVAPY = 0.0
9572.     C
9573.             DO 1068  I=1,5
9574.                ERSTOT(I) = 0.0
9575.                ROBTOT(I) = 0.0
9576.                INFTOT(I) = 0.0
9577.                PRTTOT(I) = 0.0
9578.                PRSTOT(I) = 0.0
9579.                PROTOT(I) = 0.0
9580.                UPITOT(I) = 0.0
9581.      1068      ROITOT(I) = 0.0
9582.     C
9583.          IF (NUTR .EQ. NO)  GO TO 1070
9584.     C
9585.     C                          ZERO YEARLY NUTRIENT ACCUMULATIONS
9586.     C
9587.          DO 534  J=1,20
9588.             LNRPY(J) = 0.0
9589.             LNRBY(J) = 0.0
9590.             GNRBY(J) = 0.0
9591.             TNRBY(J) = 0.0
9592.             TNRHVY(J) = 0.0
9593.             DO 533  IBLK=1,5
9594.                SNRSY(J,IBLK) = 0.0
9595.                SNROY(J,IBLK) = 0.0
9596.                UNRIY(J,IBLK) = 0.0
9597.                NRSY(J,IBLK) = 0.0
9598.                SNRBY(J,IBLK) = 0.0
9599.                UNRBY(J,IBLK) = 0.0
9600.     533     CONTINUE
9601.     534  CONTINUE
9602.     C
9603.     1070  RETURN
9604.     C
9605.     C
9606.     C                          FORMATS
9607.     C
9608.      1092 FORMAT ('0')
9609.      1103 FORMAT ('0',34X,'BLOCK 1 , BLOCK 2   BLOCK 3   BLOCK 4   BLOCK 5',
9610.          C  5X,'TOTAL')
9611.      1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
9612.      1207 FORMAT ('0',5X,'PESTICIDE, KILOGRAMS')
9613.      1209 FORMAT ('0', 8X,'SEDIMENT, TONS/ACRE')
9614.      1210 FORMAT (' ',11X,'ERODED SEDIMENT    ',5(3X,F7.3),4X,F7.3)
9615.      1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
9616.      1220 FORMAT ('0',5X,'PESTICIDE, POUNDS')
9617.      1221 FORMAT ('0', 8X,'SURFACE LAYER',9X,5(3X,F7.3),3X,F8.3)
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 1222 FORMAT (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 1223 FORMAT (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 1224 FORMAT ('0', 8X,'UPPER ZONE LAYER',6X,5(3X,F7.3),3X,F8.3)
 1226 FORMAT (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 1227 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 1228 FORMAT ('0', 8X,'LOWER ZONE LAYER',59X,F8.3)
 1229 FORMAT (' ',11X,'ADSORBED',64X,F8.3)
 1230 FORMAT (' ',11X,'CRYSTALLINE',61X,F8.3)
 1231 FORMAT (' ',11X,'DISSOLVED',63X,F8.3)
 1232 FORMAT ('0', 8X,'GROUNDWATER LAYER',58X,F8.3)
 1239 FORMAT ('0',8X,'PESTICIDE REMOVAL, KGS.',2X,5(F7.3,3X),F8.3)
 1240 FORMAT ('0', 8X,'PESTICIDE REMOVAL, LBS.',2X,5(F7.3,3X),F8.3)
 1241 FORMAT (' ',11X,'OVERLAND FLOW REMOVAL',1X,5(F7.3,3X),F8.3)
 1242 FORMAT (' ',11X,'SEDIMENT REMOVAL',6X,5(F7.3,3X),F8.3)
 1243 FORMAT (' ',11X,'INTERFLOW REMOVAL',5X,5(F7.3,3X),F8.3)
 1245 FORMAT (' ',11X,'TOTAL',68X,F7.3)
 1246 FORMAT (' ',11X,'FROM SURFACE',61X,F7.3)
 1247 FORMAT (' ',11X,'FROM UPPER ZONE',58X,F7.3)
 1248 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, LBS.')
 1249 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, KGS.')
 1250 FORMAT ('1',25X,'SUMMARY FOR ',I4)
 1251 FORMAT ('+',25X,'_________________')
 1252 FORMAT (' ',11X,'FROM LOWER ZONE',58X,F7.3)
 1266 FORMAT ('0',11X,'PESTICIDE BALANCE=',F8.4)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',8X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
  481 FORMAT ('0',11X,'MELT')
  482 FORMAT (' ',14X,'RADIATION',60X,F7.2)
  483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
  484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
  485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
  486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
  487 FORMAT (' ',14X,'CUM NEG HEAT',57X,F7.2)
  490 FORMAT ('0',11X,'SNOW PACK',55X,F7.2)
  491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
  492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
  488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
  367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
  368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
  369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
  383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
  370 FORMAT ('0',11X,'STORAGES')
  371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
  372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
  373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
  374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
  375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
  489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
  460 FORMAT ('0',8X,'WATER, MILLIMETERS')
C
C                                NUTRIENT FORMATS
C
 4000  FORMAT ('0','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
     1          3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
     2          'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
 4005  FORMAT  ('0',3X,'STORAGE')
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9686.      4006  FORMAT  ('0',9X,'SURFACE LAYER',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9687.      4007  FORMAT  ('0',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9688.      4008  FORMAT  ('0',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9689.      4009  FORMAT  ('0',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9690.      4011  FORMAT  ('0',3X,'REMOVAL')
9691.      4012  FORMAT  ('0',6X,'ADVECTIVE')
9692.      4013  FORMAT  ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9693.      4014  FORMAT  ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9694.      4015  FORMAT  ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9695.      4016  FORMAT  ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
9696.      4017  FORMAT  ('0',9X,'PERCOLATION TO '/,' ',12X, 'GROUNDWATER',2X,
9697.           1          F8.2,5F8.3,F8.2,3F8.3,F8.3)
9698.      4018  FORMAT  ('0',6X,'BIOLOGICAL - TOTAL ',F8.2,5F8.3,F8.2,3F8.3,F8.3,
9699.           1         /,' ',9X,'SURFACE',9X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
9700.           2         /,' ',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
9701.           3         /,' ',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
9702.           4         /,' ',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9703.      4019  FORMAT  ('0',6X,'HARVEST',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9704.      4021  FORMAT  ('0',3X,'MASS BALANCE',
9705.           1         /,' ',6X,'NITROGEN    = ',F8.3,
9706.           2         /,' ',6X,'PHOSPHORUS = ',F8.3,
9707.           3         /,' ',6X,'CHLORIDE    = ',F8.3)
9708.      4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
9709.      C
9710.            END
9712.      //LKED.SYSLMOD DD DSN=WYL.X2.A19.HD7508.ARMLM.DP100677,DISP=(NEW,KEEP),
9713.      //  UNIT=DISK,SPACE=(TRK,(30,2,2),RLSE),VOL=SER=PUB005
9714.      //LKED.SYSIN DD *
9715.       NAME ARM
9716.      /*
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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Agricultural Runoff Management (ARM) Model has been refined and tested on small agricultural watersheds in Georgia and Michigan. The ARM Model simulates the hydrologic, sediment production, pesticide, and nutrient processes on the land surface and in the soil profile that determine the quantity and quality of agricultural runoff. This report discusses the research and model refinements related to soil moisture and temperature simulation, pesticide degradations, nutrient transformations and plant nutrient uptake. The goal is to evaluate and improve the pesticide and nutrient simulation capabilities of the ARM Model. However, the runoff and sediment modeling is also analyzed since these are the critical transport mechanisms of agricultural chemicals.

In general, comparison of simulated and recorded values indicates that the ARM Model can represent the major processes affecting agricultural runoff and can be a useful tool for planning and analysis. However, discrepancies do exist and point out the need for more testing and research in specific areas.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Simulation	Nonpoint pollution	02A
Runoff	Model studies	02B
Water quality		08H
Planning		08M
Land use		13B
		20D
		68D

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