NONPOINT SOURCE MODELING OF INDIAN RUN WATERSHED

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ABSTRACT

The problem of soil erosion and sediment runoff in the Indian Run watershed (area 11, 277 acres), a major tributary to Mill Creek, is of serious concern to the Mill Creek Metroparks management and the Youngstown metropolitan area community. Mill Creek is primarily responsible for sediment deposition in Lake Newport that continues at an alarming rate. A nonpoint source simulation was performed for the Indian Run watershed using the Agricultural Nonpoint Source Pollution Model (AGNPS) water quality model with a focus on the problems of soil erosion and sediment yield. Four hypothetical storm conditions were simulated: (i) 3 in. precipitation of 6 hour duration, (ii) 2 in. precipitation of 4 hour duration, (iii) 1 in. precipitation of 1 hour duration, and (iv) 1 in. precipitation of 12 hour duration. Sensitivity of the results to changes in P, C, and K factors in the Universal Soil Loss Equation was evaluated. Using the model results, the mean flow, erosion and sediment yield for the watershed outlet on a yearly basis were estimated to be on the order of 0.944 cfs/sq. miles, 13.4 tons/acre, and 1100 tons, respectively, which compare favorably with the field measurements. The AGNPS simulation identifies five cells (each 179 acres in area) that are primarily responsible for the problems of soil erosion, and sediment deposition in the entire Indian Run watershed. The sediment deposition and the flow rate predictions are within 10% of measurements reported [MBR-HER, 1994]. The AGNPS simulation of the watershed provides information that could be of considerable help in formulating management decisions to address the problem of sediment deposition in Lake Newport.

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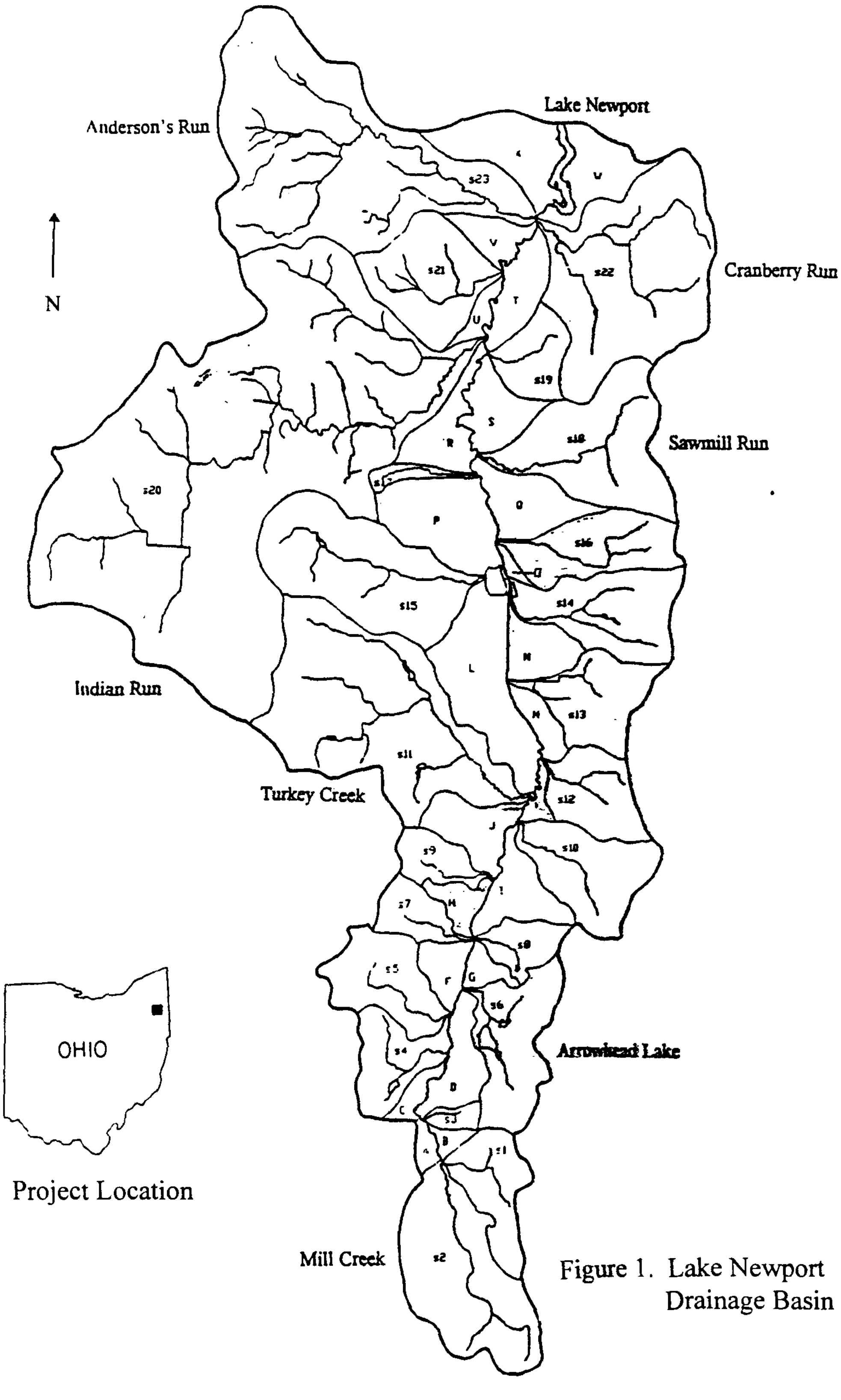
Agricultural Non-Point Source Pollution Model	AGNPS
Annualized Agricultural Nonpoint Source Pollution Model	ANN-AGNPS
Chemicals, Runoff, and Erosion from Agri. Management System	CREAMS
Chemical Oxygen Demand	COD
Directly Connected Impervious Areas	DCIA
Dissolved Oxygen	DO
Event Mean Concentration	EMC
Geographic Information Systems	GIS
Hydrologic Simulation Program - FORTRAN	HSPF
Mahoning River Basin Hydrologic Environmental Research	MRB-HER
Mill Creek Metroparks	MCM
Ohio Environmental Protection Agency	OEPA
Sediment Oxygen Demand	SOD
Soil Conservation Service	SCS
Soil and Water Assessment Tool	SWAT
Stanford Watershed Model	SWM
Suspended Solids	SS
United States Department of Agriculture	USDA
United States Environmental Protection Agency	USEPA
United States Geological Survey	USGS
Universal Soil Loss Equation	USLE

CHAPTER 1

INTRODUCTION

Lake Newport, located in Mill Creek Park, Youngstown, Ohio, is one of three reservoirs in the Mill Creek watershed. The map of the Lake Newport drainage basin is presented in Figure 1 [MRB-HER, 1994]. It was created in 1928 by construction of a dam on Mill Creek. The lake has been used for recreational activities such as fishing, boating, and ice-skating, and it suffers greatly from nonpoint source pollution, namely sedimentation. The problem is mainly caused by soil erosion along Mill Creek and two major tributaries (Indian Run and Anderson's Run) that carry relatively high sediment loads. The rapid residential and commercial development in the watershed area in recent years has further increased the sediment loading into the lake. It is estimated that over 400,000 cubic yards (cy) of sediment deposits have accumulated in the lake [MRB-HER, 1993].

During the last two decades, the Mill Creek Metroparks (MCM) administrators have considered various ways of resolving the problem of excessive accumulation of sediments. Dredging was considered as one possible solution; the plan involved disposal of the dredged sediments by spreading them on land owned by MCM. Disposal of the sediments in this manner requires a permit from the Ohio Environmental Protection Agency (OEPA) to satisfy the regulatory requirements. In 1989, MCM was asked by OEPA to conduct an Elutriate Test to assess the presence and mobility of heavy metals in the sediments to be dredged [Martin, 1989 and 1987]. This option was abandoned largely due to adverse public opinion of the proposed land disposal. More recent studies have



Project Location

Figure 1. Lake Newport Drainage Basin Map

explored other options for the future management of Lake Newport [MRB-HER, 1993 and 1994]. But problems with regulatory requirements, high costs, and the associated technical feasibility have prevented the proposed remediation ideas from being implemented.

The accumulation of sediments over the years in Lake Newport has had direct impacts on the aesthetics of the lake and its usefulness as a recreational resource. The sediment build up in Lake Newport, if not brought down to an acceptable level soon, will eventually fill up the lake and also cause sediment to accumulate in the other two lakes of Mill Creek Park (Lake Cohasset and Lake Glacier). The continuing accumulation of sediments remains a critical issue in assessing future plans for the management of Lake Newport, and this needs to be resolved quickly and economically.

Modeling can be used as a tool for assessing our understanding of the quality of a body of water, and for assessing the impacts of land use change and nonpoint source reductions on receiving waters. A computer simulation of the watershed helps water resource managers to assess which environmental control strategies are best to meet water quality goals. Without the use of modeling, it is extremely expensive and time consuming to evaluate environmental control strategies and determine the best control actions. Modeling also allows the testing of the cause-effect relationships between the inputs to the model and the resulting predictions of water quality. The water quality models that have been developed are quite realistic but complex. The complexity of the models is due to the desire for more accurate descriptions of the significant physical, chemical, and biological processes, and more accurate spatial and temporal details, including the effects of large storms and floods.

Many computer simulation models have been developed to evaluate the water quantity and quality (hydrology, erosion, and chemistry) of watersheds and to assess the effects of possible control actions for their improvement. This study presents a theoretical watershed simulation of the Indian Run Watershed, which contributes about 30% of the sediment loading to Lake Newport. The simulation is based on an event-based water quality model known as AGNPS (Agricultural Non-Point Source Pollution Model). The model simulates runoff, sediment, and nutrient transport from the watershed; however, the focus of the present study is on runoff and sediment generation and yield. The runoff and the sediment characteristics of the watershed as a whole and at intermediate points throughout the watershed are provided. The results of this study will help identify the key locations in the watershed that are prone to excessive soil erosion and primarily responsible for sediment generation and yield. It is hoped that the study will provide possible management alternatives for the improvement of water quality and help in remediation of the sediment deposition in Lake Newport.

CHAPTER 2

LITERATURE REVIEW

2.1 Nonpoint Source Pollution

Nonpoint source (NPS) pollution is defined as the runoff transport of constituents from diffuse sources on the land to streams [Browne, 1990]. Some of the constituents composing nonpoint source pollution are oxygen-demanding substances, nutrients, toxic matter, and suspended solids.

Oxygen-demanding substances are organic and inorganic residues, which consume the dissolved oxygen (DO) of the water. The impact of low dissolved oxygen concentrations in the water (anaerobic condition) results in an unbalanced ecosystem, fish mortality, and odor problems. Suspended solids (SS) are particles transported by water that decrease water clarity and threaten aquatic life. The deposition of SS can adversely affect habitats, clog drainage structures, and reduce flow capacity. In addition, these particles carry other pollutants such as nutrients, metals and other toxic substances to the receiving water bodies. Nutrients such as nitrogen and phosphorus create algae and aquatic weed conditions in water bodies and accelerate the eutrophication of lakes. Eutrophication interferes with the recreational use of water, creates large variations in dissolved oxygen concentrations that might result in lower levels at night, and generates sediment oxygen demand (SOD) that affects the level of dissolved oxygen. Toxic materials, ingested directly via drinking water, can cause cancer, tumors, and birth defects if provisions are not made to ensure adequate water quality [Browne, 1990].

Metals, industrial and agricultural chemicals, hydrocarbons, and radioactive materials are the main sources of toxic substances. Nonpoint source pollution originates in urban, agriculture, and mining areas. Specifically, urban and agricultural areas have been recognized by the United States Environmental Protection Agency (USEPA) as major national problems due to their highly polluted runoff [Browne, 1990]. The NPS pollution in urban runoff includes suspended solids, bacteria, heavy metals, oxygen demanding substances, nutrients, oil and grease. These constituents are derived from construction sites, developed urban lands, streets and parking lots. Runoff from agricultural areas transport pesticides, sediments, nutrients, organic materials and pathogens, resulting from cultivation, grazing, and fertilizer and pesticide applications.

In modeling NPS pollution, current engineering practice has been unable to adequately achieve the important goals of describing the constituent mobilization and accounting for the spatial variability of the terrain [Olivera and Maidment, 1996]. The first goal requires relating land-use, storm intensity and watershed conditions (antecedent moisture condition, constituent load condition, etc.) to runoff constituent concentrations. However, despite the fact that studies have been conducted to quantify pollutant loads in urban runoff, the data collected so far are insufficient to develop definite cause-effect relationships between pollutant sources and runoff concentrations [Urbonas and Roesner, 1993]. This problem becomes even more complex when instantaneous concentrations are to be predicted. The second goal, accounting for spatial variability of the terrain, has been approached in recent years by use of Geographic Information Systems (GIS), employing software specifically developed to store and handle spatially distributed data.

According to Huber and Dickinson [1998], land use has a strong influence only on the amount of runoff (volume of water per unit time), while its effect on the runoff concentration (mass of pollutant per unit volume of water) is somewhat less important. However, land use does affect the pollutant load (mass of pollutant per unit time) for high values of runoffs. Huber further notes that the concentration of constituents at the watershed outlet usually shows larger values at the beginning of a storm, reflecting what has been called the *first flush*. This first flush is particularly evident from impervious surfaces on which pollutants accumulate during dry days, while for pervious surfaces no build-up takes place and entrainment of pollutants in runoff is caused by erosion and dissolution.

Due to the difficulty of obtaining sufficient accurate data to generate "pollutographs" (concentration-time plots) or "loadographs" (mass-time plots), NPS pollution is commonly represented by the *event mean concentration* (EMC), which is the ratio of the total pollutant mass to the total runoff volume of an event. The median and coefficient of variation of the EMC are used to describe the variability of levels of a given constituent in a certain watershed from storm to storm [Huber and Dickinson, 1988]. In general, it can be said that the quality of storm water depends on a large number of factors, such as rainfall intensity and duration, number of antecedent dry days, land use, etc., that require statistical modeling. Although these models do not produce good predictions of specific events, they can perform well when calculating annual loadings, because these represent statistical averages over many events [Soeur *et al*, 1995].

The actions taken towards decreasing the effects of NPS pollution are called *runoff quality controls* [Browne, 1990]. Approaches used in controlling urban runoff quality include: preventing or reducing pollutant deposition in urban areas, preventing pollutant contact with runoff, minimizing directly connected impervious areas (DCIA), designing controls for small storms (usually less than 1 in. rainfall), and using the *treatment train* concept that assumes source controls, individual building lot controls, group of lots controls, and regional controls in sequence.

Treatment practices are grouped into two broad categories: infiltration and detention practices. Infiltration practices include swales and filter strips, porous pavement, percolation trenches, and infiltration basins. The detention practices include extended catchment basins and retention ponds.

2.2 Sedimentation in Mill Creek Park

The concern about water quality in the Mill Creek watershed goes back to the mid-1970's, when it was observed that the use of boats at the southern end of the Lake Newport, near the mouth of the Mill Creek, had been severely hampered by the accumulation of sediment deposits. In the following years, the MCM administrators started to develop tentative plans to dredge a portion of the lake. Surveys of the volume of sediment deposits accumulated in Lake Newport were performed in 1975 and 1987. The survey from 1975 indicated that the southernmost part of the lake contained about 74,000 cy of sediment deposits. The survey from 1987 revealed that the sediment volume had increased by about 50% to 111,000 cy in this section, and the southernmost part of the lake contained 204,000 cy of the sediment deposits [Martin, 1987]. A study performed by Mahoning River Basin Hydrologic Environment Research (MRB-HER) in 1993 estimated the volume of the entire lake to be 400,000 cy [MRB-HER, 1993]. This trend shows that the rate of accumulation of sediment deposits has been increasing over the years. This is consistent with the rapid development of the watershed for commercial and residential uses over the last two decades.

The dredging plan involved disposal of the dredged sediments by spreading them on land owned by MCM. A permit from the OEPA had to be obtained to dispose the sediments in this manner. In order to obtain the permit, the Park was asked by the OEPA to conduct an Elutriate Test to assess the mobility of heavy metals in the sediments to be dredged. The Elutriate Test procedures simulate the mixing of sediments with overlying water that occurs during the dredging phase. The Elutriate Test study was conducted on Lake Newport's bottom sediments according to procedures set forth by the United States Environmental Protection Agency (USEPA) and the U. S. Army Corps of Engineers. The results of this study indicated that heavy metals bound to Lake Newport bottom sediments were relatively immobile and were not likely to be released into solution in harmful amounts during dredging. The dredging plan was unsuccessful in being implemented due to regulatory requirement problems, high costs, technical feasibility, and adverse public opinion.

Recent studies have explored several options for the future management of Mill Creek watershed [MRB-HER, 1993 and the US Army Corps of Engineers, 1995]. The MRB-HER study examined the following four basic alternatives for Lake Newport at a time when it was drained: (i) no fill, no action - no sediment removal, and no refilling of the lake, (ii) refill, no action - no sediment removal, refill lake after dam modifications, (iii) refill, full excavation - removal of all accumulated sediment, refill lake after dam modifications, and (iv) refill, partial excavation - removal of a portion of the accumulated sediment, refill after dam modifications. MRB-HER recommended that a system of wetlands and wet detention basins be developed at the southern end of the Lake Newport basin, and a "Greenway Plan" be developed to identify methods for protecting the Mill Creek watershed from increased runoff, soil erosion, loss of aquatic habitat, and other problems. The US Army Corps of Engineers report recommended the following alternatives: (i) construction of a 50 acre detention pond within the southern end of Lake Newport, (ii) maintaining current conditions through regular dredging of the lake and dewatering on park lands, and (iii) maintaining current conditions through regular lake dredging utilizing a tanker to remove dredge sediments.

In the mid 1990's, the average inflow rate to Lake Newport from Mill Creek was estimated at about 100 cubic feet per second (cfs). The monitoring data collected by MRB-HER indicate that the suspended solids (SS) loading rate to the lake from Mill Creek is around 9,327 kilograms per day (kg/d) [MRB-HER, 1994]. Of the tributaries sampled in this study, Indian Run and Anderson's Run were reported to contribute the largest SS loadings to Lake Newport.

A large amount of sediment deposition has occurred in the stream channels of Mill Creek and its tributaries, which in turn has greatly increased the annual rate of sediment accumulation in Lake Newport. The sediment deposition in the streams has resulted in the widening of the streams, bank erosion, and more frequent flooding.

The modeling of NPS pollution in a watershed such as Mill Creek's can help identify the main problem spots. In the following sections, a brief overview of the theory of water quality modeling techniques is presented.

2.3 Hydrology - Storm Runoff

For estimating storm runoff, the unit hydrograph method is often used. Sherman first proposed it in 1932, and since then it has been used as a key concept [Chow *et al*, 1988]. The unit hydrograph is defined as the watershed response to a unit depth of excess rainfall, uniformly distributed over the entire watershed and applied at a constant rate for a given period of time. In 1938, after studying watersheds in the Appalachian mountains of the United States, Snyder proposed relations between some of the characteristics of the unit hydrograph, i.e., peak flow, lag time, base time, and width (in units of time) at 50% and 75% of the peak flow [Chow *et al*, 1988]. A significant contribution to the unit hydrograph theory is due to Clark, who proposed a unit hydrograph which is the result of a combination of a pure translation routing process (plug-flow) followed by a pure storage routing process (completely stirred tank reactor) [Clark, 1945]. The translation part of the routing is based on the time-area diagram of the watershed. The storage part consists in routing the response of the translation through a single linear reservoir located at the watershed outlet. Later, Nash proposed a unit hydrograph equation which is a gamma distribution, i.e., the response of a cascade of identical linear reservoirs to a unit impulse [Nash, 1957]. The method proposed by Nash did not model the watershed itself, and was merely a fitting technique based on the first and second moments of the calculated and observed hydrographs.

Pilgrim conducted an experimental study which focused on tracing flood runoff from specific points of a 0.39 km^2 watershed near Sydney, Australia, and measuring the travel time of labeled particles to the outlet [Pilgrim and Cordery, 1993]. An important conclusion of his study is that, at medium to high flows, the travel times and average velocities become almost constant, indicating that linearity is approximated at this range of flows. Pilgrim also observed that variations in curves of tracer activity versus time made an additional contribution to the non-linearity of the runoff process.

Rodriguez-Iturbe and Valdes [1979] made an important attempt to link the geomorphological characteristics with the hydrologic response of a watershed. In their paper, Horton's empirical laws, i.e., the law of stream numbers, lengths and areas, were used to describe the geomorphology of the system. The instantaneous unit hydrograph is defined as the probability density function of the time a rainfall drop, chosen at random, takes to reach the outlet. This time is given by the sum of the time spent by the drop at various locations in the stream on its way to the outlet. The time spent at each location is taken as a random variable with an exponential probability density function whose parameters depend on the Horton length ratio, mean velocity of the stream flow (dynamic parameter), and a scale factor.

Studying the storm rainfall-runoff relation involves more than simply studying the unit hydrograph. Consequently, along with the unit hydrograph assumptions of uniform and constant rainfall, considerable research has been done in recent years to account for spatial variability of the catchment, and many related articles are available in the literature.

2.4 Water Quality Models

Modeling storm runoff consists of determining the flow at the watershed outlet generated by a storm, while modeling NPS pollution consists of determining the pollutant transport at the outlet. NPS pollution is strongly related to the storm runoff process since it is the runoff which transports the pollutants. This relationship implies that the understanding of the water quantity problem is essential for understanding the water quality problem. For NPS pollution modeling, spatial variability of the terrain needs also to be taken into account, an important consideration given that the pollutant generation is strongly related to land-use. Moreover, point sources of pollution can also be handled as diffuse sources affecting specific flow elements.

The concern about NPS pollution has greatly increased during the last two decades. A large number of computer modeling tools have been developed and applied to aid in resource conservation planning and management for soil erosion and NPS pollutant mitigation. A list of several of the more widely used models include: CREAMS, a field-scale model for Chemicals, Runoff, and Erosion from Agricultural Management Systems [Knisel, 1980]; EPIC, Erosion/Productivity Interactive Calculator [Williams *et al*, 1984]; SWRRB, Simulator for Water Resources in Rural Basins [Arnold *et al*, 1990]; ANSWERS, Areal Nonpoint Source Watershed Environmental Response Simulator [Beasley *et al*, 1980]; GAMES [Rudra *et al*, 1986]; HSPF, Hydrologic Simulation Program - FORTRAN [Barnwell and Johanson, 1981]; SWAT, Soil and Water Assessment Tool [Stallings, 1988]; and AGNPS, Agricultural NonPoint Source Pollution Model [Young *et al*, 1989 and 1986]. A brief description of some of these models follows.

The Soil and Water Assessment Tool (SWAT) was developed to predict the effect of alternative management decisions on water, sediment, and chemical yields with reasonable accuracy for ungaged rural basins. The SWAT model operates on a daily time step and is capable of simulating a time frame of up to 100 years or more. Major components of the model include hydrology, weather, sedimentation, soil temperature, crop growth, nutrients, pesticides, ground water and lateral flow, and agricultural management. It offers distributed parameter and continuous-time, flexible watershed configuration, irrigation and water transfer, lateral flow, ground water, and detailed lake water quality components. The model has the following general characteristics: physically based (calibration is not possible on ungaged basins), uses readily available inputs, computationally efficient to operate on large basins in a reasonable time, and continuous time simulation over long periods for computing the effects of management changes.

The Hydrologic Simulation Program - FORTRAN (HSPF), developed by the USEPA, simulates watershed hydrology and water quality. It allows an integrated simulation of land contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The model computes a continuous hydrograph of stream flow at the basin outlet based on continuous record of precipitation and evaporation data. The HSPF also simulates transport of sand, clay and silt sediments, and a single organic chemical and the transformation products of that chemical. Transfer and reaction processes modeled are hydrolysis, oxidation, biodegradation, volatilization, and absorption. The spatial variability of the watershed is considered by partitioning it into subwatersheds and applying the lumped model to each of them. The water quantity routines in the HSPF are FORTRAN versions of the Hydrocomp Simulation Program developed from the Stanford Watershed Model of 1959 [Barnwell and Johanson, 1981].

The Agricultural Nonpoint Source Pollution Model (AGNPS) is an event-based model that simulates runoff water quality from agricultural watersheds. The model uses geographic data cells of 0.4 to 16 hectares to represent land surface conditions, and, within the framework of these cells, runoff characteristics and transport processes for sediment, nutrients, and chemical oxygen demand are simulated. Flows and pollutants are routed through the channel system to the basin outlet. Runoff volume is calculated by the Soil Conservation Service Curve Number procedure, and peak flow is determined by using an empirical formula that takes into account drainage area, channel slope, runoff volume, and watershed length-width ratio. The AGNPS model was developed by the Agricultural Research Service in cooperation with the Minnesota Pollution Control Agency and the Soil Conservation Service. Recently, a new model known as ANN-AGNPS has been developed (an extension of the AGNPS) for a continuous simulation of an agricultural watershed on an annual basis. This considerably enhances the capacity of the earlier single event model [Needham and Young, 1993].

2.5 Model Selection

Models for agricultural diffuse pollution have different approaches. They can be lumped or distributed-parameter, continuous or event-type models for use at field or watershed scales. The common elements among most of these models are the processes affecting the entrainment and transport of sediment, nutrients, and pesticides in surface runoff. The dominant transport vector is runoff; while low intensity events produce little runoff, larger storms are generally responsible for the transport of pollution from wide areas.

A good review of the available models applicable to NPS pollution of urban and agricultural watersheds can be found in Giorgini and Zingales [1986] and [Rose *et al*

[1988]. For the present simulation of the Indian Run watershed, the event-based AGNPS model was selected. The choice is based on the following considerations: (i) it is available for a free download from an internet site and is easy to run on an IBM-compatible, Pentium II, Windows 95 platform PC, (ii) it provides distributed spatial abilities and a representative stochastic description of physical processes controlling the movement of sediments and chemicals, and (iii) it has been widely tested for predicting runoff and sediment yield, which is the main focus of the present study.

CHAPTER 3

AGNPS: MODEL STRUCTURE AND COMPONENTS

3.1 Fundamentals of Surface Water Quality Modeling

Since the 1920's, scientists and engineers have been using mathematical models to simulate the transport and fate of pollutants in natural waters in an effort to develop economical solutions to water quality problems. Scientific communities along with the decision-makers have been trying to seek rigorous means for evaluating the effectiveness of environmental control actions. The outcome of these control actions can be measured by the attainment of a water quality standard and of a concomitant expected water use associated with that water quality. The intent is to achieve the desired water quality and water use objectives through an environmental control program, in which the benefits outweigh the costs.

Decision makers who assess which environmental control actions to implement are primarily concerned with two possibilities: (i) reducing waste inputs to a body of water and observing little or no improvement in water quality, and (ii) mandating control actions that are costly in relation to water use benefits [Thomann and Mueller, 1987]. Computational modeling of water quality systems arose out of the need to address these two possibilities, as the questions became more complex and the economic consequences of making a wrong decision increased markedly. The modeling of surface water quality should attain two objectives. First, it should provide a better understanding of the mechanisms and interactions that give rise to various types of water quality behavior through formulation and testing of the cause-effect relationships between the model inputs and the resulting water quality. Second, it should help the decision-makers in adopting a more rational basis for water quality control decisions.

Removing waste loads to a water body without first evaluating the likely responses using a model is not a practical way of meeting water quality objectives. Such approaches have been used in the past for water quality measurement, and the results have proven to be cost inefficient. It is important that an attempt be made to evaluate the outcomes expected from water quality controls before the implementation of those environmental controls, and to continue to monitor the effectiveness of the controls by field sampling and analysis, as well as by reevaluation of mathematical modeling predictions.

Modeling of the water quality system should allow one to examine the relationship between waste load inputs and the resulting water quality response predicted by the model. The development and application of such a water quality model involves a variety of considerations, including the specification of model parameters and conditions. The principal components of a mathematical model are presented in Figure 2. The upper two steps enclosed within the dashed lines, namely *Theoretical Construct* and *Numerical Specification*, constitute what is considered a mathematical model. This is to distinguish the writing of equations for a model from assigning a set of representative numbers to input and parameters.

Mathematical modeling of the water quality system includes the following tasks:

- Development of Model: Theoretical construction of mathematical equations together with assignment of preliminary numerical values to the model

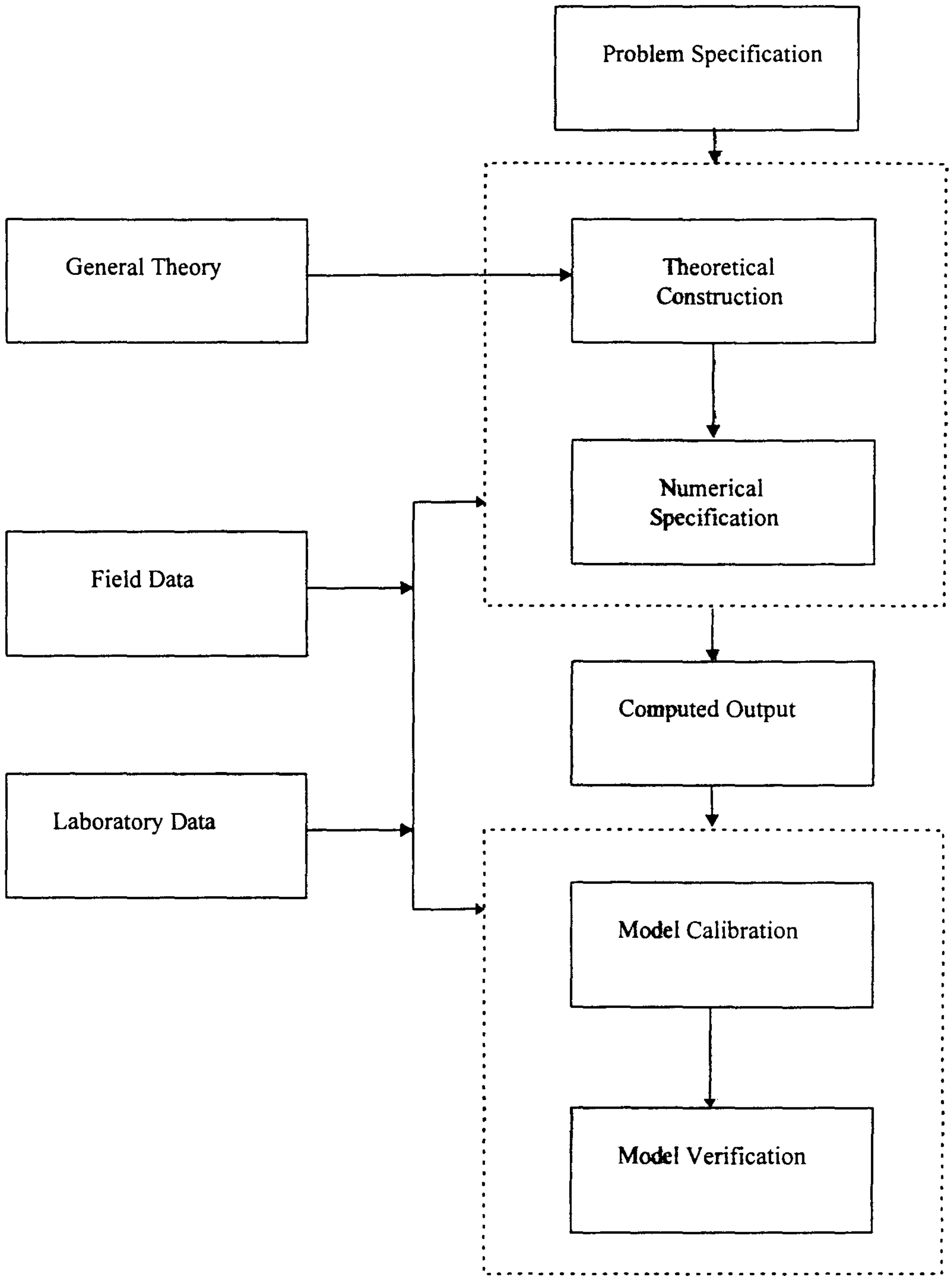


Figure 2. Principal Components of Modeling Framework

parameters, incorporating some prior observations from field and laboratory data;

- Development of computer programs;
- Calibration of Model: First stage testing or tuning of a model to a system-specific set of field data not used in the original model construction; and
- Verification of Model: Subsequent testing of a calibrated model to additional field data, preferably under different external conditions, to further examine the validity of the chosen model.

Once the model is verified it can then be used to predict the water quality under a variety of potential scenarios. Water quality modeling can be used as a tool for predicting the consequences of environmental control actions to assess the advantages and disadvantages of various alternatives. As mentioned earlier, results of the modeling in this project will help the MCM administrators to make appropriate management and technical decisions that can be instituted to achieve specific environmental quality objectives.

3.2 Description of the AGNPS Framework

The AGNPS (Agricultural Non-Point Source Pollution Model) is an event-based model that simulates surface runoff, sediment, and nutrient transport, primarily from agricultural watersheds. The nutrients considered include nitrogen (N) and phosphorous (P); both essential plant nutrients and major contributors to surface water pollution. Basic model components include hydrology, sediment transport, and chemical transport.

In addition, the model considers point sources of water, sediment, nutrients, and chemical oxygen demand (COD) from animal feedlots, and springs. Water impoundments, such as tile-outlet terraces, are also considered as depositional areas of sediment and sediment-associated nutrients. The model has the ability to output water quality characteristics at intermediate points throughout the watershed network. This capability is based on the model's implementation of the 'cell'. Cells are uniformly square areas subdividing the watershed and all watershed characteristics and inputs are expressed at the cell level.

Model components use equations and methodologies that have been well established and are extensively used by agencies such as the United States Department of Agriculture (USDA) Soil Conservation Service (SCS). Runoff volume and peak flow rate are estimated using the SCS runoff curve number method [Young *et al*, 1989]. Peak runoff rate for each cell is estimated using an empirical relationship proposed by Smith and Williams [Smith and Williams, 1980]. Upland erosion and sediment transport is estimated using a modified form of the Universal Soil Loss Equation (USLE) [Wischmeier and Smith, 1978]. Sediment is routed from cell to cell through the watershed to the outlet using a sediment transport and depositional relationship described by Foster and associates, which is based on a steady-state continuity equation [Foster *et al*, 1981]. Chemical transport is calculated based on the relationships adapted from a field scale model for Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) and a feedlot evaluation model [Knisel, 1980; Young *et al*, 1986]. Feedlots are treated as point sources and chemical contributions are estimated using the feedlot pollution model by Young *et al* [1986]. Other point source inputs of water and nutrients, such as springs and wastewater treatment plant discharges are accounted for by specifying incoming flow rates and concentrations of nutrients to the cells where they occur.

3.3 Conceptualization of Model

The model operates on a geographic cell basis (Dirichlet tesselation) that is used to represent upland and channel conditions. Dirichlet tesselation is a process of splitting up and grouping a study area into cells or tiles, also known as Thiessen or Voronoi polygons [Young *et al*, 1986]. Cells are uniformly square areas subdividing the watersheds, allowing analyses at any point within the watershed. Potential pollutants are routed through cells from the watershed divide to the outlet in a stepwise manner so that flow at any point between cells can be examined. All watershed characteristics and inputs are expressed at the cell level.

A single cell or a data unit can be at resolutions of 2.5 acres to 40 acres or more. Smaller cell sizes such as 10 acres are recommended for watersheds less than 2000 acres. For watersheds exceeding 2000 acres, cell sizes of 40 acres or above are normally used to "pixelize" the watershed. In a 40-acre main unit cell segmentation scheme, different and smaller cell sizes than can also be used to meet the further resolution needs for complex topography or smaller-than-40-acre watershed characteristic units. Figure 2 shows the cell-based segmentation scheme for a watershed. Accuracy of results can be increased by reducing the cell size, but this increases the time and labor required to run the model. Conversely, enlarging the cell size reduces time and labor, but the savings must be balanced against the loss of accuracy resulting from treating larger areas as homogeneous units.

The computations in AGNPS occur in three stages based on twenty-three items of information per cell. Initial calculations for all cells in the watershed are made in the first stage. These calculations include estimates for upland erosion, overland runoff volume, time until the overland flow becomes concentrated, level of soluble pollutants leaving the watershed via overland runoff, sediment and runoff leaving impoundment-terrace systems, and pollutants coming from point source inputs such as feedlots.

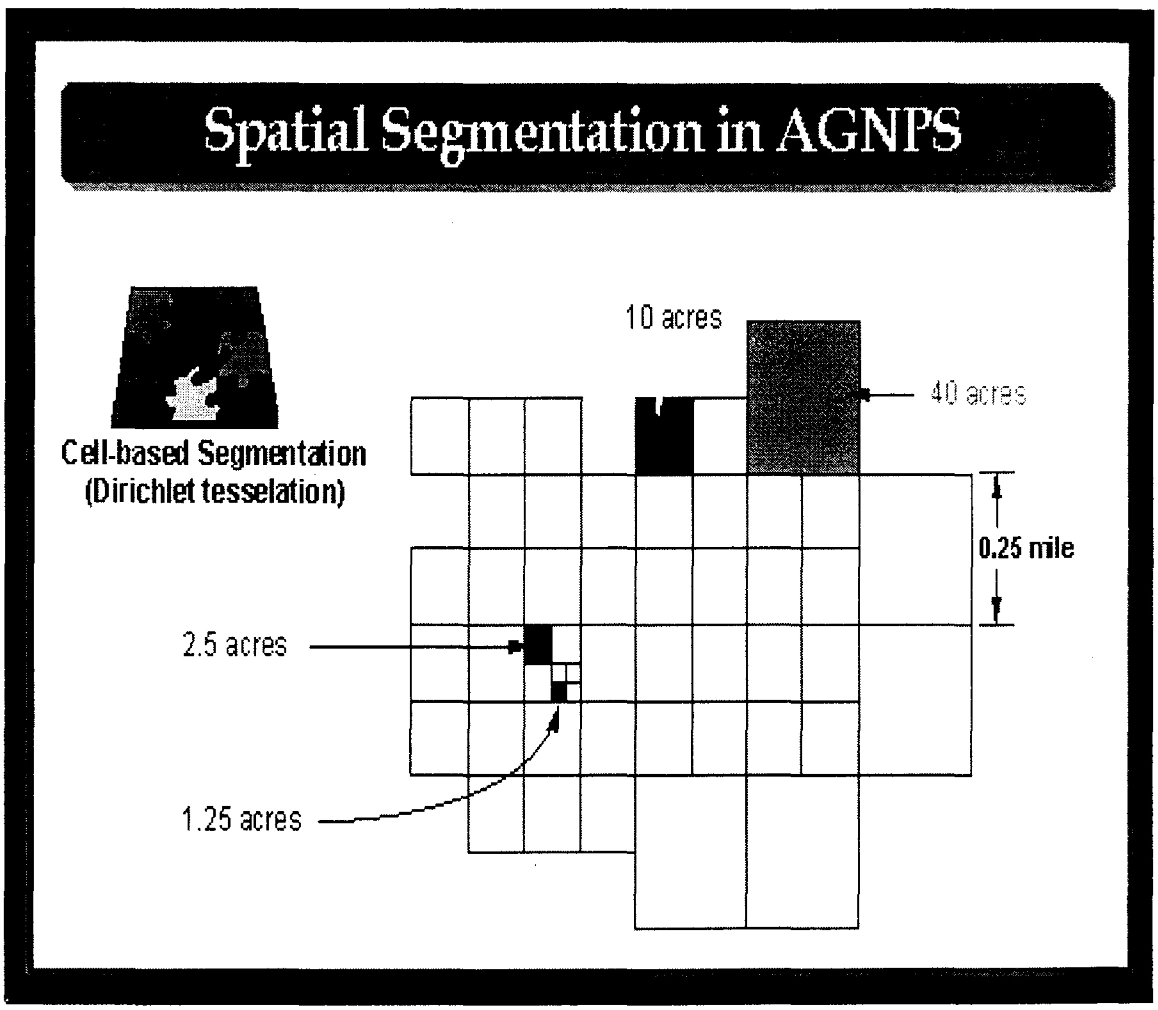


Figure 3. Example of Cell-Based Segmentation Scheme for a Watershed

The second stage involves calculation of the runoff volume leaving the cells containing impoundments and the sediment yields for primary cells. A primary cell is one that no other cell drains into. The sediment from these and other cells is broken down into five particle-size classes: clay, silt, small aggregates, large aggregates, and sand.

The sediment and nutrients are routed through the rest of the watershed in stage three. Calculations are made to establish the concentrated flow rates, to derive the channel transport capacity, and to calculate the actual sediment and nutrient flow rates.

The pollutant transport part of the model estimates transport of nitrogen, phosphorous and chemical oxygen demand (COD) throughout the watershed. The pollutant transport portion is subdivided into two parts, one handling soluble pollutants and another handling sediment-attached pollutants. Pollutant transport for soluble nitrogen and phosphorus is calculated using a relationship adapted from CREAMS [Needham and Young, 1993] and a feedlot evaluation model [Frere *et al*, 1980]. Soluble nitrogen and phosphorus in runoff waters represent the effects of rainfall, fertilization, solid waste and leaching from the soil in each cell. The nutrient yield associated with the sediment is calculated using the total sediment yield from each cell and relationships proposed in the CREAMS nutrient submodel [Frere *et al*, 1980].

The contributions of soluble nitrogen and phosphorous from each of the cells are calculated first and routed into the channel. Once soluble nutrients reach concentrated flow, they are assumed to remain as constants. That is, the amount arriving in the overland flow from any particular cell is simply added to what is already present in the channel, with no losses of soluble nutrients in the channel allowed.

A brief description of the physical components of AGNPS is presented next.

3.4 Hydraulics

Hydraulic radius is calculated by the following equation:

$$d_w = R = A / W \qquad (1)$$

where

d_w = hydraulic depth, m;

R = hydraulic radius, m;

A = flow area, m^2; and

W = flow width, m.

The velocity of flow is calculated from the equation:

$$v_w = (1/n) d_w^{2/3} S_o^{0.5} \qquad (2)$$

where

v_w = flow velocity of water, m/s;

n = Manning's retardance; and

S_o = channel slope, m/m.

For hydraulic depth and velocity when the discharge is given, the following equations are used:

$$d_w = \left[(nq_w) / \left(S_o^{0.5} \right) \right]^{0.6} = n^{0.6} S_o^{-0.3} q_w^{0.6} \qquad (3)$$

$$v_w = Q_w / \left(dd_w \right) = q_w / d_w \qquad (4)$$

where

Q_w = water discharge, m^3/s; and

$q_W = Q_W/W$, unit-width water discharge, m³/m·s.

The following equation, derived from Equation 2, is used in the subsequent formulas:

$$d_w * S_o = n^{0.6} * S_o^{0.7} * q_w^{0.6} \qquad (5)$$

3.5 Hydrology

3.5.1 Runoff Volume

Runoff volume estimates are based on the SCS curve method as follows:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad (6)$$

where

Q = the runoff volume, in.;

P = the rainfall, in. (P > 0.2S); and

S = retention parameter, in.

The retention parameter is defined in terms of a curve number (CN) as follows:

$$S = \frac{1000}{CN} - 10 \qquad (7)$$

The curve number depends on the land use, the soil type, and the hydrologic soil condition. This method is chosen because of its simplicity and widespread use.

3.5.2 Peak Runoff Rate

The peak runoff rate for each cell is estimated by an empirical relationship which is also adopted in the CREAMS model [Smith and Williams, 1980]. The estimate is given by:

$$Q_P = 3.79\,A^{0.7}(CS)^{0.16}\left(0.0393RO\right)^{\left(0.903\,A^{0.017}\right)}LW^{-0.19} \qquad (8)$$

where

Q_P = peak runoff rate in m^3/s;

A = drainage area in km^2;

CS = channel slope in m/km;

RO = runoff in in.; and

LW = watershed length-width ratio.

The parameter LW is calculated by L^2/A where L is the watershed length. The values for the coefficients are based on a large number of field measurements.

3.5.3 Hydrograph Shape

The model assumes a triangular shape for the hydrograph. Since the sediment transport is only concerned with the duration of an average discharge, the time to peak is not important and a right triangle hydrograph is assumed to calculate the sediment transport. The time to base of the hydrograph (duration of surface runoff event) is given by the empirical equation:

$$t_b = 20\left(R \cdot D_a / Q_p\right) \qquad (9)$$

where

Q_p = peak discharge, ft^3/s;

D_a = total drainage area, acres;

R = surface runoff volume from upstream drainage area, in.; and

t_b = time base, s.

The hydrograph as a function of time is described by:

$$Q_w = \left(Q_p / t_b\right) \cdot t \ where \ 0 \le t \le t_b \qquad (10)$$

where

Q_W = discharge as a function of time, m^3/s; and

t = time from beginning of runoff, s.

The unit-width peak discharge is calculated by:

$$q_p = Q_p / W \qquad (11)$$

where

q_p = unit-width peak discharge, m^3/s.m.

3.6 Erosion and Sediment Transport

3.6.1 Modified Universal Soil Loss Equation

Wischmeier developed the Universal Soil Loss Equation (USLE) in 1958 [Wischmeier and Smith, 1978]. Over the next 20 years, he refined and improved the USLE and published the results of his efforts in 1978 in Agriculture Handbook 537, which is still a standard reference. The USLE is widely used for land management planning worldwide and, according to the International Soil and Water Conservation Society, is regarded as the primary tool of conservationists for planning purposes.

The equation provides techniques for numerically evaluating effects of climate, soil properties, topography, crop-productivity level, time and method of seeding, crop sequence, residue management, special conservation practices, and other pertinent variables that effect soil erosion. It is a required element in farm and ranch plans used to qualify for USDA assistance programs and is an invaluable tool for natural resource inventories carried out in the United States. The USLE has been the basis of economic analyses related to agriculture, and has been an important element in analyses dealing with assessment and control of surface water quality [Young and Onstad, 1986].

Soil loss equations were developed to enable conservation planners to project limited erosion data to the many localities and conditions that have not been directly represented in the research. The USLE is an erosion model designed to predict the longtime average soil losses in runoff from specific field areas in specified cropping and management systems. Widespread field use has substantiated its usefulness and validity for this purpose. It is also applicable for such nonagricultural conditions as construction sites.

With appropriate selection of its factor values, the equation computes the average soil loss for a multicrop system, for a particular crop year in a rotation, or for a particular cropstage period within a crop year. It computes the soil loss for a given site as the product of six major factors whose most likely values at a particular location can be expressed numerically. Erosion variables reflected by these factors vary considerably about their means from storm to storm, but effects of the fluctuations tend to average out over extended periods. The modified soil loss equation is given by:

$$SL = (EI) \cdot K \cdot (LS) \cdot CP \cdot (SSF) \qquad (12)$$

where

SL = Erosion loss, Mg/ha/yr or tons/acre/yr;

EI = Product of storm total kinetic energy and maximum 30-minute intensity, foot-tons per acre-inch

K = Soil erodibility factor, dimensionless;

LS = Slope-length factor, dimensionless;

C = Cover and management factor, dimensionless;

P = Erosion control practice factor, dimensionless; and

SSF = Factor to adjust for slope within the cell, dimensionless.

The major purpose of the soil loss equation is to guide methodical decision making in conservation planning on a site basis. The USLE equation enables the planners to predict the average rate of soil erosion for each feasible alternative combination of crop system and management practices in association with a specified soil type, rainfall pattern, and topography. Research is continuing with emphasis on obtaining a better understanding of the basic principles and processes of soil erosion and sedimentation, and development of models capable of predicting storm-specific soil losses and deposition during overland flow.

3.6.2 Types of Water Erosion

Water erosion results from the removal of soil material by flowing water. A part of the process is the detachment of soil material by the impact of raindrops. The soil material is suspended in runoff water and carried away. Four kinds of accelerated water erosion are commonly recognized: sheet, rill, gully, and tunnel (piping).

Sheet erosion is the uniform removal of soil from an area without the development of water channels. The channels are usually tiny or tortuous, and unstable.

They enlarge and straighten as the volume of runoff increases. Sheet erosion is less apparent, particularly in its early stages, than other types of erosion. It can be significant over soils that have a slope gradient of only 1 or 2 percent, however, it is generally more serious as slope gradient increases.

Rill erosion is the removal of soil through the cutting of many small channels where runoff concentrates. Rill erosion is intermediate between sheet and gully erosion. The channels are shallow enough that they are easily obliterated by tillage, for example, after an eroded field has been cultivated. Determining whether the soil losses resulted from sheet or rill erosion is generally difficult.

Gully erosion results from water that cuts down into the soil along the line of flow. Gullies form in exposed natural drainageways, plow furrows, animal trails, vehicle ruts, between rows of crop plants, and below broken man-made terraces. In contrast to rills, they cannot be obliterated by ordinary tillage. Deep gullies cannot be crossed with common types of farm equipment.

Tunnel erosion may occur in soils with subsurface horizons or layers that are more subject to entrainment in moving water. The water enters the soil through ponded infiltration into surface-connected macropores. Desiccation cracks and rodent burrows are examples of macropores that may initiate the process. The soil material entrained in the moving water moves downward within the soil and may move out of the soil completely if there is an outlet. The result is the formation of tunnels (also referred to as pipes) which enlarge and coalesce. The portion of the tunnel near the inlet may enlarge disproportionately to form a funnel-shaped feature referred to as a *jug*. Hence, the terms *piping* and *jugging*.

The deposition of sediment carried by water occurs when the velocity of running water is reduced at the mouth of gullies, at the base of slopes, along stream banks, in reservoirs, and at the mouth of streams. Rapidly moving water, when slowed, drops stones, then cobbles, pebbles, sand, and finally silt and clay. Sediment transport slope length has been defined as the distance from the highest point on the slope where runoff may start to where the sediment in the runoff would be deposited. The following sections will cover the technical equations used in the AGNPS model components to simulate sediment transport [Young and Onstad, 1994].

3.6.3 <u>Sediment Concentration</u>

The sediment concentration in the model is defined as:

$$C_s = (S / M_W) \qquad (13)$$

where

S = sediment mass, Mg; and

M_W = water mass from upstream drainage area, Mg ($1 m^3 = 1 Mg$).

In the model, the sediment concentration is assumed to be constant throughout the hydrograph, therefore, the sediment load for a given discharge at any time during the runoff hydrograph is:

$$q_s = (C_S \cdot q_w) \qquad (14)$$

where

q_W = unit-width water discharge at any time, Mg/s/m.

3.6.4 Sediment Routing

After runoff and upland erosion are determined, the detached sediment is routed from cell to cell through the watershed to its final outlet [Foster *et al*, 1981; Lane *et al*, 1982]. The basic routing equation, derived from the steady-state continuity equation, is given by :

$$Q_S(x) = Q_S(O) + Q_{SL}(x / L_r) - \int_0^x D(x) w \ dx \qquad (15)$$

where

$Q_S(x)$ = the sediment discharge at the downstream end of the channel reach;

$Q_S(O)$ = the sediment discharge into the upstream end of the channel reach;

Q_{SL} = lateral sediment inflow rate;

L_R = reach length;

w = the channel width; and

$D(x)$ = the deposition rate.

The equation is a generalized relationship valid in any system of units.

3.6.5 Sediment Yield

All sediment routing calculations in the concentrated flow channels are performed for each of the five particle-size classes (sand, large & small aggregates, silt, and clay) and for each increment of the hydrograph. If the sum of all incoming sediment (q_{s1}) is greater than the sediment transport capacity (q_{sc}) see Section 3.6.8, then the model uses the sediment deposition algorithm. If that sum is less than or equal to the sediment transport capacity, then the sediment discharge at the outlet of the reach (q_{s1}) is equal to the sediment transport capacity for an erodible channel (by particle-size). Otherwise, if the upstream sediment discharge (q_{s1}) is less than or equal to the sediment transport capacity (q_{sc}) and the channel is non-erodible for that particular particle-size, then the model sets the downstream sediment discharge (q_{s2}) equal to the upstream sediment discharge (q_{s1}). In summary:

• If (q_{s1}-q_{sc}) ≤ 0 and the bed is erodible for the particular particle-size class,

then $q_{s2} = q_{sc}$; or

• If (q_{s1}-q_{sc}) ≤ 0 and the bed is non-erodible for the particular particle-size class,

then $q_{s2} = q_{s1}$; or

• If (q_{s1}-q_{sc}) > 0, then the model uses the sediment deposition algorithm.

3.6.6 Deposition Rate

The deposition rate is given by,

$$D(x) = \left(V_{ss} / q(x)\right)\left(q_s(x) - g_s'(x)\right) \qquad (16)$$

where

V_{SS} = particle fall velocity;

$q(x)$ = discharge per unit width;

$q_S(x)$ = sediment load per unit width; and

$g_S'(x)$ = effective transport capacity per unit width.

The equation is a generalized relationship valid in any system of units.

3.6.7 Sediment Transport Capacity

The effective transport capacity is determined by modification of the Bagnold stream power equation which results in [Young *et al*, 1989, 1986 and 1994]:

$$g_s'(x) = \eta g_s = (\eta k)(\tau V^2 / V_{ss}) \qquad (17)$$

where

g_S = the transport capacity;

η = the effective transport factor;

k = the transport capacity factor;

τ = the shear stress; and

v = the average channel flow velocity determined by the Manning's equation.

The equation is a generalized relationship valid in any system of units.

3.6.8 Sediment Transport Capacity Algorithm

The sediment transport capacity (q_{sc}) and the unit-width water discharge (q_w) are based upon the parameters at the upstream end of the reach (x_1). The shear velocity, assuming unit-width, is based upon the parameters at the upstream end of the reach (x_1) and is defined to be:

$$U_* = \left[g \cdot d_w \cdot S_o\right]^{1/2} = g^{0.5} \cdot n^{0.3} \cdot S_o^{0.35} . q_w^{0.3} \qquad (18)$$

where

g = gravitational constant, 9.81 m/s^2;

q_p = unit-width water discharge, m^3/m·s; and

U_* = shear velocity at x_1, m/s.

For estimating sediment transport capacity, a parameter A_E (non-dimensional Einstein's constant of proportionality) needs to be defined for any given flow and particle size, between the depth-average suspended sediment concentration and the concentration at the laminar sublayer plane. The Einstein's constant of proportionality is the ratio of the suspended sediment concentration at the bottom of the water column (near the bed surface) to the average concentration of suspended sediment throughout the water column. This constant of proportionality is used in later modeling equations. For clay, silt, and small aggregates, the model uses A_E = 1; for sand and large aggregates, the model uses the following equation:

$$A_E = \left[\left(6V_f\right)/\left(\kappa \cdot U_*\right)\right]/\left[1-\exp\left\{\left(6V_f\right)/\left(\kappa \cdot U_f\right)\right\}\right] \qquad (19)$$

where

A_E= The Einstein's constant of proportionality;

κ = von Karman's turbulent-flow mixing-length constant (model assumes a value of 0.4),non-dimensional; and

V_f= particle fall velocity, m/s.

For each particle-size, the sediment transport capacity is provided by:

$$q_{sc} = \eta \cdot \kappa \cdot \tau \cdot V_w^2 / V_f \qquad (20)$$

where

q_{sc}= unit-width sediment transport capacity, Mg/s·m;

k = transport capacity factor (see Table 1 for the values), non-dimensional; and

V_f = particle fall velocity (see Table 1 for the values), m/s.

The effective transport factor at this at this stage is estimated by the following equation:

$$\eta = 0.322\left[\frac{(\gamma_p - \gamma_w)}{(\tau / D_p)}\right]^{1.626} \leq 1 \qquad (21)$$

where

η = effective transport factor, non-dimensional;

τ = bed shear stress, Mg/m^2;

γ_w = 1.00, water density, Mg/m^3;

γ_p = particle density, (see Table 1 for values), Mg/m^3; and

D_p = equivalent sand size particle diameter (see Table1 for values), m.

The bed shear stress is computed by the following equation:

$$\tau = \gamma_w \cdot d_w \cdot S_o \qquad (22)$$

where

τ = bed shear stress, Mg/m^2;

γ_w = 1.00, water density, Mg/m^3;

d_w = hydraulic depth, m; and

S_o = channel slope, m/m.

Table 1 contains the physical properties for each particle-size class.

Table 1. Particle-Size Class Physical Properties

Particle-Size Class	**Particle-Size Range (mm)**	γ_p **Particle Density (Mg/m^3)**	V_f **Fall Velocity (mm/s)**	**k Transport Capacity Factor**	**Dp Equivalent Sand Size (mm)**
Clay	<0.002	2.60	$3.11X10^{-3}$	$6.242X10^{-3}$	$2.00X10^{-3}$
Silt	0.002-0.050	2.65	$8.02X10^{-2}$	$6.053X10^{-3}$	$1.00X10^{-2}$
Sand	0.050-2.000	2.65	$2.31X10^{+1}$	$6.053X10^{-3}$	$2.00X10^{-1}$
Small Aggregates (SAGG)	0.020-0.075	1.80	$3.81X10^{-1}$	$12.478X10^{-3}$	$3.51X10^{-2}$
Large Aggregates (LAGG)	0.200-1.000	1.6	$1.65X10^{+1}$	$16.631X10^{-3}$	$5.00X10^{-1}$

Separating the hydraulic from the sediment particle related terms, one obtains:

$$\eta = \left[C / \left(n^{0.6} \cdot S_o^{0.7} \right) \cdot q_w^{0.6} \right]^{1.626} \leq 1 \ \ and$$

$$C_1 = \left\{ \left[D_p / 2004 \right] \cdot \left[\left(\gamma_p - \gamma_w \right) \right] / \gamma_w \right\} \qquad (23)$$

where

C_1 = particle-size class constant for the effective transport factor (see Table 2), m;

and D_p = particle diameter (see Table 2), mm.

The effective transport factor (η) is equal to 1 when $S_0 \cdot d_w = C_1$. Therefore,

$$q_n = \left[C_1 / \left(n^{0.6} . S_o^{0.7} \right) \right]^{1.67} \qquad (24)$$

where

q_η = critical unit-width water discharge below which effective transport factor (η) is 1 and above which it is calculated according to the earlier equation, $m^3/s/m$;

The critical unit-width water discharge (q_η) occurs at the critical transport factor time (t_η). When $0 \geq t < t_\eta$, $\eta = 1$; and when $t \geq t_\eta$, η is solved for. The following equation results:

$$t_\eta = t_b \left(q_\eta / q_p \right) \qquad (25)$$

where

t_η = critical effective transport factor time, when $t < t_\eta$, $\eta = 1$, s.

Combining the equations results in:

$$\begin{aligned} &For\ 0 \leq 1 \leq t_\eta : \\ &C_2 = 322 \cdot k \cdot \gamma_w / V \quad and \\ &q_{sc} = C_2 \cdot n^{-0.6} \cdot S_o^{1.3} \cdot q_w^{1.4} \end{aligned}$$

$$\begin{aligned} &For\ t \geq t_\eta : \\ &C_3 = C_1^{1.626} \cdot C_2 \quad and \\ &q_{sc} = C_3 \cdot n^{-1.5756} \cdot S_o^{0.1618} \cdot q_w^{0.4244} \qquad (26) \end{aligned}$$

where

C_2 = particle-size class constant for the sediment transport capacity for $\eta = 1$ (see Table 2), $Mg \cdot s/m^4$; and

C_3 = particle-size class constant for the sediment transport capacity for $\eta < 1$ (see Table 2), $Mg \cdot s/m^{2.374}$.

The analysis of sediment transport capacity in previous studies has shown that variation of η does not lead to rational results. Therefore, η is set to 1 for all flow conditions in the model. The total sediment transport capacity for the hydrograph is given by the following equation:

When $t_\eta \geq t_b$,:

$$S_{sc} = \int_0^{t_b} (W \cdot q_{sc}) dt = W \cdot C_2 \cdot n^{-0.6} \cdot S_0^{1.3} \cdot q_p^{1.4} \cdot t_b / 2.4 \qquad (27)$$

Otherwise, when $0 < t_\eta < t_b$,:

$$S_{sc} = \left[\int_0^{t_\eta} q_{sc}\, dt + \int_{t_\eta}^{t_b} q_{sc}\, dt \right]$$

$$S_{sc} = \left\{ \begin{array}{l} \left[C_2 \cdot n^{-0.6} \cdot S_0^{1.3} \cdot q_p^{1.4} \cdot t_\eta / 2.4\right] + \\ \left[\left(C_3 \cdot n^{-1.5756} \cdot S_o^{0.1618} \left(q_p / t_b\right)^{0.4244}\right) \cdot \left(t_b^{1.4244} - t_\eta^{1.4244}\right) / 1.4244\right] \end{array} \right\} \qquad (28)$$

Table 2 contains the sediment transport capacity constants for each particle-size class.

Table 2. Sediment Particle-size Class Sediment Transport Capacity Values

Sediment Class	D_p (mm)	γ_p (Mg/m^3)	V_f (mm/s)	C_1 (m)	C_2 (Mg-s/m^4)	C_3 (Mg-s/m$^{2.374}$)
Clay	0.002	2.60	0.003	1.597X10^{-6}	2.007X10^{3}	7.534X10^{-7}
Silt	0.01	2.65	0.08	8.23X10^{-6}	7.547X10^{1}	4.079X10^{-7}
Sand	0.02	2.65	23.1	1.64X10^{-4}	2.6X10^{-1}	1.848X10^{-7}
SAGG	0.0351	1.80	0.038	1.40X10^{-5}	3.276X10^{1}	4.202X10^{-7}
LAGG	0.05	1.60	16.5	1.50X10^{-4}	1.008X10^{0}	6.086X10E^{-7}

3.6.9 Sediment Deposition Algorithm

The sediment routing for each reach is done the same way using the unit-width, steady-state, uniform, spatially-varied sediment discharge model as included in the code. Sediment discharges (q_{s1}) from a local cell will be the sum of all incoming sediment from upstream reaches plus the local sediment generated. Primary cell upstream sediment discharges (q_{s1}) will consist only of local loading since there is no incoming sediment from upstream reaches to a primary cell.

The sediment discharge relationship is given by the equation:

$$q_{s2} = q_{sc} + \left[(q_{s1} - q_{sc}) \cdot \exp(-N_d) \right] \qquad (29)$$

where,

$N_d = (A_E \cdot v_f \cdot L_2)/q_w$, deposition number, non-dimensional;

A_E = Einstein's constant of proportionality, non-dimensional;

L_2 = distance from x_1 to x_2, m; and

q_{S2} = downstream unit-width sediment discharge at x_2, Mg/s/m.

For primary cells, the distance from x_1 to x_2 is the distance from the hydraulically most distant point (x_1) to the cell outlet (x_2). For secondary cells, the distance from x_1 to x_2 of its associated reach is the length of the concentrated flow channel segment for the reach. The outlet for each reach is always x_2 in the above equations. All incoming sediment from upstream reaches is assumed to enter at the upstream end of the reach (x_1). Local loading (originating within the associated cell) is assumed to be delivered to the downstream end of the cell's associated reach (x_2).

3.6.10 <u>Sediment Load</u>

The sediment load for each of the five particle size classes leaving a cell is estimated by the equation:

$$Q_S(x) = \left[\frac{2q(x)}{2q(x) + \Delta x \, V_{SS}}\right] \bullet$$

$$\left[Q_S(0) + Q_{SL}(x/L) - (w\Delta x/2)\left(\frac{V_{SS}}{q(0)}\left[q_S(0) - g_S^{\cdot}(0)\right] - \frac{V_{SS}}{q(x)} q_S(x)\right)\right] \quad (30)$$

where the symbols are as defined before. This is the primary equation that drives the sediment transport model in the AGNPS simulation.

3.7 Chemical Transport

The chemical component of the model estimates the transport of N, P, and COD throughout the watershed. Relationships used to calculate chemical transports are derived from the CREAMS model and a feedlot evaluation model, with modifications to accommodate variation in soil texture [Young *et al*, 1989, 1986, and 1984]. The basic equations (generalized relationships valid in any system of units) are as follows.

Nutrient Yield: $Nut_{SED} = (Nut_f)\, Q_S(x)\, E_R$ (31)

Enrichment Ratio: $E_R = 7.4\left(Q_S(x)\right)^{-0.2} T_f$ (32)

Soluble Nutrient: $Nut_{SOL} = C_{NUT}\, Nut_{EXT}\, Q$ (33)

The symbols are as given below:

Nut_{SED} = N or P transported by sediment;

E_R = enrichment ratio;

Nut_{SOL} = concentration of soluble N or P in the runoff;

$Q_S(x)$ = sediment yield,

$Nutf$= N or P content in the field soil,

T_f= a correction factor for soil texture,

Nut_{EXT}= an extraction coefficient for N or P,

C_{NUT}= mean concentration of soluble N or P, and

Q= total runoff.

The chemical transport assessment has been ignored in the present study.

This completes a brief review of the structure and components of the AGNPS model used in the present study.

CHAPTER 4

AGNPS: METHOD OF IMPLEMENTATION

Many versions of the AGNPS computer program are available, some may be downloaded free of charge from internet websites. The associated documentation provided for users is, in general, not sufficiently clear. Some programs are sensitive to computer platforms, and, in some cases, presence of "glitches" make it difficult to run the programs. For the present study, the AGNPS version used was obtained from the website of Old Dominion University. The program ran well, after a little trouble-shooting, on an IBM-compatible, Pentium II, Windows 95 platform based PC. Little technical support, however, was available.

For AGNPS applications, it is important to obtain an accurate description of the geographical features of the watershed to be studied. A large map of the Indian Run watershed drainage basin was prepared using the USGS 7.5 Minute Series Topographic maps of the following four quadrangles: (i) Columbiana, (ii) Salem, (iii) Mahoning, and (iv) Canfield. These maps were all photo-revised in 1985, and were therefore somewhat outdated. The USGS maps contain all the details of land contours, land coverage, residential and commercial developments, roads, waterways, utilities, etc. The values for some of the cell input parameters for the model were estimated using the delineated topographic map; values for the other remaining parameters were obtained from a literature search. Following is a brief description of the grid generation, the watershed (global) input parameters, and the local cell input parameters, indicating the sources from which these parameters were obtained.

4.1 AGNPS Grid Development For Watershed

The grid generation for application of the AGNPS model consists of dividing a watershed into a number of square grid cells. The grid profile routines are then applied within each cell, and the water flow and sediment are routed from cell-to-cell to the end of the watershed. The cells are uniformly square areas subdividing the watershed, allowing analysis at any point within the watershed.

The area of the watershed was estimated using the topographic map. The watershed area was found to be 4.92 x 10^8 ft^2 (about 11,277 acres). The watershed map having a scale of 1 in. to 2,795 ft., was then split into cells, each of size 1 in. by 1 in. The total number of cells was 63, with the area of each cell being 7.81 x 10^6 ft^2 (about 179 acres). A number was applied to identify each cell in the watershed. The cells were numbered consecutively, as prescribed by the AGNPS program, beginning at the cell in the northwest corner, and sweeping from the west to the east, and from the north to the south. These numbers were then automatically read by the program. The details of the grid and the Indian Run watershed map are shown in Figure 4 (reduced to fit the page, scale: 1 in. = 0.94 miles).

4.2 AGNPS Watershed (Global) Initial Input Parameters

Watershed Identification:

The watershed identification input is where the user can enter the name of the watershed. This is an optional parameter and is intended to help the user identify the data file. This entry is used on the output reports to identify the watershed.

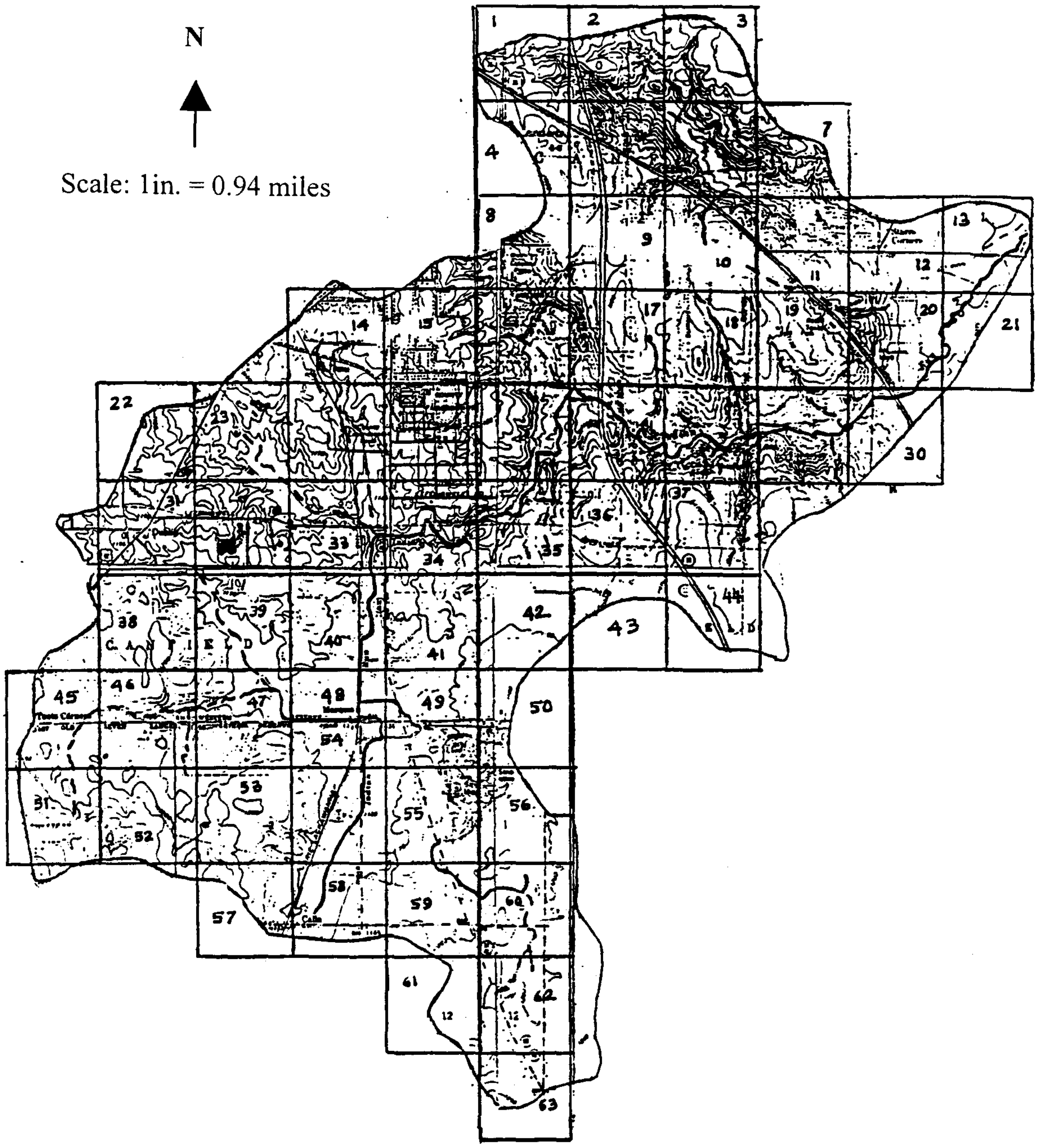


Figure 4. Indian Run Watershed Map with the AGNPS Grid

Area of Each Cell:

The area of each cell is a number representing the base cell size of all the cells in the watershed. As mentioned before, the area of each cell was 179 acres for the application of the AGNPS program. The initial area is required to be in the range from 0.01 to 1000 acres.

Number of Cells:

The number of cells is the total number of base cells in the watershed. The user can enter up to 28,000 cells in a watershed. The total number of cells in the grid used for the Indian Run watershed was 63.

Precipitation:

Precipitation is the amount of rainfall for the storm event. This version of AGNPS is an event-based model, and not a continuous time annualized model. This means that the model must be run for each separate storm event. The lower limit of the input range is 0.01 and there is no upper limit. Simulations were run for events ranging from one to three inches.

Duration:

The duration is the length of the storm in hours. This value is only needed if the Energy-Intensity (EI) value is not known, which was the case in this application. If the EI value is known, duration is set equal to zero.

Energy Intensity (EI) Value:

The energy-intensity value is the rainfall erosion index for the storm event used in the modified USLE. The value of EI for a given rainstorm equals the product of total storm energy (E) and the maximum 30-minute intensity (I_{30}). The units are foot-tons per acre-inch. If the energy-intensity (EI) value is not known, the model will calculate it from the values of the user inputs for the storm duration, storm precipitation and the storm type.

Storm Events:

The storm events simulated are typical for the geographic region where the Indian Run watershed is located and were based on the following scenarios:

A. 3 inch precipitation, 6 hours duration (Energy-Intensity = 91.0) - severe storm

B. 2 inch precipitation, 4 hours duration (Energy-Intensity = 45.0) - strong storm

C. 1 inch precipitation, 1 hour duration (Energy-Intensity = 18.0) - normal storm

D. 1 inch precipitation, 12 hours duration (Energy-Intensity = 6.0) - light storm

Storm Type:

The storm type is a value representing the type of synthetic 24-hour rainfall distribution being simulated. This parameter is used in calculating an EI value if it is not known. The storm type values were developed by the SCS to represent the rainfall intensity distributions throughout the various geographical regions of the United States. Type IA is the least intense and type II the most intense short duration rainfall. Types I and IA represent the Pacific maritime climate with wet winters and dry summers; Type II applies for the rest of the country not represented by the other types; and Type III represents the Gulf of Mexico and the Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts. Type II Storm was selected for the present simulation of the Indian Run watershed.

Peak Flow Calculations:

The AGNPS method assumes a triangular channel and uses the formulations of the CREAMS method for calculation of the peak flow.

Hydrograph Shape Factor:

The hydrograph shape factor is used in the model to calculate the triangular hydrograph. The triangular hydrograph means that there is a different flow rate for each increment in the hydrograph.

4.3 AGNPS Cell (Local) Input Parameters

Cell Number:

The cell number is the main identifier prescribed for each cell in the watershed. The cell numbering must follow the strict sequence prescribed by the AGNPS program.

Receiving Cell Number:

The receiving cell number is the number of the cell into which the most significant portion of the runoff from a cell drains. The receiving cell number for the watershed outlet is required by the model to be greater than the total number of cells in the watershed. Cell number 64 was designated as the receiving cell for the watershed; the watershed outlet cell was number 13.

Flow Direction:

The flow direction is determined by the cell topography and/or channel flow. The flow direction is a single digit in the range of 1 to 8, indicating the principal direction of drainage from the cell. Each value refers to a direction with 1 representing north, and, proceeding clockwise to 8, representing northwest. The flow direction representation scheme is illustrated in Figure 5. For example, in Figure 5, the flow direction of cell 2 is to the west and is designated by the number 7. The flow directions for cells 1 and 3 would both be 5, since the flow path is to the south. Even numbered values only apply when the current cell and the receiving cell touch at a corner. If there is no drainage from the cell (i.e., a sink-hole cell), a value of 0 for the flow direction is to be prescribed as the input.

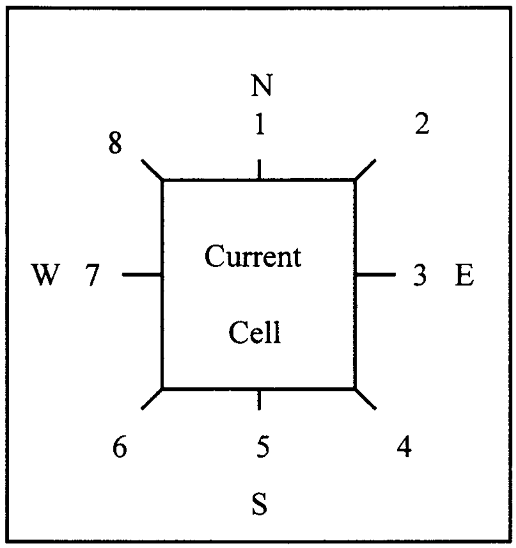


Figure 5. Flow Direction Scheme

SCS Curve Number:

The Soil Conservation Service (SCS) curve number or the hydrologic soil-cover complex number is used in the SCS equation for estimating direct runoff from the storm rainfall. The values for moisture condition type II (average moisture) are listed in Table 3. In situations where more than one land use code existed within the cell, a weighted average value was used. Source of data used to obtain appropriate values included USDA Soil Conservation Service (1976), USDA Soil Conservation Service (1972), and Land Use Data of Mahoning County.

Table 3. Runoff Curve Number for Type II Storms with Antecedent Moisture Condition II

Land Use	**Soil Group**			
	A	B	C	D
Fallow	77	86	91	94
Row Crop-Straight	67	78	85	89
Row Crop-Contoured	65	75	82	86
Small Grain	63	74	82	85
Legumes or rotation meadow	58	72	81	85
Pasture-Poor[1]	68	79	86	89
Pasture-Fair[2]	49	69	79	84
Pasture-Good[3]	39	61	74	80
Permanent Meadow	30	58	71	78
Woodland	36	60	73	79
Forest with heavy litter	25	55	70	77
Farmsteads	59	74	82	86
Urban (21-27%) Impervious	72	79	85	88
Grass Waterway	49	69	79	84
Water	100	100	100	100
Marsh	85	85	85	85
Animal Lot-Unpaved	91	91	91	91
Animal Lot-Paved	94	94	94	94
Roof Area	100	100	100	100

Source: U.S. Dept. of Agricultural, Soil Conservation Service (1976)
[1]Pasture should be considered poor if it is heavily grazed with no mulch.
[2]Fair pasture has between 50-75% plant cover and is moderately grazed.
[3]Good pasture is lightly grazed and has more than 75% plant cover.

Land Slope:

The land slope parameter was calculated as [Elevation change x 100 / Horizontal distance] using the USGS Topographic Map. The value for each cell was entered as a percentage. A typical or average slope was estimated if the cell was irregular. A value of 0 was entered if the cell was predominantly water or marsh.

Slope Shape Factor:

The slope shape factor parameter is an identification number used to indicate the dominant slope shape within the cell. The slope shape factors used by the model are illustrated in Figure 6. The USGS 7.5 Minute Series Topographic Maps were used to determine the shape factor for each cell. The values are prescribed by numerical values of 1 for uniform slope, 2 for convex slope, and 3 for concave slope.

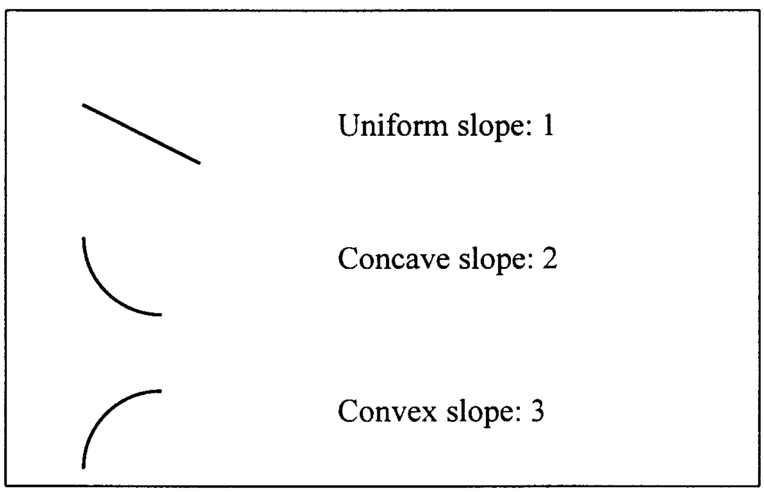


Figure 6. Examples of various slope forms as per AGNPS

Field Slope Length:

The field slope length parameter is defined as the length of the overland portion of the flow, from the top of the slope to the point where the flow becomes concentrated. These values are dependent upon the topography of the cells and in general are rough estimates. Earlier AGNPS simulations studies indicate these values to be nearly the same for most cells other than for cells which are predominantly water or marsh (for such cells the code prescribes a value of 0). The model does not permit this length to exceed more than 300 feet. Further, it is noted that the code is not very sensitive to the choice of this parameter. In the present simulation study, the choice of this parameter was based on the overall topography of the cells as available from the USGS 7.5 Minute Series Topographic Maps, and making an average estimate. A value of 100 ft. was used for most cells.

Overland Manning's Coefficient:

The overland Manning's coefficient is the roughness coefficient for the predominant surface condition within the cell at the time of the storm. These values are listed in Table 5. Sources used to estimate this parameter for each cell include Foster *et al.* [1981], Land Use Data of Mahoning County [EDTA, 1997], and USDA Soil Conservation Service (1971) Soil Survey: Mahoning County, Ohio.

Table 4. Overland Manning's Coefficients [Foster *et al*, 1981]

Overland Cover and Cover Density	Overland Manning's Coefficient
Smooth Bare Soil less than 1 inch deep	0.030
Smooth Bare Soil, 1 - 2 inches deep	0.033
Smooth Bare Soil, 2 – 4 inches deep	0.038
Smooth Bare Soil, 4 – 6 inches deep	0.045
Grass, sparse	0.040
Grass, poor	0.050
Grass, fair	0.060
Grass, good	0.080
Grass, excellent	0.130
Grass, dense	0.200
Grass, very dense	0.300
Water or Marsh	0.990

K-Factor (Soil Erodibility Factor):

The *K*-factor is the soil erodibility factor that is used in the modified Universal Soil Loss Equation. The soil erodibility factor varies with the chemistry of soil in each cell. If the cells were predominantly water or marsh, then a value of 0 is to be assigned. Sources of these input parameters were the USDA Soil Conservation Service (1971) Soil Survey: Mahoning County, Ohio, and USDA Agricultural Handbook number 537 [Wischmeier and Smith, 1978]. Different types of soils were identified for the watershed based on the available soil surveys and the K-values were accordingly chosen. Typical K-values in the present simulation ranged from 0 to 0.48.

C-Factor (Cropping Management Factor):

The *C*-factor is the cropping management factor used in the modified Universal Soil Loss equation. This parameter depends on cover, crop sequence, and management practices. If the cells were predominantly water or marsh, then a value of 0 is to be entered. If the cells were mostly urban or residential, a value of 0.01 was entered. Sources of these input parameters were the USGS 7.5 Minute Series Topographic Maps, the USDA Agricultural Handbook number 537 [Wischmeier and Smith, 1978], Land Use Data of Mahoning County [EDTA, 1997]. The estimated C-Factor values were based on land use in the watershed region and these values range from 0.01 to 0.6.

P-Factor (Conservation Practice Factor):

The *P*-factor is the conservation practice factor or the support practice parameter used in the modified Universal Soil Loss equation. If the cells were predominantly water or marsh, then a value of 0 is to be entered. If the cell were mostly urban or residential, a value of 1.0 is to be chosen. The USGS 7.5 Minute Series Topographic Maps and the

USDA Agricultural Handbook number 537, *Predicting Rainfall Erosion Losses* [Wischmeier and Smith, 1978] were used for obtaining the estimates of this parameter. The P-factor values in the present study ranged from 0 to 0.6.

Surface Condition Constant:

The surface condition constant is a value based on land use at the time of the storm to make adjustments for overland flow velocity. Typical values are shown in Table 6. Source of these data were derived from the Land Use Data for Mahoning County [EDTA, 1997], and the USGS 7.5 Minute Series Topographic Maps. Once the type of land use was determined, Table 6 was accordingly used to estimate the values of this parameter.

Table 5. Surface Condition Constants [Young *et al*, 1994]

Land Use	Surface Condition Constant
Fallow	0.22
Row Crop-Straight	0.05
Row Crop-Contoured	0.29
Small Grain	0.29
Legumes or rotation meadow	0.01
Pasture-Poor	0.15
Pasture-Fair	0.22
Permanent Meadow	0.59
Woodland	0.29
Forest with heavy litter	0.59
Farmsteads	0.01
Urban (21-27%) Impervious	0.01
Grass Waterway	0.00
Water	0.00
Marsh	0.00
Animal Lot-Unpaved	0.00
Animal Lot-Paved	0.00
Roof Area	0.00

Soil Texture:

The soil texture input is the major soil texture classification for the cell. The AGNPS program prescribe the values of 0, 1, 2, 3, or 4, respectively, for water, sand, silt, clay and peat. The soil texture indicator values are as shown in Table 6. These data were determined from USDA Soil Conservation Service (1971) Soil Survey: Mahoning County, Ohio, and using Table 6.

Table 6. Soil Texture Input Parameters [Young *et al*, 1994]

Soil Texture	Soil Type Input Parameter
Water	0
Sand	1
Silt	2
Clay	3
Pete	4

Chemical Parameters:

Since the simulation of chemical transport was not an objective of this project, these parameters were not prescribed, i.e., they retained their default values.

This completes a brief review of specifications and sources of the input parameters for execution of the single-event AGNPS simulation of the Indian Run watershed. A complete listing of the input parameters is presented in Table A-1.

CHAPTER 5

RESULTS & DISCUSSION

5.1 Presentation of Results

The AGNPS simulations of the Indian Run watershed were performed for four storm events: Storm A (3 inch precipitation, 6 hours duration), Storm B (2 inch precipitation, 4 hours duration), Storm C (1 inch precipitation, 1 hour duration), and Storm D (1 inch precipitation, 12 hours duration). The cell input parameters for these simulations are presented in Appendix, Table A-1. The detailed tabular outputs of the simulations for these four storm events are presented in Appendix, Tables A-2 through A-17; these include hydrology, erosion, sediment generation/transport, nutrient transport, and chemical oxygen demand. The cell erosion rate of the cells for Storm A, Storm B, Storm C, and Storm D are presented, respectively, in Figs. 7 - 10. The dependence of erosion on the storm Energy-Intensity (EI) is presented in Fig. 11 (bottom). The sediment yield of the cells for these storm events are presented, respectively, in Figs. 12 - 15. Also, the dependence of sediment yield on the storm Energy-Intensity (EI) is presented in Fig. 11 (top). In order to study the effect of cell parameter changes on sediment analysis and runoff, some runs were simulated with different sets of values of P-Factor, C-Factor, and K-Factor for only one event, Storm C. The detailed outputs of these simulations are available, but these are not included in this report. Only the key results are shown in Figs. 16 - 18. Finally, some simulations of Storm A were run for the case when the P-, C-, and K-Factors are changed for only those cells (five in all) which are noted to be primarily responsible for runoff and sediment generation and yield problems. This is to help management focus control actions

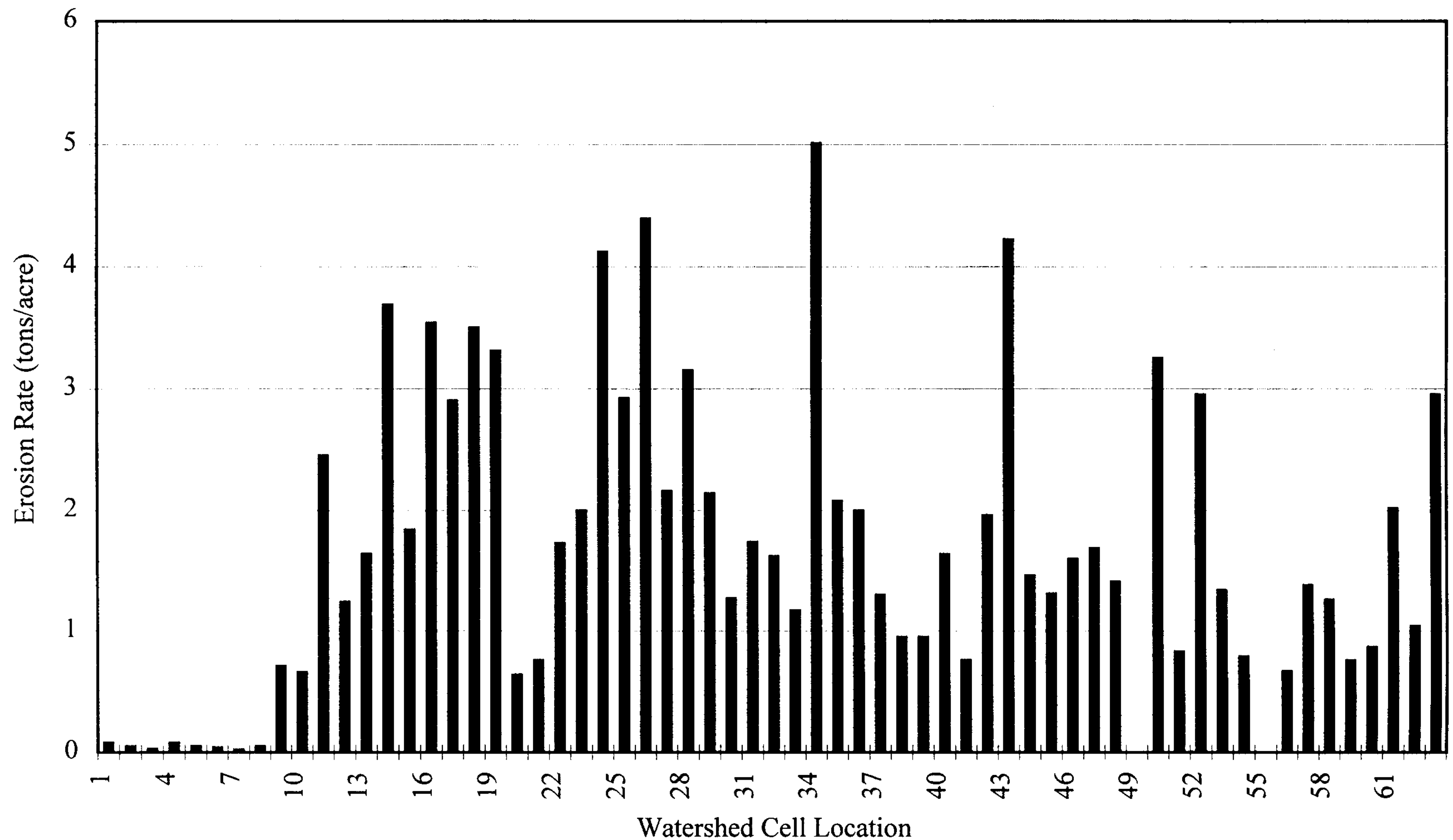


Figure 7. Watershed Erosion Rate for Storm A (3 in. precipitation, 6 hr. duration)

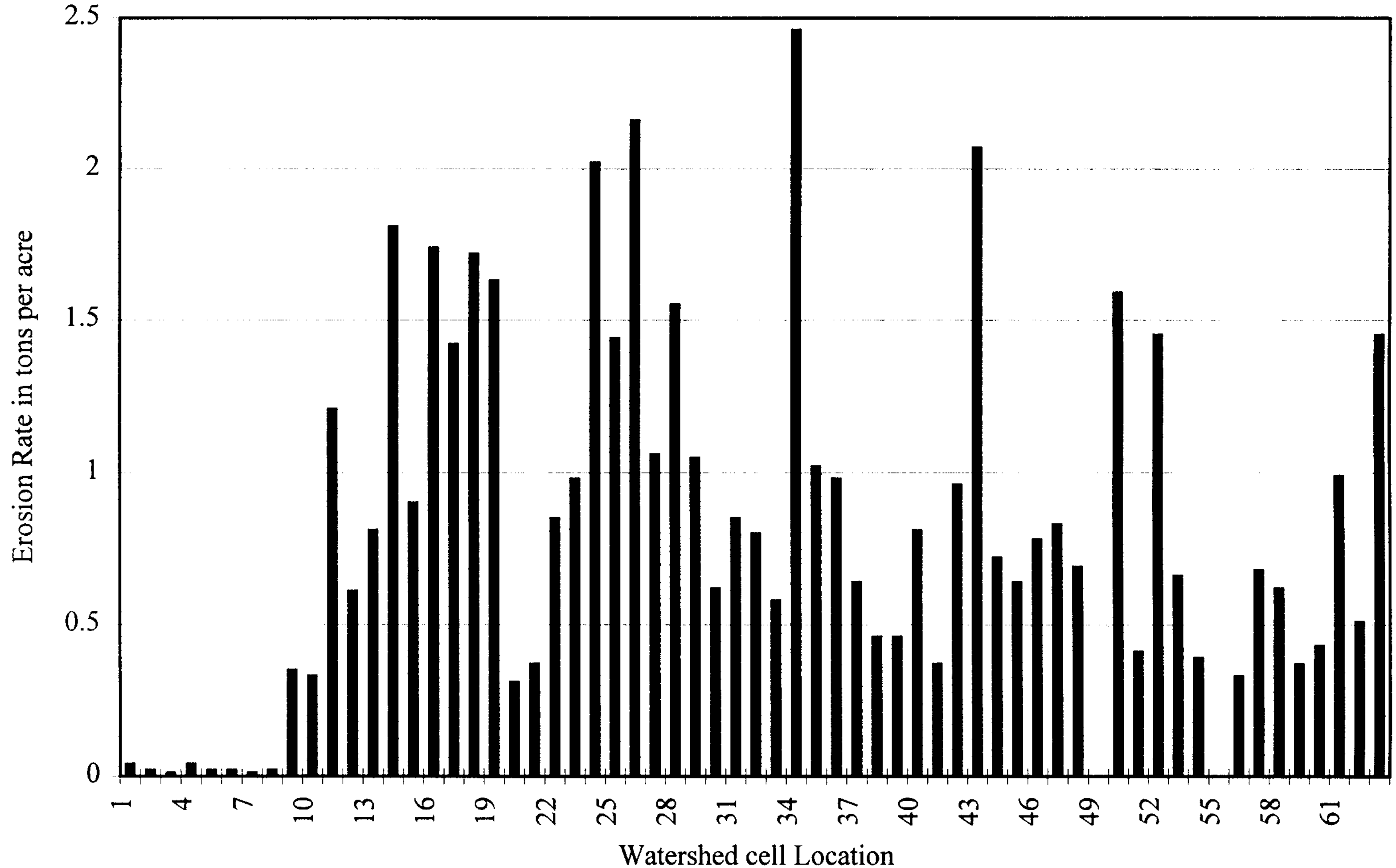


Figure 8. Watershed Erosion Rate for Storm B (2 in. precipitation, 4 hr. duration)

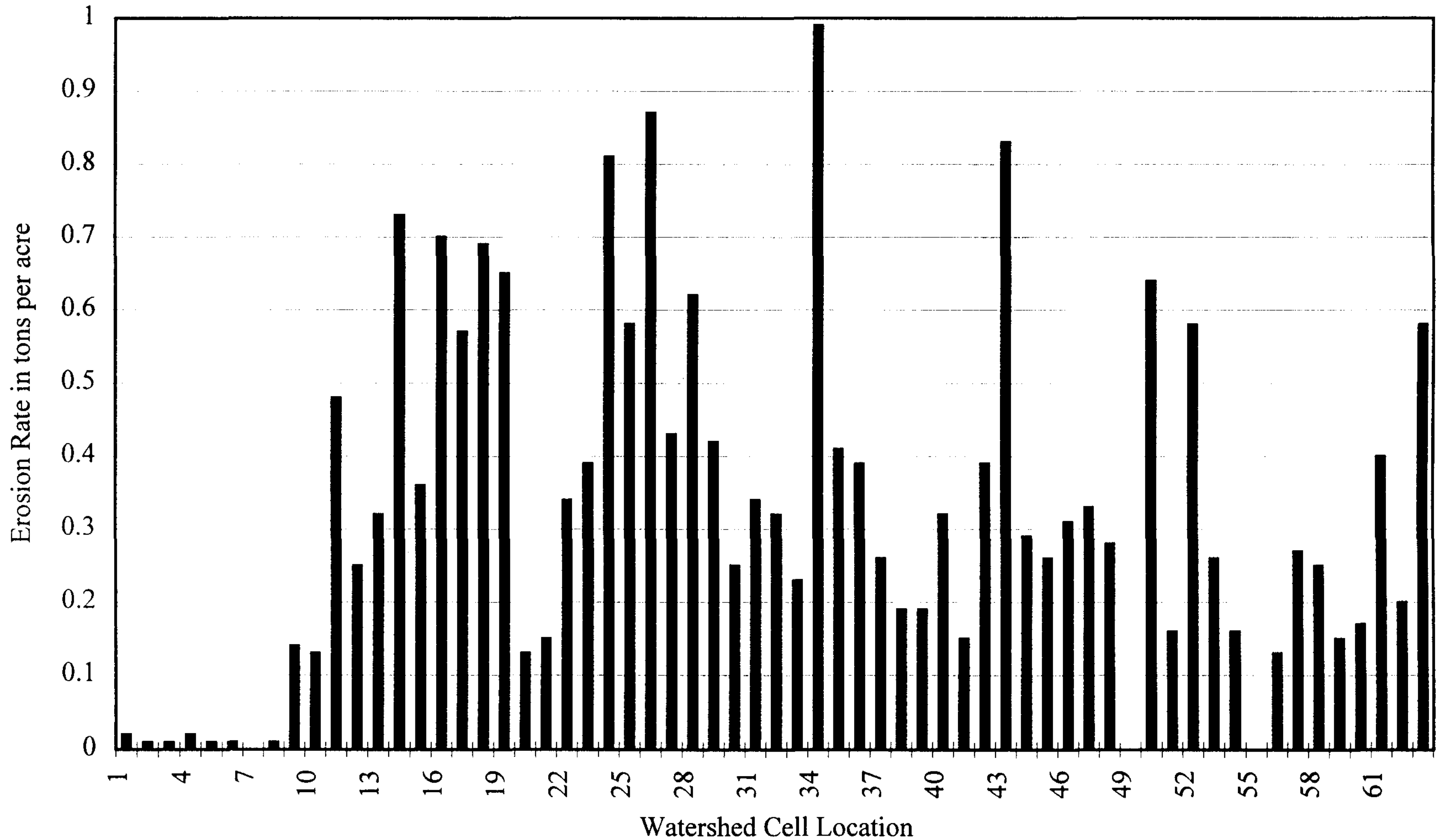


Figure 9. Watershed Erosion Rate for Storm C (1 in. precipitation, 1 hr. duration)

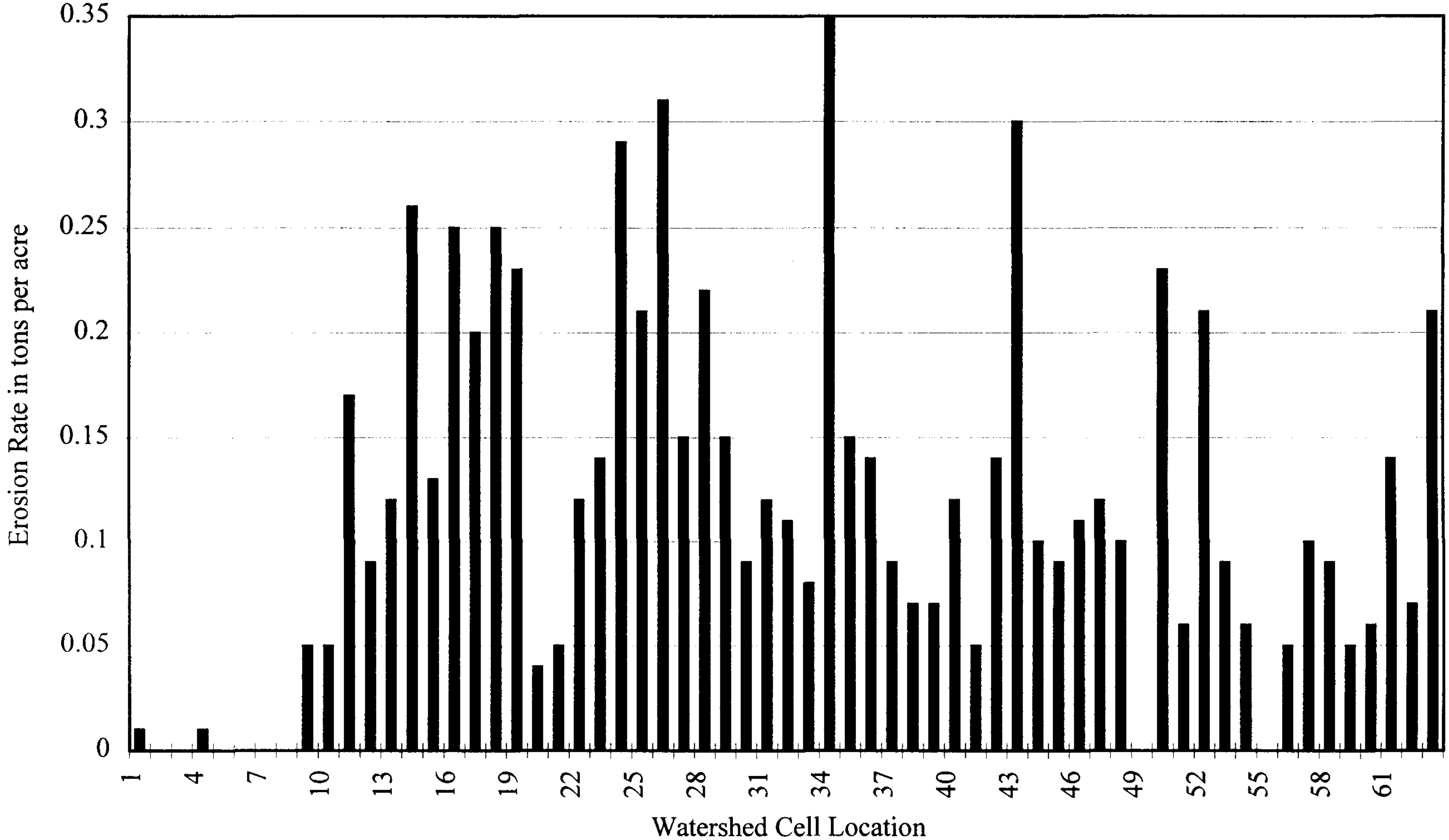


Figure 10. Watershed Erosion Rate for Storm D (1 in. precipitation, 12 hr. duration)

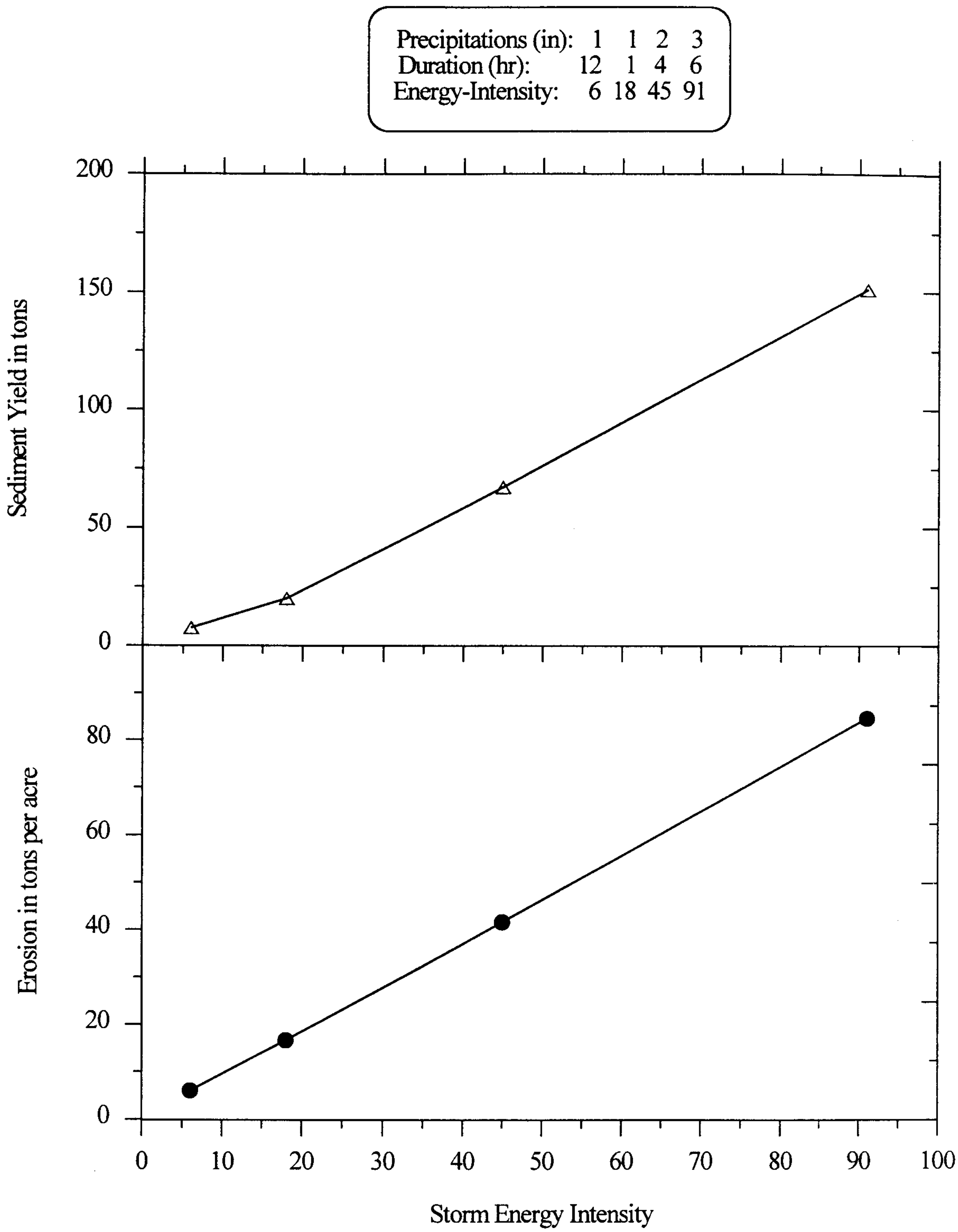


Figure 11. Erosion and Yield Dependence on Storm Energy Intensity

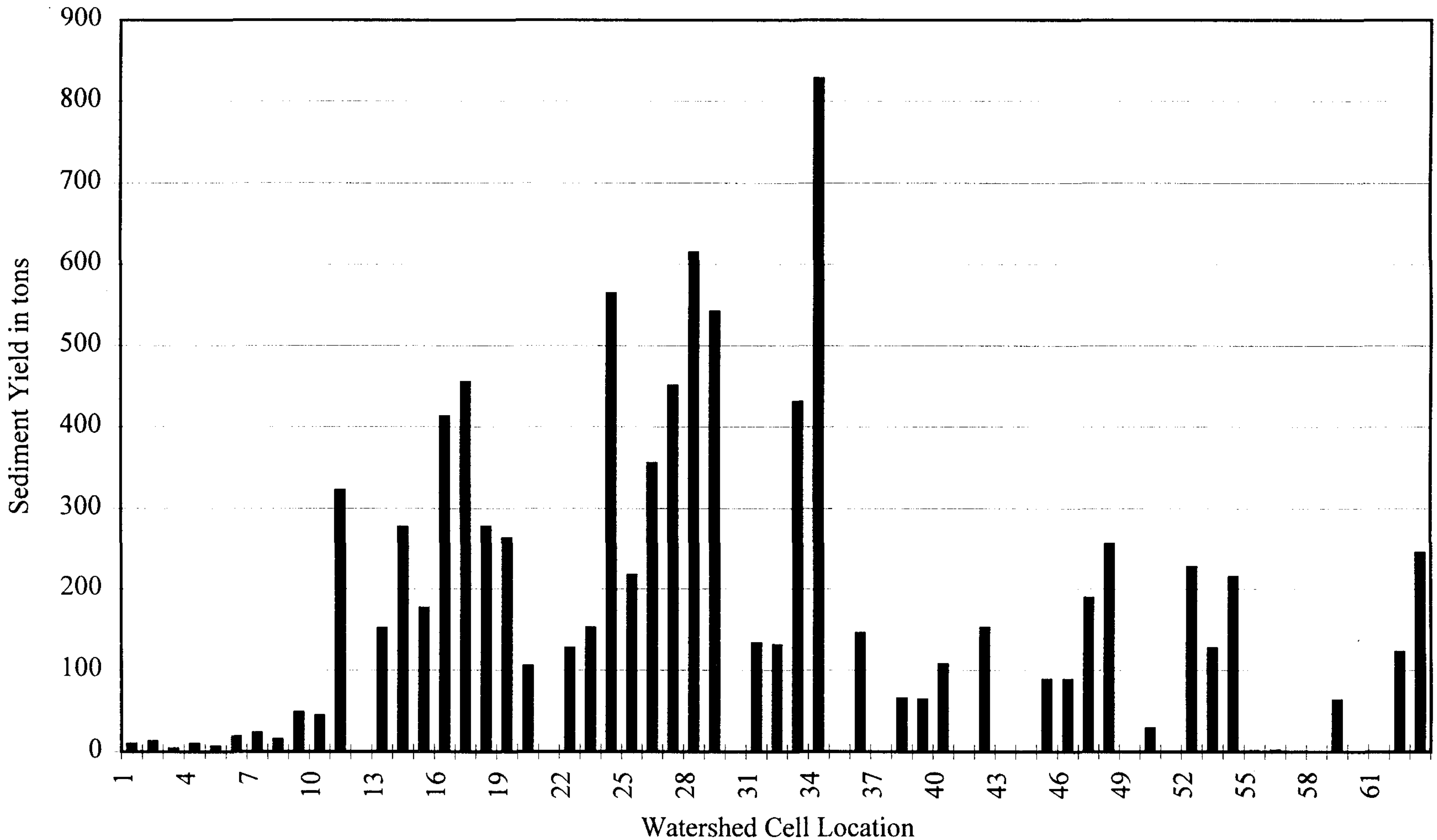


Figure 12. Watershed Sediment Yield for Storm A (3 in precipitation, 6 hr. duration)

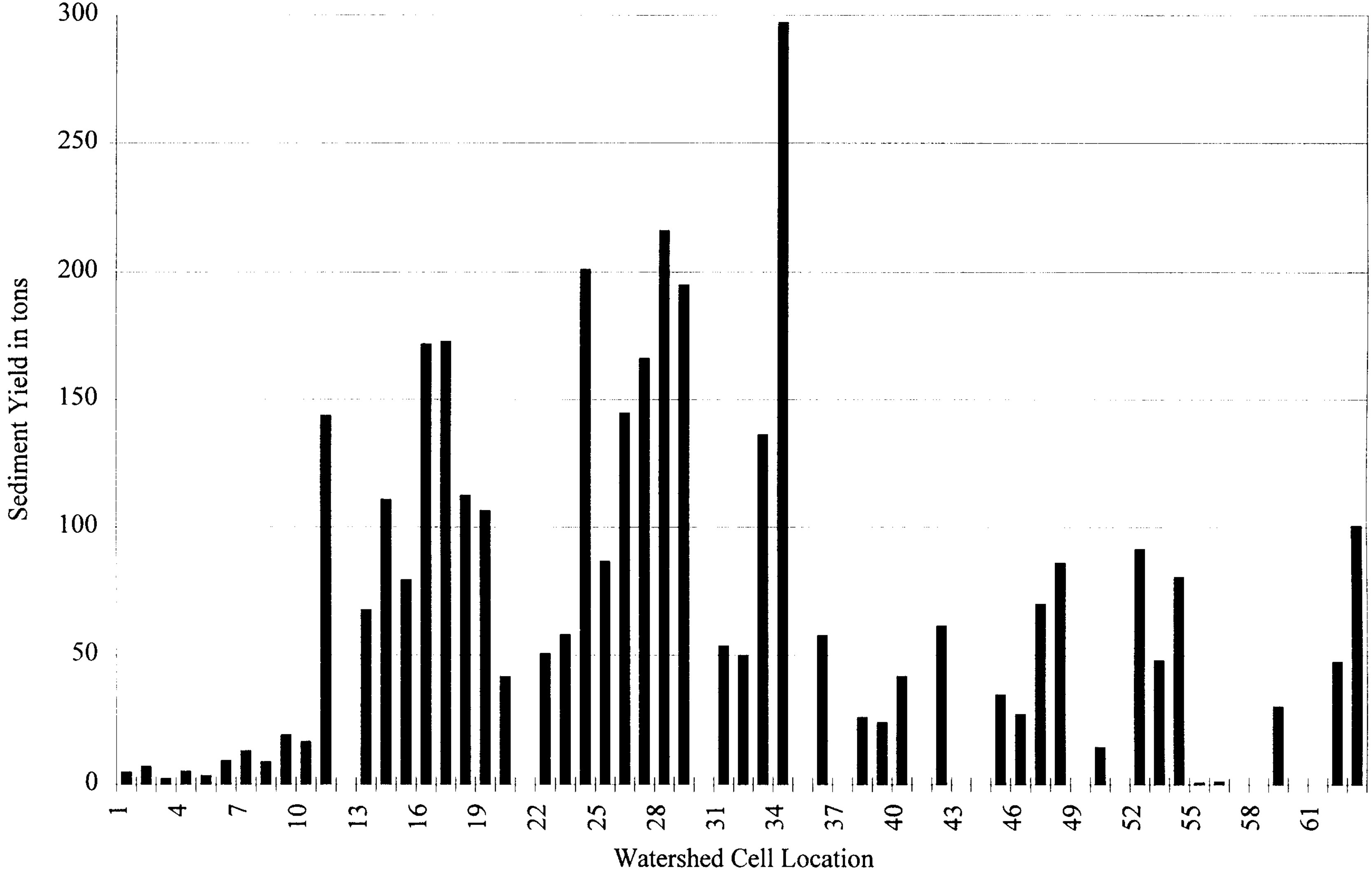


Figure 13. Watershed Sediment Yield for Storm B (2 in precipitation, 4 hr. duration)

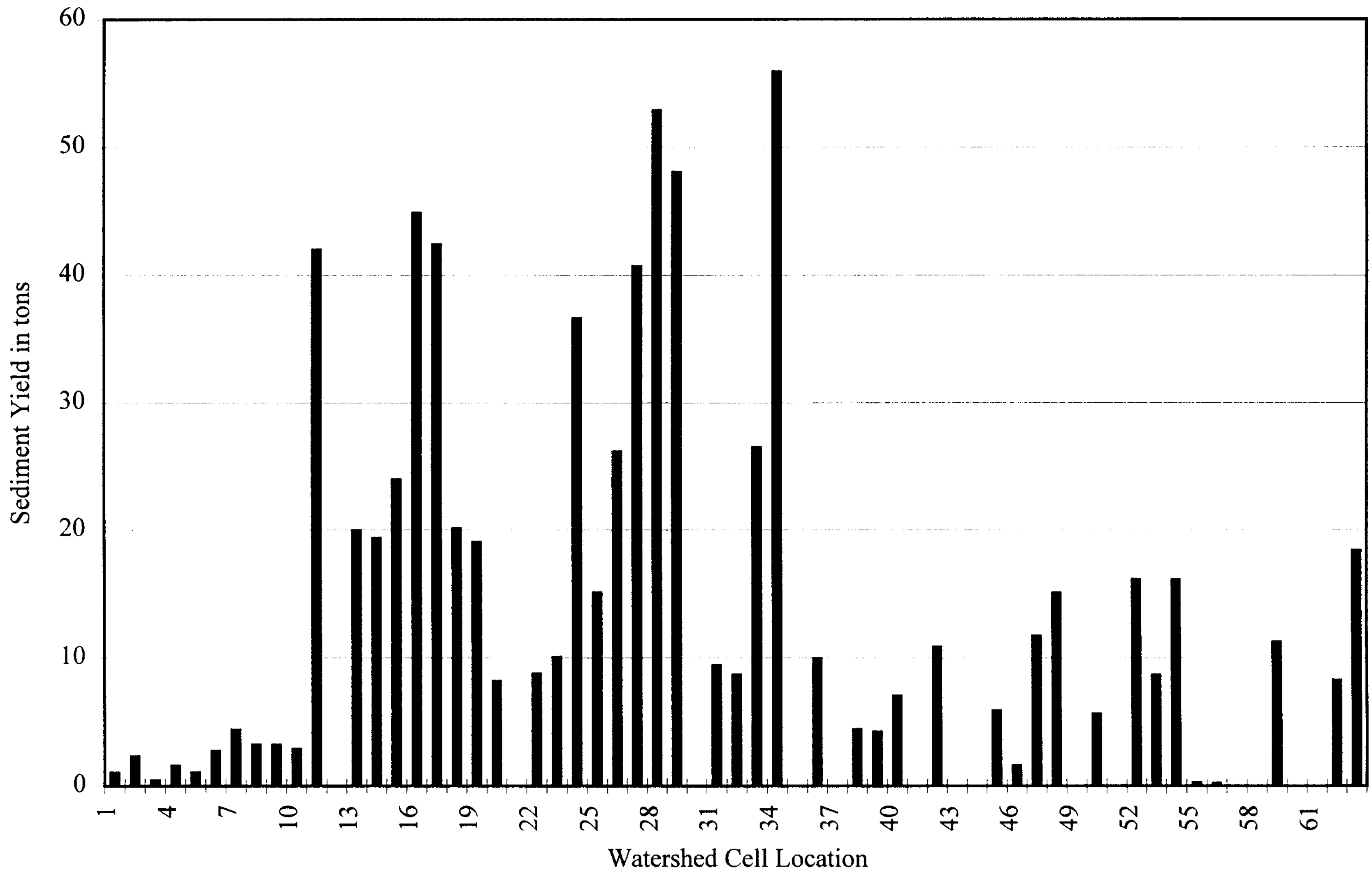


Figure 14. Watershed Sediment Yield for Storm C (1 in. precipitation, 1 hr. duration)

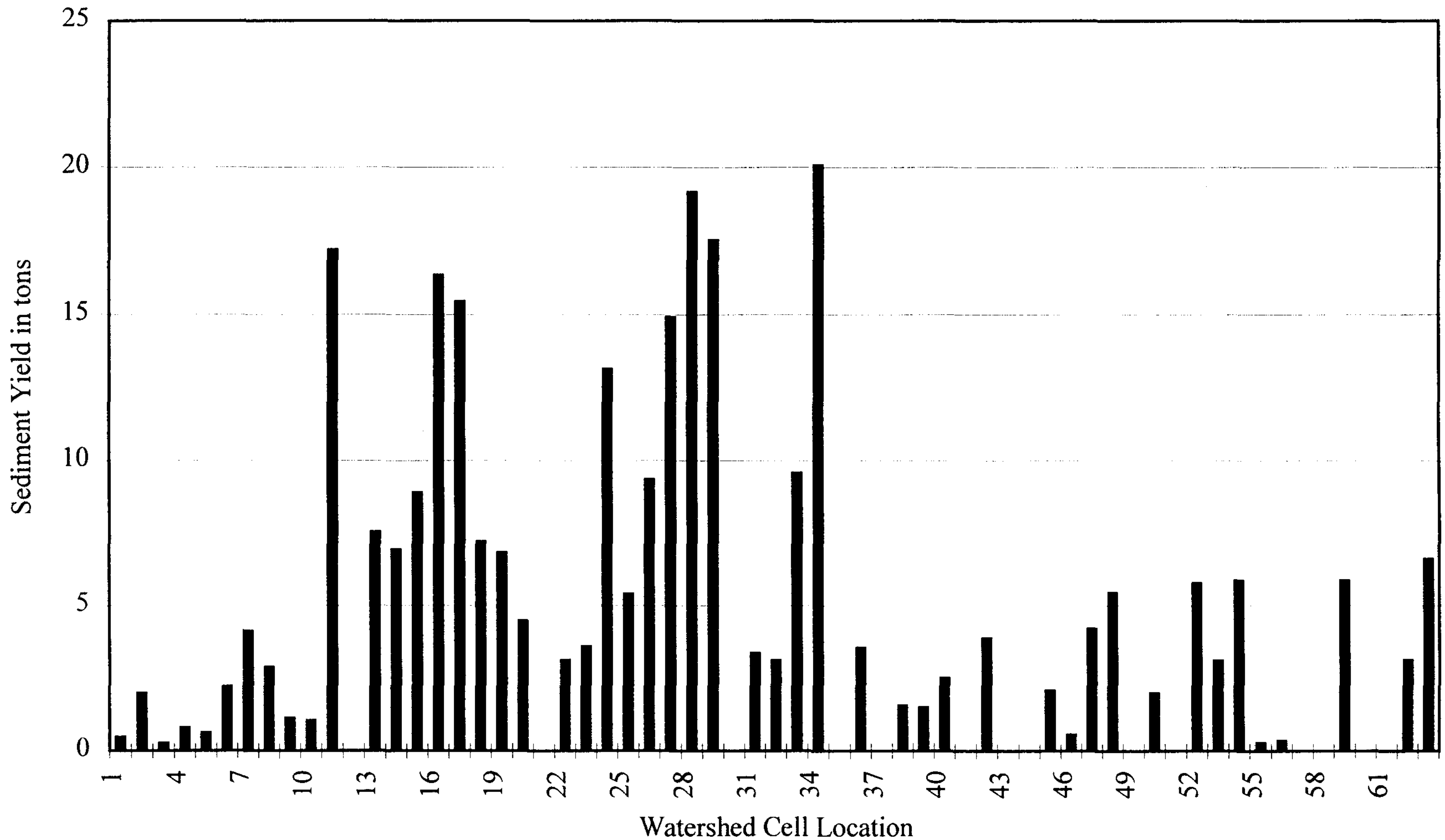


Figure 15. Watershed Sediment Yield for Storm D (1 in precipitation, 12 hr duration)

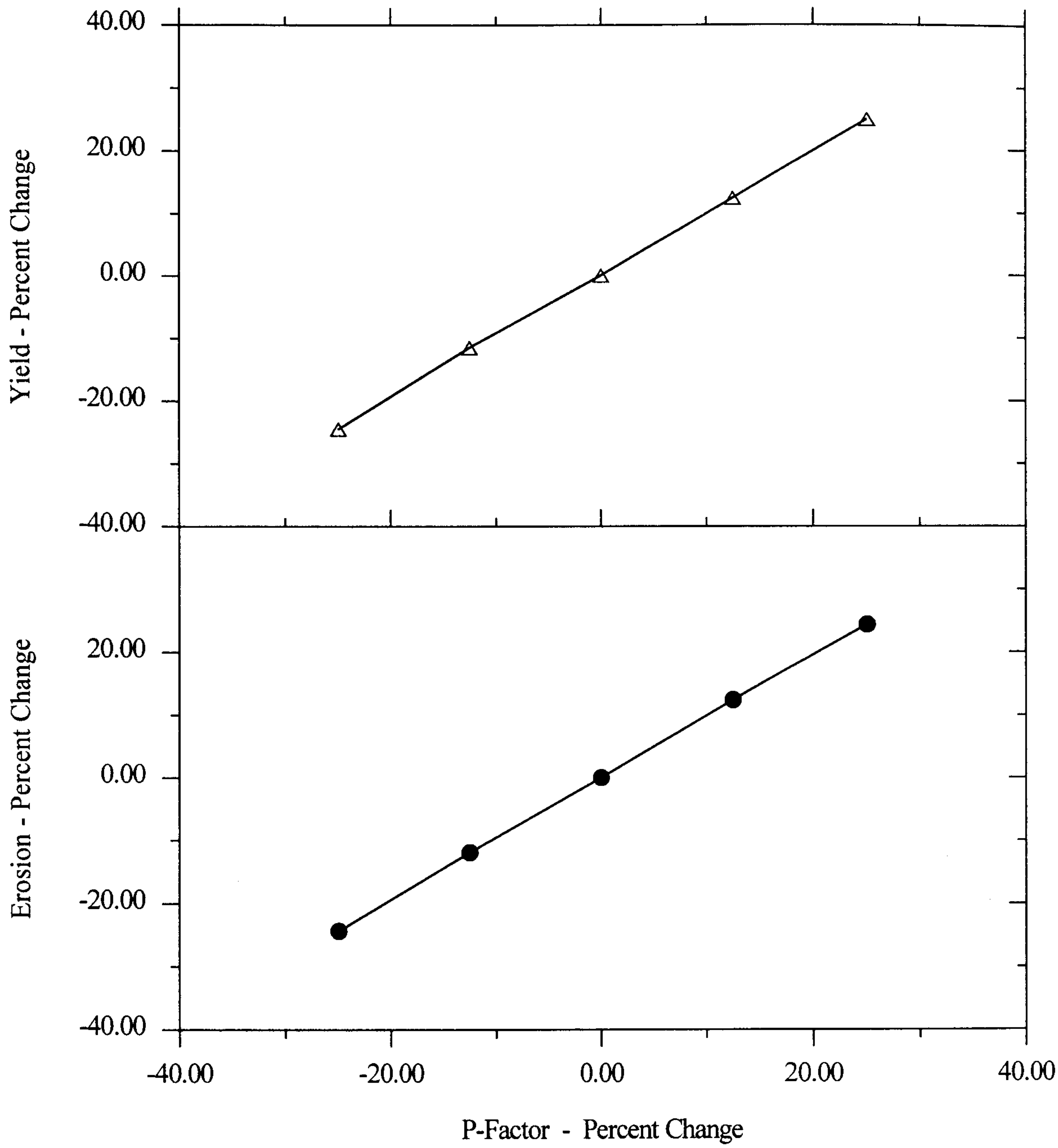


Figure 16. Sediment Sensitivity to P-Factor Variation (Storm C: 1 in, 1 hr)

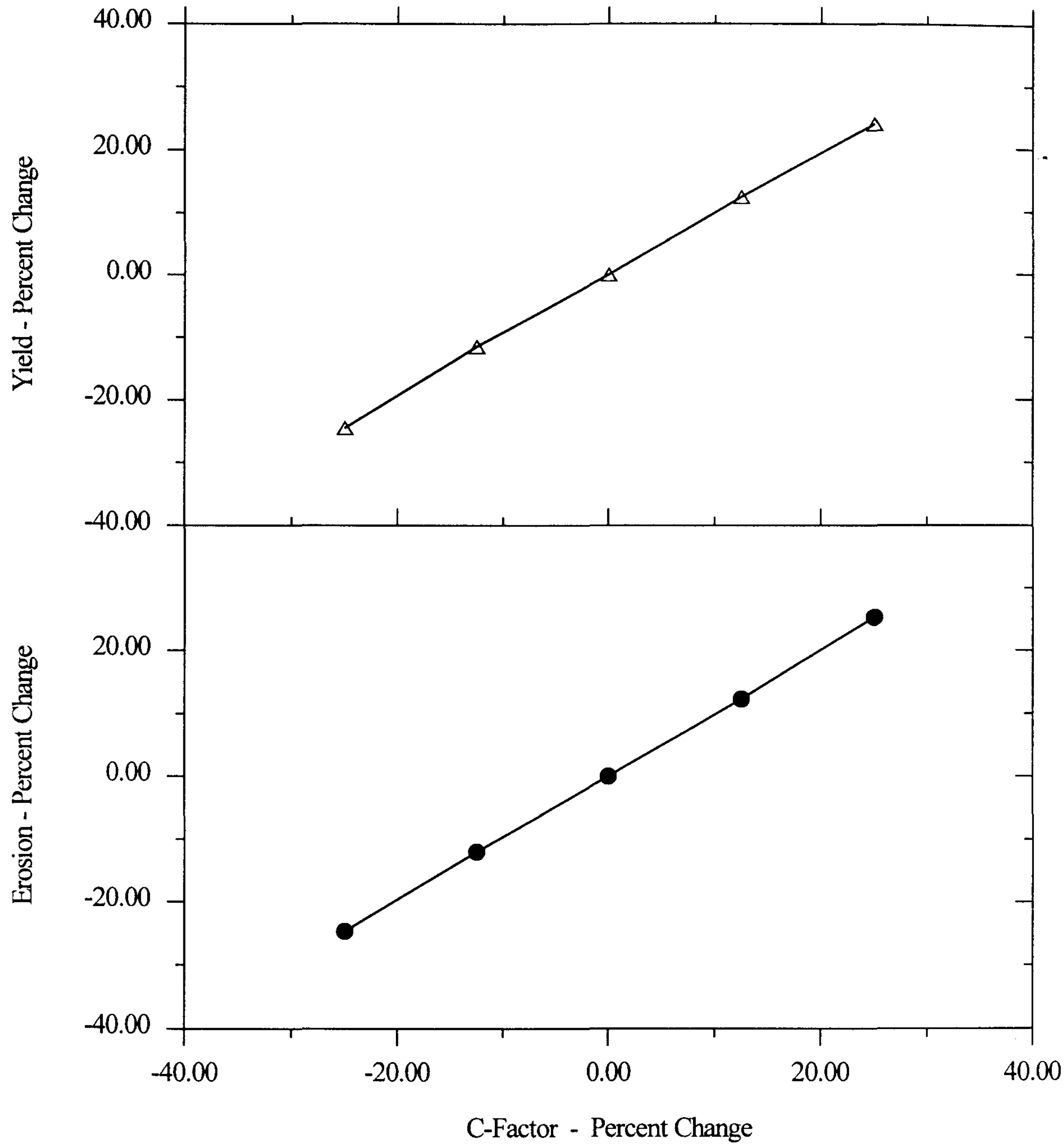


Figure 17. Sediment Sensitivity to C-Factor Variation (1 hour Storm, 1 in. Precipitation)

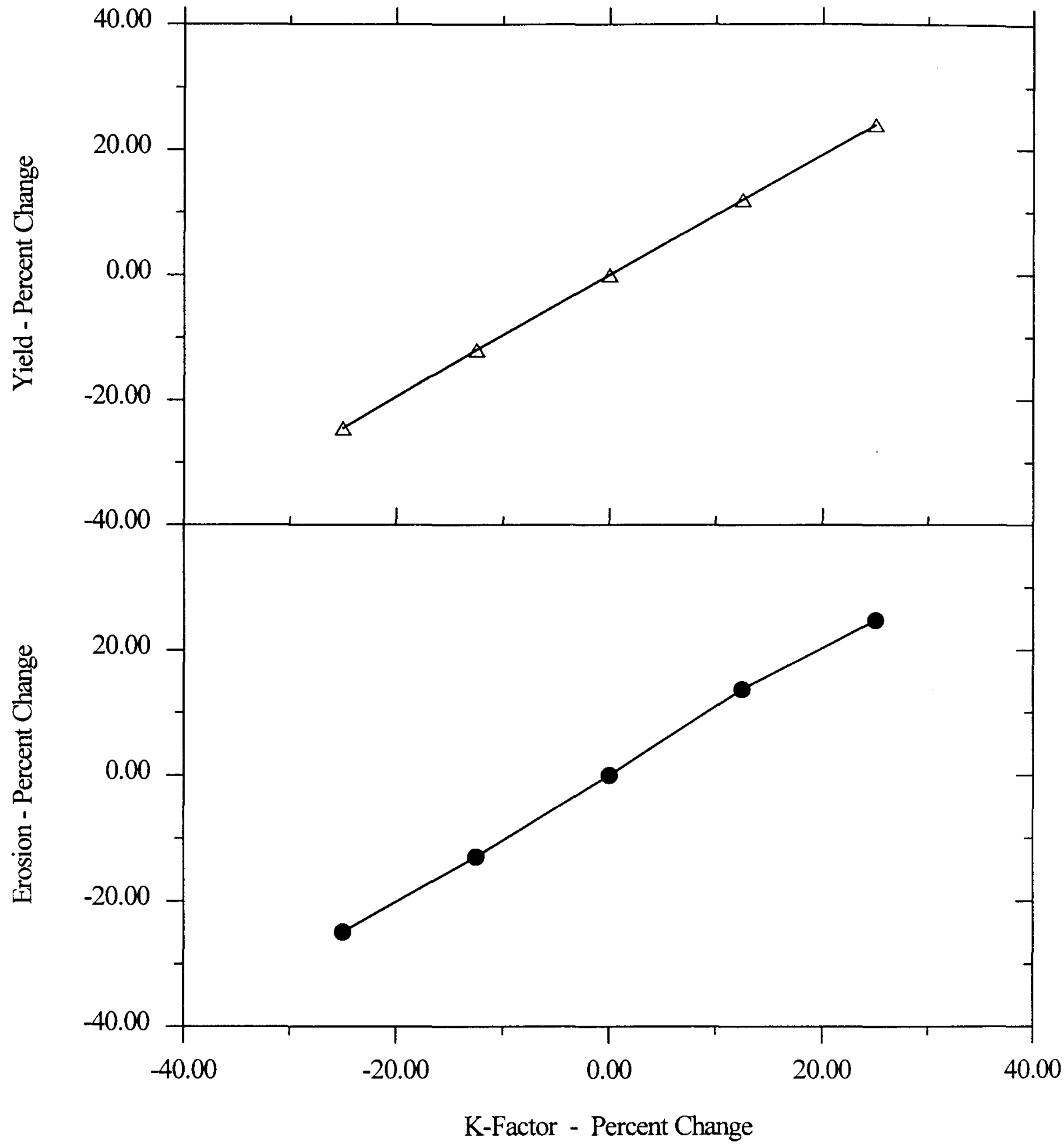


Figure 18. Sediment Sensitivity to K-Factor Variation (1 hour Storm, 1 in. Precipitation)

on areas contributing most to the problems. It should be noted that the emphasis of the present study is on runoff and sediment generation and yield; the chemical transport parameters are, therefore, allowed to take their default values.

5.2 Discussion

The AGNPS model simulation is on a single event basis. In order to apply the simulations on an annual basis, one needs a combination of storm events which characterize the precipitation of the watershed region over a year. The National Weather Service data indicate that the watershed region receives, in general, a precipitation of 40-41 inches per year. In view of the typical prevailing weather pattern, a reasonable precipitation scenario for this watershed could consist of 2 events of Storm A, 7 events of Storm B, 10 events of Storm C, and 10 events of Storm D, which total up to a precipitation of 40 inches for the year. In discussions that follow, both predictions for individual events, and yearly predictions for the watershed based on this combination of storm events, are evaluated.

First, the issue of validation of the AGNPS simulation for the Indian Run watershed is examined. This is followed, in order, by the discussions of soil erosion, sediment generation, sediment yield, and sensitivity analysis. Finally, the amount and distribution of soil erosion and sediment yields across the Indian Run watershed are examined to identify the cells (areas) of primary concern for management control actions.

5.3 Validation of the AGNPS Simulations

It should be noted that the AGNPS simulation of the Indian Run watershed, like any water quality modeling, is plagued by uncertainties regarding the inputs related to soil structure, cell shape and slope, storm characteristics, K-Factor, C-Factor, P-Factor, and other parameters. Also, the field measurements have their own uncertainties and limitations of resources - only limited measurements could be performed and only on certain days of the year. The comparisons of simulation results with the available measurements are, thus, only a preliminary test of the model.

Measurements of hydrology and sediment analysis data have been reported by MRB-HER [MRB-HER, 1994]; these measurements were done on sixteen dates scattered over a period of nine months from December 1993 to August 1994. The AGNPS predictions are compared with the reported data from this study, some of which are reproduced in Table 7. Also, an assessment is made as to how this simulation compares with other AGNPS simulations reported in the literature.

5.3.1 Suspended Solids

The experimental study of MRB-HER [MRB-HER, 1994] estimated an average suspended solid loading of 2991 kg/d or 1200 tons/year from Indian Run to Mill Creek. Based on the annual distribution of storm events selected for the watershed (equivalent to 40 in. of precipitation), as stated before, the AGNPS simulation predicts a sediment yield of [(2 events x 151.02 tons) + (7 events x 67.26 tons) + (10 events x 19.97 tons) + (10 events x 7.55 tons)] which totals 1050 tons per year (see sediment yield values for the outlet Cell 13 in Appendix, Tables A-2, A-6, A-10, and A-14). The agreement of the

Table 7. MRB-HER Field Measurements on Indian Run @ Rt. 224 [MRB-HER, 1994]

Date	Flow (cfs)	SS Conc.(mg/L)	SS Flux (kg/day)
2/1/94	166	12.8	5190
2/19/94	176	42	18100
3/11/94	48.8	6.6	788
3/22/94	766	71	13300
3/31/94	19.3	5.6	264
4/8/94	45.9	13.2	1483
4/15/94	29.5	29.2	2104
4/30/94	3.33	8.4	68.5
5/8/94	5.48	3.4	45.6
6/19/94	0.71	21.6	37.5
6/26/94	0.91	22.6	50.3
7/3/94	2.18	19.6	104.8
7/8/94	13.7	83.6	2800
8/1/94	0.82	24.8	49.5
8/7/94	3.61	12	106
8/18/94	4.15	20.4	207
Mean	80.4	24.8	10280
Std. Deviation	191	22.9	33000
Number	16	16	16

prediction with the measurement is thus excellent. An error of 12.7 % (underestimate) validates the applicability of the AGNPS simulation for the Indian Run watershed study.

5.3.2 Flow Rates

The experimental estimate of the mean flow rate of the Indian Run at Rt. 224 (the outlet Cell 13 for the present study) was reported to be 80.4 cfs, the range of data being 0.705 cfs to 766 cfs, with a standard deviation of 191. This experimental estimate, an arithmetic mean of sixteen measurements over a span of eight months, was believed by MRB-HER to be on the high side [MRB-HER, 1994]. Based on the annual distribution of storm events for the watershed, the AGNPS simulation estimates a mean peak flow rate of, [(2 events x 215 cfs) + (7 events x 115 cfs) + (10 events x 29 cfs) + (10 events x 29 cfs)]÷ 29 events, which equals 62.6 cfs (see flow rate values for Cell 13 in Appendix, Tables A-2, A-6, A-10, and A-14). Since MRB-HER believed their mean experimental estimate of 80.4 cfs to be on the high side, the predicted flow rate compares well with the measurements.

It is interesting to compare MRB-HER's flow rate data with the predictions on a selective basis. The measurements indicate very large flow rates during the two month period of February to March of 1994. Considering only this two month period, the measured mean flow rate comes to about 178 cfs. Assuming three months of dry summer and an yearly precipitation of 40 inches, a reasonable estimate for the precipitation during this period is about one-third of 40 inches, i.e., about 13 inches. This may be reasonably represented by a distribution of storm events consisting of 3 events of Storm A (a relatively rare event, but snowmelt can contribute several inches of precipitation in one day) and 2 events of Storm B. This results in a mean peak flow rate prediction of 175 cfs. This further validates the AGNPS simulation of the Indian Run watershed.

5.3.3 Comparison with Other Simulations

Young and his associates reported an assessment of AGNPS simulation studies for a large number of watersheds located in twenty states of the north-central United States [Young *et al*, 1989]. They performed a statistical analysis showing flow estimates to be 98.4% of the observed values, which has a coefficient of determination r^2 of 0.81. However, the data scatter showed significant variations for many of the reported studies; this is understandable for reasons stated earlier in regard to the nature of water quality modeling and field measurements. Favorable comparisons were noted for sediment yield also. The agreement between predictions from the present study and MRB-HER measurements is comparable to the results reported by Young and associates. The latter showed better agreement between AGNPS predictions and field measurements on average, but not necessarily on a case-by-case basis. It may, therefore, be concluded that the present simulation of the watershed is reasonably dependable.

5.4 Runoff

The AGNPS simulations of the Indian Run watershed predict runoff volumes (inches) of 1.6, 0.8, 0.2, and 0.2 for Storm A, Storm B, Storm C, and Storm D, respectively (see Appendix, Tables A-2, A-6, A8, and A-12). Assuming an annual distribution of storm events as stated before, yearly runoff for the watershed is estimated to be [2 events x 1.6 inches of runoff + 7 events x 0.8 inches of runoff + 10 events x 0.2 inches of runoff + 10 events x 0.2 inches] of runoff, which equals 12.8 inches. For this value of yearly runoff, one obtains an yearly mean flow of 16.64 cfs for the watershed which is equivalent to 0.944 cfs per square miles of the area of the Indian Run watershed.

The MRB-HER reports a field study conducted by the USGS on Mill Creek from the year 1943 to 1971 [MRB-HER, 1994]. The USGS maintained a gauging station on Mill Creek which was located one mile below the Lake Newport dam, or about 600 ft upstream from the suspension bridge in the Mill Creek park. The USGS reported a mean flow rate of 63.2 cfs monitored over a period of seventeen years. Based on the USGS data, the MRB-HER estimates an yearly mean flow rate of 0.924 cfs per square mile of the watershed, or yearly runoff of 12.5 inches from the entire Mill Creek watershed. Noting that (i) the Indian Run watershed (area of 17.9 sq. miles) is only a geographical part of the Mill Creek watershed (area of 68.4 sq. miles as per USGS estimate), and (ii) the Indian Run is one of the three major tributaries of the Mill Creek, one would expect about the same yearly mean flow rate (cfs per square miles) for both watersheds. The USGS reported yearly mean flow rate of 0.924 cfs per square miles for the Mill Creek watershed is almost the same as the AGNPS prediction of 0.944 cfs per square miles for the Indian Run watershed. This again supports the reliability of the present AGNPS simulation of the Indian Run watershed.

5.5 Erosion

Sediment load in an area is controlled either by the transport capacity of the runoff and rainfall or by the amount of detached soil material available for transport. When the amount of detached material exceeds the transport capacity, deposition occurs. The steepness of the land slope greatly affects the rate of soil erosion by water. The relation of slope to soil loss is believed to be influenced by interactions with soil properties and surface conditions, but the interaction effects have not been quantified by research data. Soil loss is also affected if the shape of a slope steepens toward the lower end (convex slope) or flattens toward the lower end (concave slope). The AGNPS program specifies sediment generated within a cell in tons/acre as erosion rate, i.e., the sediment generated equals the product of cell area and the erosion rate.

The tolerance of soil loss ranging from 2 to 4 tons/acre per year was derived by hydrologists, soil scientists, agronomists, geologists, soil conservationists, and Federal and State governments for the soils of the United States in 1961 and 1962 [Wischmeier & Smith, 1978]. A value of erosion rate in this range is unacceptable. These limits were established primarily for water quality control and are still valid estimates. When the predicted losses are compared with given soil loss tolerances, they then can provide specific guidelines for effecting erosion control within specified limits.

The simulation predicts the yearly erosion rate for the watershed to be on the order of 13.4 tons/acre (2 events x 1.651 tons/acre average erosion rate for Storm A + 7 events x 0.811 tons/acre average erosion rate for Storm B + 10 events x 0.326 tons/acre average erosion rate for Storm C + 10 events x 0.116 tons/acre average erosion rate for Storm D). This is based on a storm distribution over the year as stated before. The watershed erosion is extremely high. Therefore, one needs to analyze the erosion rate on a cell-by-cell basis to locate the major sources of erosion inside the watershed.

The erosion rate of the cells for Storm A are presented in Figure 7. The erosion rate (tons/acre) for Cell 24, Cell 26, Cell 34, and Cell 43 are, respectively, 4.12, 4.39, 5.01, and 4.22 (see Appendix, Table A-4). These cells are identified as critical areas as their erosion rates far exceeds the acceptable limits of the soil loss tolerance. The land use data in Cell 24 indicate primarily farm areas and residential development. The soil loss from the adjacent Cell 14, which is relatively a flat area, also gets transported and deposited into Cell 24, further adding to the erosion rate. These cells (24, 26, 34, and 43) have high slopes, and also the slopes are convex in nature, which is known to lead to high erosion rates. The erosion values for clay, silt, small aggregates, large aggregates, and sand in these critical cells are all noted to be relatively high. For example, in Cell 24, these values in tons/acre are, respectively, 0.21, 0.33, 2.06, 1.28, and 0.25 (see Appendix, Table A-4). These values for Cell 26, Cell 34, and Cell 43 are comparable to those of Cell 24 (see Appendix, Tables A-4). The average soil loss from the entire watershed for Storm A is 1.651 tons/acre, which is also fairly high (see Appendix, Tables A-5).

The erosion rates for these critical cells (24, 26, 34 and 43) for Storm B are, respectively, 2.02, 2.16, 2.46 and 2.07 tons/acre (see Figure 8). These cells are again noted to be areas of concern, since the erosion rate values are slightly above the lower range of soil loss tolerance limit of 2 tons/acre. The erosion values in tons/acre for clay, silt, small aggregates, large aggregates, and sand in Cell 24 are, respectively, 0.10, 0.16, 1.01, 0.63, and 0.12 which are moderately high (see Appendix, Table A-8). These values, in tons/acre, for clay, silt, small aggregates, large aggregates, and sand in Cell 26, Cell 34 and Cells 43 are also noted to be moderately high (see Appendix, Table A-8). The total amount of average soil loss for the watershed during Storm B is 0.811 tons/acre which may be considered to be significant (see Appendix, Tables A-9).

The erosion rates of the cells for Storm C are presented in Figure 9. Cell 34 shows the highest erosion rate of 0.99 tons/acre. The erosion values, in tons/acre, for Cells 24, 26 and 43 are, respectively, 0.81, 0.87, and 0.83. Since the erosion rate values are considerably below the soil loss tolerance limits, the soil loss for the four critical cells during Storm C is only minor. The erosion values for clay, silt, small aggregates, large aggregates, and sand in these four critical cells for Storm C are noted to be quite low. For example, the erosion values in tons/acre for clay, silt, small aggregates, large aggregates, and sand in Cell 26 are 0.04, 0.07, 0.43, 0.27, and 0.05, respectively, which are not of much consequence compared to Storm A or B. The average soil loss for the entire watershed during Storm C is predicted to be 0.326 tons/acre which may be considered to be acceptable (see Appendix, Tables A-13).

The erosion rates for the cells in Storm D are presented in Figure 10. Cell 34 shows the highest erosion rate of 0.35 tons/acre. The values of erosion rate for the other three critical cells are even smaller. The clay, silt, small aggregates, large aggregates, and sand contents of all the four critical cells are vanishingly small. The amount of average watershed soil loss for Storm D is only 0.116 tons/acre which is quite acceptable (see Appendix, Tables A-17).

The relationship between the energy-intensity (EI) and erosion rate for the four storm events is shown in Figure 11 (bottom). It can be seen from the graph that the erosion rate is directly proportional to the EI parameter. The EI values for Storm A, Storm B, Storm C and Storm D are estimated to be, respectively, 91, 45, 18, and 6 (see

Appendix A, Tables A-2, A-6, A-10, and A-14). Past research studies indicate that when factors other than rainfall are constant, storm soil losses from fields are directly proportional to the EI parameter [Wischmeier & Smith, 1978]. As the value of the EI parameter increases, so does the erosion rate for a storm event. The value of EI for a given rainstorm equals the product of total storm energy (E) and the maximum 30-min intensity (I_{30}). The storm energy indicates the volume of rainfall and runoff during an event. Erosion due to rainfall increases with intensity. The I_{30} term indicates the peak rates of detachment and runoff. The parameter, EI, defines how total energy and peak intensity are combined in each particular storm event.

To reduce the soil loss from the identified critical cells, a cover of mulch and/or vegetation could be applied to the areas of concern. This would intercept falling raindrops near the surface so that the drops have little fall velocity, and would also obstruct runoff flow, thereby reducing the velocity and transport capacity of runoff. This practice will significantly reduce the C-Factor (cover and management factor), thus reducing the erosion rate.

In areas that are predominantly forest lands, such as Cell 1 to Cell 5, the soil loss values are extremely low. This is because in this type of land use, the infiltration rates and organic matter content of the soils are high, and most of the surface is usually covered by a layer of compacted decaying forest duff. Such layers of duff shield the soil from the erosive forces of runoff and raindrop impact, and are extremely effective against soil erosion.

5.6 Sediment Yield

The dependence of sediment yield on the energy-intensity (EI) for the four storm events is shown in Figure 11 (top). It can be seen from the graph that the sediment yield is directly proportional to the EI parameter. As the value of the EI parameter increases, so does the sediment yield. Higher erosion rate results in greater sediment yield. The simulation estimates the watershed sediment yield per year at the outlet to be of the order of 1100 tons [(2 events x 151tons) + (7 events x 67.3 tons) + (10 events x 20 tons) + (10 events x 7.6 tons)]. This is based on a storm distribution over the year as stated before. The sediment yield is certainly excessive. Therefore, one needs to analyze the sediment yield on a cell-by-cell basis to locate the sources of large sediment yields inside the watershed.

The sediment yield in the cells for Storm A is presented in Figure 12. The three significant cells which contribute the most sediment yield are Cell 24, Cell 26, and Cell 34. Their respective values in tons are 564, 356, and 828 (see Appendix, Table A-5). The yield for Storm A at the outlet (Cell 13) of the watershed is estimated to be 151 tons over an area of 179 acres. The yield in the cells for Storm B is presented in Figure 13; the yield in tons for Cell 24, Cell 26, and Cell 34 are 201, 144, and 297, respectively (see Appendix, Table A-9). The yield at the outlet of the watershed for Storm B is 67.3 tons. The yield in the cells for Storm C is presented in Figure 14; the yield in tons for Cell 24, Cell 26, and Cell 34 are 36.6, 26.2, and 55.9, respectively (see Appendix, Table A-13). The yield at the outlet of the watershed for Storm C is estimated to be 19.97 tons. The yield in the cells for Storm D is presented in Figure 15; the yield in tons for Cell 24, Cell

26, and Cell 34 are 13.1, 9.36, and 20.1, respectively (See Appendix, Table A-17). The yield at the outlet of the watershed for Storm D is 64 tons.

It is noted that the critical cells from the point of view of sediment deposit are Cell 24, Cell 26, and Cell 34 for all four storm events; the sediment deposit contributions of these cells for the storm events A, B, C, and D, are 19%, 18%, 16%, and 15%, respectively. Although high soil erosion was predicted for Cell 43, the sediment yield was due to deposition within the cell. A reduction in sediment deposits can be attained by incorporating impoundment type terrace systems in the identified critical cells that use underground outlets. For the outlets in the lower areas of the field, the terrace ridges may be built across the areas and temporary ponds may be created around the risers of the outlet tile. The outlets are typically designed to drain the impounded runoff in 1 to 2 days. This can allow the ponds to provide a maximum stilling effect, and only the smallest and lightest soil particles will be carried off the field in the runoff water. The increased time for infiltration will also reduce the runoff.

5.7 Sensitivity Analysis

The modified USLE in the model is designed to predict the soil losses in runoff from the field areas in the watershed. The important multipliers in the equation are P-, C- and K-Factor values (see Equation 12, p. 26). The effect of changes in these three factors on predictions were also studied. Storm C (1 inch precipitation, 1 hr. duration) is selected for this purpose.

The P-Factor (Support Practice Factor) in the soil loss equation refers to management practices which include contouring, stripcropping, and terracing. Figure 16 shows the percent change in sediment yield (top figure) and in erosion (bottom figure) when the P-Factor was varied from –25% to + 25%. The values of K-Factor and C-Factor were held constant and the erosion and sediment yield were computed at the outlet. Four simulations were performed to calculate the percent change in erosion rate and sediment yield while changing the P-Factor values from the original input. In the first run, when the values of the P-Factor were increased by 25%, the erosion rate and sediment yield increased by 24.4% and 25%, respectively. In the second run, the values of the P-Factor were increased by 12.5%, and this resulted in an increase in erosion rate and sediment yield of 12.4% and 12.5%, respectively. In the third run, when the values of the P-Factor were decreased by 12.5%, the erosion rate and sediment yield decreased by 11.9% and 11.5%, respectively. In the fourth run, the values of the P-Factor were decreased by 25 %, and this caused a decrease in the erosion rate and sediment yield of 24.3% and 24.5%, respectively. A linear dependence of the P-Factor on the erosion rate for all changes in P-Factor and on the sediment yield for smaller changes is noted. For an increase in P-Factor exceeding 20%, sediment yield is noted to decrease slightly.

The C-Factor (Cover and Management Factor) in the soil loss equation refers to management practices which include crop canopy, residue mulch, incorporated residues, tillage, and land use. Figure 17 shows the percent change in sediment yield (top figure) and in erosion (bottom figure) when the C-Factor was varied in four separate runs from – 25% to + 25% while K- and P-Factors were held constant. In each run, the changes in sediment yield and erosion were of the same order as the changes in C-Factor. A linear dependence of the C-Factor on erosion rate and on sediment yield is thus noted.

The K-Factor (Soil Erodibility Factor) in the soil loss equation is determined for a particular soil. The rate of soil loss erosion in the USLE may be influenced by land slope, rainstorm characteristics, cover, and management than by the soil properties. However, some soils erode more readily than others even when all the other factors mentioned above remain the same. This difference, caused by properties of the soil itself, is referred to as the soil erodibility. A soil's erodibility is a function of complex interactions of its physical and chemical properties, and often varies within a standard texture class. Figure 18 shows the percent change of sediment yield (top figure) and of erosion (bottom figure) for four separate runs when the K-Factor is varied from –25% to + 25% while the P- and C-Factors were held constant. Again, as was the case for C-Factor change, in each run, the changes in sediment yield and erosion were of the same order as the changes in P-Factor, and a linear dependence of the P-Factor on the erosion rate and on the sediment yield was noted.

5.8 Cells of Critical Concern

It is clear from the discussion of results presented that there are four critical cells, each of 179 acres in area, which demand special attention because of their large contribution to the overall runoff, sediment generation and sediment yield in the Indian Run watershed. For an event such as Storm A (3 in. precipitation, 6 hour duration), these critical cells (Cell 24, Cell 26, Cell 34 and Cell 43) have predicted erosions (tons/acre) of 4.12, 4.39, 5.01 and 4.22, respectively; and predicted sediment yields (tons) of 564, 356, 828, and 0.00, respectively. Compared to the other cells, these values are very large. In the search for a suitable control action, it is useful to evaluate the impact on predictions if the K-Factor, C-Factor, and P-Factor values are decreased only for these critical cells. To achieve this objective, a simulation for Storm A was performed with the K, C, and P values all reduced by 25% for only these four critical cells. The resulting cell erosions (tons/acre) are 1.78, 1.92, 2.10, and 1.77, respectively; and the yields (tons) are 366, 155, 532, and 0.00, respectively. These reductions are substantial. The predictions for this situation indicate a reduction in overall watershed erosion on the order of 11%. Thus, for immediate action, significant erosion and sediment yield reductions for the entire watershed could be achieved by improving only these critical cells.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A simulation of the Indian Run watershed was performed using the AGNPS single-event water quality model. Based on the results and discussions of this simulation study, some important conclusions may be drawn.

1. The Indian Run watershed simulation indicates very high values of erosion and sediment yield. Annual loading rates were calculated by assuming a hypothetical series of storm events. The mean flow, erosion and sediment yield for the watershed outlet on yearly basis were estimated to be on the order of 0.944 cfs per square miles, 13.4 tons/acre, and 1100 tons, respectively. The erosion and sediment loading reach significant levels for storm Energy-Intensity values of the order 50 and above, i.e., for storms of 2 in. precipitation and 4 hours duration or worse.

2. The simulation identifies four cells which cause large contributions to the sediment yield of the watershed. Reductions of 25% in K-Factor, C-Factor and P-Factor for these critical cells result in erosion reductions on the order of 11%.

3. The simulation appears to be reasonably validated. The sediment deposit and the flow rate predictions are within 10% of measurements reported [MBR-HER, 1994].

6.2 Recommendations

6.2.1 Early Action:

The four critical cells identified by this study of the Indian Run watershed demand immediate BMP actions. Though these cells are identified as *bad* cells (tracts of relatively large slopes, poor vegetation covers, and poor soil characteristics resulting in significant erosions and sediment yields), the USGS topographic map indicates that only selected portions need improvements. The implementation of the BMP's for these selected areas of the watershed should be less time consuming and more cost effective than for the whole watershed. If only the sediment loading from the Indian Run to the Mill Creek is to be reduced, only one cell (outlet: Cell 13) of 179 acres needs improvement.

6.2.2 General Action:

It would be useful to apply the water quality model known as ANN-AGNPS to perform a more detailed study of both the Indian Run, Anderson's Run, and Southern Mill Creek watersheds. The ANN-AGNPS is a distributed parameter, continuous simulation watershed model which is an extension of the AGNPS single-event model, and it employs continuous routines for weather generation, soil structure, plant growth and decay, a modified soil erosion model, and detailed calculations for K-, C-, and P-Factor. Further, the critical cells should be simulated by dividing them into smaller subcells. Also, a Geographical Information System (GIS) could be developed and employed to automatically prescribe the input parameters and display the results. This would improve the simulation and make interpretation of the results easier. The application of ANN-

AGNPS would reduce the uncertainties related to hypothetical storm distributions within a year, and also enhance the accuracy of predictions.

There is a need for more frequent or continuous-time monitoring of some key variables including flow and suspended solids. For the model to be of practical use, it must be reasonably validated. In addition a better data base could reduce model uncertainty.

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APPENDIX

TABULAR AGNPS OUTPUTS (A-1 TO A-17)

OF

THE INIDAN RUN WATERSHED

Table A-1: Cell Input Parameters - Same for Storms A, B, C, and D

Cell No.	Cell Div	RCell No.	Rcell Div	Asp	Crv No.	Lnd Slp	Slp Shp	Slp Len	Man Cf	K Fact	C Fact	P Fact
1	0	2	0	3	75	4.7	2	100	0.04	0.29	0.01	0.5
2	0	6	0	4	85	3.3	2	100	0.04	0.27	0.01	0.5
3	0	6	0	5	75	1.8	2	100	0.05	0.22	0.01	0.6
4	0	8	0	5	85	3.2	2	150	0.05	0.41	0.01	0.5
5	0	6	0	3	85	3.2	3	100	0.05	0.38	0.01	0.5
6	0	7	0	3	79	2.3	3	150	0.05	0.31	0.01	0.6
7	0	11	0	5	79	0.9	3	100	0.05	0.28	0.01	0.6
8	0	16	0	5	85	2.5	2	150	0.04	0.28	0.01	0.5
9	0	10	0	3	73	0.9	3	100	0.3	0.29	0.5	0.5
10	0	11	0	3	73	0.8	3	100	0.3	0.33	0.43	0.5
11	0	12	0	3	85	4.4	3	100	0.04	0.32	0.43	0.5
12	0	12	0	3	85	1.2	1	100	0.04	0.32	0.5	0.6
13	0	64	0	2	85	0.6	1	100	0.05	0.48	0.6	0.6
14	0	24	0	5	73	2.2	2	100	0.3	0.48	0.5	0.6
15	0	16	0	3	85	1.4	3	100	0.05	0.48	0.51	0.6
16	0	17	0	3	73	5	3	100	0.3	0.28	0.59	0.5
17	0	27	0	5	60	3.1	2	100	0.3	0.28	0.59	0.5
18	0	28	0	5	73	4.2	2	100	0.3	0.28	0.5	0.5
19	0	20	0	3	73	4	2	100	0.3	0.28	0.5	0.5
20	0	21	0	3	85	0.6	1	100	0.05	0.26	0.43	0.6
21	0	21	0	1	85	0.6	1	100	0.06	0.31	0.43	0.6
22	0	23	0	3	73	1.9	3	100	0.3	0.31	0.6	0.6
23	0	24	0	3	73	3	3	100	0.3	0.29	0.6	0.5
24	0	33	0	5	73	4	2	100	0.2	0.29	0.6	0.5
25	0	34	0	5	73	2	2	100	0.3	0.41	0.6	0.5
26	0	35	0	5	73	5	3	100	0.3	0.41	0.5	0.5
27	0	28	0	3	73	2.5	3	100	0.2	0.31	0.6	0.6
28	0	29	0	3	73	4.2	3	100	0.3	0.31	0.5	0.6
29	0	30	0	3	60	3	3	100	0.2	0.31	0.6	0.5
30	0	30	0	1	60	1	3	100	0.2	0.41	0.6	0.5
31	0	32	0	3	73	1.7	2	100	0.2	0.33	0.5	0.5
32	0	33	0	3	73	2	3	100	0.2	0.33	0.51	0.6
33	0	34	0	3	60	0.8	3	100	0.2	0.41	0.51	0.6
34	0	35	0	3	73	5	2	100	0.2	0.31	0.51	0.5
35	0	35	0	1	73	2	3	100	0.2	0.36	0.6	0.6
36	0	43	0	5	73	1.7	2	100	0.3	0.31	0.51	0.6
37	0	37	0	1	73	0.5	2	100	0.2	0.31	0.6	0.6
38	0	39	0	5	73	1.1	3	100	0.3	0.29	0.6	0.5
39	0	47	0	5	73	1.1	3	100	0.3	0.29	0.6	0.5
40	0	48	0	5	73	0.7	2	100	0.3	0.41	0.51	0.6
41	0	41	0	3	73	0.6	1	100	0.3	0.31	0.43	0.6
42	0	43	0	3	73	3.3	3	100	0.3	0.36	0.43	0.5
43	0	43	0	6	73	5	2	100	0.3	0.31	0.43	0.5
44	0	44	0	7	73	0.5	2	100	0.3	0.41	0.51	0.6
45	0	51	0	5	73	0.8	2	100	0.3	0.31	0.51	0.6
46	0	47	0	3	60	1	2	100	0.31	0.29	0.6	0.6
47	0	48	0	3	73	2.5	3	100	0.3	0.29	0.6	0.5
48	0	54	0	5	60	2.5	3	100	0.3	0.29	0.5	0.5
49	0	49	0	7	100	0.4	1	0	0.99	0	0	0
50	0	56	0	5	36	3.3	2	100	0.06	0.29	0.6	0.5
51	0	51	0	3	73	0.5	3	100	0.3	0.29	0.6	0.6
52	0	53	0	3	73	3	2	100	0.31	0.29	0.6	0.5
53	0	54	0	3	73	2.8	3	100	0.3	0.29	0.43	0.5
54	0	58	0	5	73	0.4	2	100	0.3	0.24	0.5	0.6
55	0	59	0	5	100	0.3	1	0	0.99	0	0.6	0
56	0	60	0	5	73	0.5	1	100	0.08	0.29	0.43	0.6
57	0	57	0	3	73	1.4	2	100	0.2	0.29	0.43	0.6
58	0	58	0	1	73	1.2	2	100	0.06	0.29	0.43	0.6
59	0	61	0	5	73	0.6	1	100	0.08	0.31	0.43	0.6
60	0	60	0	1	60	0.4	1	100	0.3	0.29	0.59	0.6
61	0	61	0	3	60	1.5	2	100	0.3	0.29	0.6	0.6
62	0	61	0	1	73	1.2	1	100	0.08	0.31	0.43	0.6
63	0	62	0	1	73	4	2	100	0.2	0.29	0.43	0.5

Table A-2: Summary of Model Output for Storm A (3 in. precipitation, 6 hr. duration)

Initial Data:

Area of the Watershed (acres)	11,277
Area of Each Cell	179
Total Number of Cells	63
Storm Precipitation (in.)	1.00
Storm Duration (hrs)	6.00
Storm Energy-Intensity Value	91.00

Values at the Watershed Outlet:

Cell Number	13
Runoff Volume (inches)	1.60
Peak Runoff Rate (cfs)	215

Sediment Analysis:

	Area Weighted Erosion				Mean	Area	
	Upland (t/a)	Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Concentration ppm)	Weighted Yield (t/a)	Yield (tons)
CLAY	4.23	0.01	2	2	463.41	0.08	14.9
SILT	6.77	0.00	2	2	684.29	0.08	14.9
SAGG	42.23	0.00	1	1	3314.98	0.08	14.9
LAGG	26.24	0.03	0	0	194.48	0.08	14.9
SAND	5.08	0.01	0	0	33.07	0.08	14.9
TOTAL	84.64	0.01	1	1	4690.22	0.84	151.0

Table A-3: Output for Storm A (3 in. precipitation, 6 hr. duration)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
1	000	179	0.96	0.00	0	0.96	189
2	000	358	1.59	0.96	178	1.27	275
3	000	179	0.96	0.00	0	0.96	160
4	000	179	1.59	0.00	0	1.59	280
5	000	179	1.59	0.00	0	1.59	280
6	000	895	1.19	1.27	479	1.26	475
7	000	1074	1.19	1.26	404	1.25	433
8	000	358	1.59	1.59	267	1.59	330
9	000	179	0.86	0.00	0	0.86	129
10	000	358	0.86	0.86	129	0.86	158
11	000	1611	1.59	1.15	679	1.20	732
12	000	1790	0.00	1.20	595	0.00	0
13	000	179	1.59	0.00	0	1.59	215
14	000	179	0.86	0.00	0	0.86	152
15	000	179	1.59	0.00	0	1.59	240
16	000	716	0.86	1.59	532	1.41	532
17	000	895	0.33	1.41	490	1.19	463
18	000	179	0.86	0.00	0	0.86	167
19	000	179	0.86	0.00	0	0.86	167
20	000	358	1.59	0.86	123	1.22	209
21	000	537	0.00	1.22	208	0.00	0
22	000	179	0.86	0.00	0	0.86	147
23	000	358	0.86	0.86	159	0.86	195
24	000	716	0.86	0.86	292	0.86	326
25	000	179	0.86	0.00	0	0.86	149
26	000	179	0.86	0.00	0	0.86	173
27	000	1074	0.86	1.19	447	1.14	464
28	000	1432	0.86	1.10	558	1.07	559
29	000	1611	0.33	1.07	534	0.98	512
30	000	1790	0.00	0.98	430	0.00	0
31	000	179	0.86	0.00	0	0.86	144
32	000	358	0.86	0.86	149	0.86	183
33	000	1253	0.33	0.86	361	0.78	343
34	000	1611	0.86	0.79	522	0.80	524
35	000	1969	0.00	0.80	500	0.00	0
36	000	179	0.86	0.00	0	0.86	144
37	000	179	0.00	0.00	0	0.00	0
38	000	179	0.86	0.00	0	0.86	134
39	000	358	0.86	0.86	133	0.86	164
40	000	179	0.86	0.00	0	0.86	123
41	000	179	0.00	0.00	0	0.00	0
42	000	179	0.86	0.00	0	0.86	161
43	000	537	0.00	0.86	319	0.00	0
44	000	179	0.00	0.00	0	0.00	0
45	000	179	0.86	0.00	0	0.86	129
46	000	179	0.33	0.00	0	0.33	57
47	000	716	0.86	0.68	218	0.73	258
48	000	1074	0.33	0.75	324	0.68	314
49	000	179	0.00	0.00	0	0.00	0
50	000	179	0.00	0.00	0	0.00	0
51	000	358	0.00	0.86	115	0.00	0

Table A-3 (Continued)

52 000	179	0.86	0.00	0	0.86	159
53 000	358	0.86	0.86	155	0.86	191
54 000	1611	0.86	0.73	322	0.74	327
55 000	179	3.00	0.00	0	3.00	319
56 000	358	0.86	0.00	0	0.43	75
57 000	179	0.00	0.00	0	0.00	0
58 000	1790	0.00	0.74	388	0.00	0
59 000	358	0.86	3.00	379	1.93	315
60 000	537	0.00	0.43	75	0.00	0
61 000	895	0.00	1.39	498	0.00	0
62 000	358	0.86	0.86	137	0.86	169
63 000	179	0.86	0.00	0	0.86	167

Table A-4: Output for Storm A (3 in. precipitation, 6 hr. duration)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
1	000	CLAY	0.00	0.00	0.74	0.89	-17
		SILT	0.01	0.00	1.18	1.27	-7
		SAGG	0.04	0.00	7.39	6.06	18
		LAGG	0.03	0.00	4.58	1.01	78
		SAND	0.00	0.00	0.89	0.25	72
		TOTL	0.08	0.00	14.78	9.48	36
2	000	CLAY	0.00	0.89	0.45	1.34	0
		SILT	0.00	1.27	0.72	1.75	12
		SAGG	0.03	6.06	4.51	4.77	55
		LAGG	0.02	1.01	2.80	3.60	5
		SAND	0.00	0.25	0.54	1.20	-34
		TOTL	0.05	9.48	9.02	12.65	32
3	000	CLAY	0.00	0.00	0.26	0.40	-36
		SILT	0.00	0.00	0.41	0.53	-21
		SAGG	0.01	0.00	2.59	2.05	21
		LAGG	0.01	0.00	1.61	0.69	57
		SAND	0.00	0.00	0.31	0.20	35
		TOTL	0.03	0.00	5.18	3.87	25
4	000	CLAY	0.00	0.00	0.75	0.90	-17
		SILT	0.01	0.00	1.20	1.29	-7
		SAGG	0.04	0.00	7.50	6.25	17
		LAGG	0.03	0.00	4.65	1.05	77
		SAND	0.01	0.00	0.90	0.26	71
		TOTL	0.08	0.00	14.99	9.75	35
5	000	CLAY	0.00	0.00	0.42	0.57	-27
		SILT	0.00	0.00	0.67	0.79	-15
		SAGG	0.02	0.00	4.16	3.56	15
		LAGG	0.01	0.00	2.58	0.87	66
		SAND	0.00	0.00	0.50	0.23	53
		TOTL	0.05	0.00	8.33	6.02	28
6	000	CLAY	0.00	2.31	0.34	2.64	0
		SILT	0.00	3.06	0.54	3.23	10
		SAGG	0.02	10.37	3.39	7.47	46
		LAGG	0.01	5.16	2.10	4.02	45
		SAND	0.00	1.64	0.41	1.24	39
		TOTL	0.04	22.55	6.78	18.61	37
7	000	CLAY	0.00	2.64	0.15	2.78	0
		SILT	0.00	3.23	0.24	3.22	7
		SAGG	0.01	7.47	1.48	5.73	36
		LAGG	0.01	4.02	0.92	8.59	-43
		SAND	0.00	1.24	0.18	2.73	-48
		TOTL	0.02	18.61	2.96	23.06	-6
8	000	CLAY	0.00	0.90	0.41	1.31	0
		SILT	0.00	1.29	0.65	1.78	8
		SAGG	0.02	6.25	4.05	5.68	45
		LAGG	0.01	1.05	2.51	4.81	-26
		SAND	0.00	0.26	0.49	1.58	-53
		TOTL	0.05	9.75	8.10	15.16	15
9	000	CLAY	0.04	0.00	6.38	6.34	1
		SILT	0.06	0.00	10.21	8.48	17
		SAGG	0.36	0.00	63.80	32.34	49
		LAGG	0.22	0.00	39.55	0.96	98
		SAND	0.04	0.00	7.66	0.14	98
		TOTL	0.71	0.00	127.60	48.26	62

Table A-4 (Continued)

10 000	CLAY	0.03	6.34	5.93	11.99	2
	SILT	0.05	8.48	9.48	10.56	41
	SAGG	0.33	32.34	59.26	20.93	77
	LAGG	0.21	0.96	36.74	0.56	99
	SAND	0.04	0.14	7.11	0.10	99
	TOTL	0.66	48.26	118.53	44.15	74
11 000	CLAY	0.12	14.78	21.97	36.68	0
	SILT	0.20	13.79	35.15	47.01	4
	SAGG	1.23	26.67	219.69	209.59	15
	LAGG	0.76	9.15	136.21	24.53	83
	SAND	0.15	2.83	26.36	4.73	84
	TOTL	2.45	67.22	439.38	322.54	36
12 000	CLAY	0.06	36.68	11.13	0.00	100
	SILT	0.10	47.01	17.81	0.00	100
	SAGG	0.62	209.59	111.29	0.00	100
	LAGG	0.39	24.53	69.00	0.00	100
	SAND	0.07	4.73	13.36	0.00	100
	TOTL	1.24	322.54	222.59	0.00	100
13 000	CLAY	0.08	0.00	14.71	14.92	-1
	SILT	0.13	0.00	23.53	22.03	6
	SAGG	0.82	0.00	147.08	106.74	27
	LAGG	0.51	0.00	91.19	6.26	93
	SAND	0.10	0.00	17.65	1.06	94
	TOTL	1.64	0.00	294.16	151.02	49
14 000	CLAY	0.18	0.00	33.07	32.88	1
	SILT	0.30	0.00	52.91	45.89	13
	SAGG	1.85	0.00	330.69	191.35	42
	LAGG	1.15	0.00	205.03	6.33	97
	SAND	0.22	0.00	39.68	0.89	98
	TOTL	3.69	0.00	661.38	277.33	58
15 000	CLAY	0.09	0.00	16.43	16.60	-1
	SILT	0.15	0.00	26.29	24.87	5
	SAGG	0.92	0.00	164.33	125.40	24
	LAGG	0.57	0.00	101.89	7.86	92
	SAND	0.11	0.00	19.72	1.26	94
	TOTL	1.84	0.00	328.66	175.99	46
16 000	CLAY	0.18	17.91	31.69	49.38	0
	SILT	0.28	26.65	50.70	69.24	10
	SAGG	1.77	131.08	316.90	281.73	37
	LAGG	1.10	12.67	196.48	10.75	95
	SAND	0.21	2.84	38.03	1.53	96
	TOTL	3.54	191.15	633.79	412.62	50
17 000	CLAY	0.14	49.38	25.91	74.81	1
	SILT	0.23	69.24	41.46	94.39	15
	SAGG	1.45	281.73	259.11	277.01	49
	LAGG	0.90	10.75	160.65	7.31	96
	SAND	0.17	1.53	31.09	1.07	97
	TOTL	2.90	412.62	518.22	454.58	51
18 000	CLAY	0.17	0.00	31.31	31.16	0
	SILT	0.28	0.00	50.09	44.37	11
	SAGG	1.75	0.00	313.08	194.04	38
	LAGG	1.08	0.00	194.11	7.06	96
	SAND	0.21	0.00	37.57	0.99	97
	TOTL	3.50	0.00	626.15	277.62	56
19 000	CLAY	0.17	0.00	29.64	29.50	0
	SILT	0.26	0.00	47.42	42.01	11
	SAGG	1.66	0.00	296.39	183.70	38
	LAGG	1.03	0.00	183.76	6.69	96
	SAND	0.20	0.00	35.57	0.94	97
	TOTL	3.31	0.00	592.77	262.82	56

Table A-4 (Continued)

20 000	CLAY	0.03	29.50	5.71	34.71	1
	SILT	0.05	42.01	9.14	35.05	31
	SAGG	0.32	183.70	57.10	31.23	87
	LAGG	0.20	6.69	35.40	3.18	92
	SAND	0.04	0.94	6.85	0.96	88
	TOTL	0.64	262.82	114.19	105.13	72
21 000	CLAY	0.04	34.71	6.81	0.00	100
	SILT	0.06	35.05	10.89	0.00	100
	SAGG	0.38	31.23	68.08	0.00	100
	LAGG	0.24	3.18	42.21	0.00	100
	SAND	0.05	0.96	8.17	0.00	100
	TOTL	0.76	105.13	136.15	0.00	100
22 000	CLAY	0.09	0.00	15.44	15.35	1
	SILT	0.14	0.00	24.70	21.26	14
	SAGG	0.86	0.00	154.39	87.16	44
	LAGG	0.53	0.00	95.72	2.81	97
	SAND	0.10	0.00	18.53	0.40	98
	TOTL	1.73	0.00	308.78	126.99	59
23 000	CLAY	0.10	15.35	17.89	32.75	1
	SILT	0.16	21.26	28.62	35.04	30
	SAGG	1.00	87.16	178.88	81.55	69
	LAGG	0.62	2.81	110.91	2.08	98
	SAND	0.12	0.40	21.47	0.31	99
	TOTL	2.00	126.99	357.77	151.72	69
24 000	CLAY	0.21	65.63	36.84	101.78	1
	SILT	0.33	80.93	58.94	118.54	15
	SAGG	2.06	272.89	368.37	332.29	48
	LAGG	1.28	8.41	228.39	10.30	96
	SAND	0.25	1.19	44.20	1.49	97
	TOTL	4.12	429.06	736.73	564.40	52
25 000	CLAY	0.15	0.00	26.15	26.00	1
	SILT	0.23	0.00	41.85	36.16	14
	SAGG	1.46	0.00	261.55	149.59	43
	LAGG	0.91	0.00	162.16	4.88	97
	SAND	0.18	0.00	31.39	0.69	98
	TOTL	2.92	0.00	523.10	217.33	58
26 000	CLAY	0.22	0.00	39.32	39.15	0
	SILT	0.35	0.00	62.92	56.13	11
	SAGG	2.20	0.00	393.24	249.61	37
	LAGG	1.36	0.00	243.81	9.42	96
	SAND	0.26	0.00	47.19	1.32	97
	TOTL	4.39	0.00	786.49	355.63	55
27 000	CLAY	0.11	74.81	19.36	93.57	1
	SILT	0.17	94.39	30.98	106.81	15
	SAGG	1.08	277.01	193.61	242.40	48
	LAGG	0.67	7.31	120.04	6.47	95
	SAND	0.13	1.07	23.23	1.01	96
	TOTL	2.16	454.58	387.23	450.26	47
28 000	CLAY	0.16	124.73	28.16	151.58	1
	SILT	0.25	151.18	45.05	158.68	19
	SAGG	1.57	436.44	281.56	295.96	59
	LAGG	0.98	13.53	174.57	6.79	96
	SAND	0.19	2.00	33.79	1.00	97
	TOTL	3.15	727.88	563.12	614.01	52
29 000	CLAY	0.11	151.58	19.12	169.29	1
	SILT	0.17	158.68	30.60	153.68	19
	SAGG	1.07	295.96	191.22	212.45	56
	LAGG	0.66	6.79	118.56	5.31	96
	SAND	0.13	1.00	22.95	0.86	96
	TOTL	2.14	614.01	382.44	541.59	46

Table A-4 (Continued)

30 000	CLAY	0.06	169.29	11.39	0.00	100
	SILT	0.10	153.68	18.22	0.00	100
	SAGG	0.64	212.45	113.86	0.00	100
	LAGG	0.39	5.31	70.59	0.00	100
	SAND	0.08	0.86	13.66	0.00	100
	TOTL	1.27	541.59	227.72	0.00	100
31 000	CLAY	0.09	0.00	15.53	15.46	0
	SILT	0.14	0.00	24.85	21.73	13
	SAGG	0.87	0.00	155.33	92.18	41
	LAGG	0.54	0.00	96.30	3.20	97
	SAND	0.10	0.00	18.64	0.46	98
	TOTL	1.74	0.00	310.65	133.03	57
32 000	CLAY	0.08	15.46	14.54	29.56	1
	SILT	0.13	21.73	23.26	31.41	30
	SAGG	0.81	92.18	145.35	67.39	72
	LAGG	0.50	3.20	90.12	1.80	98
	SAND	0.10	0.46	17.44	0.29	98
	TOTL	1.62	133.03	290.70	130.44	69
33 000	CLAY	0.06	131.33	10.48	140.42	1
	SILT	0.09	149.95	16.77	129.81	22
	SAGG	0.59	399.68	104.80	157.62	69
	LAGG	0.36	12.11	64.97	2.48	97
	SAND	0.07	1.78	12.58	0.46	97
	TOTL	1.17	694.84	209.59	430.80	52
34 000	CLAY	0.25	166.42	44.80	209.71	1
	SILT	0.40	165.98	71.68	199.62	16
	SAGG	2.50	307.22	448.02	403.64	47
	LAGG	1.55	7.36	277.77	12.72	96
	SAND	0.30	1.15	53.76	1.86	97
	TOTL	5.01	648.12	896.05	827.54	46
35 000	CLAY	0.10	248.85	18.65	0.00	100
	SILT	0.17	255.75	29.85	0.00	100
	SAGG	1.04	653.25	186.55	0.00	100
	LAGG	0.65	22.14	115.66	0.00	100
	SAND	0.13	3.18	22.39	0.00	100
	TOTL	2.08	1183.17	373.10	0.00	100
36 000	CLAY	0.10	0.00	17.86	17.75	1
	SILT	0.16	0.00	28.58	24.48	14
	SAGG	1.00	0.00	178.60	99.34	44
	LAGG	0.62	0.00	110.73	3.15	97
	SAND	0.12	0.00	21.43	0.44	98
	TOTL	2.00	0.00	357.20	145.16	59
37 000	CLAY	0.07	0.00	11.66	0.00	100
	SILT	0.10	0.00	18.66	0.00	100
	SAGG	0.65	0.00	116.63	0.00	100
	LAGG	0.40	0.00	72.31	0.00	100
	SAND	0.08	0.00	14.00	0.00	100
	TOTL	1.30	0.00	233.26	0.00	100
38 000	CLAY	0.05	0.00	8.46	8.41	1
	SILT	0.08	0.00	13.54	11.36	16
	SAGG	0.47	0.00	84.60	44.23	48
	LAGG	0.29	0.00	52.45	1.33	97
	SAND	0.06	0.00	10.15	0.19	98
	TOTL	0.95	0.00	169.20	65.53	61
39 000	CLAY	0.05	8.41	8.46	16.52	2
	SILT	0.08	11.36	13.54	15.23	39
	SAGG	0.47	44.23	84.60	31.43	76
	LAGG	0.29	1.33	52.45	0.78	99
	SAND	0.06	0.19	10.15	0.13	99
	TOTL	0.95	65.53	169.20	64.09	73

Table A-4 (Continued)

40 000	CLAY	0.08	0.00	14.67	14.56	1
	SILT	0.13	0.00	23.48	19.21	18
	SAGG	0.82	0.00	146.72	71.33	51
	LAGG	0.51	0.00	90.97	1.99	98
	SAND	0.10	0.00	17.61	0.29	98
	TOTL	1.64	0.00	293.44	107.38	63
41 000	CLAY	0.04	0.00	6.81	0.00	100
	SILT	0.06	0.00	10.89	0.00	100
	SAGG	0.38	0.00	68.08	0.00	100
	LAGG	0.24	0.00	42.21	0.00	100
	SAND	0.05	0.00	8.17	0.00	100
	TOTL	0.76	0.00	136.15	0.00	100
42 000	CLAY	0.10	0.00	17.50	17.42	0
	SILT	0.16	0.00	28.00	24.62	12
	SAGG	0.98	0.00	175.02	105.82	40
	LAGG	0.61	0.00	108.51	3.73	97
	SAND	0.12	0.00	21.00	0.53	97
	TOTL	1.96	0.00	350.04	152.11	57
43 000	CLAY	0.21	35.17	37.77	0.00	100
	SILT	0.34	49.10	60.44	0.00	100
	SAGG	2.11	205.16	377.75	0.00	100
	LAGG	1.31	6.87	234.20	0.00	100
	SAND	0.25	0.97	45.33	0.00	100
	TOTL	4.22	297.27	755.49	0.00	100
44 000	CLAY	0.07	0.00	13.11	0.00	100
	SILT	0.12	0.00	20.98	0.00	100
	SAGG	0.73	0.00	131.11	0.00	100
	LAGG	0.45	0.00	81.29	0.00	100
	SAND	0.09	0.00	15.73	0.00	100
	TOTL	1.46	0.00	262.23	0.00	100
45 000	CLAY	0.07	0.00	11.71	11.62	1
	SILT	0.10	0.00	18.73	15.55	17
	SAGG	0.65	0.00	117.05	59.32	49
	LAGG	0.41	0.00	72.57	1.72	98
	SAND	0.08	0.00	14.05	0.25	98
	TOTL	1.31	0.00	234.11	88.47	62
46 000	CLAY	0.08	0.00	14.28	14.10	1
	SILT	0.13	0.00	22.84	17.17	25
	SAGG	0.80	0.00	142.76	55.53	61
	LAGG	0.49	0.00	88.51	1.30	99
	SAND	0.10	0.00	17.13	0.18	99
	TOTL	1.60	0.00	285.53	88.30	69
47 000	CLAY	0.08	30.62	15.09	45.24	1
	SILT	0.13	32.40	24.15	44.14	22
	SAGG	0.84	86.97	150.94	95.94	60
	LAGG	0.52	2.08	93.58	2.97	97
	SAND	0.10	0.32	18.11	0.44	98
	TOTL	1.69	152.39	301.87	188.74	58
48 000	CLAY	0.07	59.80	12.58	71.69	1
	SILT	0.11	63.36	20.12	66.21	21
	SAGG	0.70	167.28	125.78	114.77	61
	LAGG	0.44	4.96	77.98	2.79	97
	SAND	0.08	0.73	15.09	0.43	97
	TOTL	1.41	296.12	251.56	255.89	53
49 000	CLAY	0.00	0.00	0.00	0.00	0
	SILT	0.00	0.00	0.00	0.00	0
	SAGG	0.00	0.00	0.00	0.00	0
	LAGG	0.00	0.00	0.00	0.00	0
	SAND	0.00	0.00	0.00	0.00	0
	TOTL	0.00	0.00	0.00	0.00	0

Table A-4 (Continued)

50 000	CLAY	0.16	0.00	29.06	19.80	32
	SILT	0.26	0.00	46.50	3.56	92
	SAGG	1.62	0.00	290.62	4.98	98
	LAGG	1.01	0.00	180.18	0.07	100
	SAND	0.19	0.00	34.87	0.01	100
	TOTL	3.25	0.00	581.24	28.42	95
51 000	CLAY	0.04	11.62	7.39	0.00	100
	SILT	0.07	15.55	11.82	0.00	100
	SAGG	0.41	59.32	73.86	0.00	100
	LAGG	0.26	1.72	45.79	0.00	100
	SAND	0.05	0.25	8.86	0.00	100
	TOTL	0.83	88.47	147.71	0.00	100
52 000	CLAY	0.15	0.00	26.43	26.29	1
	SILT	0.24	0.00	42.28	37.03	12
	SAGG	1.48	0.00	264.26	157.82	40
	LAGG	0.92	0.00	163.84	5.45	97
	SAND	0.18	0.00	31.71	0.76	98
	TOTL	2.95	0.00	528.52	227.35	57
53 000	CLAY	0.07	26.29	12.00	37.60	2
	SILT	0.11	37.03	19.20	35.79	36
	SAGG	0.67	157.82	120.00	52.44	81
	LAGG	0.42	5.45	74.40	1.17	99
	SAND	0.08	0.76	14.40	0.18	99
	TOTL	1.34	227.35	239.99	127.19	73
54 000	CLAY	0.04	109.30	7.09	114.12	2
	SILT	0.06	102.00	11.35	68.59	39
	SAGG	0.40	167.21	70.93	30.87	87
	LAGG	0.25	3.97	43.98	1.17	98
	SAND	0.05	0.61	8.51	0.26	97
	TOTL	0.79	383.08	141.86	215.02	59
55 000	CLAY	0.00	0.00	0.00	0.06	-100
	SILT	0.00	0.00	0.00	0.06	-100
	SAGG	0.00	0.00	0.00	0.07	-100
	LAGG	0.00	0.00	0.00	0.25	-100
	SAND	0.00	0.00	0.00	0.08	-100
	TOTL	0.00	0.00	0.00	0.52	-100
56 000	CLAY	0.03	19.80	6.01	0.17	99
	SILT	0.05	3.56	9.62	0.17	99
	SAGG	0.34	4.98	60.15	0.21	100
	LAGG	0.21	0.07	37.29	0.70	98
	SAND	0.04	0.01	7.22	0.22	97
	TOTL	0.67	28.42	120.30	1.46	99
57 000	CLAY	0.07	0.00	12.37	0.00	100
	SILT	0.11	0.00	19.79	0.00	100
	SAGG	0.69	0.00	123.66	0.00	100
	LAGG	0.43	0.00	76.67	0.00	100
	SAND	0.08	0.00	14.84	0.00	100
	TOTL	1.38	0.00	247.32	0.00	100
58 000	CLAY	0.06	114.12	11.28	0.00	100
	SILT	0.10	68.59	18.04	0.00	100
	SAGG	0.63	30.87	112.76	0.00	100
	LAGG	0.39	1.17	69.91	0.00	100
	SAND	0.08	0.26	13.53	0.00	100
	TOTL	1.26	215.02	225.52	0.00	100
59 000	CLAY	0.04	0.06	6.81	7.19	-5
	SILT	0.06	0.06	10.89	9.89	10
	SAGG	0.38	0.07	68.08	40.28	41
	LAGG	0.24	0.25	42.21	4.66	89
	SAND	0.05	0.08	8.17	1.24	85
	TOTL	0.76	0.52	136.15	63.26	54

Table A-4 (Continued)

60 000	CLAY	0.04	0.17	7.78	0.00	100
	SILT	0.07	0.17	12.45	0.00	100
	SAGG	0.43	0.21	77.80	0.00	100
	LAGG	0.27	0.70	48.23	0.00	100
	SAND	0.05	0.22	9.34	0.00	100
	TOTL	0.87	1.46	155.59	0.00	100
61 000	CLAY	0.10	42.27	18.04	0.00	100
	SILT	0.16	46.90	28.86	0.00	100
	SAGG	1.01	88.15	180.40	0.00	100
	LAGG	0.62	6.52	111.85	0.00	100
	SAND	0.12	1.67	21.65	0.00	100
	TOTL	2.02	185.50	360.79	0.00	100
62 000	CLAY	0.05	26.30	9.27	35.07	1
	SILT	0.08	38.04	14.84	37.01	30
	SAGG	0.52	172.90	92.72	47.86	82
	LAGG	0.32	6.91	57.49	1.87	97
	SAND	0.06	0.98	11.13	0.43	96
	TOTL	1.04	245.13	185.44	122.24	72
63 000	CLAY	0.15	0.00	26.40	26.30	0
	SILT	0.24	0.00	42.24	38.04	10
	SAGG	1.47	0.00	264.00	172.90	35
	LAGG	0.91	0.00	163.68	6.91	96
	SAND	0.18	0.00	31.68	0.98	97
	TOTL	2.95	0.00	527.99	245.13	54

Table A-5: Output for Storm A (3 in. precipitation, 6 hr. duration)

Condensed Soil Loss

Cell Num	Div	RUNOFF Drainage Area (acres)	Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
1	000	179	0.96	0.0	189	0.08	0.00	14.78	9.48	36
2	000	358	1.59	37.7	275	0.05	9.48	9.02	12.65	32
3	000	179	0.96	0.0	160	0.03	0.00	5.18	3.87	25
4	000	179	1.59	0.0	280	0.08	0.00	14.99	9.75	35
5	000	179	1.59	0.0	280	0.05	0.00	8.33	6.02	28
6	000	895	1.19	81.1	475	0.04	22.55	6.78	18.61	37
7	000	1074	1.19	84.1	433	0.02	18.61	2.96	23.06	-6
8	000	358	1.59	50.0	330	0.05	9.75	8.10	15.16	15
9	000	179	0.86	0.0	129	0.71	0.00	127.60	48.26	62
10	000	358	0.86	50.0	158	0.66	48.26	118.53	44.15	74
11	000	1611	1.59	85.3	732	2.45	67.22	439.38	322.54	36
12	000	1790	0.00	0.0	0	1.24	322.54	222.59	0.00	100
13	000	179	1.59	0.0	215	1.64	0.00	294.16	151.02	49
14	000	179	0.86	0.0	152	3.69	0.00	661.38	277.33	58
15	000	179	1.59	0.0	240	1.84	0.00	328.66	175.99	46
16	000	716	0.86	84.8	532	3.54	191.15	633.79	412.62	50
17	000	895	0.33	94.4	463	2.90	412.62	518.22	454.58	51
18	000	179	0.86	0.0	167	3.50	0.00	626.15	277.62	56
19	000	179	0.86	0.0	167	3.31	0.00	592.77	262.82	56
20	000	358	1.59	35.1	209	0.64	262.82	114.19	105.13	72
21	000	537	0.00	0.0	0	0.76	105.13	136.15	0.00	100
22	000	179	0.86	0.0	147	1.73	0.00	308.78	126.99	59
23	000	358	0.86	50.0	195	2.00	126.99	357.77	151.72	69
24	000	716	0.86	75.0	326	4.12	429.06	736.73	564.40	52
25	000	179	0.86	0.0	149	2.92	0.00	523.10	217.33	58
26	000	179	0.86	0.0	173	4.39	0.00	786.49	355.63	55
27	000	1074	0.86	87.4	464	2.16	454.58	387.23	450.26	47
28	000	1432	0.86	89.9	559	3.15	727.88	563.12	614.01	52
29	000	1611	0.33	96.2	512	2.14	614.01	382.44	541.59	46
30	000	1790	0.00	0.0	0	1.27	541.59	227.72	0.00	100
31	000	179	0.86	0.0	144	1.74	0.00	310.65	133.03	57
32	000	358	0.86	50.0	183	1.62	133.03	290.70	130.44	69
33	000	1253	0.33	93.9	343	1.17	694.84	209.59	430.80	52
34	000	1611	0.86	88.1	524	5.01	648.12	896.05	827.54	46
35	000	1969	0.00	0.0	0	2.08	1183.17	373.10	0.00	100
36	000	179	0.86	0.0	144	2.00	0.00	357.20	145.16	59
37	000	179	0.00	0.0	0	1.30	0.00	233.26	0.00	100
38	000	179	0.86	0.0	134	0.95	0.00	169.20	65.53	61
39	000	358	0.86	50.0	164	0.95	65.53	169.20	64.09	73
40	000	179	0.86	0.0	123	1.64	0.00	293.44	107.38	63
41	000	179	0.00	0.0	0	0.76	0.00	136.15	0.00	100
42	000	179	0.86	0.0	161	1.96	0.00	350.04	152.11	57
43	000	537	0.00	0.0	0	4.22	297.27	755.49	0.00	100
44	000	179	0.00	0.0	0	1.46	0.00	262.23	0.00	100
45	000	179	0.86	0.0	129	1.31	0.00	234.11	88.47	62
46	000	179	0.33	0.0	57	1.60	0.00	285.53	88.30	69
47	000	716	0.86	70.5	258	1.69	152.39	301.87	188.74	58
48	000	1074	0.33	91.9	314	1.41	296.12	251.56	255.89	53
49	000	179	0.00	0.0	0	0.00	0.00	0.00	0.00	0
50	000	179	0.00	0.0	0	3.25	0.00	581.24	28.42	95

Table A-5 (Continued)

51	000	358	0.00	0.0	0	0.83	88.47	147.71	0.00	100
52	000	179	0.86	0.0	159	2.95	0.00	528.52	227.35	57
53	000	358	0.86	50.0	191	1.34	227.35	239.99	127.19	73
54	000	1611	0.86	87.1	327	0.79	383.08	141.86	215.02	59
55	000	179	3.00	0.0	319	0.00	0.00	0.00	0.52	-100
56	000	358	0.86	0.0	75	0.67	28.42	120.30	1.46	99
57	000	179	0.00	0.0	0	1.38	0.00	247.32	0.00	100
58	000	1790	0.00	0.0	0	1.26	215.02	225.52	0.00	100
59	000	358	0.86	77.8	315	0.76	0.52	136.15	63.26	54
60	000	537	0.00	0.0	0	0.87	1.46	155.59	0.00	100
61	000	895	0.00	0.0	0	2.02	185.50	360.79	0.00	100
62	000	358	0.86	50.0	169	1.04	245.13	185.44	122.24	72
63	000	179	0.86	0.0	167	2.95	0.00	527.99	245.13	54

Table A-6: Summary of Model Output for Storm B (2 in. precipitation, 4 hr. duration)

Initial Data:

Area of the Watershed (acres)	11,277
Area of Each Cell	179
Total Number of Cells	63
Storm Precipitation (in.)	2.00
Storm Duration (hrs)	4.00
Storm Energy-Intensity Value	45.00

Values at the Watershed Outlet:

Cell Number	13
Runoff Volume (inches)	0.80
Peak Runoff Rate (cfs)	115

Sediment Analysis:

	Area Weighted Erosion				Mean	Area	
	Upland (t/a)	Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Concentration (ppm)	Weighted Yield (t/a)	Yield (tons)
CLAY	2.08	0.01	2	2	456.98	0.04	7.4
SILT	3.33	0.00	2	2	651.63	0.06	10.5
SAGG	20.79	0.00	1	1	2879.98	0.26	46.4
LAGG	12.89	0.03	0	0	154.34	0.01	2.5
SAND	2.49	0.01	0	0	29.40	0.00	0.5
TOTAL	41.58	0.01	1	1	4172.34	0.38	67.3

Table A-7: Output for Storm B (2 in. precipitation, 4 hr. duration)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
1	000	179	0.38	0.00	0	0.38	82
2	000	358	0.80	0.38	77	0.59	136
3	000	179	0.38	0.00	0	0.38	70
4	000	179	0.80	0.00	0	0.80	150
5	000	179	0.80	0.00	0	0.80	150
6	000	895	0.52	0.59	235	0.57	231
7	000	1074	0.52	0.57	196	0.57	209
8	000	358	0.80	0.80	143	0.80	176
9	000	179	0.32	0.00	0	0.32	53
10	000	358	0.32	0.32	53	0.32	65
11	000	1611	0.80	0.50	316	0.54	347
12	000	1790	0.00	0.54	281	0.00	0
13	000	179	0.80	0.00	0	0.80	115
14	000	179	0.32	0.00	0	0.32	63
15	000	179	0.80	0.00	0	0.80	129
16	000	716	0.32	0.80	282	0.68	272
17	000	895	0.06	0.68	250	0.55	228
18	000	179	0.32	0.00	0	0.32	69
19	000	179	0.32	0.00	0	0.32	69
20	000	358	0.80	0.32	50	0.56	102
21	000	537	0.00	0.56	102	0.00	0
22	000	179	0.32	0.00	0	0.32	61
23	000	358	0.32	0.32	65	0.32	80
24	000	716	0.32	0.32	118	0.32	132
25	000	179	0.32	0.00	0	0.32	62
26	000	179	0.32	0.00	0	0.32	71
27	000	1074	0.32	0.55	220	0.51	223
28	000	1432	0.32	0.49	263	0.47	259
29	000	1611	0.06	0.47	247	0.42	232
30	000	1790	0.00	0.42	194	0.00	0
31	000	179	0.32	0.00	0	0.32	60
32	000	358	0.32	0.32	61	0.32	75
33	000	1253	0.06	0.32	145	0.28	134
34	000	1611	0.32	0.29	203	0.29	205
35	000	1969	0.00	0.29	195	0.00	0
36	000	179	0.32	0.00	0	0.32	60
37	000	179	0.00	0.00	0	0.00	0
38	000	179	0.32	0.00	0	0.32	55
39	000	358	0.32	0.32	55	0.32	67
40	000	179	0.32	0.00	0	0.32	51
41	000	179	0.00	0.00	0	0.00	0
42	000	179	0.32	0.00	0	0.32	66
43	000	537	0.00	0.32	130	0.00	0
44	000	179	0.00	0.00	0	0.00	0
45	000	179	0.32	0.00	0	0.32	53
46	000	179	0.06	0.00	0	0.06	12
47	000	716	0.32	0.23	82	0.26	99
48	000	1074	0.06	0.27	125	0.23	117
49	000	179	0.00	0.00	0	0.00	0
50	000	179	0.00	0.00	0	0.00	0
51	000	358	0.00	0.32	47	0.00	0

Table A-7 (Continued)

52 000	179	0.32	0.00	0	0.32	66
53 000	358	0.32	0.32	64	0.32	78
54 000	1611	0.32	0.26	122	0.26	124
55 000	179	2.00	0.00	0	2.00	222
56 000	358	0.32	0.00	0	0.16	31
57 000	179	0.00	0.00	0	0.00	0
58 000	1790	0.00	0.26	148	0.00	0
59 000	358	0.32	2.00	263	1.16	199
60 000	537	0.00	0.16	30	0.00	0
61 000	895	0.00	0.74	278	0.00	0
62 000	358	0.32	0.32	56	0.32	69
63 000	179	0.32	0.00	0	0.32	69

Table A-8: Output for Storm B (2 in. precipitation, 4 hr. duration)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
1	000	CLAY	0.00	0.00	0.36	0.45	-20
		SILT	0.00	0.00	0.58	0.62	-6
		SAGG	0.02	0.00	3.63	2.64	27
		LAGG	0.01	0.00	2.25	0.49	78
		SAND	0.00	0.00	0.44	0.13	69
		TOTL	0.04	0.00	7.26	4.34	40
2	000	CLAY	0.00	0.45	0.22	0.67	1
		SILT	0.00	0.62	0.35	0.81	16
		SAGG	0.01	2.64	2.22	1.72	65
		LAGG	0.01	0.49	1.37	2.50	-25
		SAND	0.00	0.13	0.27	0.81	-51
		TOTL	0.02	4.34	4.43	6.52	26
3	000	CLAY	0.00	0.00	0.13	0.21	-40
		SILT	0.00	0.00	0.20	0.26	-23
		SAGG	0.01	0.00	1.27	0.88	31
		LAGG	0.00	0.00	0.79	0.39	51
		SAND	0.00	0.00	0.15	0.12	24
		TOTL	0.01	0.00	2.54	1.86	27
4	000	CLAY	0.00	0.00	0.37	0.47	-22
		SILT	0.00	0.00	0.59	0.65	-9
		SAGG	0.02	0.00	3.68	2.86	22
		LAGG	0.01	0.00	2.28	0.57	75
		SAND	0.00	0.00	0.44	0.16	65
		TOTL	0.04	0.00	7.36	4.71	36
5	000	CLAY	0.00	0.00	0.20	0.31	-34
		SILT	0.00	0.00	0.33	0.41	-20
		SAGG	0.01	0.00	2.05	1.65	20
		LAGG	0.01	0.00	1.27	0.52	59
		SAND	0.00	0.00	0.25	0.15	40
		TOTL	0.02	0.00	4.09	3.03	26
6	000	CLAY	0.00	1.20	0.17	1.36	0
		SILT	0.00	1.49	0.27	1.52	13
		SAGG	0.01	4.25	1.66	2.57	57
		LAGG	0.01	3.40	1.03	2.58	42
		SAND	0.00	1.07	0.20	0.80	37
		TOTL	0.02	11.40	3.33	8.83	40
7	000	CLAY	0.00	1.36	0.07	1.42	0
		SILT	0.00	1.52	0.12	1.52	7
		SAGG	0.00	2.57	0.73	2.11	36
		LAGG	0.00	2.58	0.45	5.69	-47
		SAND	0.00	0.80	0.09	1.80	-50
		TOTL	0.01	8.83	1.45	12.53	-18
8	000	CLAY	0.00	0.47	0.20	0.71	-5
		SILT	0.00	0.65	0.32	0.89	9
		SAGG	0.01	2.86	1.99	2.21	54
		LAGG	0.01	0.57	1.23	3.43	-47
		SAND	0.00	0.16	0.24	1.10	-64
		TOTL	0.02	4.71	3.98	8.34	4
9	000	CLAY	0.02	0.00	3.13	3.10	1
		SILT	0.03	0.00	5.01	3.70	26
		SAGG	0.18	0.00	31.34	11.65	63
		LAGG	0.11	0.00	19.43	0.29	99
		SAND	0.02	0.00	3.76	0.04	99
		TOTL	0.35	0.00	62.67	18.78	70

Table A-8 (Continued)

10 000	CLAY	0.02	3.10	2.91	5.78	4
	SILT	0.03	3.70	4.66	3.46	59
	SAGG	0.16	11.65	29.11	6.69	84
	LAGG	0.10	0.29	18.05	0.20	99
	SAND	0.02	0.04	3.49	0.04	99
	TOTL	0.33	18.78	58.22	16.17	79
11 000	CLAY	0.06	7.20	10.79	17.95	0
	SILT	0.10	4.98	17.27	20.97	6
	SAGG	0.60	8.80	107.91	91.94	21
	LAGG	0.37	5.89	66.90	10.23	86
	SAND	0.07	1.84	12.95	2.24	85
	TOTL	1.21	28.71	215.82	143.33	41
12 000	CLAY	0.03	17.95	5.47	0.00	100
	SILT	0.05	20.97	8.75	0.00	100
	SAGG	0.31	91.94	54.67	0.00	100
	LAGG	0.19	10.23	33.89	0.00	100
	SAND	0.04	2.24	6.56	0.00	100
	TOTL	0.61	143.33	109.33	0.00	100
13 000	CLAY	0.04	0.00	7.22	7.37	-2
	SILT	0.06	0.00	11.56	10.50	9
	SAGG	0.40	0.00	72.24	46.42	36
	LAGG	0.25	0.00	44.79	2.49	94
	SAND	0.05	0.00	8.67	0.47	95
	TOTL	0.81	0.00	144.49	67.26	53
14 000	CLAY	0.09	0.00	16.24	16.08	1
	SILT	0.15	0.00	25.99	20.53	21
	SAGG	0.91	0.00	162.43	71.70	56
	LAGG	0.56	0.00	100.71	1.82	98
	SAND	0.11	0.00	19.49	0.26	99
	TOTL	1.81	0.00	324.86	110.39	66
15 000	CLAY	0.05	0.00	8.07	8.18	-1
	SILT	0.07	0.00	12.91	11.91	8
	SAGG	0.45	0.00	80.72	55.39	31
	LAGG	0.28	0.00	50.05	2.97	94
	SAND	0.05	0.00	9.69	0.52	95
	TOTL	0.90	0.00	161.44	78.98	51
16 000	CLAY	0.09	8.89	15.57	24.29	1
	SILT	0.14	12.80	24.91	31.98	15
	SAGG	0.87	57.60	155.66	111.02	48
	LAGG	0.54	6.40	96.51	3.58	97
	SAND	0.10	1.62	18.68	0.52	97
	TOTL	1.74	87.31	311.31	171.40	57
17 000	CLAY	0.07	24.29	12.73	36.66	1
	SILT	0.11	31.98	20.36	41.15	21
	SAGG	0.71	111.02	127.27	91.83	61
	LAGG	0.44	3.58	78.91	2.43	97
	SAND	0.09	0.52	15.27	0.37	98
	TOTL	1.42	171.40	254.55	172.44	60
18 000	CLAY	0.09	0.00	15.38	15.25	1
	SILT	0.14	0.00	24.60	20.10	18
	SAGG	0.86	0.00	153.78	74.43	52
	LAGG	0.53	0.00	95.34	2.03	98
	SAND	0.10	0.00	18.45	0.29	98
	TOTL	1.72	0.00	307.56	112.10	64
19 000	CLAY	0.08	0.00	14.56	14.44	1
	SILT	0.13	0.00	23.29	19.03	18
	SAGG	0.81	0.00	145.58	70.46	52
	LAGG	0.50	0.00	90.26	1.93	98
	SAND	0.10	0.00	17.47	0.27	98
	TOTL	1.63	0.00	291.16	106.12	64

Table A-8 (Continued)

20 000	CLAY	0.02	14.44	2.80	16.83	2
	SILT	0.03	19.03	4.49	12.03	49
	SAGG	0.16	70.46	28.04	9.88	90
	LAGG	0.10	1.93	17.39	1.96	90
	SAND	0.02	0.27	3.37	0.73	80
	TOTL	0.31	106.12	56.09	41.44	74
21 000	CLAY	0.02	16.83	3.34	0.00	100
	SILT	0.03	12.03	5.35	0.00	100
	SAGG	0.19	9.88	33.44	0.00	100
	LAGG	0.12	1.96	20.73	0.00	100
	SAND	0.02	0.73	4.01	0.00	100
	TOTL	0.37	41.44	66.88	0.00	100
22 000	CLAY	0.04	0.00	7.58	7.51	1
	SILT	0.07	0.00	12.13	9.47	22
	SAGG	0.42	0.00	75.83	32.40	57
	LAGG	0.26	0.00	47.02	0.82	98
	SAND	0.05	0.00	9.10	0.12	99
	TOTL	0.85	0.00	151.67	50.31	67
23 000	CLAY	0.05	7.51	8.79	15.88	3
	SILT	0.08	9.47	14.06	13.09	44
	SAGG	0.49	32.40	87.87	27.99	77
	LAGG	0.30	0.82	54.48	0.61	99
	SAND	0.06	0.12	10.54	0.09	99
	TOTL	0.98	50.31	175.73	57.67	74
24 000	CLAY	0.10	31.96	18.09	49.46	1
	SILT	0.16	33.62	28.95	47.34	24
	SAGG	1.01	99.69	180.94	100.40	64
	LAGG	0.63	2.44	112.18	3.01	97
	SAND	0.12	0.35	21.71	0.45	98
	TOTL	2.02	168.06	361.88	200.67	62
25 000	CLAY	0.07	0.00	12.85	12.72	1
	SILT	0.11	0.00	20.56	16.14	21
	SAGG	0.72	0.00	128.47	55.84	57
	LAGG	0.44	0.00	79.65	1.41	98
	SAND	0.09	0.00	15.42	0.20	99
	TOTL	1.44	0.00	256.94	86.31	66
26 000	CLAY	0.11	0.00	19.32	19.16	1
	SILT	0.17	0.00	30.91	25.54	17
	SAGG	1.08	0.00	193.16	96.58	50
	LAGG	0.67	0.00	119.76	2.71	98
	SAND	0.13	0.00	23.18	0.38	98
	TOTL	2.16	0.00	386.31	144.37	63
27 000	CLAY	0.05	36.66	9.51	45.71	1
	SILT	0.09	41.15	15.22	44.07	22
	SAGG	0.53	91.83	95.10	73.46	61
	LAGG	0.33	2.43	58.96	2.23	96
	SAND	0.06	0.37	11.41	0.38	97
	TOTL	1.06	172.44	190.20	165.85	54
28 000	CLAY	0.08	60.96	13.83	73.77	1
	SILT	0.12	64.17	22.13	61.79	28
	SAGG	0.77	147.88	138.30	77.76	73
	LAGG	0.48	4.27	85.75	2.19	98
	SAND	0.09	0.66	16.60	0.34	98
	TOTL	1.55	277.95	276.60	215.84	61
29 000	CLAY	0.05	73.77	9.39	82.04	1
	SILT	0.08	61.79	15.03	55.19	28
	SAGG	0.52	77.76	93.93	55.20	68
	LAGG	0.33	2.19	58.23	1.83	97
	SAND	0.06	0.34	11.27	0.33	97
	TOTL	1.05	215.84	187.85	194.59	52

Table A-8 (Continued)

30 000	CLAY	0.03	82.04	5.59	0.00	100
	SILT	0.05	55.19	8.95	0.00	100
	SAGG	0.31	55.20	55.93	0.00	100
	LAGG	0.19	1.83	34.67	0.00	100
	SAND	0.04	0.33	6.71	0.00	100
	TOTL	0.62	194.59	111.85	0.00	100
31 000	CLAY	0.04	0.00	7.63	7.56	1
	SILT	0.07	0.00	12.21	9.77	20
	SAGG	0.43	0.00	76.30	34.83	54
	LAGG	0.26	0.00	47.30	0.94	98
	SAND	0.05	0.00	9.16	0.14	99
	TOTL	0.85	0.00	152.59	53.24	65
32 000	CLAY	0.04	7.56	7.14	14.33	3
	SILT	0.06	9.77	11.42	11.61	45
	SAGG	0.40	34.83	71.40	23.03	78
	LAGG	0.25	0.94	44.27	0.56	99
	SAND	0.05	0.14	8.57	0.10	99
	TOTL	0.80	53.24	142.79	49.63	75
33 000	CLAY	0.03	63.79	5.15	67.74	2
	SILT	0.05	58.95	8.24	43.29	36
	SAGG	0.29	123.43	51.47	23.76	86
	LAGG	0.18	3.57	31.91	0.88	98
	SAND	0.03	0.55	6.18	0.19	97
	TOTL	0.58	250.30	102.95	135.85	62
34 000	CLAY	0.12	80.46	22.01	101.14	1
	SILT	0.20	59.43	35.21	70.35	26
	SAGG	1.23	79.60	220.06	121.10	60
	LAGG	0.76	2.28	136.44	3.68	97
	SAND	0.15	0.39	26.41	0.56	98
	TOTL	2.46	222.16	440.13	296.82	55
35 000	CLAY	0.05	120.31	9.16	0.00	100
	SILT	0.08	95.88	14.66	0.00	100
	SAGG	0.51	217.67	91.63	0.00	100
	LAGG	0.32	6.39	56.81	0.00	100
	SAND	0.06	0.94	11.00	0.00	100
	TOTL	1.02	441.19	183.26	0.00	100
36 000	CLAY	0.05	0.00	8.77	8.68	1
	SILT	0.08	0.00	14.04	10.87	23
	SAGG	0.49	0.00	87.73	36.76	58
	LAGG	0.30	0.00	54.39	0.91	98
	SAND	0.06	0.00	10.53	0.13	99
	TOTL	0.98	0.00	175.45	57.35	67
37 000	CLAY	0.03	0.00	5.73	0.00	100
	SILT	0.05	0.00	9.17	0.00	100
	SAGG	0.32	0.00	57.29	0.00	100
	LAGG	0.20	0.00	35.52	0.00	100
	SAND	0.04	0.00	6.87	0.00	100
	TOTL	0.64	0.00	114.57	0.00	100
38 000	CLAY	0.02	0.00	4.16	4.11	1
	SILT	0.04	0.00	6.65	4.99	25
	SAGG	0.23	0.00	41.55	16.07	61
	LAGG	0.14	0.00	25.76	0.39	98
	SAND	0.03	0.00	4.99	0.06	99
	TOTL	0.46	0.00	83.11	25.62	69
39 000	CLAY	0.02	4.11	4.16	7.97	4
	SILT	0.04	4.99	6.65	5.15	56
	SAGG	0.23	16.07	41.55	10.20	82
	LAGG	0.14	0.39	25.76	0.26	99
	SAND	0.03	0.06	4.99	0.05	99
	TOTL	0.46	25.62	83.11	23.63	78

Table A-8 (Continued)

40 000	CLAY	0.04	0.00	7.21	7.11	1
	SILT	0.06	0.00	11.53	8.32	28
	SAGG	0.40	0.00	72.07	25.41	65
	LAGG	0.25	0.00	44.68	0.58	99
	SAND	0.05	0.00	8.65	0.09	99
	TOTL	0.81	0.00	144.14	41.50	71
41 000	CLAY	0.02	0.00	3.34	0.00	100
	SILT	0.03	0.00	5.35	0.00	100
	SAGG	0.19	0.00	33.44	0.00	100
	LAGG	0.12	0.00	20.73	0.00	100
	SAND	0.02	0.00	4.01	0.00	100
	TOTL	0.37	0.00	66.88	0.00	100
42 000	CLAY	0.05	0.00	8.60	8.52	1
	SILT	0.08	0.00	13.75	11.10	19
	SAGG	0.48	0.00	85.97	40.24	53
	LAGG	0.30	0.00	53.30	1.08	98
	SAND	0.06	0.00	10.32	0.15	99
	TOTL	0.96	0.00	171.94	61.09	64
43 000	CLAY	0.10	17.20	18.55	0.00	100
	SILT	0.17	21.97	29.69	0.00	100
	SAGG	1.04	77.00	185.54	0.00	100
	LAGG	0.64	1.99	115.04	0.00	100
	SAND	0.12	0.28	22.27	0.00	100
	TOTL	2.07	118.44	371.09	0.00	100
44 000	CLAY	0.04	0.00	6.44	0.00	100
	SILT	0.06	0.00	10.30	0.00	100
	SAGG	0.36	0.00	64.40	0.00	100
	LAGG	0.22	0.00	39.93	0.00	100
	SAND	0.04	0.00	7.73	0.00	100
	TOTL	0.72	0.00	128.80	0.00	100
45 000	CLAY	0.03	0.00	5.75	5.68	1
	SILT	0.05	0.00	9.20	6.79	26
	SAGG	0.32	0.00	57.50	21.37	63
	LAGG	0.20	0.00	35.65	0.50	99
	SAND	0.04	0.00	6.90	0.07	99
	TOTL	0.64	0.00	114.99	34.41	70
46 000	CLAY	0.04	0.00	7.01	6.79	3
	SILT	0.06	0.00	11.22	6.03	46
	SAGG	0.39	0.00	70.12	13.78	80
	LAGG	0.24	0.00	43.48	0.25	99
	SAND	0.05	0.00	8.41	0.04	100
	TOTL	0.78	0.00	140.25	26.89	81
47 000	CLAY	0.04	14.76	7.41	21.75	2
	SILT	0.07	11.18	11.86	15.20	34
	SAGG	0.41	23.98	74.14	31.70	68
	LAGG	0.26	0.51	45.97	0.86	98
	SAND	0.05	0.09	8.90	0.14	98
	TOTL	0.83	50.52	148.28	69.65	65
48 000	CLAY	0.03	28.86	6.18	34.44	2
	SILT	0.06	23.52	9.89	22.26	33
	SAGG	0.35	57.11	61.78	28.09	76
	LAGG	0.21	1.44	38.30	0.81	98
	SAND	0.04	0.22	7.41	0.13	98
	TOTL	0.69	111.15	123.56	85.73	63
49 000	CLAY	0.00	0.00	0.00	0.00	0
	SILT	0.00	0.00	0.00	0.00	0
	SAGG	0.00	0.00	0.00	0.00	0
	LAGG	0.00	0.00	0.00	0.00	0
	SAND	0.00	0.00	0.00	0.00	0
	TOTL	0.00	0.00	0.00	0.00	0

Table A-8 (Continued)

50 000	CLAY	0.08	0.00	14.27	9.72	32
	SILT	0.13	0.00	22.84	1.75	92
	SAGG	0.80	0.00	142.75	2.45	98
	LAGG	0.49	0.00	88.50	0.04	100
	SAND	0.10	0.00	17.13	0.01	100
	TOTL	1.59	0.00	285.50	13.96	95
51 000	CLAY	0.02	5.68	3.63	0.00	100
	SILT	0.03	6.79	5.80	0.00	100
	SAGG	0.20	21.37	36.28	0.00	100
	LAGG	0.13	0.50	22.49	0.00	100
	SAND	0.02	0.07	4.35	0.00	100
	TOTL	0.41	34.41	72.55	0.00	100
52 000	CLAY	0.07	0.00	12.98	12.86	1
	SILT	0.12	0.00	20.77	16.66	20
	SAGG	0.73	0.00	129.80	59.76	54
	LAGG	0.45	0.00	80.48	1.57	98
	SAND	0.09	0.00	15.58	0.22	99
	TOTL	1.45	0.00	259.60	91.07	65
53 000	CLAY	0.03	12.86	5.89	18.18	3
	SILT	0.05	16.66	9.43	11.95	54
	SAGG	0.33	59.76	58.94	17.24	85
	LAGG	0.20	1.57	36.54	0.35	99
	SAND	0.04	0.22	7.07	0.06	99
	TOTL	0.66	91.07	117.88	47.77	77
54 000	CLAY	0.02	52.61	3.48	54.11	4
	SILT	0.03	34.21	5.57	15.75	60
	SAGG	0.19	45.32	34.84	9.79	88
	LAGG	0.12	1.16	21.60	0.48	98
	SAND	0.02	0.19	4.18	0.12	97
	TOTL	0.39	133.50	69.68	80.24	61
55 000	CLAY	0.00	0.00	0.00	0.05	-100
	SILT	0.00	0.00	0.00	0.05	-100
	SAGG	0.00	0.00	0.00	0.06	-100
	LAGG	0.00	0.00	0.00	0.20	-100
	SAND	0.00	0.00	0.00	0.06	-100
	TOTL	0.00	0.00	0.00	0.42	-100
56 000	CLAY	0.02	9.72	2.95	0.10	99
	SILT	0.03	1.75	4.73	0.10	98
	SAGG	0.17	2.45	29.54	0.12	100
	LAGG	0.10	0.04	18.32	0.41	98
	SAND	0.02	0.01	3.55	0.13	96
	TOTL	0.33	13.96	59.09	0.86	99
57 000	CLAY	0.03	0.00	6.07	0.00	100
	SILT	0.05	0.00	9.72	0.00	100
	SAGG	0.34	0.00	60.74	0.00	100
	LAGG	0.21	0.00	37.66	0.00	100
	SAND	0.04	0.00	7.29	0.00	100
	TOTL	0.68	0.00	121.48	0.00	100
58 000	CLAY	0.03	54.11	5.54	0.00	100
	SILT	0.05	15.75	8.86	0.00	100
	SAGG	0.31	9.79	55.39	0.00	100
	LAGG	0.19	0.48	34.34	0.00	100
	SAND	0.04	0.12	6.65	0.00	100
	TOTL	0.62	80.24	110.77	0.00	100
59 000	CLAY	0.02	0.05	3.34	3.64	-7
	SILT	0.03	0.05	5.35	4.78	12
	SAGG	0.19	0.06	33.44	17.55	48
	LAGG	0.12	0.20	20.73	3.03	86
	SAND	0.02	0.06	4.01	0.87	79
	TOTL	0.37	0.42	66.88	29.86	56

Table A-8 (Continued)

60 000	CLAY	0.02	0.10	3.82	0.00	100
	SILT	0.03	0.10	6.11	0.00	100
	SAGG	0.21	0.12	38.21	0.00	100
	LAGG	0.13	0.41	23.69	0.00	100
	SAND	0.03	0.13	4.59	0.00	100
	TOTL	0.43	0.86	76.43	0.00	100
61 000	CLAY	0.05	20.65	8.86	0.00	100
	SILT	0.08	18.08	14.18	0.00	100
	SAGG	0.50	33.40	88.61	0.00	100
	LAGG	0.31	3.83	54.94	0.00	100
	SAND	0.06	1.08	10.63	0.00	100
	TOTL	0.99	77.05	177.22	0.00	100
62 000	CLAY	0.03	12.88	4.55	17.01	2
	SILT	0.04	17.40	7.29	13.31	46
	SAGG	0.25	67.69	45.54	15.85	86
	LAGG	0.16	2.00	28.24	0.80	97
	SAND	0.03	0.28	5.47	0.21	96
	TOTL	0.51	100.26	91.09	47.19	75
63 000	CLAY	0.07	0.00	12.97	12.88	1
	SILT	0.12	0.00	20.75	17.40	16
	SAGG	0.72	0.00	129.67	67.69	48
	LAGG	0.45	0.00	80.40	2.00	98
	SAND	0.09	0.00	15.56	0.28	98
	TOTL	1.45	0.00	259.34	100.26	61

Table A-9: Output for Storm B (2 in. precipitation, 4 hr. duration)

Condensed Soil Loss

Cell Num	Div	Drainage Area (acres)	RUNOFF Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
1	000	179	0.38	0.0	82	0.04	0.00	7.26	4.34	40
2	000	358	0.80	32.4	136	0.02	4.34	4.43	6.52	26
3	000	179	0.38	0.0	70	0.01	0.00	2.54	1.86	27
4	000	179	0.80	0.0	150	0.04	0.00	7.36	4.71	36
5	000	179	0.80	0.0	150	0.02	0.00	4.09	3.03	26
6	000	895	0.52	81.8	231	0.02	11.40	3.33	8.83	40
7	000	1074	0.52	84.6	209	0.01	8.83	1.45	12.53	-18
8	000	358	0.80	50.0	176	0.02	4.71	3.98	8.34	4
9	000	179	0.32	0.0	53	0.35	0.00	62.67	18.78	70
10	000	358	0.32	50.0	65	0.33	18.78	58.22	16.17	79
11	000	1611	0.80	83.5	347	1.21	28.71	215.82	143.33	41
12	000	1790	0.00	0.0	0	0.61	143.33	109.33	0.00	100
13	000	179	0.80	0.0	115	0.81	0.00	144.49	67.26	53
14	000	179	0.32	0.0	63	1.81	0.00	324.86	110.39	66
15	000	179	0.80	0.0	129	0.90	0.00	161.44	78.98	51
16	000	716	0.32	88.2	272	1.74	87.31	311.31	171.40	57
17	000	895	0.06	97.8	228	1.42	171.40	254.55	172.44	60
18	000	179	0.32	0.0	69	1.72	0.00	307.56	112.10	64
19	000	179	0.32	0.0	69	1.63	0.00	291.16	106.12	64
20	000	358	0.80	28.7	102	0.31	106.12	56.09	41.44	74
21	000	537	0.00	0.0	0	0.37	41.44	66.88	0.00	100
22	000	179	0.32	0.0	61	0.85	0.00	151.67	50.31	67
23	000	358	0.32	50.0	80	0.98	50.31	175.73	57.67	74
24	000	716	0.32	75.0	132	2.02	168.06	361.88	200.67	62
25	000	179	0.32	0.0	62	1.44	0.00	256.94	86.31	66
26	000	179	0.32	0.0	71	2.16	0.00	386.31	144.37	63
27	000	1074	0.32	89.6	223	1.06	172.44	190.20	165.85	54
28	000	1432	0.32	91.4	259	1.55	277.95	276.60	215.84	61
29	000	1611	0.06	98.4	232	1.05	215.84	187.85	194.59	52
30	000	1790	0.00	0.0	0	0.62	194.59	111.85	0.00	100
31	000	179	0.32	0.0	60	0.85	0.00	152.59	53.24	65
32	000	358	0.32	50.0	75	0.80	53.24	142.79	49.63	75
33	000	1253	0.06	96.9	134	0.58	250.30	102.95	135.85	62
34	000	1611	0.32	87.8	205	2.46	222.16	440.13	296.82	55
35	000	1969	0.00	0.0	0	1.02	441.19	183.26	0.00	100
36	000	179	0.32	0.0	60	0.98	0.00	175.45	57.35	67
37	000	179	0.00	0.0	0	0.64	0.00	114.57	0.00	100
38	000	179	0.32	0.0	55	0.46	0.00	83.11	25.62	69
39	000	358	0.32	50.0	67	0.46	25.62	83.11	23.63	78
40	000	179	0.32	0.0	51	0.81	0.00	144.14	41.50	71
41	000	179	0.00	0.0	0	0.37	0.00	66.88	0.00	100
42	000	179	0.32	0.0	66	0.96	0.00	171.94	61.09	64
43	000	537	0.00	0.0	0	2.07	118.44	371.09	0.00	100
44	000	179	0.00	0.0	0	0.72	0.00	128.80	0.00	100
45	000	179	0.32	0.0	53	0.64	0.00	114.99	34.41	70
46	000	179	0.06	0.0	12	0.78	0.00	140.25	26.89	81
47	000	716	0.32	68.6	99	0.83	50.52	148.28	69.65	65
48	000	1074	0.06	95.7	117	0.69	111.15	123.56	85.73	63
49	000	179	0.00	0.0	0	0.00	0.00	0.00	0.00	0
50	000	179	0.00	0.0	0	1.59	0.00	285.50	13.96	95

Table A-9 (Continued)

51	000	358	0.00	0.0	0	0.41	34.41	72.55	0.00	100
52	000	179	0.32	0.0	66	1.45	0.00	259.60	91.07	65
53	000	358	0.32	50.0	78	0.66	91.07	117.88	47.77	77
54	000	1611	0.32	86.4	124	0.39	133.50	69.68	80.24	61
55	000	179	2.00	0.0	222	0.00	0.00	0.00	0.42	-100
56	000	358	0.32	0.0	31	0.33	13.96	59.09	0.86	99
57	000	179	0.00	0.0	0	0.68	0.00	121.48	0.00	100
58	000	1790	0.00	0.0	0	0.62	80.24	110.77	0.00	100
59	000	358	0.32	86.2	199	0.37	0.42	66.88	29.86	56
60	000	537	0.00	0.0	0	0.43	0.86	76.43	0.00	100
61	000	895	0.00	0.0	0	0.99	77.05	177.22	0.00	100
62	000	358	0.32	50.0	69	0.51	100.26	91.09	47.19	75
63	000	179	0.32	0.0	69	1.45	0.00	259.34	100.26	61

Table A-10: Summary of Model Output for Storm C (1 in. precipitation, 1 hr. duration)

Initial Data:

Area of the Watershed (acres)	11,277
Area of Each Cell	179
Total Number of Cells	63
Storm Precipitation (in.)	1.00
Storm Duration (hrs)	1.00
Storm Energy-Intensity Value	18.00

Values at the Watershed Outlet:

Cell Number	13
Runoff Volume (inches)	0.20
Peak Runoff Rate (cfs)	29

Sediment Analysis:

	Area Weighted Erosion				Mean	Area	
	Upland (t/a)	Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Concentration (ppm)	Weighted Yield (t/a)	Yield (tons)
CLAY	0.83	0.00	2	2	836.12	0.02	2.9
SILT	1.33	0.00	2	2	1051.60	0.02	3.7
SAGG	8.34	0.00	1	1	3571.55	0.07	12.6
LAGG	5.17	0.01	0	0	175.41	0.00	0.6
SAND	1.00	0.01	0	0	39.71	0.00	0.1
TOTAL	16.69	0.01	1	1	5674.39	0.11	20.0

Table A-11: Output for Storm C (1 in. precipitation, 1 hr. duration)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
1	000	179	0.03	0.00	0	0.03	8
2	000	358	0.17	0.03	7	0.10	28
3	000	179	0.03	0.00	0	0.03	7
4	000	179	0.17	0.00	0	0.17	38
5	000	179	0.17	0.00	0	0.17	38
6	000	895	0.07	0.10	47	0.10	44
7	000	1074	0.07	0.10	37	0.09	39
8	000	358	0.17	0.17	36	0.17	44
9	000	179	0.02	0.00	0	0.02	4
10	000	358	0.02	0.02	3	0.02	5
11	000	1611	0.17	0.07	52	0.08	62
12	000	1790	0.00	0.08	50	0.00	0
13	000	179	0.17	0.00	0	0.17	29
14	000	179	0.02	0.00	0	0.02	5
15	000	179	0.17	0.00	0	0.17	33
16	000	716	0.02	0.17	70	0.13	62
17	000	895	0.00	0.13	56	0.11	50
18	000	179	0.02	0.00	0	0.02	5
19	000	179	0.02	0.00	0	0.02	5
20	000	358	0.17	0.02	3	0.10	21
21	000	537	0.00	0.10	20	0.00	0
22	000	179	0.02	0.00	0	0.02	4
23	000	358	0.02	0.02	4	0.02	6
24	000	716	0.02	0.02	8	0.02	9
25	000	179	0.02	0.00	0	0.02	4
26	000	179	0.02	0.00	0	0.02	5
27	000	1074	0.02	0.11	48	0.09	46
28	000	1432	0.02	0.08	50	0.07	47
29	000	1611	0.00	0.07	44	0.07	41
30	000	1790	0.00	0.07	34	0.00	0
31	000	179	0.02	0.00	0	0.02	4
32	000	358	0.02	0.02	4	0.02	5
33	000	1253	0.00	0.02	9	0.01	9
34	000	1611	0.02	0.01	13	0.02	13
35	000	1969	0.00	0.02	12	0.00	0
36	000	179	0.02	0.00	0	0.02	4
37	000	179	0.00	0.00	0	0.00	0
38	000	179	0.02	0.00	0	0.02	4
39	000	358	0.02	0.02	3	0.02	5
40	000	179	0.02	0.00	0	0.02	4
41	000	179	0.00	0.00	0	0.00	0
42	000	179	0.02	0.00	0	0.02	5
43	000	537	0.00	0.02	9	0.00	0
44	000	179	0.00	0.00	0	0.00	0
45	000	179	0.02	0.00	0	0.02	4
46	000	179	0.00	0.00	0	0.00	0
47	000	716	0.02	0.01	5	0.01	6
48	000	1074	0.00	0.01	8	0.01	7
49	000	179	0.00	0.00	0	0.00	0
50	000	179	0.00	0.00	0	0.00	0
51	000	358	0.00	0.02	3	0.00	0

Table A-11 (Continued)

52 000	179	0.02	0.00	0	0.02	5
53 000	358	0.02	0.02	4	0.02	5
54 000	1611	0.02	0.01	7	0.01	8
55 000	179	1.00	0.00	0	1.00	119
56 000	358	0.02	0.00	0	0.01	2
57 000	179	0.00	0.00	0	0.00	0
58 000	1790	0.00	0.01	9	0.00	0
59 000	358	0.02	1.00	141	0.51	94
60 000	537	0.00	0.01	2	0.00	0
61 000	895	0.00	0.26	107	0.00	0
62 000	358	0.02	0.02	4	0.02	5
63 000	179	0.02	0.00	0	0.02	5

Table A-12: Output for Storm C (1 in. precipitation, 1 hr. duration)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
1	000	CLAY	0.00	0.00	0.15	0.17	-12
		SILT	0.00	0.00	0.23	0.19	18
		SAGG	0.01	0.00	1.46	0.55	62
		LAGG	0.01	0.00	0.90	0.10	89
		SAND	0.00	0.00	0.17	0.03	83
		TOTL	0.02	0.00	2.91	1.04	64
2	000	CLAY	0.00	0.17	0.09	0.25	3
		SILT	0.00	0.19	0.14	0.24	29
		SAGG	0.00	0.55	0.89	0.45	69
		LAGG	0.00	0.10	0.55	1.04	-37
		SAND	0.00	0.03	0.11	0.33	-59
		TOTL	0.01	1.04	1.78	2.31	18
3	000	CLAY	0.00	0.00	0.05	0.07	-28
		SILT	0.00	0.00	0.08	0.07	11
		SAGG	0.00	0.00	0.51	0.17	68
		LAGG	0.00	0.00	0.32	0.09	72
		SAND	0.00	0.00	0.06	0.03	54
		TOTL	0.01	0.00	1.02	0.43	58
4	000	CLAY	0.00	0.00	0.15	0.19	-23
		SILT	0.00	0.00	0.24	0.24	-3
		SAGG	0.01	0.00	1.48	0.87	41
		LAGG	0.01	0.00	0.92	0.21	77
		SAND	0.00	0.00	0.18	0.06	65
		TOTL	0.02	0.00	2.96	1.57	47
5	000	CLAY	0.00	0.00	0.08	0.13	-35
		SILT	0.00	0.00	0.13	0.16	-16
		SAGG	0.00	0.00	0.82	0.51	38
		LAGG	0.00	0.00	0.51	0.20	61
		SAND	0.00	0.00	0.10	0.06	39
		TOTL	0.01	0.00	1.64	1.05	36
6	000	CLAY	0.00	0.45	0.07	0.51	1
		SILT	0.00	0.47	0.11	0.42	27
		SAGG	0.00	1.12	0.67	0.52	71
		LAGG	0.00	1.33	0.41	0.96	45
		SAND	0.00	0.42	0.08	0.30	40
		TOTL	0.01	3.78	1.34	2.71	47
7	000	CLAY	0.00	0.51	0.03	0.53	1
		SILT	0.00	0.42	0.05	0.43	7
		SAGG	0.00	0.52	0.29	0.58	28
		LAGG	0.00	0.96	0.18	2.15	-47
		SAND	0.00	0.30	0.03	0.67	-50
		TOTL	0.00	2.71	0.58	4.37	-25
8	000	CLAY	0.00	0.19	0.08	0.30	-9
		SILT	0.00	0.24	0.13	0.32	14
		SAGG	0.00	0.87	0.80	0.58	65
		LAGG	0.00	0.21	0.50	1.53	-54
		SAND	0.00	0.06	0.10	0.48	-68
		TOTL	0.01	1.57	1.60	3.21	-1
9	000	CLAY	0.01	0.00	1.26	1.17	7
		SILT	0.01	0.00	2.01	0.71	65
		SAGG	0.07	0.00	12.58	1.29	90
		LAGG	0.04	0.00	7.80	0.03	100
		SAND	0.01	0.00	1.51	0.00	100
		TOTL	0.14	0.00	25.15	3.20	87

Table A-12 (Continued)

10 000	CLAY	0.01	1.17	1.17	1.92	18
	SILT	0.01	0.71	1.87	0.38	85
	SAGG	0.07	1.29	11.68	0.55	96
	LAGG	0.04	0.03	7.24	0.03	100
	SAND	0.01	0.00	1.40	0.01	100
	TOTL	0.13	3.20	23.37	2.89	89
11 000	CLAY	0.02	2.45	4.33	6.73	1
	SILT	0.04	0.82	6.93	6.69	14
	SAGG	0.24	1.14	43.31	25.43	43
	LAGG	0.15	2.17	26.85	2.49	91
	SAND	0.03	0.68	5.20	0.64	89
	TOTL	0.48	7.26	86.62	41.98	55
12 000	CLAY	0.01	6.73	2.19	0.00	100
	SILT	0.02	6.69	3.51	0.00	100
	SAGG	0.12	25.43	21.94	0.00	100
	LAGG	0.08	2.49	13.60	0.00	100
	SAND	0.01	0.64	2.63	0.00	100
	TOTL	0.25	41.98	43.88	0.00	100
13 000	CLAY	0.02	0.00	2.90	2.94	-1
	SILT	0.03	0.00	4.64	3.70	20
	SAGG	0.16	0.00	28.99	12.57	57
	LAGG	0.10	0.00	17.98	0.62	97
	SAND	0.02	0.00	3.48	0.14	96
	TOTL	0.32	0.00	57.99	19.97	66
14 000	CLAY	0.04	0.00	6.52	6.19	5
	SILT	0.06	0.00	10.43	4.39	58
	SAGG	0.36	0.00	65.19	8.63	87
	LAGG	0.23	0.00	40.42	0.15	100
	SAND	0.04	0.00	7.82	0.02	100
	TOTL	0.73	0.00	130.38	19.37	85
15 000	CLAY	0.02	0.00	3.24	3.27	-1
	SILT	0.03	0.00	5.18	4.28	17
	SAGG	0.18	0.00	32.40	15.61	52
	LAGG	0.11	0.00	20.09	0.67	97
	SAND	0.02	0.00	3.89	0.14	96
	TOTL	0.36	0.00	64.79	23.97	63
16 000	CLAY	0.03	3.57	6.25	9.65	2
	SILT	0.06	4.60	10.00	9.99	32
	SAGG	0.35	16.20	62.47	24.49	69
	LAGG	0.22	2.20	38.73	0.60	99
	SAND	0.04	0.62	7.50	0.09	99
	TOTL	0.70	27.18	124.94	44.83	71
17 000	CLAY	0.03	9.65	5.11	14.40	2
	SILT	0.05	9.99	8.17	10.30	43
	SAGG	0.29	24.49	51.08	17.22	77
	LAGG	0.18	0.60	31.67	0.43	99
	SAND	0.03	0.09	6.13	0.07	99
	TOTL	0.57	44.83	102.16	42.41	71
18 000	CLAY	0.03	0.00	6.17	5.91	4
	SILT	0.06	0.00	9.87	4.57	54
	SAGG	0.34	0.00	61.72	9.47	85
	LAGG	0.21	0.00	38.27	0.16	100
	SAND	0.04	0.00	7.41	0.02	100
	TOTL	0.69	0.00	123.44	20.13	84
19 000	CLAY	0.03	0.00	5.84	5.59	4
	SILT	0.05	0.00	9.35	4.33	54
	SAGG	0.33	0.00	58.43	8.96	85
	LAGG	0.20	0.00	36.23	0.15	100
	SAND	0.04	0.00	7.01	0.02	100
	TOTL	0.65	0.00	116.86	19.05	84

Table A-12 (Continued)

20 000	CLAY	0.01	5.59	1.13	5.92	12
	SILT	0.01	4.33	1.80	0.66	89
	SAGG	0.06	8.96	11.26	0.19	99
	LAGG	0.04	0.15	6.98	0.99	86
	SAND	0.01	0.02	1.35	0.41	70
	TOTL	0.13	19.05	22.51	8.17	80
21 000	CLAY	0.01	5.92	1.34	0.00	100
	SILT	0.01	0.66	2.15	0.00	100
	SAGG	0.07	0.19	13.42	0.00	100
	LAGG	0.05	0.99	8.32	0.00	100
	SAND	0.01	0.41	1.61	0.00	100
	TOTL	0.15	8.17	26.84	0.00	100
22 000	CLAY	0.02	0.00	3.04	2.88	5
	SILT	0.03	0.00	4.87	1.98	59
	SAGG	0.17	0.00	30.44	3.83	87
	LAGG	0.11	0.00	18.87	0.07	100
	SAND	0.02	0.00	3.65	0.01	100
	TOTL	0.34	0.00	60.87	8.77	86
23 000	CLAY	0.02	2.88	3.53	5.62	12
	SILT	0.03	1.98	5.64	1.65	78
	SAGG	0.20	3.83	35.26	2.72	93
	LAGG	0.12	0.07	21.86	0.05	100
	SAND	0.02	0.01	4.23	0.01	100
	TOTL	0.39	8.77	70.53	10.06	87
24 000	CLAY	0.04	11.81	7.26	17.91	6
	SILT	0.06	6.04	11.62	5.88	67
	SAGG	0.41	11.35	72.62	12.54	85
	LAGG	0.25	0.20	45.02	0.25	99
	SAND	0.05	0.03	8.71	0.04	100
	TOTL	0.81	29.43	145.24	36.62	79
25 000	CLAY	0.03	0.00	5.16	4.89	5
	SILT	0.05	0.00	8.25	3.41	59
	SAGG	0.29	0.00	51.56	6.67	87
	LAGG	0.18	0.00	31.97	0.11	100
	SAND	0.03	0.00	6.19	0.02	100
	TOTL	0.58	0.00	103.12	15.10	85
26 000	CLAY	0.04	0.00	7.75	7.44	4
	SILT	0.07	0.00	12.40	5.94	52
	SAGG	0.43	0.00	77.52	12.55	84
	LAGG	0.27	0.00	48.06	0.22	100
	SAND	0.05	0.00	9.30	0.03	100
	TOTL	0.87	0.00	155.05	26.17	83
27 000	CLAY	0.02	14.40	3.82	17.74	3
	SILT	0.03	10.30	6.11	9.11	44
	SAGG	0.21	17.22	38.17	13.31	76
	LAGG	0.13	0.43	23.66	0.43	98
	SAND	0.03	0.07	4.58	0.08	98
	TOTL	0.43	42.41	76.34	40.68	66
28 000	CLAY	0.03	23.65	5.55	28.08	4
	SILT	0.05	13.68	8.88	9.67	57
	SAGG	0.31	22.78	55.51	14.71	81
	LAGG	0.19	0.59	34.41	0.35	99
	SAND	0.04	0.11	6.66	0.06	.99
	TOTL	0.62	60.80	111.01	52.88	69
29 000	CLAY	0.02	28.08	3.77	30.61	4
	SILT	0.03	9.67	6.03	6.82	57
	SAGG	0.21	14.71	37.70	10.16	81
	LAGG	0.13	0.35	23.37	0.35	99
	SAND	0.03	0.06	4.52	0.08	98
	TOTL	0.42	52.88	75.39	48.02	63

Table A-12 (Continued)

30 000	CLAY	0.01	30.61	2.24	0.00	100
	SILT	0.02	6.82	3.59	0.00	100
	SAGG	0.13	10.16	22.45	0.00	100
	LAGG	0.08	0.35	13.92	0.00	100
	SAND	0.02	0.08	2.69	0.00	100
	TOTL	0.25	48.02	44.89	0.00	100
31 000	CLAY	0.02	0.00	3.06	2.92	5
	SILT	0.03	0.00	4.90	2.13	56
	SAGG	0.17	0.00	30.62	4.27	86
	LAGG	0.11	0.00	18.98	0.08	100
	SAND	0.02	0.00	3.67	0.01	100
	TOTL	0.34	0.00	61.24	9.42	85
32 000	CLAY	0.02	2.92	2.87	5.07	12
	SILT	0.03	2.13	4.58	1.36	80
	SAGG	0.16	4.27	28.65	2.18	93
	LAGG	0.10	0.08	17.77	0.06	100
	SAND	0.02	0.01	3.44	0.01	100
	TOTL	0.32	9.42	57.31	8.67	87
33 000	CLAY	0.01	22.98	2.07	22.76	9
	SILT	0.02	7.24	3.31	1.38	87
	SAGG	0.12	14.72	20.66	2.23	94
	LAGG	0.07	0.30	12.81	0.11	99
	SAND	0.01	0.05	2.48	0.03	99
	TOTL	0.23	45.29	41.32	26.51	69
34 000	CLAY	0.05	27.64	8.83	33.98	7
	SILT	0.08	4.80	14.13	6.93	63
	SAGG	0.49	8.90	88.32	14.67	85
	LAGG	0.31	0.22	54.76	0.30	99
	SAND	0.06	0.05	10.60	0.05	100
	TOTL	0.99	41.61	176.64	55.93	74
35 000	CLAY	0.02	41.42	3.68	0.00	100
	SILT	0.03	12.86	5.88	0.00	100
	SAGG	0.21	27.22	36.78	0.00	100
	LAGG	0.13	0.52	22.80	0.00	100
	SAND	0.02	0.08	4.41	0.00	100
	TOTL	0.41	82.10	73.55	0.00	100
36 000	CLAY	0.02	0.00	3.52	3.33	6
	SILT	0.03	0.00	5.63	2.24	60
	SAGG	0.20	0.00	35.21	4.31	88
	LAGG	0.12	0.00	21.83	0.07	100
	SAND	0.02	0.00	4.22	0.01	100
	TOTL	0.39	0.00	70.42	9.96	86
37 000	CLAY	0.01	0.00	2.30	0.00	100
	SILT	0.02	0.00	3.68	0.00	100
	SAGG	0.13	0.00	22.99	0.00	100
	LAGG	0.08	0.00	14.26	0.00	100
	SAND	0.02	0.00	2.76	0.00	100
	TOTL	0.26	0.00	45.98	0.00	100
38 000	CLAY	0.01	0.00	1.67	1.56	6
	SILT	0.01	0.00	2.67	0.98	63
	SAGG	0.09	0.00	16.68	1.81	89
	LAGG	0.06	0.00	10.34	0.03	100
	SAND	0.01	0.00	2.00	0.01	100
	TOTL	0.19	0.00	33.36	4.39	87
39 000	CLAY	0.01	1.56	1.67	2.69	17
	SILT	0.01	0.98	2.67	0.59	84
	SAGG	0.09	1.81	16.68	0.88	95
	LAGG	0.06	0.03	10.34	0.03	100
	SAND	0.01	0.01	2.00	0.01	100
	TOTL	0.19	4.39	33.36	4.19	89

Table A-12 (Continued)

40 000	CLAY	0.02	0.00	2.89	2.69	7
	SILT	0.03	0.00	4.63	1.54	67
	SAGG	0.16	0.00	28.92	2.75	90
	LAGG	0.10	0.00	17.93	0.05	100
	SAND	0.02	0.00	3.47	0.01	100
	TOTL	0.32	0.00	57.85	7.04	88
41 000	CLAY	0.01	0.00	1.34	0.00	100
	SILT	0.01	0.00	2.15	0.00	100
	SAGG	0.07	0.00	13.42	0.00	100
	LAGG	0.05	0.00	8.32	0.00	100
	SAND	0.01	0.00	1.61	0.00	100
	TOTL	0.15	0.00	26.84	0.00	100
42 000	CLAY	0.02	0.00	3.45	3.29	5
	SILT	0.03	0.00	5.52	2.47	55
	SAGG	0.19	0.00	34.50	5.01	85
	LAGG	0.12	0.00	21.39	0.09	100
	SAND	0.02	0.00	4.14	0.01	100
	TOTL	0.39	0.00	69.01	10.87	84
43 000	CLAY	0.04	6.62	7.45	0.00	100
	SILT	0.07	4.71	11.91	0.00	100
	SAGG	0.42	9.32	74.47	0.00	100
	LAGG	0.26	0.16	46.17	0.00	100
	SAND	0.05	0.02	8.94	0.00	100
	TOTL	0.83	20.83	148.93	0.00	100
44 000	CLAY	0.01	0.00	2.58	0.00	100
	SILT	0.02	0.00	4.14	0.00	100
	SAGG	0.14	0.00	25.85	0.00	100
	LAGG	0.09	0.00	16.03	0.00	100
	SAND	0.02	0.00	3.10	0.00	100
	TOTL	0.29	0.00	51.69	0.00	100
45 000	CLAY	0.01	0.00	2.31	2.15	7
	SILT	0.02	0.00	3.69	1.30	65
	SAGG	0.13	0.00	23.08	2.37	90
	LAGG	0.08	0.00	14.31	0.04	100
	SAND	0.02	0.00	2.77	0.01	100
	TOTL	0.26	0.00	46.15	5.87	87
46 000	CLAY	0.02	0.00	2.81	1.27	55
	SILT	0.03	0.00	4.50	0.14	97
	SAGG	0.16	0.00	28.14	0.19	99
	LAGG	0.10	0.00	17.45	0.00	100
	SAND	0.02	0.00	3.38	0.00	100
	TOTL	0.31	0.00	56.29	1.60	97
47 000	CLAY	0.02	3.96	2.98	6.28	9
	SILT	0.03	0.73	4.76	1.86	66
	SAGG	0.17	1.07	29.76	3.51	89
	LAGG	0.10	0.03	18.45	0.07	100
	SAND	0.02	0.01	3.57	0.01	100
	TOTL	0.33	5.79	59.51	11.74	82
48 000	CLAY	0.01	8.96	2.48	10.41	9
	SILT	0.02	3.40	3.97	1.62	78
	SAGG	0.14	6.26	24.80	3.00	90
	LAGG	0.09	0.12	15.37	0.07	100
	SAND	0.02	0.02	2.98	0.01	100
	TOTL	0.28	18.77	49.59	15.11	78
49 000	CLAY	0.00	0.00	0.00	0.00	0
	SILT	0.00	0.00	0.00	0.00	0
	SAGG	0.00	0.00	0.00	0.00	0
	LAGG	0.00	0.00	0.00	0.00	0
	SAND	0.00	0.00	0.00	0.00	0
	TOTL	0.00	0.00	0.00	0.00	0

Table A-12 (Continued)

50 000	CLAY	0.03	0.00	5.73	3.90	32
	SILT	0.05	0.00	9.17	0.70	92
	SAGG	0.32	0.00	57.29	0.98	98
	LAGG	0.20	0.00	35.52	0.02	100
	SAND	0.04	0.00	6.88	0.00	100
	TOTL	0.64	0.00	114.58	5.61	95
51 000	CLAY	0.01	2.15	1.46	0.00	100
	SILT	0.01	1.30	2.33	0.00	100
	SAGG	0.08	2.37	14.56	0.00	100
	LAGG	0.05	0.04	9.03	0.00	100
	SAND	0.01	0.01	1.75	0.00	100
	TOTL	0.16	5.87	29.12	0.00	100
52 000	CLAY	0.03	0.00	5.21	4.96	5
	SILT	0.05	0.00	8.34	3.66	56
	SAGG	0.29	0.00	52.10	7.37	86
	LAGG	0.18	0.00	32.30	0.13	100
	SAND	0.03	0.00	6.25	0.02	100
	TOTL	0.58	0.00	104.19	16.14	85
53 000	CLAY	0.01	4.96	2.37	6.23	15
	SILT	0.02	3.66	3.78	0.99	87
	SAGG	0.13	7.37	23.66	1.42	95
	LAGG	0.08	0.13	14.67	0.03	100
	SAND	0.02	0.02	2.84	0.01	100
	TOTL	0.26	16.14	47.31	8.68	86
54 000	CLAY	0.01	16.64	1.40	14.72	18
	SILT	0.01	2.61	2.24	0.54	89
	SAGG	0.08	4.42	13.98	0.78	96
	LAGG	0.05	0.10	8.67	0.07	99
	SAND	0.01	0.02	1.68	0.02	99
	TOTL	0.16	23.79	27.97	16.13	69
55 000	CLAY	0.00	0.00	0.00	0.03	-100
	SILT	0.00	0.00	0.00	0.03	-100
	SAGG	0.00	0.00	0.00	0.04	-100
	LAGG	0.00	0.00	0.00	0.13	-100
	SAND	0.00	0.00	0.00	0.04	-100
	TOTL	0.00	0.00	0.00	0.28	-100
56 000	CLAY	0.01	3.90	1.19	0.02	100
	SILT	0.01	0.70	1.90	0.02	99
	SAGG	0.07	0.98	11.86	0.03	100
	LAGG	0.04	0.02	7.35	0.09	99
	SAND	0.01	0.00	1.42	0.05	97
	TOTL	0.13	5.61	23.71	0.20	99
57 000	CLAY	0.01	0.00	2.44	0.00	100
	SILT	0.02	0.00	3.90	0.00	100
	SAGG	0.14	0.00	24.38	0.00	100
	LAGG	0.08	0.00	15.11	0.00	100
	SAND	0.02	0.00	2.93	0.00	100
	TOTL	0.27	0.00	48.76	0.00	100
58 000	CLAY	0.01	14.72	2.22	0.00	100
	SILT	0.02	0.54	3.56	0.00	100
	SAGG	0.12	0.78	22.23	0.00	100
	LAGG	0.08	0.07	13.78	0.00	100
	SAND	0.01	0.02	2.67	0.00	100
	TOTL	0.25	16.13	44.46	0.00	100
59 000	CLAY	0.01	0.03	1.34	1.53	-10
	SILT	0.01	0.03	2.15	1.83	16
	SAGG	0.07	0.04	13.42	5.64	58
	LAGG	0.05	0.13	8.32	1.75	79
	SAND	0.01	0.04	1.61	0.53	68
	TOTL	0.15	0.28	26.84	11.27	58

Table A-12 (Continued)

60 000	CLAY	0.01	0.02	1.53	0.00	100
	SILT	0.01	0.02	2.45	0.00	100
	SAGG	0.09	0.03	15.34	0.00	100
	LAGG	0.05	0.09	9.51	0.00	100
	SAND	0.01	0.05	1.84	0.00	100
	TOTL	0.17	0.20	30.67	0.00	100
61 000	CLAY	0.02	7.55	3.56	0.00	100
	SILT	0.03	2.75	5.69	0.00	100
	SAGG	0.20	6.78	35.56	0.00	100
	LAGG	0.12	1.87	22.05	0.00	100
	SAND	0.02	0.57	4.27	0.00	100
	TOTL	0.40	19.53	71.13	0.00	100
62 000	CLAY	0.01	5.01	1.83	6.02	12
	SILT	0.02	4.17	2.92	0.92	87
	SAGG	0.10	9.07	18.28	1.14	96
	LAGG	0.06	0.16	11.33	0.13	99
	SAND	0.01	0.02	2.19	0.04	98
	TOTL	0.20	18.43	36.56	8.26	85
63 000	CLAY	0.03	0.00	5.20	5.01	4
	SILT	0.05	0.00	8.33	4.17	50
	SAGG	0.29	0.00	52.04	9.07	83
	LAGG	0.18	0.00	32.27	0.16	99
	SAND	0.03	0.00	6.25	0.02	100
	TOTL	0.58	0.00	104.09	18.43	82

Table A-13: Output for Storm C (1 in. precipitation, 1 hr. duration)

Condensed Soil Loss

Cell Num	Div	RUNOFF Drainage Area (acres)	Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
1	000	179	0.03	0.0	8	0.02	0.00	2.91	1.04	64
2	000	358	0.17	14.9	28	0.01	1.04	1.78	2.31	18
3	000	179	0.03	0.0	7	0.01	0.00	1.02	0.43	58
4	000	179	0.17	0.0	38	0.02	0.00	2.96	1.57	47
5	000	179	0.17	0.0	38	0.01	0.00	1.64	1.05	36
6	000	895	0.07	85.3	44	0.01	3.78	1.34	2.71	47
7	000	1074	0.07	87.2	39	0.00	2.71	0.58	4.37	-25
8	000	358	0.17	50.0	44	0.01	1.57	1.60	3.21	-1
9	000	179	0.02	0.0	4	0.14	0.00	25.15	3.20	87
10	000	358	0.02	50.0	5	0.13	3.20	23.37	2.89	89
11	000	1611	0.17	77.0	62	0.48	7.26	86.62	41.98	55
12	000	1790	0.00	0.0	0	0.25	41.98	43.88	0.00	100
13	000	179	0.17	0.0	29	0.32	0.00	57.99	19.97	66
14	000	179	0.02	0.0	5	0.73	0.00	130.38	19.37	85
15	000	179	0.17	0.0	33	0.36	0.00	64.79	23.97	63
16	000	716	0.02	96.8	62	0.70	27.18	124.94	44.83	71
17	000	895	0.00	100.0	50	0.57	44.83	102.16	42.41	71
18	000	179	0.02	0.0	5	0.69	0.00	123.44	20.13	84
19	000	179	0.02	0.0	5	0.65	0.00	116.86	19.05	84
20	000	358	0.17	9.0	21	0.13	19.05	22.51	8.17	80
21	000	537	0.00	0.0	0	0.15	8.17	26.84	0.00	100
22	000	179	0.02	0.0	4	0.34	0.00	60.87	8.77	86
23	000	358	0.02	50.0	6	0.39	8.77	70.53	10.06	87
24	000	716	0.02	75.0	9	0.81	29.43	145.24	36.62	79
25	000	179	0.02	0.0	4	0.58	0.00	103.12	15.10	85
26	000	179	0.02	0.0	5	0.87	0.00	155.05	26.17	83
27	000	1074	0.02	96.9	46	0.43	42.41	76.34	40.68	66
28	000	1432	0.02	97.1	47	0.62	60.80	111.01	52.88	69
29	000	1611	0.00	100.0	41	0.42	52.88	75.39	48.02	63
30	000	1790	0.00	0.0	0	0.25	48.02	44.89	0.00	100
31	000	179	0.02	0.0	4	0.34	0.00	61.24	9.42	85
32	000	358	0.02	50.0	5	0.32	9.42	57.31	8.67	87
33	000	1253	0.00	99.9	9	0.23	45.29	41.32	26.51	69
34	000	1611	0.02	87.5	13	0.99	41.61	176.64	55.93	74
35	000	1969	0.00	0.0	0	0.41	82.10	73.55	0.00	100
36	000	179	0.02	0.0	4	0.39	0.00	70.42	9.96	86
37	000	179	0.00	0.0	0	0.26	0.00	45.98	0.00	100
38	000	179	0.02	0.0	4	0.19	0.00	33.36	4.39	87
39	000	358	0.02	50.0	5	0.19	4.39	33.36	4.19	89
40	000	179	0.02	0.0	4	0.32	0.00	57.85	7.04	88
41	000	179	0.00	0.0	0	0.15	0.00	26.84	0.00	100
42	000	179	0.02	0.0	5	0.39	0.00	69.01	10.87	84
43	000	537	0.00	0.0	0	0.83	20.83	148.93	0.00	100
44	000	179	0.00	0.0	0	0.29	0.00	51.69	0.00	100
45	000	179	0.02	0.0	4	0.26	0.00	46.15	5.87	87
46	000	179	0.00	0.0	0	0.31	0.00	56.29	1.60	97
47	000	716	0.02	66.7	6	0.33	5.79	59.51	11.74	82
48	000	1074	0.00	99.9	7	0.28	18.77	49.59	15.11	78
49	000	179	0.00	0.0	0	0.00	0.00	0.00	0.00	0
50	000	179	0.00	0.0	0	0.64	0.00	114.58	5.61	95

Table A-13 (Continued)

51	000	358	0.00	0.0	0	0.16	5.87	29.12	0.00	100
52	000	179	0.02	0.0	5	0.58	0.00	104.19	16.14	85
53	000	358	0.02	50.0	5	0.26	16.14	47.31	8.68	86
54	000	1611	0.02	85.7	8	0.16	23.79	27.97	16.13	69
55	000	179	1.00	0.0	119	0.00	0.00	0.00	0.28	-100
56	000	358	0.02	0.6	2	0.13	5.61	23.71	0.20	99
57	000	179	0.00	0.0	0	0.27	0.00	48.76	0.00	100
58	000	1790	0.00	0.0	0	0.25	16.13	44.46	0.00	100
59	000	358	0.02	98.3	94	0.15	0.28	26.84	11.27	58
60	000	537	0.00	0.0	0	0.17	0.20	30.67	0.00	100
61	000	895	0.00	0.0	0	0.40	19.53	71.13	0.00	100
62	000	358	0.02	50.0	5	0.20	18.43	36.56	8.26	85
63	000	179	0.02	0.0	5	0.58	0.00	104.09	18.43	82

Table A-14: Summary of Model Output for Storm D (1 in. precipitation, 12 hr. duration)

Initial Data:

Area of the Watershed (acres)	11,277
Area of Each Cell	179
Total Number of Cells	63
Storm Precipitation (in.)	1.00
Storm Duration (hrs)	12.00
Storm Energy-Intensity Value	6.00

Values at the Watershed Outlet:

Cell Number	13
Runoff Volume (inches)	0.20
Peak Runoff Rate (cfs)	29

Sediment Analysis:

	Area Weighted Erosion				Mean	Area	
	Upland (t/a)	Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Concentration (ppm)	Weighted Yield (t/a)	Yield (tons)
CLAY	0.30	0.00	2	3	312.47	0.01	1.1
SILT	0.48	0.00	2	2	389.18	0.01	1.4
SAGG	2.98	0.00	1	1	1293.51	0.03	4.6
LAGG	1.85	0.02	0	0	119.20	0.00	0.4
SAND	0.36	0.01	0	0	31.90	0.00	0.1
TOTAL	5.97	0.02	1	1	2146.27	0.04	7.6

Table A-15: Output for Storm D (1 in. precipitation, 12 hr. duration)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
1	000	179	0.03	0.00	0	0.03	8
2	000	358	0.17	0.03	7	0.10	28
3	000	179	0.03	0.00	0	0.03	7
4	000	179	0.17	0.00	0	0.17	38
5	000	179	0.17	0.00	0	0.17	38
6	000	895	0.07	0.10	47	0.10	44
7	000	1074	0.07	0.10	37	0.09	39
8	000	358	0.17	0.17	36	0.17	44
9	000	179	0.02	0.00	0	0.02	4
10	000	358	0.02	0.02	3	0.02	5
11	000	1611	0.17	0.07	52	0.08	62
12	000	1790	0.00	0.08	50	0.00	0
13	000	179	0.17	0.00	0	0.17	29
14	000	179	0.02	0.00	0	0.02	5
15	000	179	0.17	0.00	0	0.17	33
16	000	716	0.02	0.17	70	0.13	62
17	000	895	0.00	0.13	56	0.11	50
18	000	179	0.02	0.00	0	0.02	5
19	000	179	0.02	0.00	0	0.02	5
20	000	358	0.17	0.02	3	0.10	21
21	000	537	0.00	0.10	20	0.00	0
22	000	179	0.02	0.00	0	0.02	4
23	000	358	0.02	0.02	4	0.02	6
24	000	716	0.02	0.02	8	0.02	9
25	000	179	0.02	0.00	0	0.02	4
26	000	179	0.02	0.00	0	0.02	5
27	000	1074	0.02	0.11	48	0.09	46
28	000	1432	0.02	0.08	50	0.07	47
29	000	1611	0.00	0.07	44	0.07	41
30	000	1790	0.00	0.07	34	0.00	0
31	000	179	0.02	0.00	0	0.02	4
32	000	358	0.02	0.02	4	0.02	5
33	000	1253	0.00	0.02	9	0.01	9
34	000	1611	0.02	0.01	13	0.02	13
35	000	1969	0.00	0.02	12	0.00	0
36	000	179	0.02	0.00	0	0.02	4
37	000	179	0.00	0.00	0	0.00	0
38	000	179	0.02	0.00	0	0.02	4
39	000	358	0.02	0.02	3	0.02	5
40	000	179	0.02	0.00	0	0.02	4
41	000	179	0.00	0.00	0	0.00	0
42	000	179	0.02	0.00	0	0.02	5
43	000	537	0.00	0.02	9	0.00	0
44	000	179	0.00	0.00	0	0.00	0
45	000	179	0.02	0.00	0	0.02	4
46	000	179	0.00	0.00	0	0.00	0
47	000	716	0.02	0.01	5	0.01	6
48	000	1074	0.00	0.01	8	0.01	7
49	000	179	0.00	0.00	0	0.00	0
50	000	179	0.00	0.00	0	0.00	0
51	000	358	0.00	0.02	3	0.00	0

Table A-15 (Continued)

52 000	179	0.02	0.00	0	0.02	5
53 000	358	0.02	0.02	4	0.02	5
54 000	1611	0.02	0.01	7	0.01	8
55 000	179	1.00	0.00	0	1.00	119
56 000	358	0.02	0.00	0	0.01	2
57 000	179	0.00	0.00	0	0.00	0
58 000	1790	0.00	0.01	9	0.00	0
59 000	358	0.02	1.00	141	0.51	94
60 000	537	0.00	0.01	2	0.00	0
61 000	895	0.00	0.26	107	0.00	0
62 000	358	0.02	0.02	4	0.02	5
63 000	179	0.02	0.00	0	0.02	5

Table A-16: Output for Storm D (1 in. precipitation, 12 hr. duration)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
1	000	CLAY	0.00	0.00	0.05	0.07	-29
		SILT	0.00	0.00	0.08	0.08	2
		SAGG	0.00	0.00	0.52	0.21	59
		LAGG	0.00	0.00	0.32	0.10	71
		SAND	0.00	0.00	0.06	0.03	53
		TOTL	0.01	0.00	1.04	0.49	53
2	000	CLAY	0.00	0.07	0.03	0.17	-39
		SILT	0.00	0.08	0.05	0.17	-23
		SAGG	0.00	0.21	0.32	0.27	49
		LAGG	0.00	0.10	0.20	1.06	-72
		SAND	0.00	0.03	0.04	0.33	-80
		TOTL	0.00	0.49	0.64	2.01	-44
3	000	CLAY	0.00	0.00	0.02	0.04	-53
		SILT	0.00	0.00	0.03	0.04	-25
		SAGG	0.00	0.00	0.18	0.08	59
		LAGG	0.00	0.00	0.11	0.09	21
		SAND	0.00	0.00	0.02	0.03	-22
		TOTL	0.00	0.00	0.37	0.27	26
4	000	CLAY	0.00	0.00	0.05	0.10	-45
		SILT	0.00	0.00	0.08	0.12	-27
		SAGG	0.00	0.00	0.53	0.34	35
		LAGG	0.00	0.00	0.33	0.19	41
		SAND	0.00	0.00	0.06	0.06	6
		TOTL	0.01	0.00	1.06	0.81	23
5	000	CLAY	0.00	0.00	0.03	0.07	-61
		SILT	0.00	0.00	0.05	0.08	-44
		SAGG	0.00	0.00	0.29	0.22	26
		LAGG	0.00	0.00	0.18	0.19	-5
		SAND	0.00	0.00	0.04	0.06	-41
		TOTL	0.00	0.00	0.59	0.63	-6
6	000	CLAY	0.00	0.29	0.02	0.31	0
		SILT	0.00	0.30	0.04	0.29	13
		SAGG	0.00	0.56	0.24	0.37	54
		LAGG	0.00	1.34	0.15	0.96	35
		SAND	0.00	0.42	0.03	0.30	33
		TOTL	0.00	2.90	0.48	2.23	34
7	000	CLAY	0.00	0.31	0.01	0.40	-20
		SILT	0.00	0.29	0.02	0.39	-21
		SAGG	0.00	0.37	0.10	0.52	-9
		LAGG	0.00	0.96	0.06	2.15	-52
		SAND	0.00	0.30	0.01	0.67	-54
		TOTL	0.00	2.23	0.21	4.13	-41
8	000	CLAY	0.00	0.10	0.03	0.24	-49
		SILT	0.00	0.12	0.05	0.25	-34
		SAGG	0.00	0.34	0.29	0.38	40
		LAGG	0.00	0.19	0.18	1.54	-76
		SAND	0.00	0.06	0.03	0.49	-81
		TOTL	0.00	0.81	0.57	2.89	-52
9	000	CLAY	0.00	0.00	0.45	0.42	6
		SILT	0.00	0.00	0.72	0.25	65
		SAGG	0.03	0.00	4.50	0.46	90
		LAGG	0.02	0.00	2.79	0.01	100
		SAND	0.00	0.00	0.54	0.00	100
		TOTL	0.05	0.00	8.99	1.15	87

Table A-16 (Continued)

10 000	CLAY	0.00	0.42	0.42	0.69	18
	SILT	0.00	0.25	0.67	0.14	85
	SAGG	0.02	0.46	4.18	0.20	96
	LAGG	0.01	0.01	2.59	0.02	99
	SAND	0.00	0.00	0.50	0.01	98
	TOTL	0.05	1.15	8.35	1.06	89
11 000	CLAY	0.01	1.09	1.55	2.62	1
	SILT	0.01	0.53	2.48	2.63	13
	SAGG	0.09	0.72	15.48	9.40	42
	LAGG	0.05	2.17	9.60	1.97	83
	SAND	0.01	0.68	1.86	0.57	78
	TOTL	0.17	5.19	30.97	17.19	52
12 000	CLAY	0.00	2.62	0.78	0.00	100
	SILT	0.01	2.63	1.26	0.00	100
	SAGG	0.04	9.40	7.84	0.00	100
	LAGG	0.03	1.97	4.86	0.00	100
	SAND	0.01	0.57	0.94	0.00	100
	TOTL	0.09	17.19	15.69	0.00	100
13 000	CLAY	0.01	0.00	1.04	1.10	-6
	SILT	0.01	0.00	1.66	1.37	17
	SAGG	0.06	0.00	10.37	4.55	56
	LAGG	0.04	0.00	6.43	0.42	93
	SAND	0.01	0.00	1.24	0.11	91
	TOTL	0.12	0.00	20.73	7.55	64
14 000	CLAY	0.01	0.00	2.33	2.21	5
	SILT	0.02	0.00	3.73	1.57	58
	SAGG	0.13	0.00	23.31	3.09	87
	LAGG	0.08	0.00	14.45	0.05	100
	SAND	0.02	0.00	2.80	0.01	100
	TOTL	0.26	0.00	46.62	6.93	85
15 000	CLAY	0.01	0.00	1.16	1.21	-4
	SILT	0.01	0.00	1.85	1.57	15
	SAGG	0.06	0.00	11.58	5.63	51
	LAGG	0.04	0.00	7.18	0.40	94
	SAND	0.01	0.00	1.39	0.10	93
	TOTL	0.13	0.00	23.17	8.91	62
16 000	CLAY	0.01	1.45	2.23	3.62	2
	SILT	0.02	1.81	3.57	3.67	32
	SAGG	0.12	6.01	22.34	8.76	69
	LAGG	0.08	1.94	13.85	0.24	98
	SAND	0.01	0.59	2.68	0.04	99
	TOTL	0.25	11.80	44.67	16.34	71
17 000	CLAY	0.01	3.62	1.83	5.32	2
	SILT	0.02	3.67	2.92	3.73	43
	SAGG	0.10	8.76	18.26	6.17	77
	LAGG	0.06	0.24	11.32	0.20	98
	SAND	0.01	0.04	2.19	0.04	98
	TOTL	0.20	16.34	36.53	15.45	71
18 000	CLAY	0.01	0.00	2.21	2.11	4
	SILT	0.02	0.00	3.53	1.63	54
	SAGG	0.12	0.00	22.07	3.39	85
	LAGG	0.08	0.00	13.68	0.06	100
	SAND	0.01	0.00	2.65	0.01	100
	TOTL	0.25	0.00	44.13	7.20	84
19 000	CLAY	0.01	0.00	2.09	2.00	4
	SILT	0.02	0.00	3.34	1.55	54
	SAGG	0.12	0.00	20.89	3.20	85
	LAGG	0.07	0.00	12.95	0.06	100
	SAND	0.01	0.00	2.51	0.01	100
	TOTL	0.23	0.00	41.78	6.82	84

Table A-16 (Continued)

20 000	CLAY	0.00	2.00	0.40	2.12	12
	SILT	0.00	1.55	0.64	0.33	85
	SAGG	0.02	3.20	4.02	0.19	97
	LAGG	0.01	0.06	2.50	1.37	46
	SAND	0.00	0.01	0.48	0.47	5
	TOTL	0.04	6.82	8.05	4.48	70
21 000	CLAY	0.00	2.12	0.48	0.00	100
	SILT	0.00	0.33	0.77	0.00	100
	SAGG	0.03	0.19	4.80	0.00	100
	LAGG	0.02	1.37	2.97	0.00	100
	SAND	0.00	0.47	0.58	0.00	100
	TOTL	0.05	4.48	9.60	0.00	100
22 000	CLAY	0.01	0.00	1.09	1.03	5
	SILT	0.01	0.00	1.74	0.71	59
	SAGG	0.06	0.00	10.88	1.37	87
	LAGG	0.04	0.00	6.75	0.03	100
	SAND	0.01	0.00	1.31	0.00	100
	TOTL	0.12	0.00	21.76	3.14	86
23 000	CLAY	0.01	1.03	1.26	2.01	12
	SILT	0.01	0.71	2.02	0.59	78
	SAGG	0.07	1.37	12.61	0.98	93
	LAGG	0.04	0.03	7.82	0.03	100
	SAND	0.01	0.00	1.51	0.01	100
	TOTL	0.14	3.14	25.22	3.61	87
24 000	CLAY	0.01	4.22	2.60	6.41	6
	SILT	0.02	2.16	4.15	2.11	67
	SAGG	0.15	4.06	25.96	4.49	85
	LAGG	0.09	0.08	16.10	0.11	99
	SAND	0.02	0.01	3.12	0.02	99
	TOTL	0.29	10.54	51.93	13.14	79
25 000	CLAY	0.01	0.00	1.84	1.75	5
	SILT	0.02	0.00	2.95	1.22	59
	SAGG	0.10	0.00	18.44	2.38	87
	LAGG	0.06	0.00	11.43	0.04	100
	SAND	0.01	0.00	2.21	0.01	100
	TOTL	0.21	0.00	36.87	5.40	85
26 000	CLAY	0.02	0.00	2.77	2.66	4
	SILT	0.02	0.00	4.43	2.12	52
	SAGG	0.15	0.00	27.72	4.49	84
	LAGG	0.10	0.00	17.18	0.08	100
	SAND	0.02	0.00	3.33	0.01	100
	TOTL	0.31	0.00	55.44	9.36	83
27 000	CLAY	0.01	5.32	1.36	6.51	3
	SILT	0.01	3.73	2.18	3.29	44
	SAGG	0.08	6.17	13.65	4.79	76
	LAGG	0.05	0.20	8.46	0.25	97
	SAND	0.01	0.04	1.64	0.07	96
	TOTL	0.15	15.45	27.29	14.90	65
28 000	CLAY	0.01	8.62	1.98	10.20	4
	SILT	0.02	4.93	3.18	3.48	57
	SAGG	0.11	8.17	19.85	5.27	81
	LAGG	0.07	0.31	12.30	0.17	99
	SAND	0.01	0.08	2.38	0.04	99
	TOTL	0.22	22.10	39.69	19.16	69
29 000	CLAY	0.01	10.20	1.35	11.10	4
	SILT	0.01	3.48	2.16	2.46	56
	SAGG	0.08	5.27	13.48	3.66	80
	LAGG	0.05	0.17	8.36	0.23	97
	SAND	0.01	0.04	1.62	0.07	96
	TOTL	0.15	19.16	26.96	17.52	62

Table A-16 (Continued)

30 000	CLAY	0.00	11.10	0.80	0.00	100
	SILT	0.01	2.46	1.28	0.00	100
	SAGG	0.04	3.66	8.03	0.00	100
	LAGG	0.03	0.23	4.98	0.00	100
	SAND	0.01	0.07	0.96	0.00	100
	TOTL	0.09	17.52	16.05	0.00	100
31 000	CLAY	0.01	0.00	1.09	1.04	5
	SILT	0.01	0.00	1.75	0.76	56
	SAGG	0.06	0.00	10.95	1.53	86
	LAGG	0.04	0.00	6.79	0.03	100
	SAND	0.01	0.00	1.31	0.01	100
	TOTL	0.12	0.00	21.90	3.38	85
32 000	CLAY	0.01	1.04	1.02	1.81	12
	SILT	0.01	0.76	1.64	0.49	80
	SAGG	0.06	1.53	10.25	0.78	93
	LAGG	0.04	0.03	6.35	0.04	99
	SAND	0.01	0.01	1.23	0.01	99
	TOTL	0.11	3.38	20.49	3.13	87
33 000	CLAY	0.00	8.22	0.74	8.14	9
	SILT	0.01	2.60	1.18	0.51	87
	SAGG	0.04	5.27	7.39	0.81	94
	LAGG	0.03	0.15	4.58	0.09	98
	SAND	0.00	0.03	0.89	0.03	97
	TOTL	0.08	16.26	14.77	9.58	69
34 000	CLAY	0.02	9.89	3.16	12.15	7
	SILT	0.03	1.73	5.05	2.48	63
	SAGG	0.18	3.20	31.58	5.26	85
	LAGG	0.11	0.13	19.58	0.14	99
	SAND	0.02	0.03	3.79	0.03	99
	TOTL	0.35	14.98	63.16	20.07	74
35 000	CLAY	0.01	14.81	1.31	0.00	100
	SILT	0.01	4.61	2.10	0.00	100
	SAGG	0.07	9.74	13.15	0.00	100
	LAGG	0.05	0.22	8.15	0.00	100
	SAND	0.01	0.04	1.58	0.00	100
	TOTL	0.15	29.43	26.30	0.00	100
36 000	CLAY	0.01	0.00	1.26	1.19	5
	SILT	0.01	0.00	2.01	0.80	60
	SAGG	0.07	0.00	12.59	1.54	88
	LAGG	0.04	0.00	7.80	0.03	100
	SAND	0.01	0.00	1.51	0.00	100
	TOTL	0.14	0.00	25.18	3.57	86
37 000	CLAY	0.00	0.00	0.82	0.00	100
	SILT	0.01	0.00	1.32	0.00	100
	SAGG	0.05	0.00	8.22	0.00	100
	LAGG	0.03	0.00	5.10	0.00	100
	SAND	0.01	0.00	0.99	0.00	100
	TOTL	0.09	0.00	16.44	0.00	100
38 000	CLAY	0.00	0.00	0.60	0.56	6
	SILT	0.01	0.00	0.95	0.35	63
	SAGG	0.03	0.00	5.96	0.65	89
	LAGG	0.02	0.00	3.70	0.01	100
	SAND	0.00	0.00	0.72	0.00	100
	TOTL	0.07	0.00	11.93	1.58	87
39 000	CLAY	0.00	0.56	0.60	0.96	17
	SILT	0.01	0.35	0.95	0.21	84
	SAGG	0.03	0.65	5.96	0.32	95
	LAGG	0.02	0.01	3.70	0.02	99
	SAND	0.00	0.00	0.72	0.01	99
	TOTL	0.07	1.58	11.93	1.52	89

Table A-16 (Continued)

40 000	CLAY	0.01	0.00	1.03	0.96	7
	SILT	0.01	0.00	1.65	0.55	67
	SAGG	0.06	0.00	10.34	0.99	90
	LAGG	0.04	0.00	6.41	0.02	100
	SAND	0.01	0.00	1.24	0.00	100
	TOTL	0.12	0.00	20.68	2.52	88
41 000	CLAY	0.00	0.00	0.48	0.00	100
	SILT	0.00	0.00	0.77	0.00	100
	SAGG	0.03	0.00	4.80	0.00	100
	LAGG	0.02	0.00	2.97	0.00	100
	SAND	0.00	0.00	0.58	0.00	100
	TOTL	0.05	0.00	9.60	0.00	100
42 000	CLAY	0.01	0.00	1.23	1.18	5
	SILT	0.01	0.00	1.97	0.88	55
	SAGG	0.07	0.00	12.34	1.79	85
	LAGG	0.04	0.00	7.65	0.03	100
	SAND	0.01	0.00	1.48	0.01	100
	TOTL	0.14	0.00	24.67	3.89	84
43 000	CLAY	0.01	2.37	2.66	0.00	100
	SILT	0.02	1.69	4.26	0.00	100
	SAGG	0.15	3.33	26.63	0.00	100
	LAGG	0.09	0.06	16.51	0.00	100
	SAND	0.02	0.01	3.20	0.00	100
	TOTL	0.30	7.46	53.25	0.00	100
44 000	CLAY	0.01	0.00	0.92	0.00	100
	SILT	0.01	0.00	1.48	0.00	100
	SAGG	0.05	0.00	9.24	0.00	100
	LAGG	0.03	0.00	5.73	0.00	100
	SAND	0.01	0.00	1.11	0.00	100
	TOTL	0.10	0.00	18.48	0.00	100
45 000	CLAY	0.00	0.00	0.83	0.77	7
	SILT	0.01	0.00	1.32	0.47	65
	SAGG	0.05	0.00	8.25	0.85	90
	LAGG	0.03	0.00	5.12	0.02	100
	SAND	0.01	0.00	0.99	0.00	100
	TOTL	0.09	0.00	16.50	2.10	87
46 000	CLAY	0.01	0.00	1.01	0.45	55
	SILT	0.01	0.00	1.61	0.05	97
	SAGG	0.06	0.00	10.06	0.07	99
	LAGG	0.03	0.00	6.24	0.00	100
	SAND	0.01	0.00	1.21	0.00	100
	TOTL	0.11	0.00	20.13	0.57	97
47 000	CLAY	0.01	1.42	1.06	2.25	9
	SILT	0.01	0.26	1.70	0.67	66
	SAGG	0.06	0.38	10.64	1.26	89
	LAGG	0.04	0.02	6.60	0.04	99
	SAND	0.01	0.01	1.28	0.01	99
	TOTL	0.12	2.09	21.28	4.22	82
48 000	CLAY	0.00	3.21	0.89	3.72	9
	SILT	0.01	1.22	1.42	0.58	78
	SAGG	0.05	2.24	8.87	1.08	90
	LAGG	0.03	0.06	5.50	0.04	99
	SAND	0.01	0.01	1.06	0.01	99
	TOTL	0.10	6.74	17.73	5.43	78
49 000	CLAY	0.00	0.00	0.00	0.00	0
	SILT	0.00	0.00	0.00	0.00	0
	SAGG	0.00	0.00	0.00	0.00	0
	LAGG	0.00	0.00	0.00	0.00	0
	SAND	0.00	0.00	0.00	0.00	0
	TOTL	0.00	0.00	0.00	0.00	0

Table A-16 (Continued)

50 000	CLAY	0.01	0.00	2.05	1.40	32
	SILT	0.02	0.00	3.28	0.25	92
	SAGG	0.11	0.00	20.48	0.35	98
	LAGG	0.07	0.00	12.70	0.01	100
	SAND	0.01	0.00	2.46	0.00	100
	TOTL	0.23	0.00	40.97	2.01	95
51 000	CLAY	0.00	0.77	0.52	0.00	100
	SILT	0.00	0.47	0.83	0.00	100
	SAGG	0.03	0.85	5.21	0.00	100
	LAGG	0.02	0.02	3.23	0.00	100
	SAND	0.00	0.00	0.62	0.00	100
	TOTL	0.06	2.10	10.41	0.00	100
52 000	CLAY	0.01	0.00	1.86	1.78	5
	SILT	0.02	0.00	2.98	1.31	56
	SAGG	0.10	0.00	18.63	2.64	86
	LAGG	0.06	0.00	11.55	0.05	100
	SAND	0.01	0.00	2.24	0.01	100
	TOTL	0.21	0.00	37.25	5.77	84
53 000	CLAY	0.00	1.78	0.85	2.23	15
	SILT	0.01	1.31	1.35	0.36	87
	SAGG	0.05	2.64	8.46	0.51	95
	LAGG	0.03	0.05	5.24	0.02	100
	SAND	0.01	0.01	1.01	0.00	100
	TOTL	0.09	5.77	16.92	3.12	86
54 000	CLAY	0.00	5.95	0.50	5.27	18
	SILT	0.00	0.94	0.80	0.20	88
	SAGG	0.03	1.59	5.00	0.29	96
	LAGG	0.02	0.06	3.10	0.07	98
	SAND	0.00	0.01	0.60	0.02	96
	TOTL	0.06	8.55	10.00	5.85	68
55 000	CLAY	0.00	0.00	0.00	0.03	-100
	SILT	0.00	0.00	0.00	0.03	-100
	SAGG	0.00	0.00	0.00	0.04	-100
	LAGG	0.00	0.00	0.00	0.13	-100
	SAND	0.00	0.00	0.00	0.04	-100
	TOTL	0.00	0.00	0.00	0.28	-100
56 000	CLAY	0.00	1.40	0.42	0.02	99
	SILT	0.00	0.25	0.68	0.02	98
	SAGG	0.02	0.35	4.24	0.03	99
	LAGG	0.01	0.01	2.63	0.19	93
	SAND	0.00	0.00	0.51	0.09	81
	TOTL	0.05	2.01	8.48	0.36	97
57 000	CLAY	0.00	0.00	0.87	0.00	100
	SILT	0.01	0.00	1.39	0.00	100
	SAGG	0.05	0.00	8.72	0.00	100
	LAGG	0.03	0.00	5.40	0.00	100
	SAND	0.01	0.00	1.05	0.00	100
	TOTL	0.10	0.00	17.43	0.00	100
58 000	CLAY	0.00	5.27	0.79	0.00	100
	SILT	0.01	0.20	1.27	0.00	100
	SAGG	0.04	0.29	7.95	0.00	100
	LAGG	0.03	0.07	4.93	0.00	100
	SAND	0.01	0.02	0.95	0.00	100
	TOTL	0.09	5.85	15.90	0.00	100
59 000	CLAY	0.00	0.03	0.48	0.68	-24
	SILT	0.00	0.03	0.77	0.79	2
	SAGG	0.03	0.04	4.80	2.21	54
	LAGG	0.02	0.13	2.97	1.67	46
	SAND	0.00	0.04	0.58	0.52	16
	TOTL	0.05	0.28	9.60	5.86	41

Table A-16 (Continued)

60 000	CLAY	0.00	0.02	0.55	0.00	100
	SILT	0.00	0.02	0.88	0.00	100
	SAGG	0.03	0.03	5.48	0.00	100
	LAGG	0.02	0.19	3.40	0.00	100
	SAND	0.00	0.09	0.66	0.00	100
	TOTL	0.06	0.36	10.97	0.00	100
61 000	CLAY	0.01	2.83	1.27	0.00	100
	SILT	0.01	1.13	2.03	0.00	100
	SAGG	0.07	2.65	12.72	0.00	100
	LAGG	0.04	1.82	7.88	0.00	100
	SAND	0.01	0.57	1.53	0.00	100
	TOTL	0.14	9.00	25.43	0.00	100
62 000	CLAY	0.00	1.79	0.65	2.16	12
	SILT	0.01	1.49	1.05	0.35	86
	SAGG	0.04	3.24	6.54	0.43	96
	LAGG	0.02	0.06	4.05	0.15	96
	SAND	0.00	0.01	0.78	0.06	93
	TOTL	0.07	6.60	13.07	3.14	84
63 000	CLAY	0.01	0.00	1.86	1.79	4
	SILT	0.02	0.00	2.98	1.49	50
	SAGG	0.10	0.00	18.61	3.24	83
	LAGG	0.06	0.00	11.54	0.06	99
	SAND	0.01	0.00	2.23	0.01	100
	TOTL	0.21	0.00	37.22	6.60	82

Table A-17: Output for Storm D (1 in. precipitation, 12 hr. duration)

Condensed Soil Loss

Cell Num	Div	Drainage Area (acres)	RUNOFF Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Generated Within (tons)	Yield (tons)	Depo (%)
1	000	179	0.03	0.0	8	0.01	0.00	1.04	0.49	53
2	000	358	0.17	14.9	28	0.00	0.49	0.64	2.01	-44
3	000	179	0.03	0.0	7	0.00	0.00	0.37	0.27	26
4	000	179	0.17	0.0	38	0.01	0.00	1.06	0.81	23
5	000	179	0.17	0.0	38	0.00	0.00	0.59	0.63	-6
6	000	895	0.07	85.3	44	0.00	2.90	0.48	2.23	34
7	000	1074	0.07	87.2	39	0.00	2.23	0.21	4.13	-41
8	000	358	0.17	50.0	44	0.00	0.81	0.57	2.89	-52
9	000	179	0.02	0.0	4	0.05	0.00	8.99	1.15	87
10	000	358	0.02	50.0	5	0.05	1.15	8.35	1.06	89
11	000	1611	0.17	77.0	62	0.17	5.19	30.97	17.19	52
12	000	1790	0.00	0.0	0	0.09	17.19	15.69	0.00	100
13	000	179	0.17	0.0	29	0.12	0.00	20.73	7.55	64
14	000	179	0.02	0.0	5	0.26	0.00	46.62	6.93	85
15	000	179	0.17	0.0	33	0.13	0.00	23.17	8.91	62
16	000	716	0.02	96.8	62	0.25	11.80	44.67	16.34	71
17	000	895	0.00	100.0	50	0.20	16.34	36.53	15.45	71
18	000	179	0.02	0.0	5	0.25	0.00	44.13	7.20	84
19	000	179	0.02	0.0	5	0.23	0.00	41.78	6.82	84
20	000	358	0.17	9.0	21	0.04	6.82	8.05	4.48	70
21	000	537	0.00	0.0	0	0.05	4.48	9.60	0.00	100
22	000	179	0.02	0.0	4	0.12	0.00	21.76	3.14	86
23	000	358	0.02	50.0	6	0.14	3.14	25.22	3.61	87
24	000	716	0.02	75.0	9	0.29	10.54	51.93	13.14	79
25	000	179	0.02	0.0	4	0.21	0.00	36.87	5.40	85
26	000	179	0.02	0.0	5	0.31	0.00	55.44	9.36	83
27	000	1074	0.02	96.9	46	0.15	15.45	27.29	14.90	65
28	000	1432	0.02	97.1	47	0.22	22.10	39.69	19.16	69
29	000	1611	0.00	100.0	41	0.15	19.16	26.96	17.52	62
30	000	1790	0.00	0.0	0	0.09	17.52	16.05	0.00	100
31	000	179	0.02	0.0	4	0.12	0.00	21.90	3.38	85
32	000	358	0.02	50.0	5	0.11	3.38	20.49	3.13	87
33	000	1253	0.00	99.9	9	0.08	16.26	14.77	9.58	69
34	000	1611	0.02	87.5	13	0.35	14.98	63.16	20.07	74
35	000	1969	0.00	0.0	0	0.15	29.43	26.30	0.00	100
36	000	179	0.02	0.0	4	0.14	0.00	25.18	3.57	86
37	000	179	0.00	0.0	0	0.09	0.00	16.44	0.00	100
38	000	179	0.02	0.0	4	0.07	0.00	11.93	1.58	87
39	000	358	0.02	50.0	5	0.07	1.58	11.93	1.52	89
40	000	179	0.02	0.0	4	0.12	0.00	20.68	2.52	88
41	000	179	0.00	0.0	0	0.05	0.00	9.60	0.00	100
42	000	179	0.02	0.0	5	0.14	0.00	24.67	3.89	84
43	000	537	0.00	0.0	0	0.30	7.46	53.25	0.00	100
44	000	179	0.00	0.0	0	0.10	0.00	18.48	0.00	100
45	000	179	0.02	0.0	4	0.09	0.00	16.50	2.10	87
46	000	179	0.00	0.0	0	0.11	0.00	20.13	0:57	97
47	000	716	0.02	66.7	6	0.12	2.09	21.28	4.22	82
48	000	1074	0.00	99.9	7	0.10	6.74	17.73	5.43	78
49	000	179	0.00	0.0	0	0.00	0.00	0.00	0.00	0
50	000	179	0.00	0.0	0	0.23	0.00	40.97	2.01	95

Table A-17 (Continued)

51	000	358	0.00	0.0	0	0.06	2.10	10.41	0.00	100
52	000	179	0.02	0.0	5	0.21	0.00	37.25	5.77	84
53	000	358	0.02	50.0	5	0.09	5.77	16.92	3.12	86
54	000	1611	0.02	85.7	8	0.06	8.55	10.00	5.85	68
55	000	179	1.00	0.0	119	0.00	0.00	0.00	0.28	-100
56	000	358	0.02	0.6	2	0.05	2.01	8.48	0.36	97
57	000	179	0.00	0.0	0	0.10	0.00	17.43	0.00	100
58	000	1790	0.00	0.0	0	0.09	5.85	15.90	0.00	100
59	000	358	0.02	98.3	94	0.05	0.28	9.60	5.86	41
60	000	537	0.00	0.0	0	0.06	0.36	10.97	0.00	100
61	000	895	0.00	0.0	0	0.14	9.00	25.43	0.00	100
62	000	358	0.02	50.0	5	0.07	6.60	13.07	3.14	84
63	000	179	0.02	0.0	5	0.21	0.00	37.22	6.60	82