Application of AGNPS Model to Watersheds in Northeast Kansas

by

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INTRODUCTION

With the advent of Federal Law 92-500, Section 208, requiring that all States evaluate upland erosion and determine its effect on water quality, there has been a demand for an effective and easy-to-use tool to make such estimates. The State of Minnesota recognized this need and developed such a tool, the Agricultural Non-Point-Source-Pollution Model (AGNPS). AGNPS was constructed from existing technologies, combining the basic components of hydrology, water erosion, and sediment transport, into a parameter-based, single-event, computer simulation model.

With continued significance being placed on water quality, the USDA Soil Conservation Service (SCS) is becoming involved with examining the effects of erosion and erosion control on surface water systems. As the SCS increases its involvement in water quality management, a need has arisen for a quick, uniform method of analysis of soil erosion's effects on water quality. The tried-and-true Universal Soil Loss Equation (USLE) has been used to predict soil erosion from a specific area, but now the knowledge of what happens to the sediment generated has become of concern. The routing of the sediments generated into the flow networks of a watershed is a very cumbersome and time-consuming process.

The SCS has become interested in the AGNPS model as a tool to be used nationally in estimating the pollution potential from agricultural lands. Also, the model would be used to demonstrate the effects of management techniques on that pollution potential. In order for the model to be useful, the SCS must first be shown its applicability for various conditions found throughout the nation. Also, it must be shown that the model requires only a reasonable expenditure of workers time to use it.

As part of the SCS's examination of the AGNPS model a joint agreement was undertaken with the Department of Civil Engineering, Kansas State University to establish the usability of the AGNPS model in northeast Kansas. Personnel involved in this research project are Dr. J.K. Koelliker, Professor of Civil Engineering at KSU; C.E. Humbert, graduate student in Civil Engineering KSU; Robert Drees, Geologist at the SCS Kansas Office, Salina; and Larry Miles, Water Resources Engineer at the SCS Kansas Office, Salina.

The objective of this study is to examine the AGNPS model and its applicability to small northeastern Kansas watersheds as a planning tool for water quality management. The investigation of the AGNPS model was done in four principal steps. First, a literature search on the workings of the model was done. Next, data was collected as inputs for use by the model. Then, annual values were developed from the model outputs. Finally, techniques to simulate various management scenarios were developed and evaluated.

In order for the AGNPS model to be considered a usable tool for water quality management in northeast Kansas, it must be shown that: model inputs allow for an accurate representation of the conditions found, the model can be run on a timely basis, outputs from model simulations reasonably reflect the modeled situations, and different management techniques can be modeled and the outputs will show changes in pollutant yields.

To accomplish this research five watersheds in the northeast Kansas area were chosen for study with the AGNPS model. The SCS chose three watersheds from the upper Delaware River Basin; Webster Creek, Mosquito Creek and Barnes Creek, as a representative sample of the variety of different conditions existing in the northeast Kansas region. Locations of the test watersheds are shown in Figure I-1.1.

Two additional watersheds were chosen for study by the Kansas State personnel. These additional watersheds were chosen as possible bench-mark watersheds, each having had research done on their water quality. The two watersheds were upper Soldier Creek, located in southern Nemaha County and Kings Creek, which is part of the Konza Prairie Research National Area (KPRNA) located five miles south of Manhattan in Riley County.

The five watersheds have certain characteristics which distinguish that watershed from the others in this study. Webster Creek presents an example of a watershed with varied land uses including cropland, pastures, woodlands, feedlots and the small municipality of Sabetha. Mosquito Creek is predominately grassland with most pastures in poor condition. Barnes Creek watershed has relatively steep land slopes and has recently gone through a large change in land use from cropland to grassland. Soldier Creek is relatively flat and is predominately cultivated land with high feedlot activity. Kings Creek is

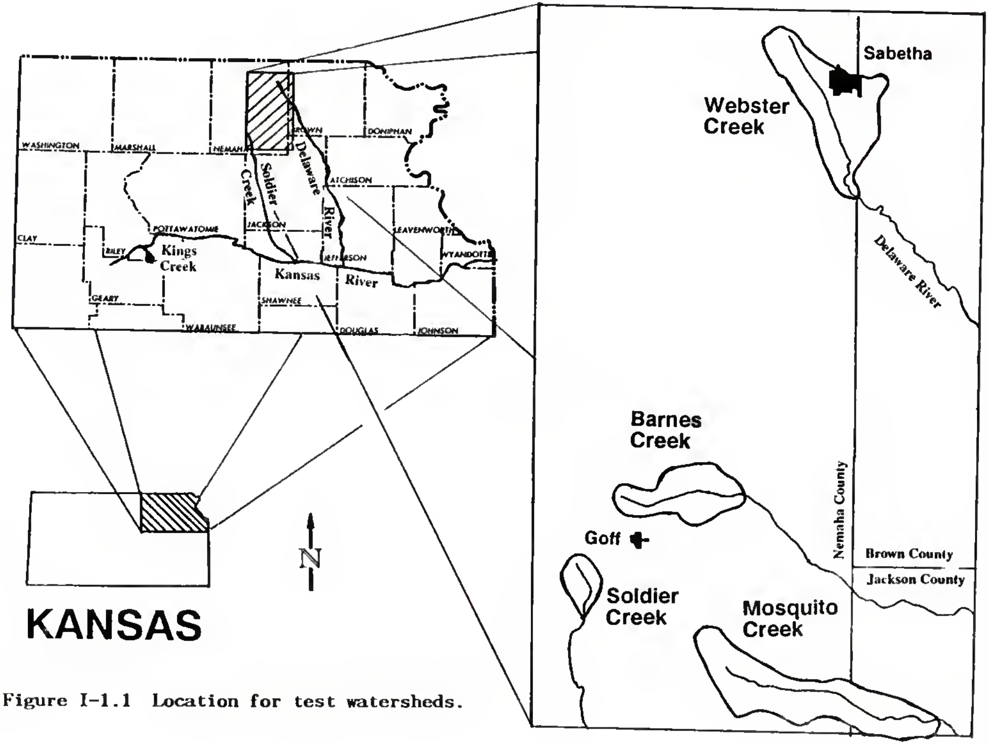

Figure I-1.1 Location for test watersheds.

a native tall-grass prairie in a "pristine" condition. It allows for simulations of an area which has not been affected by the activities of man.

The conditions represented by these watersheds give challenges for the inputting of data to reflect the difference in conditions and an opportunity to evaluate if the model simulations reflect these same differences. Additionally, these watersheds are good areas to demonstrate the effectiveness of various management practices as simulated by the model.

The drainage basins within the five watersheds are considered to be small. The actual sizes of the watersheds varied from 2.0 to 13.3 square miles[1] as follows:

Watershed	area, acres
Webster Creek	7,040
Mosquito Creek	8,520
Barnes Creek	4,400
Soldier Creek	1,280
Kings Creek	2,760

The research for this project was done during the period of September 1988 through August 1989. Collection of input data was begun in October and concluded by March. The major model runs were made from March to May, with continual modifications being made and simulated through late July. Analysis of model simulations began as soon as model runs were made and continued throughout the project.

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[1] English units are used throughout this work to be consistent with the units used in the AGNPS model.

Chapter 1. DISCUSSION OF THE AGNPS MODEL

1-1. DEFINITIONS

Essential in understanding the AGNPS model is the definition of non-point-source (NPS) pollution. This term refers to "diffuse pollution," pollution which can not be traced to a single source. Most agricultural land would be designated as non-point-sources of pollution. Soil erosion from water is a major component of NPS pollution, both as a pollutant and a carrier of other pollutants. The break down of soil particles by water action causes the release of nutrients which are naturally present in the soil. Nutrients that man has added to the soils are also released by the same water actions. Soil erosion is produced more readily on land that has been disturbed by man, but there are natural levels of pollution found in runoff from undisturbed lands.

A general understanding of the processes involved in water-caused, soil erosion is helpful in predicting levels of pollutants and in developing methods to reduce pollution. The two physical processes of soil particle detachment and transport of the detached particles are of principal concern. To understand these physical processes a brief investigation of the energy utilized by each is helpful.

The energy involved in detachment of soil particles comes from the water, either as kinetic energy released when a raindrop hits the soil or velocity energy generated as the water moves over the surface of the ground. Different kinds of erosion are caused by different applications of the water-related energy.

There are five categories of soil erosion from water found in the literature; raindrop, sheet, rill, gully and channel (Beasley et al., 1984). Raindrop erosion is the result of raindrops impacting the soil surface and the associated splashing. Sheet erosion is caused by both raindrop impact and movement of surface runoff in overland flow. Sheet erosion removes lighter soil particles, organic matter and soluble nutrients. The erosiveness of overland flow is dependent on its velocity, turbulence and amount and type of abrasive material it transports. When upward velocities exceed settling velocities transport by suspension occurs. Rill and gully erosion are the result of the concentration of overland flow into surface depressions and the detachment and movement of sufficient soil to cause growth of these depressions. Rills are of small scale and are removable by tillage whereas gullies are more extensive. Channel erosion is the result of stream's actions such as currents and change of course by the stream.

From the above discussion it can be formulated that to control the erosive effects of water the energy associated with the water must be dissipated. The reduction of kinetic energy from raindrops would reduce the effects of raindrop erosion and the part of sheet erosion caused by this energy source. The decrease in surface flow velocities would reduce the effects of rill, gully and the part of sheet erosion caused by surface water movement. Specific management practices have been developed to address energy dissipation and will be discussed later in this study.

This study includes an examination of the AGNPS model simulations of nutrient yields. The nutrients investigated by the model are Nitrogen (N), Phosphorus (P) and Chemical Oxygen Demand (COD). Also, the model examines N and P as sediment-attached or soluble.

1-2. DEVELOPMENT

The Minnesota Pollution Control Agency (MPCA) acting on the need for a uniform method of evaluating runoff from agricultural watersheds in the State initiated a joint agreement with three other governmental agencies to develop a computer model which could analyze agricultural watersheds within the state. Work was begun in the early 1980's and involved the following: MPCA, the SCS and U.S. Department of Agriculture's Agricultural Research Service (ARS), the Minnesota Soil and Water Conservation Board and the University of Minnesota Departments of Agricultural Engineering and Soil Sciences. The computer model developed was called the Agricultural Non-Point-Source Pollution Model (AGNPS).

The goal of the model developers was to provide an objective means to evaluate runoff quality, with primary emphasis on sediment and nutrient loads, and provide a method to compare the effects of various conservation alternatives as a part of management strategies for agricultural watersheds. The model was developed using previous studies and models: Wischmeier's developments on the USLE (Wischmeier and Smith, 1978) was used to predict soil losses, SCS's runoff studies (USDA, SCS, 1975), feedlot studies by Young (Young et al., 1982) was used for the generation of pollutants from feedlots, and the Chemical

Runoff and Erosion from Agricultural Management Systems (CREAMS) studies done by Smith and Williams (1980) and Frere, Ross and Lane (1980) which was developed to simulate sediment and nutrient routing.

The AGNPS model as developed is a single-event, distributed-parameter model which works on a cell basis. The original version of the model was developed for use on a main-frame computer, but was revised so it can be used on micro-computers. The model simulates the erosion process and resultant transport and deposition of sediment for single rainfall-runoff events (Lucord and Young, 1989).

The model was also developed to accept inputs for point-source pollution, such as that from feedlots, wastewater treatment plants and springs, and routes these pollutants along with the NPS pollutants to achieve the final simulation. Feedlot studies by Paul Young in 1980 were the core from which the AGNPS model was developed (Young et al., 1982).

The outputs from the model simulations predict runoff volume and peak rates of flow, upland and channel erosion, delivered amounts of sediment, and nutrient yields (N, P and COD) both as total mass and mass per unit volume.

For further understanding of the AGNPS model it is necessary to examine the equations from which the model was formulated and the inputs required to run the model. These topics are examined and discussed in the following sections.

1-3 EQUATIONS

The basic components of the model consist of two categories: generation of sediment, nutrients and runoff and the routing of the same. The model utilizes over 50 equations and relationships to perform its simulations.

The model equations are broken down into two categories, pollutant generation and routing. The form of the equation is for the most part the form used in the Conservation Research Report No. 35 (Young et al., 1987). For further reference this report will be called the AGNPS manual. Slight modifications to the forms of the equations are made herein for legibility. Some of the equations in the AGNPS manual are presented in SI units; they are presented similarly herein for consistency.

GENERATION

Runoff Volume:

The runoff volume for each cell is determined using the USDA, SCS (1975) curve number method:

$$RF = (RL - 0.2*Sr)^2 / (RL + 0.8*Sr),$$

where,

RF = runoff in inches
RL = 24-hour storm precipitation in inches
Sr = retention factor in inches:
Sr = 1000/CN-10, inches,
and,
CN = curve number.

From use of the SCS curve number method the model will predict runoff volume as a function of rainfall and surface retention. The curve number is a function of land use, soil type, and hydrologic soil conditions and is determined for each cell.

The time needed for flow to concentrate and no longer be considered sheet flow is calculated using the runoff velocity as determined in USDA, SCS (1972). First the velocity is calculated:

$$V=10^{[0.5*\log_{10}(Sl*100)-SCC]},$$

where,

V = velocity, feet/second
Sl = land slope in feet/foot
SCC = overland surface condition constant.

The surface condition constant is a cell characteristic that accounts for the effects of land use and vegetation (Young et al., 1987). From the calculated velocity the time of concentration is determined:

$$T=Ls/V,$$

where,

T = time of overland flow, hours
Ls = field-slope length, feet.

Flow hydrographs are then built from the above information for each cell. The individual cell hydrographs are combined and the runoff volumes from each cell are routed to the outlet point of the watershed. This will discussed in greater detail when the routing relationships are examined.

Upland Erosion:

The model considers upland erosion to be the sum of raindrop, sheet and rill erosion. Total sediment due to upland erosion for a single-storm event is predicted by use of the Universal Soil Loss Equation (USLE) as developed by Wischmeier and Smith (1978), with modifications to adjust for land slope shape. The modified USLE as used in the model is:

$$E = R*K*L*S*C*PF*SSF,$$

where,

E = soil loss in tons/acre
R = rainfall and runoff factor
K = soil erodibility
L = slope-length factor
S = slope-steepness factor
C = cover and management factor
PF = support-practice factor
SSF = slope-shape factor

The USLE was developed from data collected from controlled studies on experimental plots and small watersheds. The factors K, L, S, C and PF are based on comparisons to a "unit plot." The unit plot is defined to be a plot of land 72.6 feet in length, on a continuous slope of 9 percent, in a continuously, clean-tilled fallow condition with the tillage being made up and down the slope. A more detailed explanation of the factors in the USLE are as follows:

R, the rainfall and runoff factor is represented by the number of rainfall erosion index (EI) units. When other factors are held the same research data showed that erosion is directly proportional to the product of two rainstorm characteristics, total kinetic energy of the storm (E) times its maximum 30-minute intensity (I_{30}) which yields EI.

K, the soil erodibility factor, was experimentally determined for specific soil types by use of the unit plot, holding all other factors in the USLE constant and determining the amount of soil loss. In the USLE the factors L, S, C and PF become equal to one and K=E/R.

L, the slope length factor, is the ratio of soil loss from a field slope length to that from a 72.6-foot slope length under identical conditions. Slope length is defined as the distance from the point of origin of overland flow to a point where either the slope gradient decreases enough for deposition or the runoff enters a well-defined channel.

S, the slope-steepness factor, is the ratio of soil loss from a field-slope gradient to that from a 9-percent slope under otherwise identical conditions.

C, the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area of continuous-tilled fallow.

PF, the support-practice factor, is the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope tillage.

SSF, the slope-shape factor, is a modification of the basic USLE to take into account the effect of irregular slope shapes, specifically, convex and concave. Calculations of the SSF for a convex slope were based on a 75-foot slope with the upper third having a gradient of 2 percent, the middle third 7 percent, and lower third 12 percent. For a concave slope, a 75-foot slope was also used with the upper third having a gradient of 12 percent, the middle third 7 percent, and the lower third 2 percent (Wischmeier and Smith, 1978 and Young et al., 1987)

By using the USLE the model will predict upland soil loss as a function of rainfall intensity, soil type, land slope, slope length, ground cover and agricultural support practices. Soil texture is used to determine the fractional distribution of the eroded sediment into particle classes. The model predictions of sediment generation are made on a cell basis. The cell values are summed to give a value for the entire watershed, reported as tons/ac.

Channel Erosion:

The model uses the gully input value for each cell, in tons, as the value of channel erosion for a cell. These values from each cell are summed to give the watershed channel erosion, reported in tons/ac. The model makes no further allowances for channel erosion caused by the accumulation of stream flow. Cell values of channel erosion are combined with the values of upland erosion at the outlet of the cell, at which point they are routed through the watershed flow network.

Soluble Nutrients:

The model predicts soluble nutrient yields by use of methods developed for the CREAMS model (Frere et al., 1980). Figure 1-3.1 shows a schematic depicting the concepts used by the model to predict soluble nutrient yields. The runoff contains soluble nutrients from agricultural practices, soils and rainfall.

The basic equation to predict the soluble N and P concentrations generated from soil erosion is:

$$CON = CS*EXK*RO*0.01,$$

where,

CON = N or P concentration in runoff
CS = mean concentration of soluble portion in the surface soil
EXK = extraction coefficient for movement into runoff
RO = total runoff.

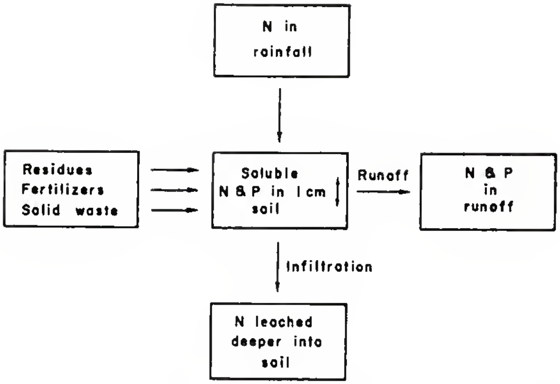

Figure 1-3.1 Diagram for estimating nutrient losses in runoff from Young et al. (1987).

The model will predict soluble nutrient concentrations derived from the soil as a function of availability of the nutrient in the particular soil and runoff volume.

Total yields of soluble N will be dependent on the amount available in the top layer of soil and from the rainfall minus that which is lost due to infiltration. Soluble N in the soil:

$$N = (SOLN + F * Fa) * CF,$$

where,

N = available soluble N content in the soil, kg/hectare
SOLN = soluble N in the top cm of soil, kg/hectare
F = N fertilizer applied in a cell, kg/hectare
Fa = fraction of fertilizer remaining is soil surface
CF = coefficient.

Soluble N in the rainfall:

$$Na = RCN * 1.0E{-}06,$$

where,

Na = available N due to rainfall, kg/hectare
RCN = concentration in the rainfall.

Soluble N lost due to infiltration is a function of the effective infiltration and a constant for downward movement:

$$EFI = ER - RO,$$

where,

EFI = effective infiltration for the storm, mm
ER = effective rainfall, mm,
and,
$ER = R - (10 * POR)$
R = storm rainfall
POR = porosity of the soil
$POR = 1-(\text{bulk density}/2.65$
RO = total storm runoff, mm.

$$Nd = DN1/(10 * POR),$$

where,

Nd = rate constant for downward movement of N into the soil
DN1 = extraction coefficient for movement into runoff, assumed to be equal to 0.25

These equations are combined and the appropriate constants are applied so that the model outputs are in lbs/ac. The model predicts soluble N yields as a function of amount available in the soil, amount available due to fertilization, amount available from rainfall and the amount lost through infiltration.

Similarly, P concentrations are predicted as the N concentrations are with the exception there is no consideration of the amount of P due to rainfall. Specifically, P concentration in the runoff is a function of that available due fertilization and in the top soil minus that which is lost to infiltration.

Feedlot-generated pollutants are treated as point-source pollutants and are routed into the channel with those produced from nonpoint sources. P and COD contributions from a feedlot are calculated using a model developed by Young et al. (1982). Concentrations of P and COD are calculated first at the edge of the feedlot:

$$Cf*ROf=C1*RO1+C2*RO2,$$

where,

Cf = concentration at the feedlot edge
ROf = runoff volume at the feedlot edge
$C1$ = concentration of runoff in the feedlot
$RO1$ = runoff volume from the feedlot
$C2$ = concentration of runoff from the area area above the feedlot
$RO2$ = runoff volume from the area above the feedlot.

The concentrations of P and COD in the feedlot itself are directly inputted to the model using data obtained from tables developed with concentrations for various animal types (Young et al., 1982).

The flow is routed through a buffer strip, if present, where reductions in concentrations are made by filtration:

$$Cr=Cf*(1-D1/100)*(1-D2/100),$$

where,

Cr = reduced pollutant concentration
$D1$ = percent reduction due to overland flow
$D2$ = percent reduction due to grass waterways.

The final concentration following the buffer is the calculated as,

$$Ct*ROt=Cr*ROf+C3*RO3,$$

where,

Ct = final concentration at the discharge point
ROt = total runoff at the discharge point
$C3$ = concentration of runoff from the area below the feedlot
$RO3$ = runoff volume from the area below the feedlot.

From these equations the model will predict concentrations of P and COD as a function of inputted concentrations, existing concentrations and the effects of buffering.

The concentration of N from a feedlot is predicted by the model as a function of input concentrations, which are dependent upon animal type, existing concentrations of N and the effects of buffering. Buffering effects are calculated using a relationship developed from studies done by Bingham et al. (1978), Dickey and Vanderholm (1979), and Young et al. (1980):

$$DN1=-16.8+42.3*\mathrm{Log}_{10}OFT,$$

where,

DN1 = percent reduction due to overland flow
OFT = overland flow time.

Adjustments are made for concentrated flow in waterways:

$$DN2=25.53+0.047*GWTC,$$

where,

DN2 = percent reduction due to channel flow
GWTC = flow time in grass waterway.

The pollutants from feedlot are considered to be soluble and are thus routed with the runoff flow.

Nutrient Yields Attached to Sediments:

The total sediment yield from each cell is used to calculate the nutrient yield associated with the sediment. Sediment transported nutrients are estimated using an equation from the Chemicals, Runoff, and Erosion From Agricultural Management Systems (CREAMS) model (Frere et al., 1980).

$$SED\_\_ = SOIL\_\_ * SED * ER * 0.892,$$

where,

SED__ = N or P transported by sediment, lbs/ac
SOIL__ = N or P concentration in the soil
SED = sediment yield, kg/hectare
ER = enrichment ratio,
and,

$$ER = a * sed^{b} * Tf$$

a and b are assumed constants equal to 7.4 and -0.20, respectively,
and,
Tf = factor for soil texture

The N concentration in the soil is estimated as 0.001 lb N per pound of soil, and the P concentration is estimated as 0.0005 lb P per pound of soil (Frere et al., 1980). Model simulations for transported nutrients levels thus are a function of availability in the soil and amount and type of sediment.

Chemical Oxygen Demand:

All COD is assumed by the model to be soluble. Calculations of the amount of soluble COD in the runoff are based on the runoff volume and the average concentration of COD. Values for COD are generalized into land-use categories, with values ranging from 60 mg/L for pasture to 120 mg/L for row crops. The COD factor as entered into the model is in mg/L. This value is modified by the model to give output values as lbs/ac. Estimated values of COD yields and concentrations for each cell are dependent upon the input data.

ROUTING

Hydrology:

Peak flow rates are determined by use of equation developed by Smith and Williams (1980) for use in the CREAMS model.

$$Qp = [8.48*A^{0.7}*Sc^{0.159}*RF^{(0.824*A^{0.0166})}]* [Lc^{2}/(A*43560)]^{-0.187}.$$

Qp = peak discharge, cfs
A = drainage area, acres
Sc = channel slope, feet/foot
RF = runoff volume for the 24-hour storm, inches
Lc = channel length, feet

The calculations for peak flow rate are made for the area draining into a cell by using the drainage area above the cell, slope of the channel within the cell, runoff volume from above the cell and length of the longest flow path to the cell. Peak flow rates at the exit from the cell use the drainage area above the cell plus that of the cell, channel slope within the cell, runoff volumes from above the cell plus that generated within the cell, and the length of flow is the longest flow path within the cell. Peak flow rates for primary cells, cells that have no drainage area above them, are calculated using the area of the cell and a length of flow equal to half the length of the cell.

The channelized flow duration, a factor which affects the transport of sediment, based on the peak flow rate,

$$D = RF * 3630 * A / Qp,$$

where,

D = duration, seconds
RF = runoff volume, inches
A = drainage area, acres
Qp = peak discharge, cubic feet per second.

All channels are assumed to be triangular and flow is uniform within them. The width of the channel is calculated using

$$W = 2.05*z^{-0.625}*(1+z^2)^{0.125}*(Qp*n/Sc^{0.5})^{0.375},$$

where,

W = channel width, feet
z = channel side slope, feet/foot
n = Manning's roughness coefficient for the channel

Impoundment Routing:

An impoundment within a cell will cause an alteration in the runoff hydrograph. The model will incorporate this change and decrease the peak flow rate leaving the cell. The impoundment only receives sheet flow from within the cell which it is located. The model will only route the runoff volumes, sediment yields and nutrient yields generated within the cell where the impoundment is located through the impoundment. No runoff or pollutants developed upstream of the cells with impoundments are routed through the impoundment. In other words, the impoundments receive no channelized flow. This will be shown to be a major limiting factor for the model later in this study.

The routing of sheet flow and associated pollutants is simulated using relationships developed by Laflen et al. (1978) and Foster et al. (1980).

$$Q = y^{0.5} * CD / 3600,$$

where,

Q = peak flow rate leaving, cubic feet per second
y = pond depth, feet
CD = coefficient.

CD is a function of volume held within the pond, diameter of the discharge pipe and infiltration rates of the particular soil where the impoundment is placed. The impoundment system is assumed to concentrate flow into a pipe-outlet. Table 1-3.1 shows the infiltration rates used by the model for various soil types.

Table 1-3.1 Infiltration rates for each of the major soils from Young et al. (1987).

Soil texture	Infiltration rate (inches/hr)
High clay soils	0.05
Silt soils	0.40
High sand soils	0.70
Peat soils	1.50

Routing through the impoundment is a function of surface area and depth, diameter of outflow pipe, infiltration rate and inflow rate. Impoundments are assumed to have a trapezoidal shape.

Sediment and Nutrient Routing:

Routing of sediment and nutrients is derived from the steady-state continuity equation and is an application of equations for sediment transport and deposition described by Foster et al. (1981) and Lane (1982).

$$Qs_x = (Qs_o + Qs_l*dx/Lr) - (W*dx/2*(D_o+D_x).$$

where,

$Qs_{\_}$ = sediment discharge at,
$_x$ = downstream, $_o$ = upstream, $_l$ = lateral.
Lr = reach length
dx = change in down slope distance
D_o = sediment deposition rate upstream
W = channel width

The model will predict sediment discharge as a function of sediment inflow from above the cell, sediment generated within a cell, length of flow within the cell and deposition within the cell. Deposition is calculated as a function of sediment particle size, runoff rate, sediment flow rate, and effective sediment transport capacity,

$$D_i = Vss/q*(qs-gs),$$

where,

D_i = sediment deposition rate at point i
Vss = particle fall velocity
q = runoff rate
qs = sediment flow rate
gs = sediment transport capacity

The effective sediment transport capacity is determined using a modification of the Bagnold (1966) stream power equation. The final calculated sediment capacity is a function of velocity, channel length, channel width and shear stress.

Chapter 2. MODEL INPUTS

2-1. STORM INPUTS

The AGNPS model requires two inputs from the storm selected for simulation. These inputs are the 24-hour rainfall amount and the EI of the storm. Values for rainfall amounts were taken from the U.S. Department of Commerce Technical Paper No. 40 (Hershfield, 1963), which provides rainfall depths for the continental U.S. for storms with durations from 30 minutes to 24 hours and return periods from 1 to 100 years.

Annual rainfall data for three stations in close proximity of the five watersheds were taken from the National Oceanic and Atmospheric Administration publication of Climatological Data for Kansas (NOAA, 1988). The three stations are; Holton, which is 15 miles east of the general area of the four watersheds in Nemaha County, with annual rainfall of 35.68 inches; Centralia, which is 10 miles west of the general area of the four watersheds in Nemaha County, with annual rainfall of 34.55 inches; and Manhattan, which is near Kings Creek, with annual rainfall of 32.88 inches.

Values for EI were taken from USDA Agricultural Handbook No. 537 (Wischmeier and Smith, 1978). This publication includes an isoerodent map of annual EI values for the continental U.S. and average values of EI for storms of different frequencies for various locations. An annual EI value of 190 was read for the five watersheds. The closest station to the study that had individual storm EI values and an annual EI value of 190 was St. Joseph, Missouri.

AGNPS requires the input of one set of storm data to run a simulation. The storm can be of any frequency as long as the rainfall amounts and EI values are known. For the purposes of comparing model simulations of the different watersheds and comparing different agricultural management techniques, the AGNPS manual recommends using the 25-year, 24-hour storm.

The five watersheds lie within the same isohyhetal and isoerodent lines. Thus, the same storm inputs for storms of similar frequencies can be used for all the watersheds. The storm inputs for the 25-year, 24-hour storm were rainfall of 5.8 inches and an EI value of 130. These values served as storm inputs for all comparisons except for annualized results. The storms used for annualizing will be discussed in Chapter 3.

Storm inputs are the easiest input data to change for a simulation run. The AGNPS program allows changing these two inputs at the beginning of a run. These changes do not alter the input file being run.

2-2 LAND CHARACTERISTICS

PREPARATIONS

For purposes of gathering input values needed to run the AGNPS model the five watersheds were divided into 40-acre cells. The 40-acre cell size was recommended by Young et al.(1987) for watersheds over 2000 acres. This resolution was felt to be sufficient for the purposes of this study. A grid of 40-acre cells was anchored from a specific point on each watershed. Anchor points were section corners that were identifiable on all three of the data sources: topographic maps, soils maps and aerial photos. The specific grid-anchor points for each watershed will be discussed later when the five watersheds are examined in detail. The use of the 40-acre cell grid provides easy setup on section lines, dividing each quarter section into four cells.

Once the grid system was in place, the cells were numbered consecutively starting in the northwest corner of the watershed proceeding east through the row, returning to the west end of the next row south, or simply stated, like reading the written page, see Figure 2-2.1. This was repeated until all cells were numbered. A cell was considered as part of the watershed if at least half of its area was within the watershed.

After the grids were numbered, data were collected for the 22 inputs per cell required by the model for a simulation. The input data for a cell is in three categories: topographic data, soils data and land use data. Topographic data was collected from U.S. Geological Survey quadrangle topographic maps. Soil inputs were taken from SCS County Soils Surveys. Land-use inputs were collected from 1:12,000 scale aerial photographs and field surveys, except for Kings Creek which was modeled as one land use. The following is a closer examination of the three categories of data inputs.

TOPOGRAPHIC INPUTS

The topographic inputs for the five watersheds were gathered from USGS quadrangles, 7.5-minute series, 1:24,000 scale, obtained from the Kansas Geological Survey in Lawrence, Kansas. From these maps the

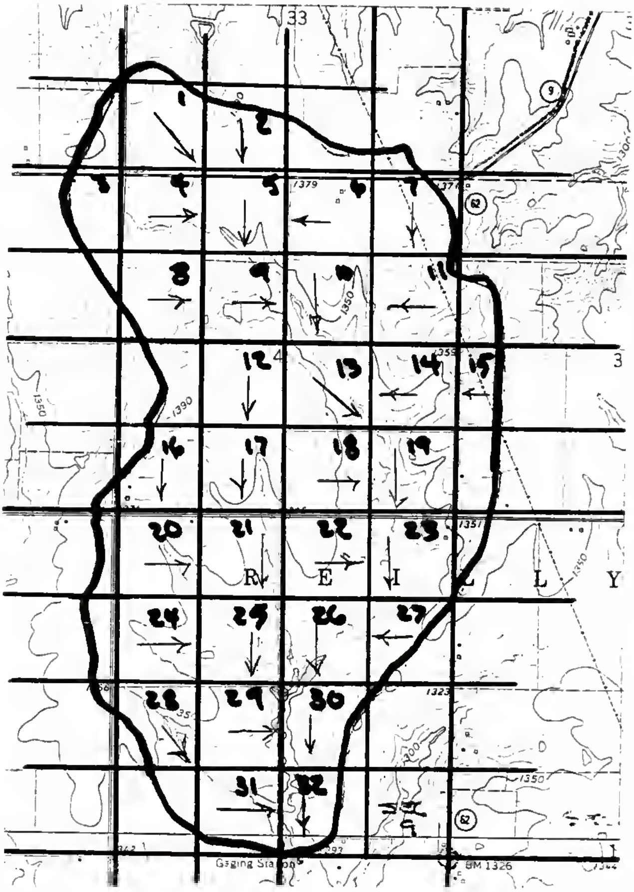

Figure 2-2.1 Soldier Creek watershed with grid applied and aspects shown on USGS map, Goffs quadrangle, scale 1:24000.

following information was gathered for each cell: land slope, slope shape, the presence of channels and channel slope. Using this data these specific model inputs were made:

Cell number, which was established from the grid network.

Receiving cell number, the cell which receives the most significant portion of the runoff from the upstream cell.

Aspect, a single digit from 1-8 designating the direction of drainage from the cell. The single digit used corresponds to one of the directions on an 8-point compass.

Land slope (S1), the major slope within the cell, percent.

Slope-shape factor (SSF), an identification number used to indicate if the cell is uniform slope(1), convex(2) or concave(3).

Channel slope (Sc), the average slope of the channel or channels present within the cell, percent. If there are no definable channels then this input is assumed to be one half of the land slope.

Channel indicator, the number of defined channels within the cell.

Field-slope length (Ls), the distance from the point of origin of overland flow to a point where deposition occurs or the runoff enters a well-defined channel. Input values were generalized as a function of slope steepness. Table 2-2.1 shows the generalized inputs for field slope length. These values were based upon observations and modification of Table 4 in the AGNPS manual (Young et al. 1987).

Table 2-2.1 Inputs for field slope length from Young et al. (1987).

Slope steepness (%)	Field slope length (feet)
0-2	100
3-6	250
7-12	200
>=13	150

The model uses inputs of cell number, receiving cell, aspect, channel indicator and channel slope to build a flow network for the watershed. The remaining topographic inputs, Ls, Sc and SSF, are used in the USLE to predict sediment generation. Simulations of nutrient yields and routing also utilize the topographic inputs.

SOILS INPUTS

The soils inputs were taken from four USDA SCS County Soil Surveys: Nemaha County (Kutnink et al. 1982), Brown County (Eikleberry and Templin 1960), Jackson County (Campbell et al. 1979) and Riley County (Jantz et al. 1975). The Riley County Soil survey had a scale of 1:24,000 so the same 40-acre grid used for the topographic map could be used on it. The remaining three county soil maps had a scale of 1:20,000 when required a new 40-acre grid to be made for that scale. From the soil maps the name of the soils in each cell was determined. The name identifies the soil as to hydrologic group and texture group. Two specific model inputs were made from this information, the soil erodibility factor, K, and the soil texture number.

The K factor was established from the specific soil names of the two or three dominant soils within a cell from the USDA SCS TG Notice KA-6, (1974) and the SCS soil surveys. These numerical values were weighted by percent area of the cell for each soil and the weighted value used as the input for the cell.

The soil texture number defines the major soil textural classification for each cell. Figure 2-2.1 was used to assign a value for each soil type. The value for the dominant soil in a cell was used for the model input.

The specific soil inputs of K and soil texture number are used by the model in two areas. The K-factor value is used directly in the USLE. The soil texture number is used in division of sediment into sizes which are used in the transport equations.

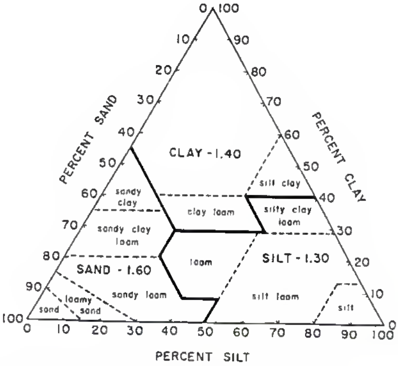

Figure 2-2.2 Soil bulk density (g/cm^3) for each of the major soil textures as found in Young et. al (1987). Soil texture input values noted within each soil texture group.

LAND USE INPUTS

Basic land-use categories within the four watersheds in Nemaha County were established by examination of the 1:12,000-scale aerial photos taken in the mid 1980's. Four major land uses were found: land under cultivation (henceforth referred to as cropland), rangeland, woodland, and areas of urban development. Certain management practices were also detectable from the aerial photos. These included terraces, contouring and location of ponds.

The land-use data for Kings Creek was not gathered from the aerial photos. Kings Creek lies within the KPRNA and is maintained as a natural grassland. All of the land-use related inputs for the watershed were made to reflect grassland conditions.

To supplement the land-use data collected from the aerial photos, a field survey of the four watersheds in Nemaha County was done on January 31-February 1,1989 by Dr. James Koelliker, Bob Drees and Erik Humbert. The field survey provided additional land-use data which was not readily available from the aerial photos or the maps. This additional data included specific information on cropping practices support, fertilization information, and locations of point-sources. Data was also collected on the topographic inputs of channel characteristics and general identification of gully locations.

The land-use data collected from both the aerial photos and the field survey were used to establish the following specific input values: channel roughness used in Manning's equation (n), channel sideslopes, cropping factor (C), practice factor (PF), surface condition (c), fertilization level, fertilization availability, point sources, impoundments, gullies and COD factor. Topographic and land-use data were both used to establish the SCS curve numbers.

Establishment of the input values for channel conditions were made directly from data collected during the field survey. Channels were divided into two categories, headwater and established channels. Headwater channels were considered to be those found in primary cells, where a primary cell is one that has a 40-acre or smaller drainage area. These channels were found mostly to be grass waterways. Cells with more than a 40-acre drainage area were found to have established channels.

Channel side-slope inputs were standardized such that the input values for headwater channels were 10 percent and established channels were 99.9 percent (1:1). The n values were also standardized. Values for headwater channels were established as 0.080, which represents a grassed waterway in good condition, and n for established channels was fixed at 0.040, which reflected a clean, winding channel with some pools and shoals. These n values were used for all watershed except Kings Creek. For headwater channels a value for n of 0.100, reflecting a grass waterway in near excellent condition was used. For established channels an n value of 0.048 was used, which represented a clean, winding stream with stones and pools. All n values were taken from Chow (1959).

The C for each land-use category was obtained from two sources. Values for cropland were obtained from the Nemaha County Office of the SCS (Schwant, 1989) and C values for grassland and woodland were obtained from Wischmeier and Smith (1978). The C value for urban areas was determined by assuming these areas were either built up, paved or grassed. Values for C for each land use are shown in Table 2-2.2.

Table 2-2.2 Input values for cropping factor, C (Wischmeier and Smith, 1978).

Land use	Cropping factor, C
grassland	0.10
woodland	0.10
urban	0.10
contoured cropland	0.25

The two or three dominant land uses for each cell were collected, the C factor for each use was assigned and weighted by area and this weighted value used for the cell.

PF values for each land use were obtained from Wischmeier and Smith (1978). A generalized condition of contoured cropland on a land slope of 6 to 8 percent was used, which has a PF of 0.5, as shown in Table 2-2.3. For pasture, woodland and urban areas a PF of 1.0 was used. PF for the two or three most dominant land uses in the cell were obtained, and then were weighted by percent area of the cell to obtain the value inputted.

Values of c were based on the land use within a cell. The values of c for each land use were obtained from Young et al. (1987) as shown in Table 2-2.4. The land use data was gathered for the dominant two or three land uses in a cell and weighted by percent area to obtain the value inputted.

Table 2-2.3 Practice factor, PF, values and slope-length limits for contouring from Young et al. (1987).

Land slope percent	PF value	Maximum length[1], feet
1 to 2	0.6	400
3 to 5	0.5	300
6 to 8	0.5	200
9 to 12	0.6	120
13 to 16	0.7	80
17 to 20	0.8	60
21 to 25	0.9	50

[1] Limit may be increased by 25 percent if residue cover after crop seedlings will regularly exceed 50 percent.

Table 2-2.4 Surface condition constant, c, values from Young et al. (1980).

Land-use condition	Surface condition constant, c
Fallow	0.22
Row crop	
Straight row	0.05
Contoured	0.29
Small grain	0.29
Legumes or rotation meadow	0.29
Pasture	
Poor	0.01
Fair	0.15
Good	0.22
Permanent meadow	0.59
Woodland	0.29
Forest with heavy litter	0.59
Farmsteads	0.01
Urban (21%-27% impervious surfaces)	0.01
Grass waterway	1.00

Model inputs for fertilization level and availability were based on generalized values for the areas receiving fertilizer. All cropland was assumed to receive fertilizer at the rate of 100 lb/ac N and 40 lb/ac P. The fertilizer was assumed to be applied by use of a row cultivator. This data was translated into input values by using Tables 2-2.5 and 6 as found in Young et al. (1987). The input for fertilization level is 2 and for availability is 50% for any cell receiving fertilization. If the cell was one half or less cropland a value of 1 was used, but it was still considered to be 50% available.

The point-source indicator value shows the number of point sources in a cell. From the field survey there were two types of point-sources found, feedlots and wastewater treatment plants. When a point-source is present within a cell, the values used to describe it are entered in the data file as described by Young et al. (1987).

Input values needed for a feedlot simulation include: area of the feedlot, curve number for the feedlot area, area and curve number of land draining into the feedlot, area and curve number of lands that have drainage which mixes directly with the feedlot drainage before it enters an established channel, roofed area, buffer area slope surface condition and length and number and type of animals. These data were collected during the field survey of the watersheds.

Generalized inputs for the area of the feedlots covered by roofs were made by assuming that value to be 25 percent of the total feedlot area. Specific inputs of animal type were obtained from Tables 2-2.7 and 8 which come from Young et al. (1987) and Young et al. (1982).

Table 2-2.5 Fertilization inputs based on application rates from Young et al. (1987).

Level of fertilization	Assumed fertilization (lb/acre)		
	N	P	Input
None	0	0	0
Low	50	20	1
Medium	100	40	2
High	200	80	3

Table 2-2.6 Fertilizer availability factors according to tillage practice from Williams (1983) and reported in Young et al. (1987).

Tillage practice	Fertilizer availability factor (%)
Large offset disk	40
Moldboard plow	10
Lister	20
Chisel plow	67
Disk	50
Field cultivator	70
Row cultivator	50
Anhydrous applicator	85
Rod weeder	95
Planter	85
Smooth	100

[1] If more than one tillage has been made since the fertilizer application, use the product of the two factors divided by 100.

Table 2-2.7 Ratio of total N, P and COD by various animals to that produced by a 1,000-pound slaughter steer from Young et al. (1982) and Young et al. (1987).

Animal Type[1]	Design weight[2]	N	P	COD
	(Pounds)			
Slaughter steer.....	1000	1.00	1.00	1.00
Young beef..........	500	0.60	0.51	0.50
Dairy cow...........	1400	1.68	0.92	1.96
Young dairy stock...	500	0.46	0.33	0.70
Swine...............	200	0.26	0.27	0.17
Feeder pig..........	50	0.07	0.07	0.04
Sheep...............	100	0.13	0.06	0.18
Turkey..............	10	0.02	0.03	0.02
Chicken.............	4	0.01	0.01	0.01
Duck................	4	0.01	0.01	0.01
Horse...............	1000	0.81	0.42	0.42

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[1] Data from Midwest Plan Service (1975) except swine, which is from American Society of Agricultural Engineers (1982).

[2] Interpolation of values should be based on the maximum weight animals would be expected to reach.

Table 2-2.8 Chemical oxygen demand (COD) factors for various land-use situations from Young et al. (1987).

Land use	COD factor (mg/L)
Row crops	170
Small grain	80
Pasture and open	60
Alfalfa	20
Forested	65
Fallow	115
Farmsteads and urban nonresidential	80
Water	0
Marsh	25

Input values for a wastewater treatment plant simulation include discharge flow (cfs) and concentrations of N, P and COD (mg/L or ppm). There was only one waste water treatment plant in the studied area, specific inputs for it were made from data obtained from a conversation with the plant operator (Hayden, 1989).

Impoundment factor input values represent the number of impoundments found within a cell. When impoundments are present their drainage area and outlet pipe diameter are entered as described by Young et al. (1987).

The values for gully inputs were taken from studies done by Bob Drees, and values were based on information gathered from comparisons of aerial photos of different dates, data collected during the field survey and experience in estimating gully progress. The model requires a value in tons for the gully activity within a cell for the specific storm being simulated. Data was provided for the 25-year storm gully activity and a corresponding annual value for each cell of the studied watersheds (except for Kings Creek which was assumed to have no gully activity).

The COD-factor value for each land use was obtained from Young et al. (1987) as shown in Table 2-2.8. This data was gathered for the dominant two or three land uses in a cell, then weighted by percent area.

The SCS curve number was obtained from the table developed by the SCS (1975) using the topographic, soils and land use data previously collected. Table 2-2.9 shows the curve numbers as a function of land use and soil type as found in Young et al. (1987). A weighted value

Table 2-2.9 Runoff curve numbers for various land-use situations from Young et al. (1987).

Land-use condition	Runoff curve number[1]			
	Soil group A	Soil group B	Soil group C	Soil group D
Fallow	77	86	91	94
Row crop				
Straight row	67	78	85	89
Contoured	65	75	82	86
Small grain	63	74	82	85
Legumes or rotation meadow	58	72	81	85
Pasture				
Poor	68	79	86	89
Fair	49	69	79	84
Good	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 surfaces)	72	79	85	88
Grass waterway	49	69	79	84

[1] Source: USDA, SCS (1976). Values given are for Antecedent Moisture Condition II.

for the curve number of each cell was made by using percent areas for each of the variables used to determine the curve number. All values were taken for antecedent moisture condition II (AMC II).

2-3 SPECIFIC WATERSHED INPUTS

WEBSTER CREEK

Webster Creek watershed was modeled as 176, 40-acre cells. The grid system was anchored as follows: the north-south anchor line was Highway 75 (Nemaha-Brown County line), the east-west anchor line was the section line road on the south side of Sections 16, 15 and 14. Two USGS topographic maps were used, the Sabetha and Woodlawn quadrangles.

The watershed lies in two counties, Nemaha and Brown, so both county's SCS soil surveys were used. This presented some problems because the soils had different names in each county. The two sets of soil names were correlated by examination of their characteristics and locations. The Brown County survey was published in 1960 and used an older naming system than the Nemaha County survey which was published in 1982. All soil names were translated into the naming system used for the Nemaha County survey.

Webster Creek lies in the Wymore-Pawnee association of soils: deep, gently or moderately sloping; moderately well-drained soils that have a dominantly clayey subsoil found on uplands. There were ten soils found in the watershed in significant amounts to be inputted: Burchard-Steinauer, Kennebec, Kipson, Olmitz, Pawnee, Reading, Steiner and Wymore. (See Appendix 1, Table 1.) The dominant soils for the drainage basin were Wymore silty clay loam (K=0.37 and hydrologic group C), found on the uplands and Pawnee clay loam (K=0.37 and hydrologic group D), found on the valley walls and lower parts of the basin.

Webster Creek had 12 feedlots as of January 31, 1989, the date of the field inspection, with five different animals found: feeder steers, swine, dairy cattle, sheep and llama, totaling 1,725 head. (The llama were treated as sheep.) (See Appendix 1, Table 2.) There was one non-feedlot point source found in the watershed, the city of Sabetha's wastewater treatment plant, located in Cell 68. (See Appendix 1, Table 7.)

Gully activity within the watershed was a significant input to the model. Fifty-six percent of the cells had gullies present. The gully activity was inputted as follows: 77 cells with 60 tons erosion per cell and 21 cells with 120 tons erosion per cell for the 25-year storm. The remaining 78 cells had no gully inputs. (See Appendix 1, Table 6.)

Within the watershed boundaries there were 21 ponds. The total drainage area for these ponds is 2,740 acres, which represents 39 percent of the drainage area of Webster Creek. (See Appendix 1, Table 3.) Ninety-one cells were considered to be primary cells and modeled as having headwater channels. (See Appendix 1, Table 5.) This represents 52 percent of the total drainage area.

For land use inputs the watershed was modeled as: 62 percent cropland, 46 percent rangeland, 7 percent urban and 5 percent woodland. (See Appendix 1, Table 4.) The cropland was considered to be contoured and the pastures were modeled as being in fair condition.

MOSQUITO CREEK

Mosquito Creek watershed was modeled as 213, 40-acre cells. The grid system was anchored as follows: the north-south anchor line was the Nemaha-Jackson county line, the east-west anchor line was also the Nemaha-Jackson county line. The watershed extends over three USGS topographic maps, Netawaka, Circleville and Soldier quadrangles.

The drainage area of Mosquito Creek watershed covers parts of two counties, southeastern Nemaha and north central Jackson. SCS County Soil Surveys from both counties were used. The soil names were not consistent for the two counties. This area lies within the Pawnee-Burchard-Steinauer association of soils, (referred to as Pawnee-Shelby-Burchard in the Jackson county survey): deep, gently sloping to moderately steep, moderately to well-drained soils that have a loamy or clayey subsoil, found on uplands. There were ten soils found in significant amounts: Burchard-Steinauer, Kennebec, Olmitz, Pawnee, Steinauer, Shelby clay loam, Shelby gravel loam, Wabash, Wymore and Zook. (See Appendix 1, Table 1.) The dominant soils in the watershed were the Pawnee clay loam (K=0.37 and hydrologic group D), found on the uplands, and Burchard-Steinauer clay loam (K=0.28 and hydrologic group D), found on the valley sides and lower parts of the watershed.

Mosquito Creek watershed was not particularly active with feedlots. There were three feedlots with two animal types, feeder steers and dairy cattle. At the time of the field survey there were a total of 450 head in the three lots. (See Appendix 1, Table 2.)

Gully activity was inputted for 167 cells, which represented 78 percent of the watershed. This activity was inputted as follows: 102 cells with 30 tons erosion per cell and 65 cells with 80 tons erosion per cell for the 25-year storm. The remaining 48 cells were treated as not having any gully activity. (See Appendix 1, Table 6.)

Thirteen percent of Mosquito Creek watershed was above ponds. These were modeled as 17 ponds with a total drainage area of 1,065 acres. (See Appendix 1, Table 3.) The drainage basin was modeled as having 73 primary cells, thus 34 percent of the area was represented as headwater cells. (See Appendix 1, Table 5.)

For land-use inputs the watershed was modeled as 83 percent rangeland, 14 percent cropland, and 3 percent woodland. (See Appendix 1, Table 4.) Cropland was considered to be contoured and the pasture varied from poor to fair condition.

BARNES CREEK

Barnes Creek watershed was modeled as 110, 40-acre cells. The grid system was anchored as follows: the north-south anchor line was on the section line road between Sections 36 and 31, the east-west anchor line was the section line road along the south line of Sections 14 and 13. Two USGS quadrangle maps were needed for Barnes Creek, Wetmore and Goff.

The Nemaha County Soil Survey was used for soil names and area because Barnes Creek lies entirely within the county. The watershed lies within the Pawnee-Burchard-Steinauer association of soils with the same characteristics as described for Mosquito Creek. There were three soils found in substantial quantities, Burchard-Steinauer, Kennebec and Pawnee. (See Appendix 1, Table 1.) Pawnee clay loam (K=0.37 and hydrologic group D) was found on the upland areas of the watershed, Burchard-Steinauer clay loam (K=0.28 and hydrologic group B) was on the valley walls and lower areas and Kennebec silt loam (K= 0.32 and hydrologic group B) was found in small amounts along the streams.

There was only one feedlot found in the drainage basin, having 100 head of feeder steers. (See Appendix 1, Table 2.)

Barnes Creek has the most active gullies of the five watersheds studied. The watershed showed evidence of having been extensively used for cropland within the recent past. Over the past few years the land had been turned back to rangeland. The high gully activity appears to be a result of the period of cultivation. The watershed has steep slopes which, when disturbed, initiated formation of gullies. For the watershed there were 58 cells inputted as 120 tons per cell and 25 cells as 160 tons per cell for the 25-year storm. This meant that 75 percent of the watershed received gully inputs. (See Appendix 1, Table 6.)

For land use inputs Barnes Creek was inputted as 82 percent rangeland, 13 percent cropland and 5 percent woodland. (See Appendix 1, Table 4.) The pasture was modeled as being in from poor to fair condition. Cropland was considered to be contoured.

SOLDIER CREEK

Soldier Creek watershed was modeled as 32, 40-acre cells. The grid system was anchored as follows: the north-south anchor line was Highway 62 (section line between Sections 9 and 10), the east-west anchor line was the south side of Sections 9 and 10. The watershed extended into two USGS quadrangles, Soldier and Goff.

The portion of Soldier Creek being examined is entirely within Nemaha County. Soils inputs came from the Nemaha County SCS Soil Survey. The majority of the watershed lies within the Wymore-Pawnee association with characteristics as described for Webster Creek. There were only two soils present in quantities significant enough to be inputted, Pawnee and Wymore. (See Appendix 1, Table 1.) The Wymore silt clay loam (K=0.37 and hydrologic group C) was found in the uplands, while the Pawnee clay loam (K=0.37 and hydrologic group D) was found in the low reaches of the watershed.

Gully activity for the watershed was low. Seventy-five percent of the watershed was modeled as having gullies, but the activity of the gullies was minor. This activity was inputted as: 16 cells with 12 tons erosion per cell and 8 cells with 16 tons erosion per cell for the 25-year storm. The remaining 8 cells were treated as having no activity. (See Appendix 1, Table 6.)

Ten percent of the drainage basin was above ponds. This consisted of two small ponds with with a total drainage area of 130 acres. (See Appendix 1, Table 3.) Fifty percent, 16 cells, of the watershed was modeled as primary or headwater cells. (See Appendix 1, Table 5.)

Soldier Creek was the most heavily cropped of the five watersheds. The land-use inputs were as follows: 82 percent cropland, 16 percent rangeland and 2 percent woodland. (See Appendix 1, Table 4.) The pastures were considered to be in good condition, the cropland was input as contoured.

KINGS CREEK

Kings Creek watershed was modeled as 69, 40-acre cells. The grid system was anchored as follows: the north-south anchor line was the section line between Sections 24 and 19, the east-west anchor line was the Riley-Geary county line which is the section line along the south edge of Sections 24 and 19. The entire watershed was within the Swede Creek quadrangle map.

Soils information for Kings Creek was taken from the Riley County Soil Survey. The watershed was found to lie in two different soil associations, Clime-Sogn and Benfield-Florence. The northern portions were in the Clime-Sogn which had the following characteristics: soil depths from shallow to moderately deep, on sloping to moderately steep uplands, silty clay loams. The southern reaches of the watershed were in the Benfield-Florence which had the following characteristics: moderately deep soils, on sloping to moderately steep uplands, silty clay loams and cherty silt loams.

There were five soils found in quantities significant enough to be inputted: Benfield-Florence, Clime-Sogn, Dwight-Irwin, Tully and Reading. Benfield-Florence silty clay loam was found on the uplands of the watershed. This soil complex is relatively erosive, K=0.37, and in the C hydrologic group the soil complex, shows characteristics of slow infiltration and high runoff. The Clime-Sogn silty clay loam was found in the mid-levels of the valley sides. This soil complex exhibits the same characteristics as the Benfield-Florence, K=0.37 and hydrologic group C. These two soil complexes comprise the greater portion of the watershed soils, with the remaining soils located on the stream terraces, except the Dwight silt loam which was found on one hilltop. The valley soils, Reading silt loam and Tully silty clay loam, are formed of alluvial sediments and exhibit the basic characteristics of the parent soils from the uplands and valley sides. (See Appendix 1, Table 1.)

Kings Creek was modeled as a "pristine" watershed, one with minimal influence by man. There were no inputs for feedlots, impoundments or gullies. For land use the drainage basin was modeled as 100 percent rangeland in excellent condition. These model inputs reflected actual conditions on Kings Creek watershed quite accurately.

2-4 COMPARISON OF INPUTS

The five watersheds examined can be divided into two categories as defined by the present conditions of the watershed. Three of the watersheds, Mosquito Creek, Barnes Creek and Kings Creek, are predominantly grassland. The remaining watersheds, Webster Creek and Soldier Creek, are predominantly cropland.

The input values from each of the watersheds, in general, show the separation between grassland-dominated and cropland-dominated. The values for curve number inputs are the only area where this does not hold true. Characteristically, the curve numbers for the grass-lands would be expected to be significantly lower than that for the cropland. This would vary slightly as a function of soil type, however, the five watersheds have fairly similar soils allowing for this comparison. Mosquito Creek does not follow this separation in curve numbers. Its curve numbers are more in line with those of the cropland-dominated watersheds. This is due to the pastures within Mosquito Creek being modeled as being in poor condition.

Figure 2-4.1 and Tables 2-4.1 and .2 compare the values for nine of the most important model inputs found in the different watersheds. Examination of these comparisons show a few notable facts. Kings Creek has two factors which would indicate a relatively high yield of sediment when compared to the other watersheds: the soil is the most erosive of those studied and the land slopes are considerably steeper. This, of course, is offset by the land use inputs.

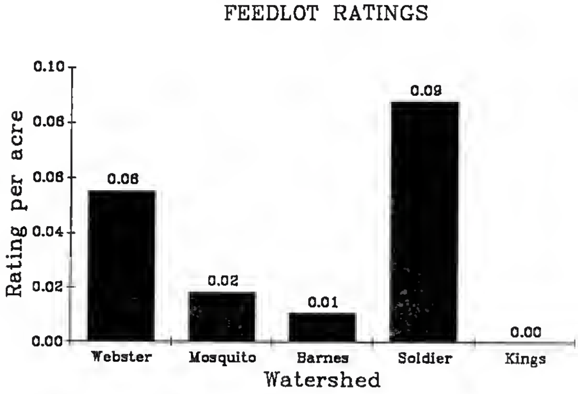

Figure 2-4.1 Feedlot ratings per acre for the five watersheds.

Table 2-4.1 Inputted land use in the five watersheds.

Watershed	Land use, % Cropland	Rangeland	Woodland	Urban
Webster Creek	62	26	5	7
Mosquito Creek	14	83	3	0
Barnes Creek	13	82	5	0
Soldier Creek	82	16	2	0
Kings Creek	0	100	0	0

Table 2-4.2 Average values for the five watersheds for 12 AGNPS model inputs.

Input	Watershed Webster	Mosquito	Barnes	Soldier	Kings
Gully, ton/ac for 25-year storm	1.01	0.97	2.46	0.25	0.00
Curve number, CN	81.9	81.3	72.7	83.1	74.0
Land slope, %	3.5	4.8	5.4	3.3	9.4
Field slope lnth, ft	213.	243.	244.	184.	198.
Channel slope, %	1.69	2.84	2.99	1.41	6.12
Manning's, n	0.06	0.05	0.05	0.06	0.08
Soil, K	0.36	0.31	0.30	0.36	0.37
Cover, C	0.16	0.04	0.04	0.21	0.01
Practice factor, PF	0.72	0.93	0.94	0.59	1.00
Surface, c	0.23	0.06	0.06	0.23	0.22
Fertilization	1.24	0.29	0.25	1.72	0.00
COD, mg/L	74.	63.	63.	76.	60.

Comparisons of the feedlot ratings per acre indicate that Soldier Creek, and to a lessor degree, Webster Creek have abundant feedlot activity. The feedlot rating system for individual feedlots was developed by Young et al. (1982) to compare a feedlot's potential pollution hazard. The feedlot rating per acre is the total of all feedlot ratings within a watershed divided by the watershed area. This value is used only for comparison purposes; the actual value has no specific meaning.

Comparing the gully input values for the five watersheds shows Barnes Creek with the most extensive gully activity, over double that of Webster Creek the second highest. Soldier Creek has the lowest gully activity, only 10 percent of the Barnes Creek value.

Care has been taken throughout the data-gathering process to make sure that all input values are as accurate as possible. There have been generalizations made in certain areas which have facilitated the collection process. Of primary importance of this research is not the absolute values of the inputs, but that the process for assigning values is carried out consistently for all inputs.

2-5. TIME REQUIREMENTS FOR CREATING INPUT FILES.

The building of the five input files for this project reflected a significant investment of time. To facilitate this process two undergraduate students were enlisted. The main focus of their data collection was on the physical characteristics of each watershed. All other data collection was done by the author.

The data collected from the watersheds was then converted to specific input values. This also was a time-consuming process, creating some feelings of tedium. The input values were then entered into data files usable by the model.

The three steps, data collection, translation into input values and data entry, constitute the entire process of creating an input file. The actual time required for creating all five of the input files was 185 hours. The five watersheds represented a total area of 24,000 acres which were modeled as 600, 40-acre cells. The time required was approximately an average of 20 minutes per cell to create the input files.

The AGNPS manual presented an estimate of time requirements for compilation of an input file. Estimates were one person-month (168 hours) for larger watersheds; those up to 23,000 acres in size, and about 3 person-days (24 hours) for smaller watersheds; up to 500 acres in size. The actual time spent in this study of 20 minutes per cell is within these two estimates.

Once the data files have been created the actual model simulations take less than two minutes per watershed. Modification of the files to reflect varied conditions is a relatively short process compared to the original generation of the file. Time requirements for particular modifications are dependent on the complexity of the modification. This will be discussed in a later section.

Interpretation of model results results is a time-consuming process. The ability to generate model results is much faster than the ability to interpret the results.

Chapter 3. ANNUALIZING

3-1. BASIC CONCEPTS

For water quality planning purposes it is necessary to have data on average annual yields not just a single-storm event. A catastrophic storm may generate high yields, but, because of its low frequency, its contribution to an average annual value may be small. The single-storm values are useful when designing for catastrophic events, but an annual value gives a clearer picture as to what may be expected from year to year.

Water yield is a prime example of the necessity of having annual values. Using the data from a single-storm event as expected yield each year will give distorted and meaningless results when designing any type of system which is dependent upon water yield. It is essential for a proper design to have an average annual value, one that reflects what may be expected on average over a number of years.

The AGNPS model, in its present form, is a single-storm event model. An area of examination for the usefulness of the AGNPS model in water quality studies of northeast Kansas watersheds is to see if an average annual value for runoff and pollutants can be derived from this single-storm event model.

The premise used for building an average annual value from single-storm simulation values is that each storm event contributes a portion to the average annual amount based on its frequency of occurrence. The area under the frequency curve verses yield distribution is representative of the average annual value.

To build a frequency curve verses yield distribution a battery of 15 different storms were developed. The storm frequencies ranged from 0.005 (the 200-year storm) to 80 (the 0.0125-year storm, one that would be equaled or exceeded 80 times a year). Input data for each of these storms were collected and used to modify the watershed input files. These new files were used for simulations with the results translated into annual values.

3-2. ANNUALIZING MODEL INPUTS

It was necessary to change three model inputs for each of the 15 storms used. These inputs were rainfall, EI and gully erosion inputs. The remaining inputs were treated as being independent of storm frequency and were held constant.

RAINFALL

The base data for rainfall inputs came from TP-40 (Herschfield, 1961). Rainfall amounts for storms with return periods of 100, 50, 25, 20, 10, 5, 2 and 1-years were taken directly from TP-40. A plot of the log of storm frequencies verses rainfall was made for these eight storms. This yielded a straight-line relationship between the log of storm frequency and rainfall, (a log-normal frequency distribution). The 200-year storm was determined directly from this distribution.

Rainfall amounts for storms with return periods of less than one year were based on the above mentioned distribution and were modified by comparison with actual distribution of daily precipitation amounts for a 50-year period for Horton Kansas, located 30 miles east south-east of Sabetha. This information was available from Koelliker (1984) from former work done on watershed modeling in the Horton area. An average annual rainfall amount for the 15 storms was determined by calculating the area under the frequency verses rainfall curve. The values for the low return period storms were fine tuned such that the annual rainfall would be close to the actual average annual amount. The annual rainfall amount for Manhattan of 32.9 inches was used.

Table 3-2.1 **Model inputs for different storms: Erosion Index and Rainfall.**

Return period, years	Erosion index per storm	Rainfall, inches per storm	Weighted erosion index	Weighted rainfall, in./year
200	190	8.0		
100	169	7.5	1	0.0
50	150	6.5	2	0.1
25	130	5.8	3	0.1
20	127	5.7	1	0.1
10	106	5.1	6	0.3
5	86	4.1	10	0.5
2	62	3.3	22	1.1
1	46	2.7	27	1.5
0.5	28	2.1	37	2.4
0.25	8	1.5	36	3.6
0.10	2	1.0	30	7.5
0.05	0	0.5	10	7.5
0.025	0	0.1	0	6.0
0.0125	0	0.0	0	2.0
		Annual sum	184	32.6

Note: Amount of annual total within each increment between the return periods is shown on the row with the lower return period. That is, the value on the 100-year return period is the amount in the increment between the 200- and 100-year return period events.

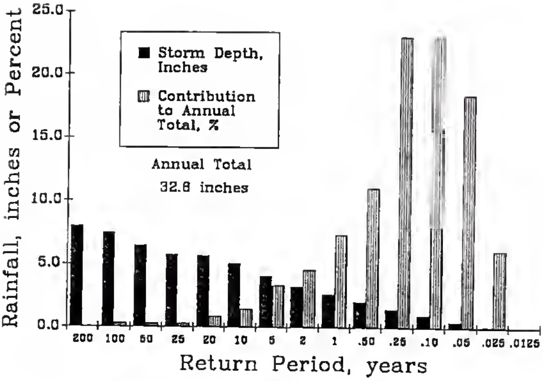

Figure 3-2.1 **Storm depths for the 15 storms used for annualizing, compared with the contribution to the annual depths from each frequency interval.**

The final 15 storms yielded an average annual rainfall of 32.6 inches, which is 0.3 inches less than the actual annual rainfall of 32.9 inches. Table 3-2.1 shows the 15 storm values and Figure 3-2.1 compares these values with the contribution to the annual amount each interval of frequency makes.

ENERGY INTENSITY

EI values for the 20-, 10-, 5-, 2- and 1-year storms were obtained from Wischmeier and Smith (1978) using St. Joseph, Missouri values. As mentioned previously, St. Joseph was used because it was the closest station on the same isoerodent line as the five watersheds which had individual storm values. Wischmeier and Smith (1978) found that EI values tend to follow a log-normal frequency distribution. The values for the 200-, 100-, 50- and 25-year storms were found from a log-normal plot of the five known storm values verses their frequency.

EI values for storms with return periods less than the 1-year storm were developed from the same distribution. The average annual value from the 15 storms was found by calculating the area under the frequency verses EI curve. Values for the lower return period storms were fine tuned so that the calculated average annual EI value would match closely the actual annual EI value.

The actual average annual EI value for the study area 190, the average annual EI value from the 15 storms is 184. Table 3-2.1 gives the EI values for each of the storms, these values are compared to the contribution to the average annual amount from each frequency interval and shown in Figure 3-2.2.

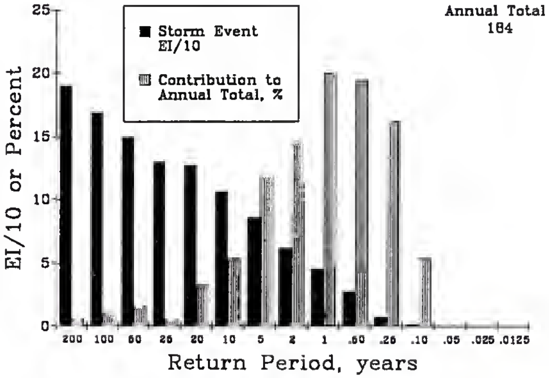

Figure 3-2.2 EI values for the storms used in annualizing, and the contribution to the annual value of each frequency interval.

GULLY INPUTS

The values for gully inputs for the battery of storms were the most difficult of the three inputs to derive. The method used to develop the gully inputs was developed specifically for this project and is a relatively complex procedure. It is still based on using the area under the frequency verses yield distribution as an average annual value.

Data supplied by Bob Drees, SCS geologist, on gully yields was the basic data used to develop the gully inputs. This data was in two forms, the 25-year storm value and a corresponding annual value. The basic premise used in building the 15 storm inputs for gully erosion was that the gully yield should be somewhat proportional to the runoff volume. This is supported by examining the development of gullies and noting that the energy required for gully erosion comes from the movement of the surface runoff.

The procedure for developing the input values for each the 15 storms started by choosing one of the pairs of data supplied by Drees. For convenience the 1.0-ton/ac annual and 1.5-tons/ac 25-year yields were chosen. These inputs were used for many of the cells in Webster Creek. From this a distribution of storms, a series of yields from gullies was to be developed which had the yield for the 25-year storm as 1.5 ton/ac and the annual yield would total 1.0 ton/ac.

The next step in our procedure was to develop annual values for surface runoff and sediment yield from Webster Creek. The input files used had no gully data entered, the only inputs changed were the rainfall and EI values for each storm. A frequency vs. yield distribution was built for runoff and sediment yield from the model simulation results. The areas under these curves were calculated with the results used as the average average annual values. Figures 3-2.3 and 3-2.4 show the frequency verses yield and the contribution to the average annual amount for each frequency interval for runoff and sediment yield, respectively.

The next step was to compare runoff volumes to sediment yields. Table 2, Appendix 3 shows the raw data from the model simulations and was used to construct Figures 3-2.3 and 3-2.4. From examination of the data in Table 2, Appendix 3, it was seen that for storms with return periods from 200-year to 0.5-year the average ratio of runoff to sediment yield was 3.06. This ratio of 3.06 inches of runoff yielding 1.0 ton/ac of sediment was used to find a runoff volume that would be expected to yield 1.5 ton/acre. This volume of runoff was 4.59 inches.

The runoff volume of 4.59 inches was 1.2 times greater than the actual runoff volume for the 25-year storm. The values of runoff for the remaining 14 storms were increased by 1.2 times to correspond with the increase in the 25-year storm. By dividing these adjusted runoff figures by the ratio of runoff to sediment yield (3.06), a value for expected erosion was obtained. These values were the "first-try" values of gully erosion for the 15 storms.

A weighted value for each frequency interval was made, this being the area under the frequency verses yield curve. The weighted values were summed giving an average annual value. For the "first-try"

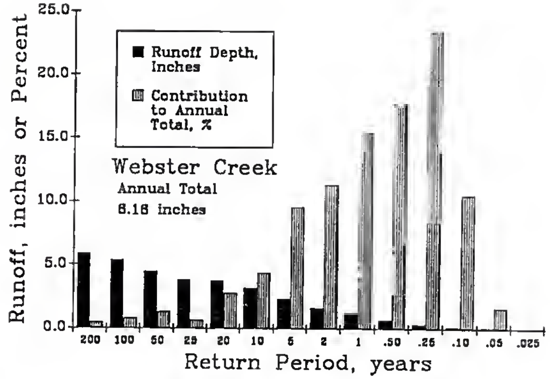

Figure 3-2.3 Runoff volumes from Webster Creek for the 15 storms used for annualizing and the contribution to the annual total of each frequency interval.

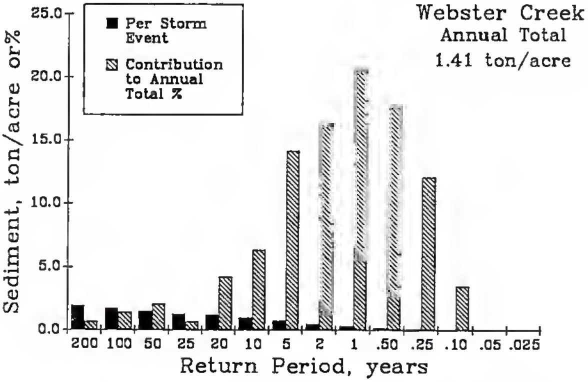

Figure 3-2.4 Generated sediment values from Webster Creek for the 15 storms used in annualizing and the contribution to the annual value for each frequency interval. The generated sediment values do not include gully inputs.

values the average annual value for gully yield was 2.42 ton/acre. This was larger than the 1.0 ton/acre target figure so the storm inputs were adjusted.

Examination of Table 2, Appendix 4 showed that the storms contributing the largest values to the annual total were the storms with return periods less than the 25-year storm. To bring the annual value for gully yield down the, values for the storms with return periods greater than the 25-year storm were increased while the values for storms with return periods less than the 25-year were decreased. This followed a secondary assumption that for very small amounts of runoff gully activity would be low, but as runoff volumes increased the gully activities would increase more rapidly.

A ratio of the final gully erosion inputs to the "first-try" values, which were based exclusively on runoff volume is shown in Table 2, Appendix 4. The inputs for the 25-, 20- and 10- year storm remained nearly the same. The inputs for the 200-, 100- and 50-year storms were increased 30, 18 and 14 percent, respectively, while those for the 5-, 2-, 1- and 0.5-year storms were reduced by 12, 22, 34 and 48 percent, respectively. Figure 3-2.5 shows the final gully inputs for each storm and the contribution to the annual value from each frequency interval.

Table 3 in Appendix 4 shows the different storm inputs for gully erosion for the different annual yields given by Bob Drees. These values were developed using the ratio of annual yield to the 1.0-ton/ac annual yield and multiplying these values by the 1.0-ton/ac values. Using this scenario the 25-year and corresponding annual

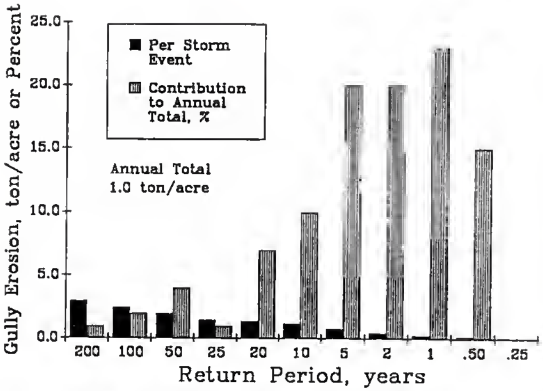

Figure 3-2.5 Final gully inputs for the annualizing storms for an annual value of 1.0 ton/ac and the contribution to the annual value for each frequency interval.

values as given by Bob Drees were matched for the 0.5-, 1.0- and 2.0-ton/ac annual yields and were within 11 percent for the 1.25- and 3.0-ton/acre annual yields. Only on the small annual gully yields were the 25-year storm missed by a substantial amount. The value for the 25-year storm for the 0.2-ton/ac annual yield was missed by 25 percent and for the 0.1-ton/ac annual yield was missed by 50 percent.

The above scenario for developing the gully erosion inputs for the 15 storms with different frequencies can be summarized by saying that the energy required for gully erosion is derived from the volume of surface runoff and the yield of a gully increases as the volume of runoff increases after a certain threshold volume is reached.

3-3 ANNUALIZING RESULTS

After the collection and development of the input data for rainfall, EI and gully erosion for the battery of storms, new input files were created for each of the watersheds. The storm inputs were easily changed on each file, but the gully inputs required some manipulations which became time consuming. The results of the modifications were 15 separate input files, one file per storm, for each watershed.

The input files were run through the AGNPS program with the results used to build frequency verses yield distributions for runoff, sediment and nutrient yields. The area under these curves was calculated and used as the average annual value.

Time requirements for the annualizing process were relatively low when compared to the time used to create an original file. Collecting of data and development of the original input file was the most lengthy portion of the entire process. An accurate record of time was not kept on this step. Much of the time expenditures were on developing the process and would not be required for subsequent watersheds.

Changing an input file was accomplished by use of a word processor. This manipulation is fairly quick and easy, requiring approximately one hour to modify the 15 input files of a watershed. Running these through the model requires less than 20 minutes for watersheds up to 250 cells. The results from the battery of storms for a watershed can then be annualized in 15 minutes per yield by inserting results into a spreadsheet on a micro-computer.

The annualizing process is most judicious for finding annual values for entire watersheds. Later in this study, an example of where this process is rather time consuming is discussed.

Chapter 4. MODIFICATIONS MADE TO SIMULATE MANAGEMENT STRATEGIES

4-1. IMPOUNDMENTS

There are two basic categories of impoundment structures in common use in northeast Kansas to reduce sediment yields, storage-type terraces and ponds. Each of these categories has many specific types of structures. The AGNPS model requires only two inputs for an impoundment, drainage area and outlet pipe diameter. The model cannot distinguish the specific type of impoundment being modeled.

In northeast Kansas the majority of the impoundments are ponds. There are three basic types of ponds: farm ponds (small ponds used for water storage), grade stabilization ponds, and flood control structures. The grade stabilization and flood control structures are a popular and well-documented management tool for reducing sediment yield.

The five watersheds studied had a total of 45 ponds with drainage areas ranging in size from 20 to 640 acres and with a total of 4,155 acres of drainage area. This was 17 percent of the total area in the study. Webster Creek had the highest concentration of ponds. Thirty-nine percent of the watershed was above ponds. The above data shows that ponds are in common use within the areas studied.

According to the AGNPS manual, a cell can have up to 13 impoundment terraces, each inputted with its drainage area and discharge pipe diameter. The format given for this data suggests that a maximum drainage area could be 999 acres and pipe diameter could be up to 99 inches. Original runs of the model for this study included the 45 impoundments which were present in the watersheds.

Examination of the output data without ponds compared to simulations with ponds revealed that the model was not responding the input data as expected. To evaluate how the model was treating the impoundment inputs, hypothetical watersheds of two and five cells were built. Using the 25-year storm these hypothetical watersheds were run with various sizes of impoundments and discharge pipes. The results are shown and discussed in Table 1 of Appendix 5.

The conclusion made from the results of the test runs is that, in its present state, the AGNPS model cannot be used to model ponds of the type typically found in northeastern Kansas watersheds. This was based upon the following two observations:

1. The model treats impoundments as receiving only overland flow generated within the cell and cannot receive channelized or overland flow from upstream cells. This limits the size of the drainage area for an impoundment to the cell size (40 acres in this study).

2. The infiltration of the impoundments reflects that of a storage-type terrace system, which is considerably higher than the rate expected for ponds in the study area. The higher infiltration rate, the effects of which become more dramatic for impoundments whose drainage area approach cell size, gives a substantially lower than expected depth of runoff. The infiltration rate used by the model is that used for a soil which is in a dry condition before it is inun

dated by the water (See Table 1 in Appendix 5). The majority of the studied ponds have conservation pools and silting in conditions which lower the infiltration rates substantially.

Because the model was not simulating ponds adequately and meaningful results were not being produced, the pond inputs were removed from the input files. This eliminated comparison of the effects of the ponds on predicted yields for the five watersheds.

The apparent pond limitation to the AGNPS model eliminates simulations of a proven and widely-used management option for reducing sediment yield. As part of this study the SCS wanted to develop a prediction for the effects of 24 grade stabilization and flood control dams with ponds which are proposed to have drainage areas ranging in size from 115 to 3,860 acres located on three of the watersheds. With the AGNPS model, as it is available presently, meaningful results would not be produced.

4-2. CONSERVATION TILLAGE

Conservation tillage refers to a tillage technique where a considerable portion of the previous crop's residue remains on the surface of the ground. This requires minimal tillage and leaves a maximum cover. This technique is becoming a widely-used management technique for reducing water erosion loss from cropland.

Application of conservation tillage will reduce the C factor for areas treated. Achieving a C-factor value as low as 0.15 is considered a goal for the process. The increase in ground cover also has an effect on the retention of surface runoff, thus affecting the curve number. Koelliker et al. (1981) suggest that the decrease in curve number achieved by conservation tillage over regular tillage would be three units.

To see if the AGNPS model could be used to simulate the effects of conservation tillage, Webster Creek was selected because of its high percentage of cropland and its more varied other land uses.

All of the cells modeled as cropland were treated with conservation. This required changing the C-factor value from 0.25, representing present conditions, to 0.15, a reduction of 40 percent. The curve numbers of all cells receiving the conservation tillage were decreased by three units. The new input file which reflected these changes was used for simulation. The storm used was the 25-year, 24-hour storm.

To see the effects of poor tillage practices, those eliminating most residue from the surface, a new input file was created to reflect these conditions. The C-factor values were changed to 0.35 and the curve numbers were increased by three units for all cropland cells.

4-3. STORAGE-TYPE TERRACES

Storage-type terraces are a system of terraces with underground drains from each terrace. The drains are designed to allow a specific flow from the terrace for a design storm. The system reduces peak flow rates which reduce the potential for erosion and causes runoff retention which allows for deposition and increases infiltration. This makes the storage-type terraces a management tool for reducing sediment yield.

Soldier Creek was used to make an assessment of the AGNPS model's usefulness in predicting yield changes when storage-type terraces are applied. Two-thirds of the watershed, 21 cells, were given storage-type terraces. The cells chosen were headwater cells.

To simulate actual practices cells receiving storage-type terraces were considered to have 75 percent of their drainage areas within the terrace system. This means that 30 of the 40 acres from each cell were within the drainage areas of the impoundments. Ten terraces each a drainage area of three acres and each with an outlet pipe of six inches diameter. The terrace system design was taken from the ASAE Standards (ASAE, 1983).

Practice factor, PF, is changed when a terrace system is added. Wischmeier and Smith (1978) suggest a value of 0.05 for the PF for storage-type terraces. This value was used for all land which was within the terrace systems. The remaining area of the cell originally had a PF of 0.5 and was increased to 0.75 to reflect possible changes made after construction of the terraces. The two PF values were weighted by area to produce the input value, 0.25. The new input value for the PF was a 50 percent reduction from the original value.

A new input file was made to reflect the addition of the storage-type terraces. This was simulated using the 25-year storm. An average annual value was developed by changing the inputs on the 15 files originally used to develop an annual value. The entire process of file changing, model running and annualizing took under two hours.

4-4. ACHIEVING "T" (ALLOWABLE SOIL LOSS)

Of particular interest for soil erosion control specialists is reducing losses to a level such that the soil resource can be maintained productive for the foreseeable future. This is referred to as soil loss tolerance and the allowable soil loss value is known as T. T values have been established for the different soils of Kansas. For the area of Nemaha County being studied the value for T is 5 tons/ac annually. The question being addressed in this section of the study is, "Can the AGNPS model be used to identify cells yielding above T and can management practices be modeled which would reduce the cell output to below T?" Three watersheds were used for this examination: Webster Creek, Mosquito Creek and Barnes Creek.

The first step in the process of achieving T for all cells was to identify all cells that were yielding above T under present conditions. The AGNPS model is a single-event model and will give values for a single-storm event. The model was run for the 25-year storm using the Webster Creek present conditions input files. An annual value of sediment yield was developed for various cells to identify the cell whose annual yield was closest to the annual T value.

The annual yield from the cell closest to T was 5.6 tons/ac or 4.0 tons/ac for the 25-year storm. A conservative reduction of this value was made to establish 3.8 tons/ac for the 25-year storm as corresponding to T. Model runs for the three watersheds under present conditions using the 25-year storm were made. From the outputs all cells above the 25-year storm value of T (3.8 tons/ac) were identified.

For the cells identified as above T, conservation tillage was applied. The cropping-factor inputs for these cells were modified from C = 0.25 to C = 0.15, a 40-percent reduction. Curve numbers for these cells were reduced by three units. The new input files were run using the 25-year storm. The outputs were examined to find cells remaining above T.

Storage-type terraces were applied to any cell remaining above T. These terraces were as described in Section 4-3, 10, 3.0-acre terraces each with a 6-inch diameter discharge pipe. PF values were changed in a slightly different manner than done in Section 4-3. A value of PF equal to 0.01 was used for areas within the terrace system and the remaining area of the cell was left as PF = 0.50. This was done to allow for comparisons of systems with different PF reductions. The PF inputs were reduced 26 percent from the original values.

These modifications were made on the input files which had been treated by conservation tillage. The new input files were run, outputs were examined to see if T had been achieved.

Establishment of the 25-year value which corresponded to the annual value of T was the most time-consuming aspect of this procedure, taking one hour. The modifications of inputs for conservation tillage required from 15 to 25 minutes per watershed, while for the terrace systems took 20 to 30 minutes per watershed. Both times were dependent on the number of cells changed.

Actual annual estimates for all cells examined would be helpful for analysis purposes. The ratio of 25-year storm values to the annual value for each cell is different and is dependent upon cell location and characteristics. The time requirements for achieving annual values for all cells examined are prohibitive.

Chapter 5. EXAMINATION OF AGNPS MODEL SIMULATIONS

5-1 INPUT DATA EFFECTS

Each input value has an effect on the AGNPS model simulation. The AGNPS manual provides the results of a sensitivity study done on the storm inputs, EI and rainfall, and the "core" watershed inputs. Core inputs are those that reflect the physiographic characteristics of the watershed and the land use. Specifically, these would include land slope, stream conditions, soil types, cropping and management conditions. The more complex inputs of impoundments, point sources and gullies were not included in this sensitivity study.

The results of the sensitivity study done for this study showed that sediment yield was affected most importantly by the following variables: land slope, the soil erodibility factor, the cropping factor and the curve numbers. Nutrient yields attached to sediments were affected in a like manner. Soluble nutrient yields were principally dependent on the curve number. Comparisons of the predicted yields from the five watersheds will illustrate the model sensitivity to these inputs. This is done in Section 5-2.

The focus of the remainder of this section will be on examining the effects that the complex, non-core inputs of point-sources and gullies have on the model simulations and an examination of the effects of C-factor changes. Illustration of the effects of the non-core inputs was made by using Webster Creek while the C-factor effects were demonstrated on Kings Creek. Webster Creek was chosen because of the variety of activity within it while Kings Creek was chosen because all of the cells within it are inputted with the same C-factor value.

Four input files for Webster Creek representing four separate conditions were run through the AGNPS program. The four conditions used were, core, feedlots added, other point-sources added and gullies added. The 25-year storm was used for each simulation. The simulation results are the basis for the following comparisons.

Predicted sediment yields are directly influenced by the inputted gully erosion amounts, but no change occurs with the addition of feedlots or other point-sources. The gully inputs which are the modeler's estimate of all erosion from gullies and channels, are added to sheet and rill erosion for the cell. Once any pollutant leaves a cell all of it will be routed unaffected. Figure 5-1.1 shows the predicted changes in outputs when the gully inputs are added.

The large influence that gully erosion inputs have on the model outputs of sediment and sediment-attached nutrients points out a weakness of the model. As in all simulation models, the results are only as good as the model inputs, so it is with the AGNPS model. Gully erosion data is the most subjective of all of the model inputs and yet its influence on the model results is one of the most important.

Nutrient yields show sensitivity to feedlots, other point-sources and gully inputs. The addition of the feedlots show a marked increase in the outputs of N, P and COD. A smaller increase was seen with the addition of the wastewater treatment plant (other point-sources). The

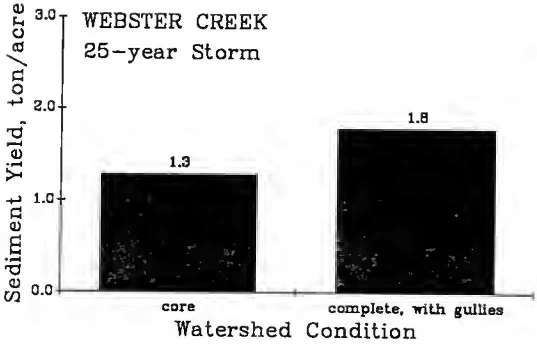

Figure 5-1.1 Changes in sediment yields from Webster Creek when watershed conditions are changed, for the 25-year storm.

wastewater treatment plant has such a small flow that its impact is nearly insignificant with respect to the whole watershed. The combined point-sources (feedlots and wastewater treatment plant) affect the soluble nutrient yields only.

The sediment-attached yields of N and P are affected by the gully inputs. The degree of effect is dependent on the magnitude of gully inputs and the amount of these nutrients available in the soil. Gully inputs have no effect on COD yields as all COD is considered to be soluble. Figures 5-1.2 through 4 show the nutrient yields as affected by the inputs discussed above.

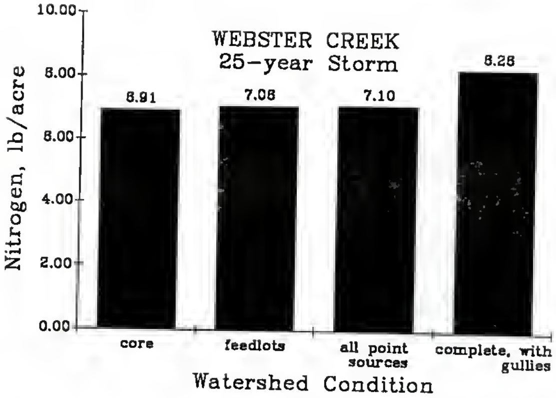

Figure 5-1.2 **Changes in nitrogen yields from Webster Creek when watershed conditions are changed, for the 25-year storm.**

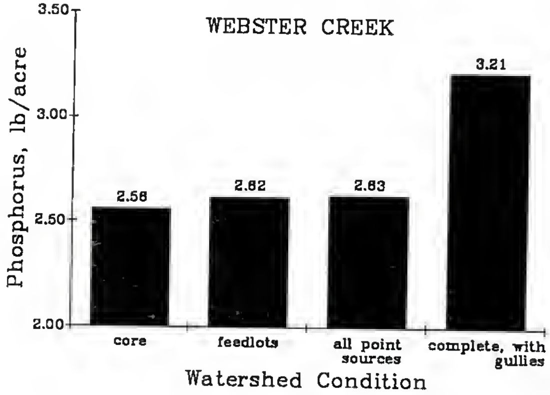

Figure 5-1.3 **Changes in phosphorus yields from Webster Creek when watershed conditions are changed, for the 25-year storm.**

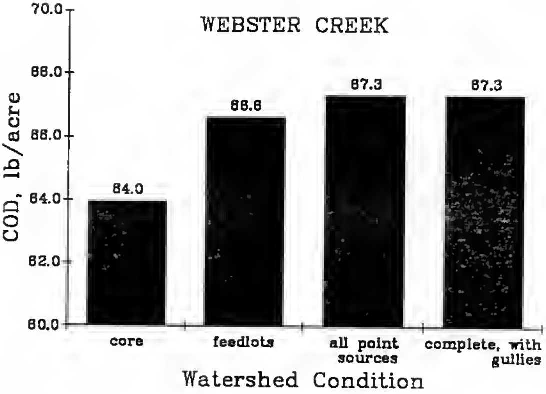

Figure 5-1.4 Changes in COD yields from Webster Creek when watershed conditions are changed, for the 25-year storm.

An additional study on the input effects upon the modeled outputs was done with Kings Creek. An input file was created for Kings Creek where the C factors for all cells were changed from their existing values of 0.01 to 0.02, a 100-percent increase. No other input values were changed. This new file was run through the AGNPS program using the 25-year storm.

Output data from the model run showed no changes in surface runoff or COD yields. Figures 5-1.5 through .7 show the comparisons for Kings Creek. Sediment yields increased nearly 100 percent from 0.41 tons/ac to 0.81 tons/ac. The increases for N and P production were not quite so dramatic, N increased 52 percent from 2.1 to 3.2 lbs/ac and P increased 75 percent from 0.8 to 1.4 lbs/ac. The above examination shows, as predicted by the AGNPS handbook, that simulated sedi-

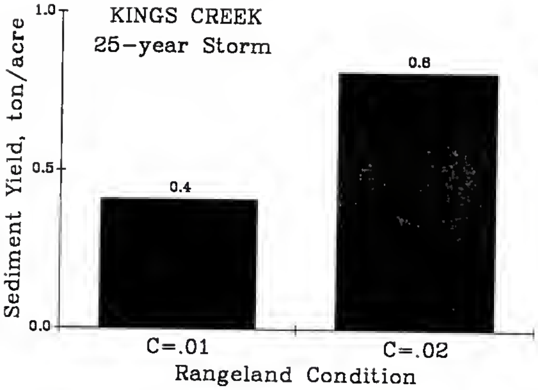

Figure 5-1.5 Changes in sediment yields from Kings Creek when C factors are changed from 0.01 to 0.02, for the 25-year storm.

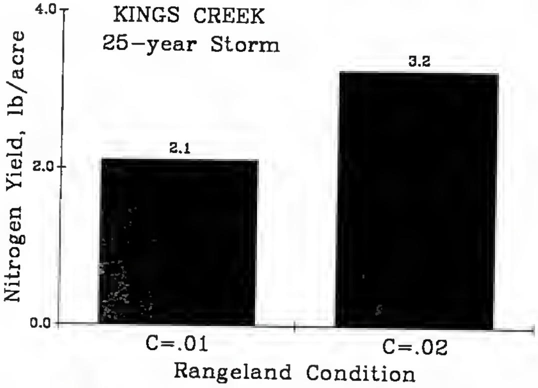

Figure 5-1.6 Changes in nitrogen yields from Kings Creek when C factors are changed from 0.01 to 0.02, for the 25-year storm.

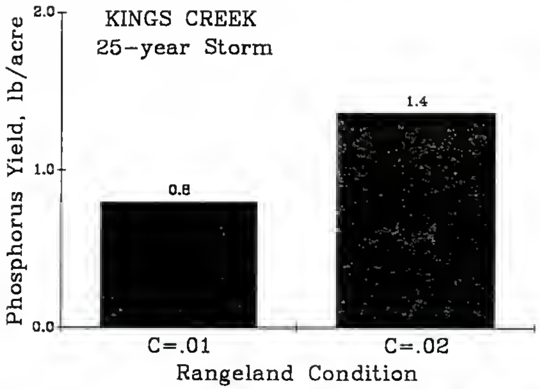

Figure 5-1.7 Changes in phosphorus yields from Kings Creek when C factors are changed from 0.01 to 0.02, for the 25-year storm.

Table 5-1.1 Effects on AGNPS simulations of feedlots, point-sources, gullies and C factor changes.

Input	Yields affected				
	Runoff	Sediment	Nitrogen	Phosphorus	COD
Feedlots	no	no	yes	yes	yes
Point source	no	no	yes	yes	yes
Gullies	no	yes	yes	yes	no
C factor	no	yes	yes	yes	no

ment yields are highly sensitive to C-factor changes. Figures 5-1.5 through 7 compare the predicted yields of sediment, N and P as the rangeland conditions are changed. Table 5-1.1 provides a short summary of which input changes affect which outputs.

5-2 COMPARISON OF THE FIVE WATERSHEDS

By examining the results from the model simulations of the 25-year storm and the annualized values for the five watersheds, it can be seen how the different input data as used for each watershed affects the results. This also requires a review of the input data files as compared in Section 2-4.

The input files showed that the watersheds studied could be separated into two categories, grassland-dominated (Mosquito Creek, Barnes Creek and Kings Creek) or cropland-dominated (Webster Creek and Soldier Creek). This separation is also seen in the model simulation results and will become apparent as the yields of surface runoff and sediment are examined. The remaining yields of N, P and COD reveal the impact of the point-source inputs.

SURFACE RUNOFF

Surface runoff values for the five watersheds demonstrate the models sensitivity to curve number inputs as related to runoff outputs. Examination of the average annual values found in Figure 5-2.1 shows that the watersheds divide nicely into the grassland-dominated and cropland-dominated categories with the grassland-dominated watersheds yielding only about half as much surface runoff as the cropland-dominated watersheds yielded. There is one very noticeable exception,

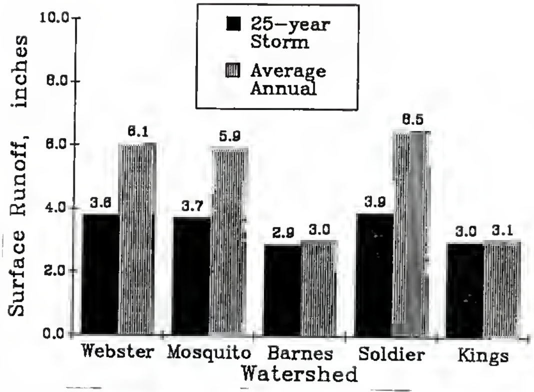

Figure 5–2.1 **Comparison of surface runoff volumes from the five watersheds, for the 25–year storm and annual amounts.**

that of Mosquito Creek, which yields runoff similar to the cropland-dominated watersheds. Examination of the curve number inputs for the watersheds reveals that Mosquito Creek's average curve number was 81, which was comparable to the values for the cropland-dominated watersheds. On average the cropland curve numbers were 10 units above the grassland-dominated watersheds.

Mosquito Creek was modeled with higher curve numbers than the other grassland-dominated watersheds because of two factors. First, the grassland found within the watershed was generally in poor conditions. Second, Mosquito Creek has a higher percentage of its drainage area covered by soils that belong to hydrologic group D which have a lower infiltration rate. The areas of the grassland-dominated watersheds are distributed in hydrologic groups as follows: 55 percent of the area of Mosquito Creek is group D, 80 percent of Barnes Creek is B and 100 percent of Kings Creek is C.

SEDIMENT YIELDS

Again, the grassland-dominated and cropland-dominated separation is apparent from examinations of the annual sediment yields. The average yield for the grassland-dominated watersheds is 0.5 tons/ac and the average for the cropland-dominated watersheds is 1.6 tons/ac. There is a noticeable exception to the separation of grassland-dominated and cropland-dominated watersheds; Barnes Creek has the highest annual yield, 2.0 tons/ac, any of the five watersheds. Figure 5-2.2 shows these comparisons.

The high yields from Barnes Creek are due the channel erosion within the watershed. As stated previously, channel erosion values are taken directly from the gully input values. The comparison of inputs showed that Barnes Creek's gully inputs were twice that of any of the other watersheds. The high gully inputs having a substantial effect on the total sediment yield from a watershed is in line with studies done in this region of Kansas by Holland (1971). Again, it has been shown that gully inputs have an important impact on the model's results.

Simulations of sediment yields show sensitivity to C-factor inputs. The grassland-dominated and cropland-dominated separation is found in the input values of C. The grassland-dominated watersheds averaged 0.03 while the cropland-dominated watersheds were 0.19. Sediment yields reflect this division in C as shown in Figure 5-2.2.

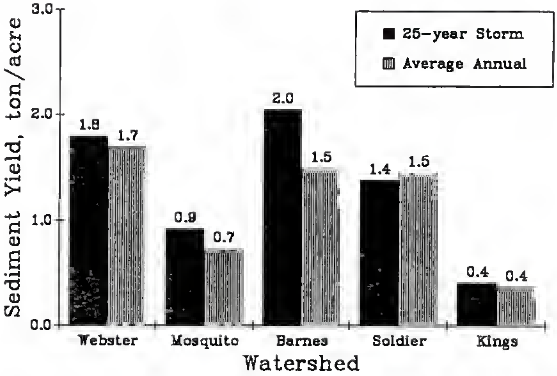

Figure 5-2.2 **Comparison of sediment yields from the five watersheds, for the 25-year storm and annual amounts.**

The delivery ratio is a value which represents the percentage of sediment generated from a watershed that is delivered at the watershed outlet. This value summarizes the impact of routing processes on the final sediment yield.

The delivery ratios for the five watersheds have an average value of 53 percent and the individual values are shown in Figure 5-2.3. Variations between the individual values shows dependence on soil-particle size inputs and to a lesser degree the watershed size. The relationship of particle size to delivery ratio is that the smaller the size, the higher the delivery ratio. The relationship between watershed size and delivery ratio is that the smaller the watershed,

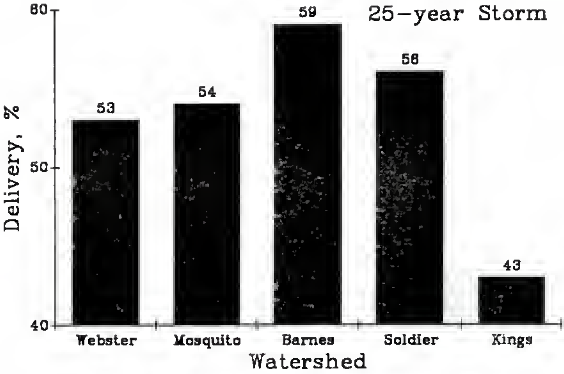

Figure 5-2.3 **Comparison of delivery percentages from the five watersheds, for the 25-year storm.**

the greater the delivery ratio. For an individual watershed, the higher the sediment load generated, the lower the deliver ratio. This indicates increased deposition within the watershed.

Studies of delivery ratios for small watersheds were done by Holland (1971). Holland predicted a stream's delivery ratio to be a function of watershed size and channel conditions.

Using Holland's estimates, the delivery ratios for the five watersheds would range from 25 to 40 percent. These estimates are lower compared with the corresponding range of AGNPS predicted delivery ratios, 43 to 59 percent. The Holland's estimates are based upon measurements of historically built-up sediment, which excludes any measurements of sediments that remained in suspension and were delivered beyond the study limits. The AGNPS predictions include the suspended particles. Also, Holland compared values predicted by USLE to the measured built-up sediments.

Reviewing the comparisons made of AGNPS simulations of sediment yields shows that of the complex inputs of point-sources and gullies, the model shows great sensitivity to the later. Again, it was shown that sediment estimates have a considerable dependence on C.

NUTRIENT AND COD YIELDS

Values for nutrient yields (see Figures 5-2.4 through .6) show a different pattern than that shown by values for runoff and sediment yields. Previously, the watersheds fell into two categories, grassland-dominated and cropland-dominated. Nutrient yields do not show this great of sensitivity to cropping activity as they do to the presence of point-sources.

The annualized yields of N, P and COD show a strong correlation to the feedlot inputs (refer to Figure 2-4.1 for relative feedlot ratings). Soldier Creek and Webster Creek have the highest feedlot activity of the five watersheds and show substantially higher nutrient and COD yields.

Yields of N and P are also affected by fertilization levels and availability as shown by the model equations (Section 1-3). The fertilization inputs (refer to Table 2-4.2) are important to the N and P yields when examined before point-sources and gullies are added (Appendix 4, Table 1).

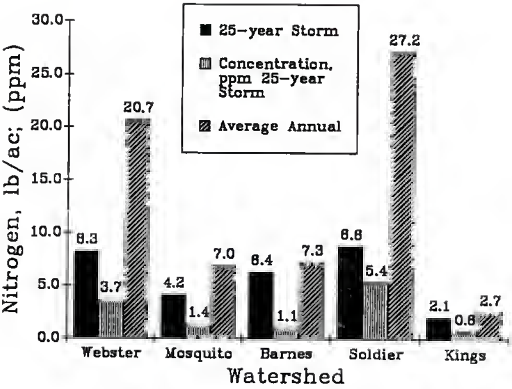

Figure 5-2.4 Comparison of nitrogen yields from the five watersheds, for the 25-year storm and annual amounts.

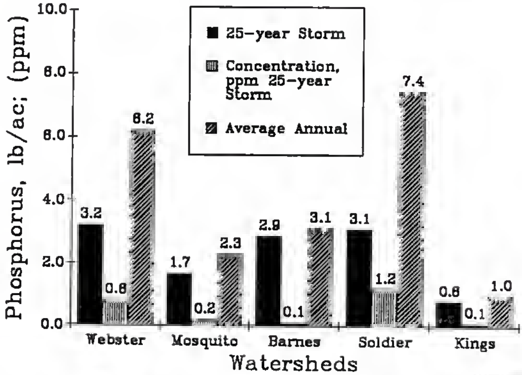

Figure 5-2.5 Comparison of phosphorus yields from the five watersheds, for the 25-year storm and annual amounts.

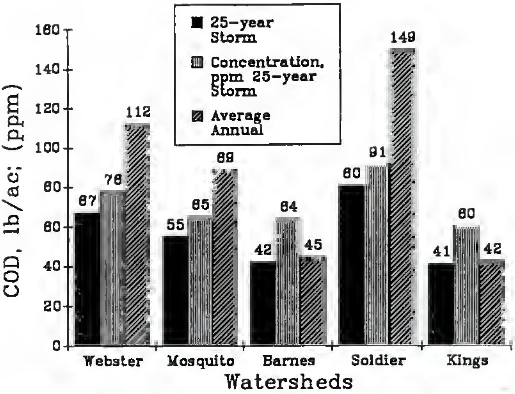

Figure 5-2.6 **Comparison of COD yields from the five watersheds, for the 25-year storm and annual amounts.**

COD yields show nearly a direct dependence on the inputted COD factors (refer to Table 2-4.2) when examined before the addition point sources. Once the point-source input values are added, the variations in COD yields becomes dependent upon them.

N and P yields are also influenced by gully activity. This can best be seen by examining the yields of watersheds with low feedlot activity. Mosquito Creek has a higher feedlot rating and fertilization level than Barnes Creek. Nevertheless, Barnes Creek has higher N and P yields. This is due to the nutrients released by gully activity within Barnes Creek.

The concentration of nutrients, as predicted by the AGNPS model, is dependent on generated nutrients and the flow volume. This is seen by examination of the results from each storm used in developing an annual value (see Appendix 3, Table 2). An annual value was not developed because it would be basically meaningless. The important concentration values are those for each storm event.

For the five watersheds, nutrient yields reflect mainly the contributions of feedlots. Those watersheds with low feedlot activity have relatively low predicted yields. Yields from Barnes Creek also show how high gully activity has a substantial effect on the simulated values for N and P yields.

SUMMARY

The AGNPS model simulations show sensitivity to the inputted conditions of the five studied watersheds in a predictable manner. This demonstrates that the AGNPS model can be used identify watersheds with relatively high pollutant potentials and those that are in condition where management changes could be damaging. The identification process is an essential component of any water quality management program.

From the studied watersheds, Soldier Creek and Webster Creek can be identified as having the highest potentials for nutrient pollution, while Barnes Creek can be identified as having the highest potential for sediment pollution. Barnes Creek and Kings Creek can be seen as being in a condition where change could be damaging; Barnes Creek because of its steep slopes, high gully activity and its known history; Kings Creek because of its steep slopes and relatively erosive soils.

5-3 COMPARISON OF 25-YEAR AND ANNUAL VALUES

Comparison of the model simulated results for 25-year storms with the annualized results for yields from a watershed presents some interesting generalizations. An important part of this examination is the ratio of the 25-year storm value to the average annual value. This ratio will be referred to as the 25-year/annual ratio.

The 25-year/annual ratio for rainfall amounts is 0.18 as seen in Figure 5-3.1. From the frequency vs. yield distribution, the contribution to the annual value of each frequency interval in percentage was calculated. The result are shown in Figure 5-3.2. Examination of this data reveals that the storms with return periods of 5-years or less contribute 97 percent of the annual rainfall amount. This information will serve as a base for the remaining comparisons.

EI values show a slightly different relationship than the rainfall values. The 25-year/annual ratio for EI values is 0.71, while contributions from the 5-year or less storms are 87 percent of the annual value (refer to Figures 5-3.3 and .4). This shows a shift away from the smaller storms when compared to the rainfall.

A generalized relationship between the 25-year/annual ratio and storm contribution can be made from the above discussions: the larger the 25-year/annual ratio, the lower the contribution from the small storms. This will be demonstrated further by the remaining comparisons.

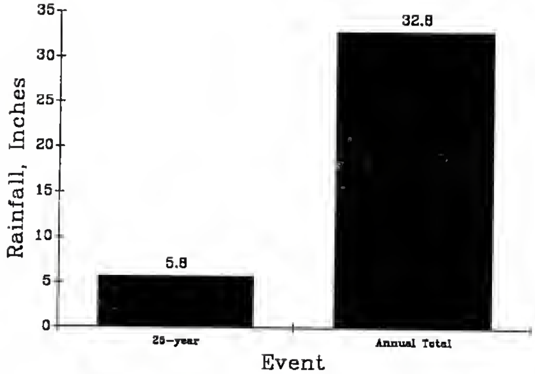

Figure 5-3.1 Comparison of the rainfall depths for the 25-year storm and annual total.

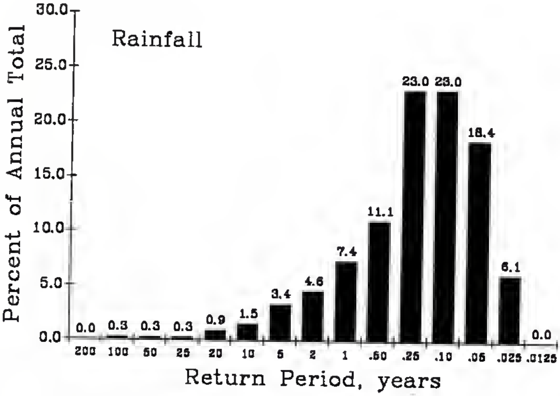

Figure 5-3.2 Contribution of each frequency interval to the annual total rainfall depth, in percent.

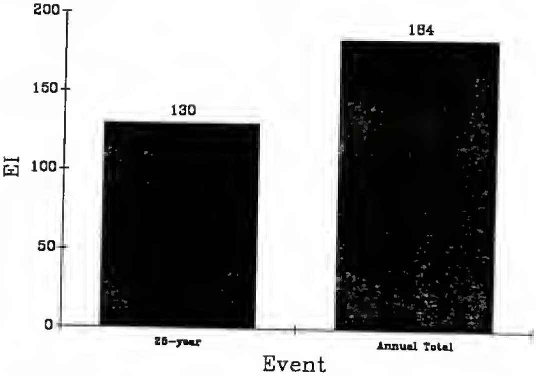

Figure 5-3.3 Comparison of EI values for the 25-year storm and annual total.

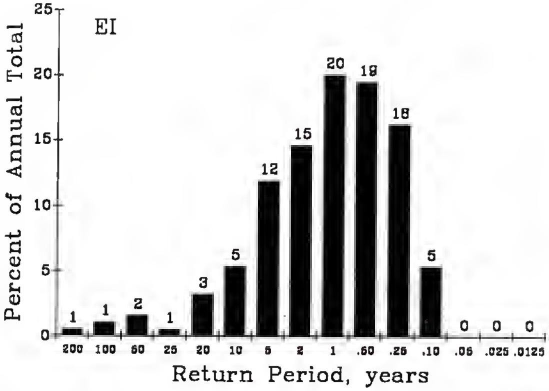

Figure 5-3.4 Contribution of each frequency interval to the annual total EI value, in percent.

The 25-year/annual ratio for surface runoff from the five watersheds shows the separation between grassland-dominated and cropland-dominated as seen in Section 5-1. This is shown by examination of Barnes Creek, typical of the grassland-dominated watersheds, and Webster Creek, typical of the cropland-dominated watersheds.

The 25-year/annual ratios for the two watersheds are, Barnes Creek 0.97 and Webster Creek 0.62. The contributions of the 5-year or less storms are, Barnes Creek 84 percent and Webster Creek 90 percent (refer to Figures 5-3.5 and .6). The decrease in curve numbers reduces the impact of smaller storms on annual surface runoff values. Comparison of the 25-year/annual ratios for sediment yields show no distinct pattern which separates the watershed. The average ratio is 1.14, considerably larger than that of the rainfall value. From the generalized relationship stated previously, the contributions from the smaller storms should be less than any from the other data compared. Barnes Creek data is used to illustrate this.

The 25-year/annual ratio for Barnes Creek sediment yield is 1.33 while the contribution from the 25-year or less storms is 77 percent (refer to Figure 5-3.7). The threshold storm before significant contributions to the annual value are made is higher than for rainfall. The 0.10-year and less storms contribute 1.1 percent of the annual sediment value, while for rainfall from these storms contribute 48 percent of the annual total. This can be attributed in part to the sediment generation process which is dependent upon rainfall energy. The influence of EI values is being shown. Contribution from the 0.10-year or less storms for EI is 5 percent of the annual value.

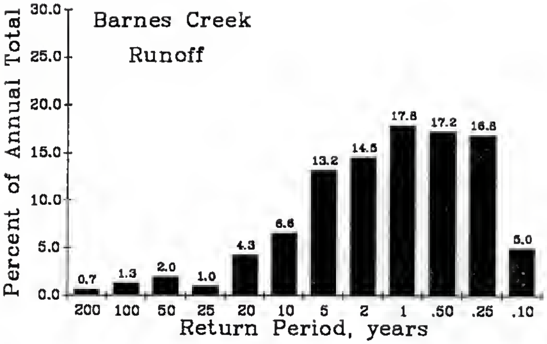

Figure 5-3.5 Contribution of each frequency interval to the annual total runoff depth from Barnes Creek, in percent.

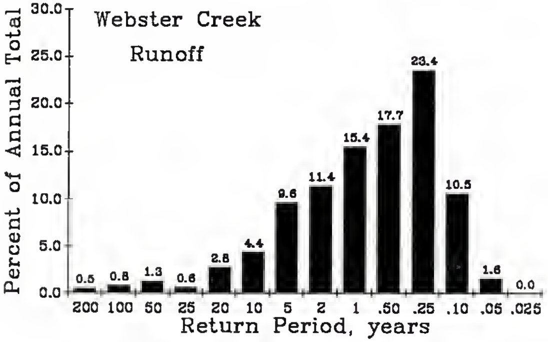

Figure 5-3.6 Contribution of each frequency interval to the annual total runoff depth from Webster Creek, in percent.

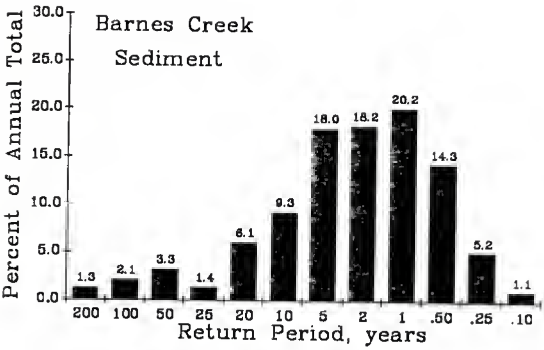

Figure 5-3.7 Contribution of each frequency interval to the annual total sediment yield from Barnes Creek, in percent.

Soluble nutrient yields show dependence on the rainfall amount. The watersheds with high dissolved nutrient loads are those with highly active feedlots as discussed in Section 5-1. Soldier Creek, highest in feedlot activity, was chosen to demonstrate the relationship between rainfall and nutrient yields, by use of the 25-year/annual ratio.

The 25-year/annual ratio for Soldier Creek N yield is 0.32, while the contribution of the 5-year or less storms is 94 percent (refer to Figure 5-3.8). These figures are very similar the rainfall values of 0.18 and and 97 percent. Physically, this indicates that the amount of loss of chemicals which dissolve in water are not influenced by the energy associated with the rainfall but rather the amount of runoff produced by the rainfall.

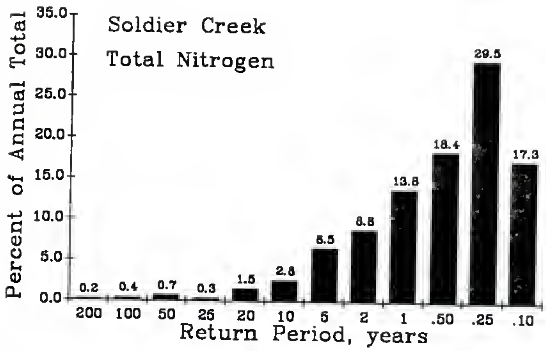

Figure 5-3.8 **Contribution of each frequency interval to the annual total nitrogen yield from Soldier Creek, in percent.**

This is not the case for sediment-attached nutrients. They follow a scenario which is similar to that of sediment. This is seen by examining the watersheds with low feedlot activity.

The knowledge of the 25-year/annual ratio based on AGNPS simulations, and what it indicates with respect to storm contributions to an annual value, can be used as part of design studies for abatement measures. In particular, this is helpful in directing the designer to the storms which are contributing most to the problem.

A specified reduction in sediment and nutrient yields may not be made by selected measures for the same storms. An 80-percent reduction in annual yield of nutrients may be achieved by selecting measures designed for the 2-year storm, while an 80-percent reduction in sediment may require consideration of a 10-year storm. The 25-year/annual ratio may be the first indicator of this.

5-4. CONSERVATION TILLAGE

Changes in tillage practices make substantial changes in the AGNPS simulated yields from Webster Creek. Figures 5-4.1 through .5 show the changes in yields of runoff, sediment and nutrients, as affected by the changes in tillage practices. The magnitude of the 25-year/annual ratios increased for each of the yields indicating reductions in the influence of the smaller storms.

Percentage reductions in yields of sediment, N and P from current tillage practices to all conservation tillage are the largest of the five yields. According to the simulations, conservation tillage practices are an effective way to reduce the pollution potential from sediment and nutrients. Table 5-4.1 shows the reductions in yield simulated when the tillage practices were changed from current tillage practices to all conservation tillage.

From previous examinations in Section 5-1, it was shown that changing only the C factor affected sediment and nutrient yields, but not runoff or COD yields. This indicated that the impact of C-factor changes was on sediment generation. When sediment generation is increased, there is an increase in sediment-attached nutrients.

Conservation tillage combines the effects of the C-factor reductions with those from curve number reductions. The curve number affects the generation of runoff (refer to equations in Section 1-3). The volume of runoff generated affects the COD yields. The combination of both C-factor and curve number changes affects all five yields.

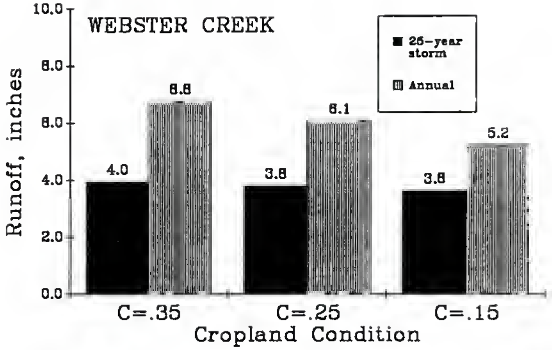

Figure 5-4.1 Changes in runoff volumes from Webster Creek as a result of tillage changes.

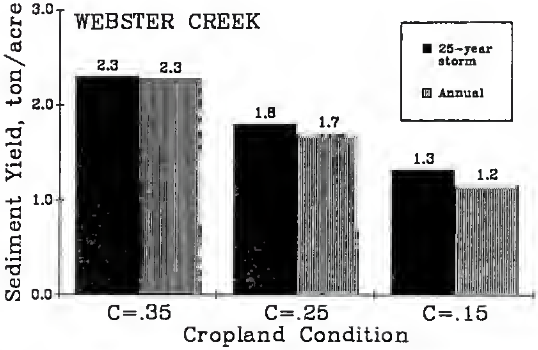

Figure 5-4.2 Changes in sediment yields from Webster Creek as a result of tillage changes.

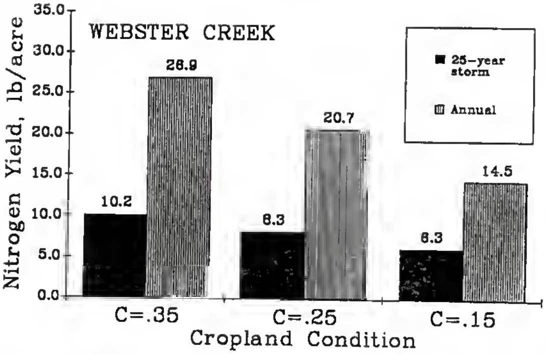

Figure 5–4.3 Changes in nitrogen yields from Webster Creek as a result of tillage changes.

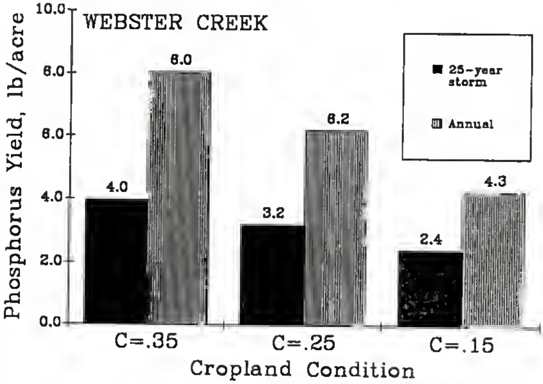

Figure 5–4.4 Changes in phosphorus yields from Webster Creek as a result of tillage changes.

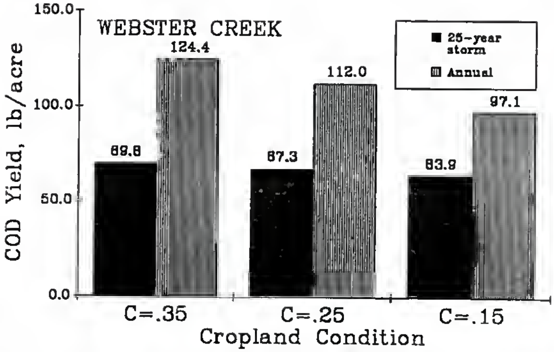

Figure 5-4.5 Changes in COD yields from Webster Creek as a result of tillage changes.

Table 5-4.1 Reductions in yields predicted if tillage practices are changed from current practices (C=0.25) to all conservation tillage (C=0.15).

Yield	Reduction, %
Runoff	23
Sediment	48
Nitrogen	46
Phosphorus	46
COD	22

Current water quality management practices include the use of conservation tillage. The knowledge of what the impact of tillage changes for a field and the entire watershed may have is an important part in determining the usefulness of this practice. The AGNPS model with its ability to demonstrate relative reductions from application of tillage practices (for both a cell or the entire watershed), can be a useful tool for a designer in the design process.

5-5 STORAGE-TYPE TERRACES

The storage-type terraces had a considerable effect on AGNPS simulation results for Soldier Creek. There were substantial reductions in yields of sediment and runoff and lesser reductions of N and P. The COD yield was not affected by the terracing systems, thus showing dependence on the originally-generated runoff and not the terrace-reduced runoff volumes. With the reduction of runoff volumes from the addition of the terraces, concentrations of all nutrients increase. Figures 5-5.1 through 5 show the predicted yields from existing conditions compared with those after storage-type terraces are added. Examination of the 25-year/annual ratio for all yields (excepting COD) shows a reduction from the existing ratios. From the discussion in Section 5-2, this would indicate reduction of the impact of larger storms. For sediment and runoff yields this provides important reductions in yields, however, for the nutrients this shows little effect. The percentage of annual yield reductions for the watershed are summarized in Figure 5-5.6.

A typical cell with a terrace system applied experiences a reduction in sediment yield of 50 percent. The applied storage-type terraces were as described in Section 4-3, with PF reductions of 50 percent (refer to Appendix 5B, Table 5).

The reduction in surface runoff of 28 percent as predicted by the model would not represent an equivalent reduction in total water yield. A total reduction in water yield of less than 10 percent would more likely expected based on work done by Scherer (1983).

The examination of the AGNPS model simulation of storage-type

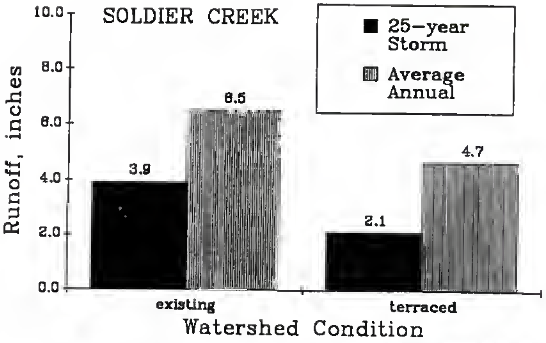

Figure 5-5.1 Changes in surface runoff depth from Soldier Creek when storage-type terraces are added, for the 25-year storm and annual total.

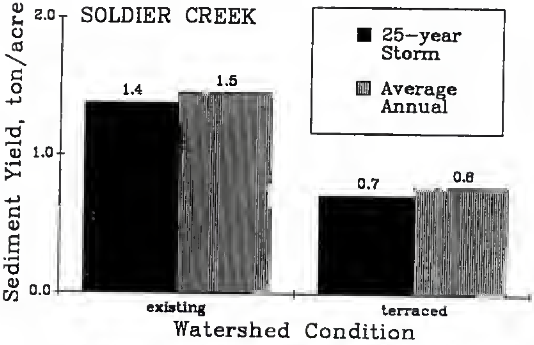

Figure 5-5.2 Changes in sediment yield from Soldier Creek when storage-type terraces are added, for the 25-year storm and annual total.

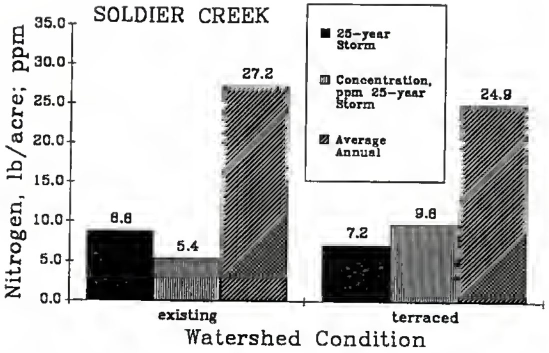

Figure 5-5.3 Changes in nitrogen yield from Soldier Creek when storage-type terraces are added, for the 25-year storm and annual total.

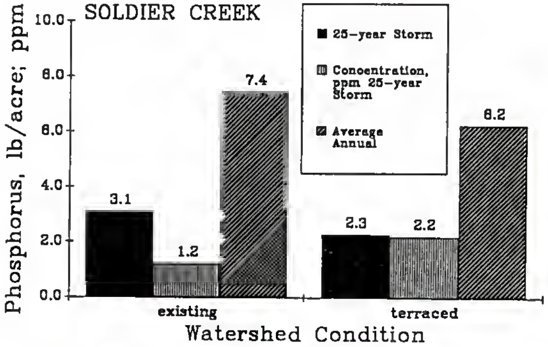

Figure 5-5.4 Changes in phosphorus yields from Soldier Creek when storage-type terraces are added, for the 25-year storm and annual total.

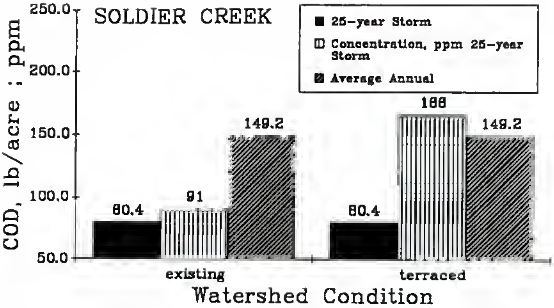

Figure 5-5.5 Changes in COD yield from Soldier Creek when storage-type terraces are added, for the 25-year storm and annual total.

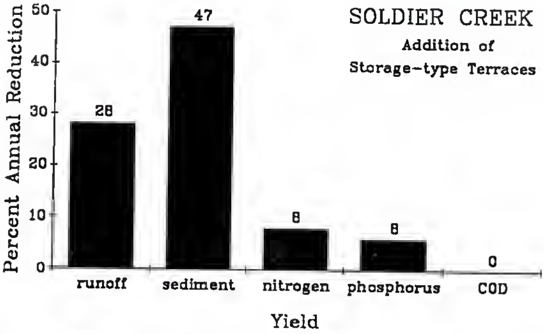

Figure 5-5.6. Summary of annual yield reductions for runoff, sediment and nutrients for addition of storage-type terraces on Soldier Creek.

terraces on Soldier Creek watershed demonstrates again the models usefulness as a planning tool. AGNPS allows for examinations of values for relative reductions brought about by different management scenarios. Storage-type terraces as applied for this study demonstrate their usefulness for reducing sediment yields and surface runoff, with minimal success in reducing nutrient loads.

5-6 RESULTS OF ACHIEVING "T"

Model simulations of existing conditions showed that 18 percent of the cells in Webster Creek, 6 percent in Mosquito Creek and 6 percent in Barnes Creek were above T (methods for determining if a cell is above T are discussed in Section 4-4). The model simulations were made using the 25-year storm. The final comparison will be of the effects on the individual watershed's output, again using the 25-year storm. Data used in these comparisons are found in Table 2 in Appendix 5.

The first modification to the input files was to apply conservation tillage (described in Section 4-4) to all cells above T. On average conservation tillage reduced the simulated yields of sediment by 40 percent. A summary of reductions is shown in Table 5-6.1 through .3. These reductions were sufficient to bring 72 percent of all cells treated from the three watersheds within T. Table 5-6.4 shows the number of cells which are above T from each watershed for the three conditions: existing, after conservation tillage was applied and after storage-type terraces were applied. The remaining cells were treated with storage-type terraces.

Table 5-6.1 Reductions in sediment yield for cells above T in order to achieve T.

Condition	Reduction from:	Average reduction, %
Conservation tillage (1)	existing	40
Storage-type terraces (2)	conservation tillage	68
(1) + (2)	existing	81

Table 5-6.2 Reductions in nutrient yields for cells above T in order to achieve T.

Condition/ watershed	Reduction, % N	P	COD
Conservation tillage added (1)			
Webster Creek	32	33	5
Mosquito Creek	32	33	5
Barnes Creek	32	33	5
Average reduction	32	33	5
Storage-type terraces added (2)			
Webster Creek	49	55	0
Mosquito Creek	56	62	0
Barnes Creek	57	63	0
Average reduction	54	60	0
Total (1) + (2)			
Webster Creek	65	70	5
Mosquito Creek	70	74	5
Barnes Creek	71	75	5
Average reduction	69	73	5

Table 5-6.3 Reductions in sediment and nutrient yields for Webster Creek, Mosquito Creek and Barnes Creek in order to achieve T.

Condition/ watershed		Reduction in yields:		
	Sediment	N	P	COD
Conservation tillage added (1)				
Webster Creek	15	10	11	1
Mosquito Creek	7	4	5	0
Barnes Creek	5	4	4	1
Average reduction	9	6	7	1
Storage-type terraces added (2)				
Webster Creek	11	6	7	0
Mosquito Creek	1	1	2	0
Barnes Creek	3	2	2	0
Average reduction	5	3	4	0
Total (1) + (2)				
Webster Creek	25	15	17	1
Mosquito Creek	8	6	7	0
Barnes Creek	7	6	6	1
average reduction	13	9	10	1

The storage-type terraces applied were as described in Section 4-4. The outputs from cells treated with the terrace systems showed an average additional reduction in sediment yield of 68 percent over the reductions previously achieved by conservation tillage. This reduction brought all cells to below T as seen in Table 5-6.4.

The combination of the conservation tillage and storage-type terraces achieved an average overall reduction in expected sediment yield of 81 percent. This can be seen in Figure 5-6.1.

Table 5-6.4 Cells above T from Webster Creek, Mosquito Creek and Barnes Creek, for existing conditions, conservation tillage and storage-type terraces.

Condition	Cells above T for: Webster Creek	Mosquito Creek	Barnes Creek
Existing	33	11	7
After conservation tillage added	11	2	2
Reduction,	67%	85%	71%
After storage-type terraces added	0	0	0

Along with reduction in sediment yields, the storage-type terraces also provide reductions in nutrient yields. Conservation tillage reduced N yields by an average of 32 percent, P 33 percent and COD 5 percent. The terrace systems gave average reductions of 54 percent for N , 60 percent for P and 0 percent for COD as shown in Table 5-6.2.

Yields for the entire watersheds were also reduced by the input modifications. The effects on each watershed were dependent on the percentage of cells originally above T, and the amount the cells were above T. Webster Creek had the largest percentage of cells above T, and showed the largest reductions in overall watershed yields (refer to Table 5-6.3).

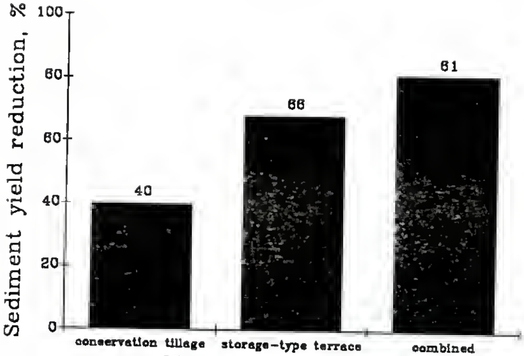

Figure 5-6.1 Comparisons of average reductions for conservation tillage and storage-type terraces when applied to a cell.

Storage-type terraces, as examined in Sections 5-5 and 5-6, were modeled identically, with the exception of PF reductions. Reductions made for an individual cell were consistent throughout a watershed, however, comparisons of reduction in PF vs. yield shows an inconsistency. When the PF was reduced 26 percent, a 68 percent reduction in sediment yield was achieved, contrasted to when the PF was reduced 50 percent there was only a 50 percent reduction in yield.

This inconsistency can be explained by the effects of conservation tillage within a storage-type terrace system. The cells receiving storage-type terraces with PF reductions of 26 percent were also treated with conservation tillage. Application of conservation tillage within the storage-type terraces produced a larger reduction than with the storage-type terraces alone. This is an area for future study which might produce some interesting results.

The AGNPS model has a limitation in simulations achieving T values for cells with extensive gully erorsion. The typical management practice for this situation would be the addition of grade stabilization structures of the type which trap sediments generated or give energy abatement to protect the channel from further erosion. At present the model only evaluates reduction in sheet and rill erosion when these structures are simulated.

5-7. GENERALIZATIONS

There are four generalizations which can be made from this chapter's examinations of the AGNPS model simulations which can be useful in water quality management studies:

1. The 25-year/annual ratio provides an indication of the significance of a particular storm's contribution.
2. Conservation tillage makes predictable reductions in yields.
3. Storage-type terraces make predictable reductions in yields.
4. Combinations of management practices have predictable results.

These generalizations as applied to AGNPS simulations can be utilized in the selection process of strategies in a water quality management project, giving the managers tools for identifying problems and demonstrating solutions.

Chapter 6 COMPARISONS OF AGNPS SIMULATIONS WITH HISTORIC EVENTS

6-1 HISTORIC STUDIES OF ANNUAL YIELDS

There are only two major studies available at present which provide data with which to compare our estimated yields for the five test watersheds. These are the 1970 study of sediment yields for small drainage areas by the Kansas Water Resources Board (Holland, 1971) and the 1982 study of Soldier Creek by the Kansas Department of Health and Environment (KDHE) (Cringan and Haslouer, 1984). The two studies do not give data for a complete comparison of any one of the watersheds. The yields examined in greatest detail are sediment and nutrients.

SEDIMENT YIELD

Sediment yield studies from the late 1960's for the dissected till plains (the northeast corner of Kansas which includes Webster, Mosquito, Barnes and Soldier Creek watersheds) predict annual sediment yields of from 2.0 to 4.5 tons/ac (Holland, 1971). Specific yields from studied watersheds for cropland ranged from 3.7 to 8.0 ton/ac while those from grassland were from 1.0 to 2.0. The average value for the AGNPS simulations of the cropland-dominated watersheds for present conditions was 1.6 tons/ac.

At the time studies were made by Holland, the C possibly ranged from 0.35 to 0.45, as compared with the C for present practices which were modeled as 0.25. Increasing the weighted values from annualized sediment yields for cropland to compensate for C-factor change gives values which range from 3.0 to 6.8 tons/ac. Although this is not an absolute check for accuracy, it does show that the annualized model simulations predicted sediment yields are within an acceptable range of actual reported yields for the extreme northeast corner of Kansas.

From the same study annual sediment yields for rangeland in the Flint Hills area of eastern Kansas were found to range from 0.23 to 1.56 tons/ac, with a specific prediction for annual yields from excellent rangeland to be 0.4 tons/ac (Holland, 1971). Conditions on the Konza Prairie have changed very little from when this study was. The predicted annualized sediment yield for Kings Creek is 0.4 tons/ac which agrees with measured yield on similar watersheds.

In 1982 the KDHE completed a four-year study of the entire Soldier Creek watershed (Cringan and Haslouer, 1984). The area of the study was 159 square miles, of which the 2.06 square mile watershed examined with the AGNPS model is known as Reach 1. Reach 1 is located at the extreme north end of Soldier Creek and represents the headwaters of the watershed.

In Water Year 1982 samples from the watershed outlet gauging station were taken and the data were used to develop annual values for sediment and nutrient yield from the watershed. That year was a wet one with annual precipitation 26 percent higher than average and it included the flood of record from a 6-inch, high-intensity rain. The annual yield for 1982 was 6.6 tons/ac. From this value an adjusted estimate for average annual erosion was made of 4.0 tons/ac (Cringan and Haslouer, 1984). The adjustment included comparison with a previous study done in the late 60's and early 70's which estimated sediment yield of 3.08 tons/ac (Carswell, 1981).

The estimate for annual sediment yield for Reach 1 of Soldier Creek made using AGNPS model simulations is 1.5 tons/ac. This value appears to be considerably low when compared to the KDHE study, however, there are inherent problems in making this comparison:

1. The KDHE study was done only for a one-year period which was 26 percent wetter than average,
2. Reach 1 of Soldier Creek contains none of the highly erodible lands of the watershed,
3. The average land slope of Reach 1 is 3.2 percent which is low for the watershed which ranges from 2 to 10 percent, and
4. Conditions have changed since the study.

NUTRIENTS

The 1982 KDHE study of Soldier Creek estimated annual yields for N of 3.16 lb/ac and P of 3.28 lb/ac. The estimated annual values for Reach 1 using the AGNPS model are 21.1 and 4.3 lb/ac, respectively. The KDHE study states that their estimates are low due to sampling techniques and accessibility at times of runoff events.

Another difficulty in comparing the estimates for Reach 1 with those of the entire watershed is that within Reach 1 were two of the three areas of cattle concentration within the entire watershed at the time of the KDHE study. The two feedlots in Reach 1 are present today and the source of the high nutrient yield estimates.

WATER YIELD

Applicable annual water yield data for each of the watersheds is shown in Table 6-1.1 along with predicted annual surface runoff for present conditions from AGNPS. The percentage of the total water yield represented the predicted annual surface runoff is presented, also. Predicted annual surface runoff depth for Kings Creek and Barnes Creek are nearly one third of annual water yield for each, while predicted surface runoff depth for Webster, Mosquito and Soldier Creeks is two thirds of the total water yield. This, again, establishes the grassland-dominated and cropland-dominated separations with the exception of Mosquito Creek (see Section 5-2 for explanations).

Using the annualized surface runoff depths and annual water yield, an estimate for base flow can be made by assuming annual water yield minus predicted annual surface runoff leaves base flow. Base flow for the cropland-dominated watersheds is about one third of the annual water yield. This is considered a reasonable approximation for the region (Koelliker). On-going studies of Kings Creek are indicating that a larger portion of its annual water yield is base flow than runoff, which is reflected by the predicted annualized surface runoff depth for Kings Creek.

Table 6-1.1 **Measured annual water yield verses predicted annual surface runoff.**

Watershed	Measured water yield, in.[1] (1)	Predicted surface runoff, in. (2)	(2) as a % of (1)
Webster Creek	9.49[2]	6.06	63.8
Mosquito Creek	9.49[2]	5.93	62.5
Barnes Creek	9.49[2]	3.03	31.9
Soldier Creek	9.10[3]	6.52	71.6
Kings Creek	9.54[4]	3.09	32.4

[1] Water Resources Data-Kansas, Water Year 1987 (Geiger et al., 1988)
[2] Upper Delaware, Station No. 890100
[3] Soldier Creek, Station No. 88910
[4] Kings Creek, Station No. 879650

6-2 SPECIFIC STORM EVENTS

At present, there is a scarcity of data from the five watersheds studied which can be used to compare with AGNPS simulations. In the early 80's the KDHE made a study of sediment and nutrient yields from the greater Soldier Creek watershed. This study provides yield data for two storm events on the portion of Soldier Creek under study. The KDHE is currently in the midst of another water quality study of numerous small watersheds within the state, which includes all of the test watersheds except Kings Creek which is being studied by others. The KDHE study includes sampling after significant runoff events and analyzing for sediment and nutrient loads. Due to the lack of significant runoff events recently, there are only three data sets available from the KDHE study.

Table 6-2.1 summarizes the results from the AGNPS simulations and the KDHE samplings from storms in 1981 (Cringan and Haslouer, 1984) and 1989 storms (unpublished results). The actual yields from the two storm events which occurred in 1981 show significantly lower yields than those predicted by the AGNPS model. There are three difficulties in this comparison. First, the rainfall amounts for the storms were only estimated, not actually measured. Secondly, the study states that due to sampling techniques actual nutrient loads may be low (Cringan and Haslouer, 1984). Thirdly, the watershed conditions have changed since the 1981 storms.

Comparison of recent storm events with simulations of similar-sized storms shows that the AGNPS model predicts concentrations of N over ten times greater than those found by sampling for both water-

Table 6-2.1 AGNPS simulations for specific storms compared with sampled results.

Watershed	Storm date	Rain in.	EI	Measured yields: N, lb/ac	N, ppm	P, lb/ac	P, ppm	AGNPS yields: N, lb/ac	N, ppm	P, lb/ac	P, ppm
Soldier	5/18/81	2.2	36	1.15		0.04		2.30		0.48	
Soldier	7/19/81	1.9	23	0.51		0.03		2.04		0.41	
Webster	4/27/89	1.2	3		1.39		4.78		15.50		3.10
Webster	5/03/89	0.9	1		1.38		3.02		20.10		4.00
Barnes	4/27/89	2.1	28		0.14		1.01		2.40		0.40

sheds. The AGNPS model concentrations directly reflect the feedlot activity and the low volumes of runoff. The P concentrations for both watersheds are more compatible.

The above comparisons do not provide any conclusive evidence to the accuracy of the AGNPS model to predict nutrient yields. The comparisons with recent storm events need to be coupled with data on feedlot conditions and fertilization activity at the time of the storms. The three storm events sampled by the KDHE provide no statistical base for meaningful conclusions.

Early on in this study an attempt was made to model the peak discharge of record for Kings Creek. The storm occurred on July 2, 1982 with a recorded rainfall of 3.5 inches falling in 45 minutes. Records indicate that this rainfall event occurred during a wet period. The 3.5-inch rainfall in 45 minutes was a 100-year storm.

To model the conditions at the time of the storm the curve numbers for all cells were increased to reflect AMC III. The 100-year, 24 hour storm, 7.5 inches and EI = 169, was used for the model simulation. Predicted peak flow was 4,700 cfs, actual measured peak flow was 4,530 cfs. The AGNPS simulation for peak discharge is within five percent of the actual value.

In summary, at present there is not enough data available to indicate a degree of accuracy of AGNPS simulations. This is an area which needs further studies. The model's usefulness at present is not limited, however, because of this lack of verification of the absolute values from the model. The usefulness of the model lies in predicting relative changes.

Chapter 7. RECOMMENDATIONS

7-1 CREATING INPUT FILES

There are two procedures in the creation of input files that could be changed from the way they were accomplished for this study. First is the process for determining input values from prorated raw data and second is the field inspection.

Proration of raw data for each cell proved to be a time-consuming and unnecessary process. If one dominant input were used for each cell, the overall inputs for the watershed would reflect the desired proration. Discussions with Dr. Bob Young and other users of the AGNPS model indicate that using one dominant input per cell instead of prorating has resulted in adequate simulations.

Prorated inputs have an additional drawback. When applying management practices changes to an input file with prorated inputs, there is unnecessary time spent prorating the new inputs.

Preparations for field inspections are reflected in their results. The complete set of maps for each watershed (topographic, soils and aerial) need to be grided and numbered prior to the inspection. These maps are indispensable in locating positions and recording of data. The more thorough the field inspections, the more usable the data.

7-2 IMPROVEMENTS TO THE MODEL

There are four specific areas where the AGNPS model could be modified to increase its usability; generation of annual values, treatment of ponds, gully inputs and graphics. At present the model does not address any of these areas adequately.

The annual values used in this study were calculated separate from the AGNPS model and proved to represent significant investments in time. A model-generated annual value would accomplish a time savings over our methods which would allow for additional annual values being available for examination. The annual value proved to be indispensable for water quality management studies.

For northeast Kansas the need for assessing the effects of ponds is a essential part of water quality management. Pond structures of many different types are used in this region as management tools. At present the AGNPS model does not adequately simulate their effects.

The gully inputs have been shown to affect the AGNPS model simulations substantial. The process for developing the gully inputs is highly subjective at present. A more precise method which would allow for less subjectivity and higher consistency needs to be developed.

The AGNPS model's usefulness would be improved markedly if it could provide the user with a sketch of the watershed which would allow for identification of areas of high pollutant yields. At present the only graphics provided are in checking the stream routing process. These graphics are useful for identifying possible incorrect input data which would affect the routing of streamflow.

All of these suggested improvements are now being made to the AGNPS model. The improved AGNPS model should also include groundwater modeling, plant growth component, irrigation applications, pesticide evaluations and interactive economics capability (Lucord and Young, 1989), all of which could be useful in northeast Kansas studies.

7-3 ADDITIONAL STUDIES

Continued studies of the AGNPS model simulations as compared with actual storm events need to be made. Data collection from actual storm events should include not only rainfall and yield data, but crop and feedlot conditions. This data will facilitate more accurate model runs. A significant data base from these studies needs to be built.

Longer term studies need to also be done for annual yields. Again, data collection should include the actual watershed conditions and times when these change.

Chapter 8. CONCLUSIONS

This study has demonstrated four important facts about the AGNPS model. First, the model responds to the inputted conditions of a watershed by generating differences in predicted yields corresponding with the different inputs. This gives the user of the model the ability to make comparisons of relative yields for different watersheds.

Second, the model outputs are usable for comparing relative changes in yields for different management techniques as they are applied to a specific watershed. This fact was illustrated by examinations of the model's response to changes in cropping conditions and additions of impoundment terraces.

Third, a method of determining annual yields by use of the AGNPS model can be made. Results from the method developed shows a potential for strong correlations with actual data. The ability to predict annual yields is a major tool in water quality management.

Fourth, the AGNPS model has two major limitations, evaluating ponds and the creating of gully input process. These limitations need to be addressed before the full potential of the model can be achieved.

From these four facts, it is concluded from this study that the AGNPS model can be used as a water quality management tool for northeast Kansas watersheds. The use of the AGNPS model to develop predictions for relative changes in yields for specific changes in watershed conditions seems to be its most promising use.

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APPENDIX 1 — INPUT DOCUMENTATION

Table 1. Soils types, erosion factors, and hydrologic groups with AGNPS input values.

Soil name (1)	Soil type (1)	K (2)	Hydro group (2)	AGNPS: (3) type	input
Nemaha County:					
Burchard-Steinauer	clay loam	0.28	B	clay	3
Kennebec	silt loam	0.32	B	silt	2
Kipson	silt loam	0.32	C	silt	2
Olmitz	clay loam	0.28	B	clay	3
Pawnee	clay loam	0.37	D	clay	3
Reading	silt loam	0.32	C	silt	2
Steinauer	clay loam	0.32	D	clay	3
Wabash	silty clay loam	0.37	D	silt	2
Wymore	silty clay loam	0.37	C	silt	2
Brown County:					
Morrill	loam	0.28	B	silt	2
Shelby	clay loam	0.28	B	clay	3
Jackson County:					
Shelby (Sa)	clay loam	0.28	B	clay	3
Shelby (Sb)	gravel loam	0.20	B	sand	1
Wymore	silty clay loam	0.37	C	silt	2
Zook	silty clay loam	0.37	C	silt	2
Riley County:					
Benfield Florence	silty clay loam	0.37	C	silt	2
Clime Sogn	silty clay loam	0.37	C	silt	2
Dwight	silt loam	0.43	D	silt	2
Reading	silty loam	0.32	C	silt	2
Tully	silty clay loam	0.37	C	silt	2

Note:
The following soils have two different names in different counties:
Grundy (Brown County) = Wymore (Nemaha County)
Judson (Brown County) = Kennebec (Nemaha County)
Burchard Shelby (Jackson County) = Burchard Steinauer (Nemaha County)

Sources:

1. SCS County Soil Surveys for the particular county.
2. Field Procedures for Estimating Soil Loss etc.
3. Young et al. (1987).

Table 2. Feedlot animal type, populations and locations.

Cell	Animal:		Area 1	Area 2	Area 3	Roofed	Buffer area:			Animal Factors:		
#	type	number	feedlot, acre	above, acre	below, acre	area, acre	slope, %	surface cond., c	flow length	COD (1)	P (1)	N (2)
Webster Creek												
25	swine	100	1	0	0	0.25	5	0.10	100	0.17	0.27	0.26
25	swine	50	1	0	0	0.25	5	0.10	100	0.17	0.27	0.26
27	swine	100	1	0	0	0.25	5	0.10	100	0.17	0.27	0.26
28	swine	50	1	0	0	0.25	5	0.10	100	0.17	0.27	0.26
29	steer	200	4	0	0	1.00	5	0.10	100	1.00	1.00	1.00
51	steer	100	2	0	0	0.50	5	0.10	100	1.00	1.00	1.00
58	steer	50	2	0	0	0.50	5	0.10	100	1.00	1.00	1.00
	swine	300								0.17	0.27	0.26
60	swine	200	2	0	0	0.50	5	0.10	100	0.17	0.27	0.26
71	steer	25	1	0	0	0.25	5	0.10	100	1.00	1.00	1.00
73	sheep	400	4	0	0	1.00	5	0.10	100	0.18	0.06	0.13
147	dairy	50	2	0	0	0.50	5	0.10	100	1.96	0.92	1.68
165	swine	100	1	0	0	0.25	5	0.10	100	0.17	0.27	0.26
Mosquito Creek												
72	steer	200	2	0	0	0.50	5	0.10	100	1.00	1.00	1.00
72	steer	200	3	0	0	0.75	5	0.10	100	1.00	1.00	1.00
184	dairy	50	2	0	0	0.50	5	0.10	100	1.96	0.92	1.68
Barnes Creek												
31	steer	100	2	0	0	0.50	5	0.10	100	1.00	1.00	1.00
Soldier Creek												
6	steer	100	2	0	0	0.50	5	0.10	100	1.00	1.00	1.00
23	dairy	200	4	0	0	1.00	5	0.10	100	1.96	0.92	1.68

Explanations:

Area 1 is the area of the feedlot.

Area 2 is the area above the feedlot which drains into the feedlot.

Area 3 is the area which does not drain into the feedlot, but the feedlot flow is joined by the flow from this area before it enters the main flow network of the watershed.

Curve numbers used for feedlots: (3)

unpaved	AMC II	91
	AMC III	97
paved	AMC II	94
	AMC III	98

Sources:

1. Young, R. A., et al. AN EVALUATION SYSTEM TO RATE FEEDLOT POLLUTION POTENTIAL, ARM-NC-17, p. 28 (Table 6)

2. AGNPS manual, p. 21 (Table 9)

3. Koelliker, J. K. et al. MODELING THE PERFORMANCE OF FEEDLOT-RUNOFF-CONTROL FACILITIES, from TRANSACTIONS OF THE ASAE Vol.18, No. 6, pp. 1118-1121,1975

Table 3. Impoundments (ponds) locations and sizes within the five watersheds.

Watershed	Cell #	Drainage area (acres)	Outlet pipe diameter (inches)
Webster Creek	15	160	24
	26	80	16
	33	640	24
	41	120	18
	53	120	18
	61 (1)	40	12
	62	20	12
	81	90	18
	82	240	24
	83	180	24
	96	90	18
	99	20	12
	102 (2)	120	18
	103	80	18
	111	80	18
	112	20	12
	117	70	18
	132	50	18
	137	200	24
	144	20	12
	154 (2)	90	18
	161	210	24
Mosquito Creek	5	120	24
	6	60	14
	11	20	12
	26	10	12
	37	20	12
	49	35	12
	50	40	12
	58	70	18
	59	50	14
	66	20	12
	93	70	18
	99	360	21
	143	20	12
	144	20	12
	181	110	24
	192	20	12
	193	20	12
Barnes Creek	2	10	12
	35	20	12
	89	100	24
	94	60	14
	105	30	12
Soldier Creek	9	60	14
	31	70	14

Notes:

(1) Pond is actually in Cell 60 but cannot input due to feedlot in 60.
(2) Entered last pond of a series only.

Table 4. Land uses in the five watersheds.

Watershed	Land use	Number of cells	Acres	% of total area
Webster Creek	Cropland	108.6	4344	61.7
	Rangeland	46.4	1856	26.4
	Woodland	8.5	340	4.8
	Urban	12.5	500	7.1
	Total	176.0	7040	100.0
Mosquito Creek	Cropland	29.7	1188	13.9
	Rangeland	177.3	7092	83.2
	Woodland	6.0	240	2.8
	Urban	0.0	0	0.0
	Total	213.0	8520	100.0
Barnes Creek	Cropland	13.9	556	12.6
	Rangeland	90.7	3628	82.5
	Woodland	5.4	216	4.9
	Urban	0.0	0	0.0
	Total	110.0	4400	100.0
Soldier Creek	Cropland	26.2	1048	81.9
	Rangeland	5.3	212	16.6
	Woodland	0.5	20	1.6
	Urban	0.0	0	0.0
	Total	32.0	1280	100.0
Kings Creek	Cropland	0.0	0	0.0
	Rangeland	69.0	2760	100.0
	Woodland	0.0	0	0.0
	Urban	0.0	0	0.0
	Total	69.0	2760	100.0

Table 5. Headwater cells in the five watersheds.

Webster Creek: (91 cells)
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 21, 23, 24, 25, 28,
30, 31, 32, 36, 37, 38, 42, 43, 44, 45, 46, 47, 48, 49, 50, 55, 56, 57, 59,
61, 62, 63, 67, 69, 71, 74, 75, 76, 79, 80, 84, 85, 89, 90, 93, 94, 95, 99,
100, 103, 104, 105, 106, 107, 109, 112, 113, 119, 120, 121, 122, 126, 128,
129, 130, 131, 134, 135, 138, 140, 144, 147, 148, 153, 155, 156, 159 160, 174.

Mosquito Creek: (73 cells)
1, 2, 3, 4, 6, 7, 8, 12, 13, 17, 18, 23, 24, 30, 31, 32, 33, 34, 43, 44, 45,
46, 47, 48, 49, 63, 64, 65, 66, 67, 68, 69, 70, 90, 91, 92, 112, 113, 114,
115, 116, 117, 137, 138, 140, 141, 142, 143, 144, 145, 146, 147, 169, 170,
171, 172, 173, 174, 175, 176, 177, 178, 179, 192, 193, 194, 204, 205, 206,
207, 210, 212, 213.

Barnes Creek: (28 cells)
1, 2, 3, 5, 6, 7, 8, 9, 18, 19, 30, 31, 32, 33, 34, 35, 47, 64, 81, 82, 95,
97, 98, 102, 106, 108, 109, 110.

Soldier Creek: (16 cells)
1, 2, 3, 4, 6, 7, 8, 11, 12, 15, 16, 20, 23, 24, 27, 28.

Kings Creek: (29 cells)
8, 10, 11, 12, 13, 18, 21, 22, 23, 27, 31, 32, 33, 37, 38, 39, 40, 41, 42, 45,
46, 49, 50, 51, 55, 56, 63, 64, 68.

Note:
Headwater cells are those with drainage areas of 40 acres or less.

Table 6. Gully input data for the five watersheds.

Webster Creek

Cells with 1.5 t/a (60 tons) for the 25-year storm, 1.0 t/a per year:
5, 6, 9, 10, 12, 15, 16, 20, 21, 22, 23, 26, 27, 28, 29, 30, 33, 34, 39, 40, 43, 46, 47, 48, 50, 51, 60, 61, 62, 68, 69, 70, 71, 72, 73, 75, 76, 78, 80, 84, 85, 86, 88, 90, 93, 94, 95, 96, 100, 101, 103, 107, 109, 111, 113, 114, 117, 118, 121, 125, 129, 135, 141, 142, 145, 146, 148, 149, 153, 157, 161, 163, 164, 165, 166, 167, 170, 173.

Cells with 3.0 t/a (120 tons) for the 25-year storm, 2.0 t/a per year:
35, 36, 42, 58, 59, 82, 83, 112, 119, 120, 127, 128, 136, 137, 138, 139, 150, 151, 152, 158, 159.

Mosquito Creek

Cells with 0.75 t/a (30 tons) for the 25-year storm, 0.50 t/a per year:
1, 4, 9, 12, 15, 18, 19, 21, 22, 23, 27, 30, 33, 39, 45, 46, 49, 53, 56, 58, 60, 66, 68, 69, 72, 73, 74, 79, 80, 81, 90, 91, 93, 94, 95, 98, 103, 107, 111, 112, 113, 114, 120, 121, 122, 123, 124, 128, 129, 130, 131, 132, 141, 142, 143, 146, 147, 149, 150, 151, 152, 153, 154, 155, 156, 161, 162, 168, 169, 170, 171, 172, 173, 174, 175, 177, 178, 179, 180, 181, 182, 183, 184, 184, 185, 192, 193, 194, 195, 198, 199, 200, 201, 202, 203, 204, 205, 208, 209, 210, 211, 212.

Cells with 2.00 t/a (80 tons) for the 25-year storm, 1.25 t/a per year:
7, 8, 10, 11, 13, 16, 24, 25, 26, 28, 29, 31, 32, 34, 35, 36, 40, 41, 42, 47, 48, 50, 51, 52, 57, 61, 62, 63, 64, 65, 67, 75, 76, 77, 87, 88, 89, 96, 97, 104, 105, 106, 110, 125, 126, 127, 133, 136, 137, 138, 139, 144, 145, 157, 158, 159, 160, 163, 164, 165, 166, 167, 176, 196, 197.

Barnes Creek

Cells with 3.0 t/a (120 tons) for the 25-year storm, 2.0 t/a per year:
2, 4, 5, 8, 11, 12, 13, 14, 17, 18, 20, 21, 22, 26, 28, 29, 29, 30, 31, 34, 40, 44, 47, 48, 50, 53, 56, 57, 58, 59, 62, 63, 64, 66, 67, 68, 69, 73, 74, 75, 78, 79, 84, 85, 86, 88, 89, 90, 91, 92, 97, 98, 99, 101, 102, 105, 106, 110.

Cells with 4.0 t/a (160 tons) for the 25-year storm, 3.0 t/a per year:
6, 7, 9, 10, 23, 24, 36, 37, 38, 39, 51, 52, 72, 77, 80, 81, 93, 94, 95, 96, 100, 103, 104, 107, 108.

Soldier Creek

Cells with 0.3 t/a (12 tons) for the 25-year storm, 0.1 t/a per year:
1, 2, 3, 7, 8, 9, 14, 18, 21, 22, 25, 26, 27, 29, 30, 32.

Cells with 0.4 t/a (16 tons) for the 25-year storm, 0.2 t/a per year:
4, 5, 6, 17, 19, 23, 28, 31.

Source:
Robert H. Drees, Geologist, SCS Kansas Office, Salina, March 14, 1989.

Table 7. Wastewater treatment plant point-source data.

Webster Creek, Cell 68, wastewater treatment plant for Sabetha, Kansas.

Sabetha:

population	2400
flow	340,000 gallons per day, .5 cfs, (inputted flow, 1 cfs) (1)
total nitrogen	30 ppm (2)
total phosphorus	8 ppm (2)
COD	60 ppm (2)
BOD	19 ppm (1)

Estimates for N, P and COD were made with the assumption that the plant removes 25 percent.

Sources:

1. Ted Hayden, Superintendent of Wastewater Treatment, City of Sabetha, Kansas.

2. Metcalf and Eddy, WASTE WATER ENGINEERING, 1979. (Table 12-3).

APPENDIX 2 — INPUT FILES FOR THE FIVE WATERSHEDS

Key to all input files that follow:

Column	Input
1	Cell number
2	Receiving cell number
3	SCS curve number
4	Land slope, %
5	Slope shape factor
6	Field slope length, ft
7	Channel slope, %
8	Channel side slope, %
9	Manning's roughness coefficient for the channel
10	Soil erodibility factor
11	Cropping factor
12	Practice factor
13	Surface condition constant
14	Aspect
15	Soil texture number
16	Fertilization level
17	Availability factor, %
18	Point source indicator
19	Gully source level, tons
20	COD factor
21	Impoundment factor
22	Channel indicator

Note:

If an impoundment factor or channel indicator, additional information follows. Refer to the AGNPS manual for details about the information that is required for these conditions.

Table 1. Input file for Webster Creek.

```
Webster Creek
40.0 176   5.8 130.0

   0   0   0   0  0  0    0    0    0    1    1   1     1  1 1 1    1 1  1    2    2 2
   1   2   3   4  5  6    7    8    9    0    1   2     3  4 5 6    7 8  9    0    1 2

   1   6  82  1.2 2 100  1.5 10.0 .080 .37 .25 1.00 .05 5 2 2  50 0   0  80   0 1
   2   7  82  1.0 1 100  0.9 10.0 .080 .37 .25 1.00 .05 5 2 2  50 0   0  80   0 1
   3   4  82  2.1 1 100  1.3 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0   0  80   0 1
   4   9  82  1.5 1 100  0.8 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0   0  80   0 1
   5   6  82  0.5 1 100  0.3 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0  60  80   0 0
   6  12  82  1.6 2 100  1.3 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  60  80   0 1
   7  13  82  3.0 1 250  2.0 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0   0  80   0 2
   8   7  82  2.7 2 250  1.4 10.0 .080 .37 .25 0.50 .29 7 2 2  50 0   0  80   0 0
   9  15  82  3.2 2 250  1.3 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  60  80   0 2
  10   9  82  2.3 1 100  2.0 10.0 .080 .37 .25 0.50 .29 7 2 2  50 0  60  80   0 1
  11  12  82  1.8 1 100  2.1 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0   0  80   0 1
  12  13  82  1.8 2 100  0.8 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0  60  80   0 2
  13  19  82  3.2 3 250  1.0 99.9 .040 .37 .25 0.50 .29 5 2 2  50 0   0  80   0 1
  14  20  82  2.3 1 100  2.7 10.0 .080 .37 .25 0.50 .29 5 3 2  50 0   0  80   0 1
  15  16  85  2.5 1 250  1.0 10.0 .080 .37 .25 0.50 .29 3 3 2  50 0  60  80   0 1
  16  22  85  3.6 1 250  1.1 10.0 .080 .37 .25 0.50 .29 5 3 2  50 0   0  80   0 2
  17  16  84  1.5 2 100  1.5 10.0 .080 .37 .25 0.50 .29 7 3 2  50 0   0  80   0 1
  18  19  82  1.4 2 100  2.3 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0   0  80   0 1
  19  20  82  2.8 2 250  1.8 99.9 .040 .37 .25 0.50 .29 3 2 2  50 0   0  80   0 3
  20  26  82  4.5 1 250  1.0 99.9 .040 .37 .25 0.50 .29 5 2 2  50 0  60  80   0 3
  21  22  83  2.9 2 250  1.5 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0  60  80   0 0
  22  28  86  3.1 1 250  0.8 99.9 .040 .37 .25 0.50 .29 5 3 2  50 0  60  80   0 2
  23  29  82  2.6 1 250  2.1 10.0 .080 .37 .25 0.50 .29 5 2 2  50 1  60  80   0 1
1    0    0.0     .0     0.0
  24  30  82  2.5 2 250  1.0 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0   0  80   0 1
  25  19  82  2.6 2 250  1.3 10.0 .080 .37 .25 0.50 .29 1 2 2  50 2   0  80   0 0
2 1.00  91
  0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0  .10 100  0.0 0.00   0  0.0  0.00  0
  100 0.17 0.27 0.26    0 0.00 0.00 0.00    0 0.00 0.00 0.00
2 1.00  91
  0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0  .10 100  0.0 0.00   0  0.0  0.00  0
   50 0.17 0.27 0.26    0 0.00 0.00 0.00    0 0.00 0.00 0.00
  26  27  84  3.2 3 250  1.7 99.9 .040 .37 .25 0.50 .29 3 2 2  50 0  60  80   0 2
  27  33  82  2.2 1 100  0.4 99.9 .040 .37 .25 0.50 .29 5 2 2  50 1  60  80   0 1
2 1.00  91
  0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0  .10 100  0.0 0.00   0  0.0  0.00  0
  100 0.17 0.27 0.26    0 0.00 0.00 0.00    0 0.00 0.00 0.00
  28  29  85  3.2 2 250  1.2 10.0 .080 .37 .25 0.50 .29 3 3 2  50 1  60  80   0 1
2 1.00  91
  0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0  .10 100  0.0 0.00   0  0.0  0.00  0
   50 0.17 0.27 0.26    0 0.00 0.00 0.00    0 0.00 0.00 0.00
  29  35  83  2.7 1 250  0.6 99.9 .040 .37 .25 0.50 .29 5 2 2  50 1  60  80   0 1
2 4.00  91
  1.00  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0  .10 100  0.0 0.00   0  0.0  0.00  0
  200 1.00 1.00 1.00    0 0.00 0.00 0.00    0 0.00 0.00 0.00
  30  36  83  2.0 1 100  1.4 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  60  80   0 1
  31  32  85  3.6 2 250  3.0 10.0 .080 .37 .25 0.50 .29 3 3 2  50 0   0  80   0 1
  32  33  86  3.3 1 250  1.8 10.0 .080 .37 .25 0.50 .29 3 3 2  50 0   0  80   0 1
  33  34  86  3.1 1 100  0.6 99.9 .040 .37 .25 0.50 .29 3 3 2  50 0  60  80   0 1
  34  39  86  3.2 2 250  0.6 99.9 .040 .37 .25 0.50 .29 5 3 2  50 0  60  80   0 1
  35  40  86  3.3 1 250  0.5 99.9 .040 .36 .25 0.50 .29 5 3 2  50 0 120  80   0 1
```

```
   0    0    0    0  0  0     0    0     0     1    1    1     1  1 1 1    1 1   1    2    2 2
   1    2    3    4  5  6     7    8     9     0    1    2     3  4 5 6    7 8   9    0    1 2

  36   41   84   2.8 2 250   1.4 10.0 .080 .36 .25 0.50 .29 5 3 2   50 0 120   80   0 1
  37   42   82   3.2 2 250   1.5 10.0 .080 .37 .25 0.50 .29 5 2 2   50 0   0   80   0 1
  38   33   84   3.0 2 250   1.5 10.0 .080 .37 .25 0.50 .29 1 3 2   50 0   0   80   0 0
  39   40   85   3.2 1 250   1.4 99.9 .040 .37 .25 0.50 .29 3 3 2   50 0  60   80   0 2
  40   41   82   3.4 2 250   0.3 99.9 .040 .36 .25 0.50 .29 3 2 2   50 0  60   80   0 2
  41   51   83   4.4 2 250   1.0 99.9 .040 .35 .01 1.00 .15 5 3 0    0 0   0   60   0 2
  42   41   82   2.9 1 250   2.2 10.0 .080 .37 .25 1.00 .05 7 2 2   50 0 120   80   0 1
  43   42   83   2.6 2 250   2.5 10.0 .080 .37 .25 1.00 .15 7 2 0    0 0  60   60   0 1
  44   43   82   1.0 1 100   0.5 10.0 .080 .37 .01 1.00 .01 7 2 0  100 0   0   80   0 0
  45   56   85   1.2 1 100   0.6 10.0 .080 .37 .01 1.00 .01 5 2 0  100 0   0   80   0 0
  46   58   82   1.8 2 100   0.9 10.0 .080 .37 .25 0.50 .29 5 2 2   50 0  60   80   0 0
  47   46   82   1.6 2 100   0.8 10.0 .080 .37 .25 0.50 .29 7 2 2   50 0  60   80   0 0
  48   60   82   0.7 1 100   0.4 10.0 .080 .37 .25 0.50 .29 5 2 2   50 0  60   80   0 0
  49   39   82   3.1 2 250   3.1 10.0 .080 .37 .25 0.75 .29 1 2 2   50 0   0   80   0 1
  50   40   80   3.3 1 250   1.7 10.0 .080 .37 .13 1.00 .22 1 2 1   50 0  60   70   0 0
  51   52   84   4.6 2 250   0.7 99.9 .040 .36 .01 1.00 .15 3 3 0    0 1  60   60   0 1
2 2.00   91
  0.50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0   .10 100   0.0 0.00   0  0.0  0.00  0
  100 1.00 1.00 1.00     0 0.00 0.00 0.00     0 0.00 0.00 0.00
  52   64   79   3.5 3 250   0.7 99.9 .040 .36 .01 1.00 .15 5 2 0    0 0   0   60   0 1
  53   65   87   3.4 1 250   0.3 99.9 .040 .37 .01 1.00 .01 5 3 0  100 0   0   80   0 1
  54   66   85   2.9 1 250   2.1 99.9 .040 .37 .01 1.00 .01 5 2 0  100 0   0   80   0 0
  55   67   85   1.8 1 100   1.5 10.0 .080 .37 .01 1.00 .01 5 2 0  100 0   0   80   0 0
  56   68   85   2.2 1 100   1.1 10.0 .080 .37 .01 1.00 .01 5 2 0  100 0   0   80   0 0
  57   56   85   2.3 1 100   1.2 10.0 .080 .37 .01 1.00 .01 7 2 0  100 0   0   80   0 0
  58   70   79   1.8 2 100   0.8 99.9 .040 .35 .13 0.75 .22 5 2 1   50 1 120   70   0 1
2 2.00   91
  0.50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0   .10 100   0.0 0.00   0  0.0  0.00  0
   50 1.00 1.00 1.00  300 0.17 0.27 0.26     0 0.00 0.00 0.00
  59   58   82   2.0 2 100   1.0 10.0 .080 .37 .25 0.50 .29 7 2 2   50 0 120   80   0 0
  60   72   79   1.6 2 100   2.1 99.9 .040 .36 .01 1.00 .15 5 2 0    0 1  60   60   0 1
2 2.00   91
  0.50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0   .10 100   0.0 0.00   0  0.0  0.00  0
  200 0.17 0.27 0.26     0 0.00 0.00 0.00     0 0.00 0.00 0.00
  61   60   81   0.7 1 100   0.4 10.0 .080 .37 .16 0.70 .23 7 2 1   50 0  60   72   0 0
  62   63   82   2.6 2 100   1.3 10.0 .080 .37 .25 0.50 .29 3 2 2   50 0  60   80   0 0
  63   64   80   2.8 1 250   1.1 10.0 .080 .37 .01 1.00 .15 3 2 0    0 0   0   60   0 2
  64   65   81   4.5 2 250   1.9 99.9 .040 .35 .01 1.00 .15 3 3 0    0 0   0   60   0 2
  65   77   84   4.1 2 250   0.5 99.9 .040 .37 .01 1.00 .08 5 3 0    0 0   0   70   0 1
  66   78   86   3.7 2 250   3.0 99.9 .040 .37 .01 1.00 .01 5 2 0  100 0   0   80   0 1
  67   68   85   2.0 2 100   1.0 10.0 .080 .37 .01 1.00 .01 3 2 0  100 0   0   80   0 0
  68   80   83   0.4 1 100   1.2 99.9 .040 .37 .01 1.00 .15 5 3 0    0 1  60   60   0 1
1    1    30.0     8.0     60.0
  69   70   85   2.2 2 100   1.1 10.0 .080 .37 .01 1.00 .01 3 2 0    0 0  60   80   0 0
  70   82   80   2.5 1 250   0.8 99.9 .040 .35 .01 1.00 .08 5 2 0    0 0  60   70   0 1
  71   83   79   2.2 2 100   1.1 10.0 .080 .37 .01 1.00 .15 5 2 0    0 1  60   60   0 0
2 1.00   91
  0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0   .10 100   0.0 0.00   0  0.0  0.00  0
   25 1.00 1.00 1.00     0 0.00 0.00 0.00     0 0.00 0.00 0.00
  72   84   77   2.2 1 100   1.2 99.9 .040 .35 .01 1.00 .15 5 2 0    0 0  60   60   0 2
  73   72   79   1.4 2 100   1.0 99.9 .040 .36 .01 1.00 .15 7 2 0    0 1  60   60   0 1
2 4.00   91
  1.00  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
  0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
  5.0   .10 100   0.0 0.00   0  0.0  0.00  0
  400 0.18 0.06 0.13     0 0.00 0.00 0.00     0 0.00 0.00 0.00
  74   73   82   1.0 1 100   0.7 10.0 .080 .37 .25 0.75 .29 7 2 2   50 0   0   80   0 1
```

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
75	63	84	3.1	2	250	2.8	10.0	.080	.37	.25	0.75	.29	1	2	2	50	0	60	80	0	1
76	77	86	3.8	2	250	3.4	10.0	.080	.37	.25	0.75	.29	3	3	2	50	0	60	80	0	1
77	87	76	4.5	1	250	1.2	99.9	.040	.34	.01	1.00	.22	5	3	0	0	0	0	60	0	2
78	88	80	3.7	2	250	1.6	99.9	.040	.37	.01	1.00	.15	5	2	0	0	0	60	60	0	1
79	67	79	3.3	2	250	1.7	10.0	.080	.37	.01	1.00	.15	1	2	0	0	0	0	60	0	0
80	81	85	3.2	2	250	0.7	10.0	.080	.37	.25	0.75	.29	3	3	2	50	0	60	80	0	1
81	91	86	2.7	2	250	1.0	99.9	.040	.37	.01	1.00	.01	5	2	0	0	0	0	80	0	1
82	92	83	2.8	2	250	1.7	99.9	.040	.35	.01	1.00	.22	5	2	0	0	0	120	70	0	2
83	82	80	2.7	1	250	0.5	99.9	.040	.35	.01	1.00	.15	7	2	0	0	0	120	60	0	1
84	83	79	2.6	2	250	1.3	10.0	.080	.37	.01	1.00	.15	7	2	0	0	0	60	60	0	1
85	86	86	3.4	2	250	3.0	10.0	.080	.37	.25	0.75	.29	3	3	2	50	0	60	80	0	1
86	96	86	3.0	2	250	1.8	99.9	.040	.37	.25	0.75	.29	5	3	2	50	0	60	80	0	2
87	97	82	5.6	2	250	0.2	99.9	.040	.34	.25	0.75	.29	5	3	2	50	0	0	80	0	1
88	87	83	4.6	2	250	3.2	99.9	.040	.37	.01	1.00	.15	7	3	0	0	0	60	60	0	2
89	88	79	3.8	2	250	1.9	10.0	.080	.37	.01	1.00	.15	7	2	0	0	0	0	60	0	0
90	91	86	3.5	2	250	1.4	10.0	.080	.37	.25	0.75	.29	3	3	2	50	0	60	80	0	1
91	101	83	3.1	2	250	1.0	99.9	.040	.37	.25	0.50	.29	5	2	2	50	0	0	80	0	1
92	102	82	4.1	1	250	1.2	99.9	.040	.35	.25	0.50	.29	5	3	2	50	0	0	80	0	2
93	92	79	3.5	1	250	1.2	10.0	.080	.36	.01	1.00	.15	7	2	0	0	0	60	60	0	1
94	93	82	3.2	2	250	2.5	10.0	.080	.37	.25	0.50	.29	7	2	2	50	0	60	80	0	1
95	96	85	3.0	2	250	1.5	10.0	.080	.37	.25	0.50	.29	3	3	2	50	0	60	80	0	0
96	97	86	3.8	1	250	1.4	99.9	.040	.37	.25	0.50	.29	3	3	2	50	0	60	80	0	2
97	98	79	5.7	2	250	1.9	99.9	.040	.34	.01	1.00	.15	3	3	0	0	0	0	60	0	3
98	108	84	5.7	2	250	2.4	99.9	.040	.37	.01	1.00	.15	5	3	0	0	0	0	60	0	2
99	98	79	4.5	2	250	5.4	10.0	.080	.37	.01	1.00	.15	7	2	0	0	0	0	60	0	1
100	110	85	3.4	2	250	1.7	10.0	.080	.37	.25	0.50	.29	5	3	2	50	0	60	80	0	0
101	111	79	4.5	2	250	1.2	99.9	.040	.31	.25	0.50	.29	5	2	2	50	0	60	80	0	2
102	101	80	3.9	2	250	2.5	99.9	.040	.37	.01	1.00	.15	7	2	0	0	0	0	60	0	1
103	102	82	2.7	2	250	1.0	10.0	.080	.37	.25	0.50	.29	7	2	2	50	0	60	80	0	1
104	103	82	1.9	1	100	2.0	10.0	.080	.37	.25	0.50	.29	7	2	2	50	0	0	80	0	0
105	106	82	2.7	2	250	3.1	10.0	.080	.37	.13	1.00	.15	3	3	0	0	0	0	61	0	1
106	96	81	3.5	1	250	2.2	10.0	.080	.37	.01	0.97	.15	1	2	0	0	0	0	60	0	1
107	108	86	3.7	1	250	1.9	10.0	.080	.37	.25	0.50	.29	3	3	2	50	0	60	80	0	0
108	115	81	4.5	2	250	0.4	99.9	.040	.35	.01	1.00	.15	5	3	0	0	0	0	60	0	1
109	110	85	5.2	2	250	5.5	10.0	.080	.37	.25	0.50	.29	3	3	2	50	0	60	80	0	2
110	117	79	3.9	2	250	4.8	99.9	.040	.33	.25	0.50	.29	5	3	2	50	0	0	80	0	2
111	110	85	4.3	2	250	1.8	99.9	.040	.37	.25	0.50	.29	7	3	2	50	0	60	80	0	2
112	111	82	3.5	2	250	1.6	10.0	.080	.36	.25	0.50	.29	7	2	2	50	0	120	80	0	1
113	103	82	2.3	1	100	1.2	10.0	.080	.37	.25	0.50	.29	1	2	2	50	0	60	80	0	0
114	115	85	4.6	2	250	2.8	99.9	.040	.37	.13	0.75	.22	3	3	1	50	0	60	70	0	1
115	123	81	5.6	2	250	0.4	99.9	.040	.35	.01	1.00	.15	5	3	0	0	0	0	60	0	1
116	124	86	4.6	2	250	0.2	99.9	.040	.36	.25	0.50	.29	5	3	2	50	0	0	80	0	1
117	116	81	4.5	2	250	1.9	99.9	.040	.35	.01	1.00	.15	7	3	0	0	0	60	60	0	3
118	117	83	3.4	2	250	1.7	99.9	.040	.37	.01	1.00	.15	7	3	0	0	0	60	60	0	0
119	127	83	3.0	2	250	0.8	10.0	.080	.37	.25	0.50	.29	5	2	2	50	0	120	80	0	1
120	119	84	2.4	2	100	1.6	10.0	.080	.35	.25	0.50	.29	7	3	2	50	0	120	80	0	1
121	129	82	0.9	1	100	0.5	10.0	.080	.37	.25	0.50	.29	5	2	2	50	0	60	80	0	0
122	123	86	4.1	2	250	1.2	10.0	.080	.37	.25	0.50	.29	3	3	2	50	0	0	80	0	1
123	124	83	6.6	2	250	1.5	99.9	.040	.36	.01	1.00	.15	3	3	0	0	0	0	60	0	2
124	133	79	3.6	2	250	0.5	99.9	.040	.34	.01	1.00	.22	5	2	1	50	0	0	70	0	2
125	124	86	4.0	1	250	2.0	99.9	.040	.37	.25	0.50	.29	7	3	2	50	0	60	80	0	0
126	118	85	5.0	2	250	2.5	10.0	.080	.37	.25	0.50	.29	1	3	2	50	0	0	80	0	0
127	136	84	3.6	2	250	1.7	99.9	.040	.37	.25	0.50	.29	5	2	2	50	0	120	80	0	1
128	137	84	3.2	2	250	1.6	10.0	.080	.37	.25	0.50	.29	5	3	2	50	0	120	80	0	0
129	138	79	2.7	2	250	1.4	10.0	.080	.35	.25	0.50	.29	5	2	2	50	0	60	80	0	0
130	129	82	2.5	1	250	1.3	10.0	.080	.37	.25	0.50	.29	7	2	2	50	0	0	80	0	0
131	122	85	4.0	2	250	3.5	10.0	.080	.37	.25	0.50	.29	1	3	2	50	0	0	80	0	1
132	133	85	8.9	2	200	2.2	99.9	.040	.37	.25	0.50	.29	3	3	2	50	0	0	80	0	1
133	142	79	5.8	2	250	3.5	99.9	.040	.33	.17	0.67	.23	5	3	2	50	0	0	68	0	2
134	143	86	5.1	2	250	2.6	10.0	.080	.37	.25	0.50	.29	5	3	2	50	0	0	80	0	0
135	144	84	3.5	2	250	3.1	10.0	.080	.37	.25	0.50	.29	5	3	2	50	0	60	80	0	1
136	145	83	1.8	2	100	2.1	99.9	.040	.35	.13	0.75	.22	5	3	1	50	0	120	70	0	1
137	146	82	3.8	2	250	1.5	99.9	.040	.32	.25	1.00	.29	5	3	2	50	0	120	80	0	1
138	137	80	3.3	2	250	2.1	10.0	.080	.37	.01	1.00	.15	7	2	0	0	0	120	60	0	1
139	138	81	1.6	1	100	0.8	99.9	.040	.35	.25	0.50	.29	7	2	2	50	0	120	80	0	0

```
     0   0   0   0 0 0   0   0    0    1   1  1    1 1 1 1  1 1  1    2    2 2
     1   2   3   4 5 6   7   8    9    0   1  2    3 4 5 6  7 8  9    0    1 2

 140 141  84  3.2 2 250  2.7 10.0 .080 .37 .25 0.50 .29 3 2 2  50 0   0  80  0 1
 141 142  84  4.6 2 250  3.7 99.9 .040 .37 .01 1.00 .15 3 3 0   0 0  60  60  0 2
 142 149  76  4.2 1 250  1.7 99.9 .040 .34 .13 1.00 .22 5 2 0   0 0   0  70  0 1
 143 142  81 11.2 1 200  3.2 99.9 .040 .35 .01 1.00 .15 7 3 0   0 0   0  60  0 2
 144 151  81  4.2 1 250  2.9 10.0 .080 .34 .01 1.00 .15 5 3 0   0 0   0  60  0 1
 145 152  73  4.2 2 250  1.4 99.9 .040 .29 .17 0.70 .21 5 3 1  50 0  60  72  0 2
 146 145  76  4.9 2 250  1.9 99.9 .040 .32 .13 0.75 .22 7 2 1  50 0  60  70  0 2
 147 154  85  2.6 1 250  2.4 10.0 .080 .37 .25 0.50 .29 5 3 2  50 1   0  80  0 1
2 2.00  91
   0.50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
   0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
   5.0  .10 100  0.0 0.00   0  0.0  0.00  0
    50 1.96 0.92 1.68    0 0.00 0.00 0.00    0 0.00 0.00 0.00
 148 141  86  3.3 1 250  1.7 10.0 .080 .37 .25 0.50 .29 1 3 2  50 0  60  80  0 0
 149 150  82  5.9 2 250  0.1 99.9 .040 .35 .18 0.65 .29 3 3 2  50 0  60  74  0 1
 150 157  78  5.1 3 250  0.4 99.9 .040 .35 .08 0.84 .26 5 3 1  50 0 120  66  0 2
 151 150  79  6.5 2 200  1.3 99.9 .040 .36 .13 1.00 .22 7 3 0   0 0 120  60  0 1
 152 151  79  4.8 2 250  0.7 99.9 .040 .32 .25 0.50 .29 7 2 2  50 0 120  80  0 1
 153 152  81  4.3 1 250  2.2 10.0 .080 .33 .25 0.50 .29 7 2 2  50 0  60  80  0 0
 154 160  83  3.3 2 250  1.3 99.9 .040 .37 .11 0.80 .21 5 3 1  50 0   0  68  0 1
 155 161  81  2.9 2 250  1.5 10.0 .080 .37 .01 1.00 .15 5 2 0   0 0   0  60  0 0
 156 162  84  2.6 2 250  6.7 10.0 .080 .37 .01 1.00 .15 5 3 0   0 0   0  60  0 1
 157 163  70  5.2 1 250  0.2 99.9 .040 .32 .01 1.00 .22 5 2 0   0 0  60  60  0 1
 158 157  76  5.7 2 250  1.6 99.9 .040 .35 .01 1.00 .22 7 2 0   0 0 120  60  0 1
 159 165  82  3.3 2 250  4.9 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0 120  80  0 1
 160 161  86  4.4 2 250  2.7 10.0 .080 .37 .25 1.00 .29 3 3 2  50 0   0  80  0 1
 161 166  83  5.7 2 250  1.9 99.9 .040 .37 .01 1.00 .15 5 3 0   0 0  60  60  0 1
 162 163  81  4.9 2 250  2.5 99.9 .040 .37 .11 0.80 .21 3 2 1  50 0   0  68  0 0
 163 168  71  9.3 1 200  1.5 99.9 .040 .33 .01 1.00 .21 5 2 0   0 0  60  60  0 1
 164 163  85  4.9 2 250  2.4 99.9 .040 .36 .25 0.50 .29 7 3 2  50 0  60  80  0 1
 165 164  81  4.8 2 250  2.4 99.9 .040 .33 .25 0.50 .29 7 2 2  50 1  60  80  0 0
2 1.00  91
   0.25  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
   0.00  0.00  0.00  0.00  0.00  0.00  0   0    0   0   0   0
   5.0  .10 100  0.0 0.00   0  0.0  0.00  0
   100 0.17 0.27 0.26    0 0.00 0.00 0.00    0 0.00 0.00 0.00
 166 167  86  6.9 2 200  4.6 99.9 .040 .37 .25 0.50 .29 3 3 2  50 0  60  80  0 2
 167 171  77  5.2 2 250  0.8 99.9 .040 .33 .01 1.00 .24 5 3 0   0 0  60  60  0 2
 168 167  76  3.9 3 250  0.2 99.9 .040 .33 .13 0.75 .22 7 2 1  50 0   0  70  0 1
 169 168  85  4.2 1 250  3.4 99.9 .040 .37 .25 0.50 .29 7 3 2  50 0   0  80  0 1
 170 171  84  5.8 2 250  3.8 99.9 .040 .37 .20 0.60 .29 3 3 2  50 0  60  76  0 1
 171 172  63  4.7 3 250  0.4 99.9 .040 .31 .07 0.85 .29 3 3 1  50 0   0  66  0 2
 172 175  67  8.4 3 200  1.6 99.9 .040 .33 .01 1.00 .29 5 2 0   0 0   0  60  0 2
 173 176  80  5.1 2 250  5.7 99.9 .040 .37 .11 0.80 .29 5 3 1  50 0  60  68  0 2
 174 175  85  3.7 1 250  1.9 10.0 .080 .37 .25 0.50 .29 3 3 2  50 0   0  80  0 0
 175 176  79  4.5 1 250  0.6 99.9 .040 .34 .13 0.75 .29 3 3 1  50 0   0  70  0 1
 176 177  67  5.7 3 250  1.8 99.9 .040 .33 .01 1.00 .29 5 2 0   0 0   0  60  0 2
```

Table 2. Input file for Mosquito Creek.

```
Mosquito Creek
40.0 213  5.8 130.0

  0  0  0   0  0   0    0    0    0   1   1    1    1  1 1 1   1  1   1   2   2 2
  1  2  3   4  5   6    7    8    9   0   1    2    3  4 5 6   7  8   9   0   1 2

  1  2  87  4.5 1 250  2.8 10.0 .080 .30 .01 1.00 .01 3 3 0   0 0  30  60   0 1
  2  5  79  3.5 1 250  2.3 10.0 .080 .29 .01 1.00 .01 5 3 0   0 0   0  60   0 2
  3  2  83  4.1 1 250  4.0 10.0 .080 .30 .01 1.00 .01 7 3 0   0 0   0  60   0 1
  4  5  83  5.0 3 250  4.2 10.0 .080 .30 .01 1.00 .01 3 3 0   0 0  30  60   0 1
  5  9  75  4.2 3 250  1.7 99.9 .040 .29 .01 1.00 .23 5 3 0   0 0   0  60   0 1
  6 10  83  4.1 1 250  3.0 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0   0  60   0 1
  7 11  83  5.7 1 250  4.0 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
  8  9  83  4.3 1 250  4.0 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0  80  60   0 2
  9 10  83  4.7 3 250  2.6 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0  30  60   0 2
 10 14  79  3.5 1 250  1.3 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0  80  60   0 2
 11 15  83  4.5 1 250  2.0 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 12 16  88  4.7 2 250  2.5 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 13 14  79  4.5 3 250  2.5 10.0 .080 .29 .01 1.00 .01 3 3 0   0 0  80  60   0 2
 14 15  79  4.3 1 250  2.2 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0   0  60   0 0
 15 20  79  5.1 1 250  3.1 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 16 20  83  3.9 1 250  3.7 99.9 .040 .30 .01 1.00 .01 6 3 0   0 0  80  60   0 1
 17 22  82  4.8 2 250  5.0 10.0 .080 .32 .25 0.50 .29 5 3 2  50 0   0  80   0 1
 18 19  79  4.8 2 250  3.7 99.9 .040 .30 .25 0.50 .29 3 3 2  50 0  30  80   0 1
 19 20  75  5.2 1 250  2.3 99.9 .040 .29 .25 0.50 .29 3 3 2  50 0  30  80   0 1
 20 26  60  6.6 2 200  1.5 99.9 .040 .30 .01 1.00 .29 5 2 0   0 0   0  60   0 2
 21 27  83  4.9 3 250  2.5 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 22 28  79  4.8 2 250  2.6 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 23 29  83  4.6 2 250  3.3 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 24 18  86  4.4 1 250  2.2 10.0 .080 .32 .01 1.00 .01 1 3 0   0 0  80  60   0 0
 25 26  79  4.6 1 250  2.8 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0  80  60   0 1
 26 27  83  4.3 1 250  6.7 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0  80  60   0 1
 27 36  75  4.4 3 250  1.8 99.9 .040 .28 .01 1.00 .08 5 3 0   0 0  30  60   0 2
 28 37  79  4.2 2 250  1.4 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 29 38  83  4.6 2 250  2.3 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 30 39  83  5.2 1 250  3.5 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 2
 31 40  86  4.2 1 250  3.3 99.9 .040 .32 .01 1.00 .01 5 3 2  50 0  80  60   0 1
 32 41  79  5.2 1 250  3.1 99.9 .040 .28 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 33 42  86  4.2 2 250  4.2 99.9 .040 .32 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 34 35  79  5.0 1 250  2.8 99.9 .040 .30 .25 0.50 .29 3 3 2  50 0  80  80   0 1
 35 36  86  5.8 2 250  3.1 99.9 .040 .32 .01 1.00 .01 3 3 0   0 0  80  60   0 2
 36 37  75  6.2 2 250  2.9 99.9 .040 .30 .25 0.50 .29 3 3 2  50 0  80  80   0 2
 37 38  79  5.0 3 250  3.1 99.9 .040 .31 .01 1.00 .01 3 2 0   0 0   0  60   0 3
 38 53  75  5.0 3 250  1.1 99.9 .040 .29 .25 0.50 .29 5 3 2  50 0   0  80   0 2
 39 54  79  4.6 3 250  2.3 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  30  60   0 0
 40 55  83  5.6 1 250  2.6 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 41 42  83  3.6 2 250  5.0 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0  80  60   0 1
 42 57  83  4.1 2 250  2.1 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 43 58  89  4.1 2 250  2.1 10.0 .080 .37 .01 1.00 .01 5 3 0   0 0   0  60   0 1
 44 59  89  3.6 1 250  2.5 10.0 .080 .37 .01 1.00 .01 5 3 0   0 0   0  60   0 1
 45 61  86  4.3 2 250  2.5 10.0 .080 .32 .01 1.00 .01 4 3 0   0 0  30  60   0 1
 46 61  81  3.4 2 250  2.5 10.0 .080 .36 .13 0.75 .15 5 3 1  50 0  30  70   0 1
 47 62  86  4.1 1 250  3.9 10.0 .080 .32 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 48 63  83  5.8 2 250  3.0 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 1
 49 50  75  6.7 1 200  4.8 10.0 .080 .28 .25 0.50 .29 3 3 2  50 0  30  80   0 1
 50 35  79  5.0 2 250  4.2 99.9 .040 .28 .01 1.00 .01 1 3 0   0 0  80  60   0 2
 51 36  79  4.2 3 250  2.5 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  80  60   0 2
 52 37  83  4.9 2 250  4.8 99.9 .040 .30 .01 1.00 .01 1 3 0   0 0  80  60   0 2
 53 54  84  5.8 2 250  5.2 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0  30  60   0 1
 54 55  75  5.5 3 250  2.1 99.9 .040 .30 .25 0.50 .29 3 3 2  50 0   0  80   0 2
 55 75  79  6.6 3 200  2.4 99.9 .040 .30 .01 1.00 .01 5 2 0   0 0   0  60   0 2
 56 55  83  4.9 3 250  4.6 99.9 .040 .30 .01 1.00 .01 7 3 0   0 0  30  60   0 1
 57 77  83  4.5 3 250  2.3 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0  80  60   0 2
 58 78  88  4.5 1 250  2.8 99.9 .040 .36 .01 1.00 .01 5 3 0   0 0  30  60   0 1
 59 79  89  3.8 1 250  1.9 99.9 .040 .37 .01 1.00 .01 5 3 0   0 0   0  60   0 1
 60 61  86  4.1 1 250  7.7 99.9 .040 .32 .01 1.00 .01 3 3 0   0 0  30  60   0 3
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  1   2   3   4 5 6    7    8    9    0   1  2     3  4 5 6    7 8   9    0    1 2

 61  81  79  3.9 1 250  2.5 99.9 .040 .29 .01 1.00 .01 5 3 0    0 0  80   60   0 2
 62  82  83  3.9 2 250  3.5 99.9 .040 .30 .01 1.00 .01 5 3 0    0 0  80   60   0 2
 63  83  79  5.0 2 250  4.8 10.0 .080 .28 .01 1.00 .01 5 3 0    0 0  80   60   0 3
 64  84  83  4.8 2 250  3.0 10.0 .080 .30 .01 1.00 .01 5 3 0    0 0  80   60   0 1
 65  85  83  4.5 2 250  3.4 10.0 .080 .30 .01 1.00 .01 5 3 0    0 0  80   60   0 1
 66  86  83  4.7 2 250  4.1 10.0 .080 .30 .01 1.00 .01 5 3 0    0 0  30   60   0 2
 67  87  79  5.7 2 250  4.0 10.0 .080 .30 .25 0.50 .29 5 3 2   50 0  80   80   0 1
 68  88  79  3.4 3 250  2.9 10.0 .080 .32 .25 0.50 .29 5 3 2   50 0  30   80   0 1
 69  88  79  4.6 2 250  3.9 10.0 .080 .28 .01 1.00 .01 6 3 0    0 0  30   60   0 1
 70  71  83  6.3 1 250  3.2 10.0 .080 .30 .01 1.00 .01 3 3 0    0 0   0   60   0 0
 71  51  83  5.0 2 250  3.8 99.9 .040 .30 .01 1.00 .01 1 3 0    0 0   0   60   0 1
 72  73  88  4.6 2 250  3.0 99.9 .040 .36 .01 1.00 .01 3 3 0    0 2  30   60   0 1
2.00  91
 .50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
5.0  .10 100  0.0 0.00   0  0.0 0.00   0
200 1.00 1.00 1.00     0 0.00 0.00 0.00     0 0.00 0.00 0.00
3.00  91
 .75  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
5.0  .10 100  0.0 0.00   0  0.0 0.00   0
200 1.00 1.00 1.00     0 0.00 0.00 0.00     0 0.00 0.00 0.00
 73  74  86  3.9 1 250  2.6 99.9 .040 .32 .01 1.00 .01 3 3 0    0 0  30   60   0 1
 74  75  79  7.1 2 200  0.7 99.9 .040 .30 .01 1.00 .01 3 3 0    0 0  30   60   0 1
 75  76  79  5.7 1 250  2.3 99.9 .040 .32 .01 1.00 .01 3 1 0    0 0  80   60   0 1
 76  77  79  5.9 3 250  3.5 99.9 .040 .29 .01 1.00 .01 3 3 0    0 0  80   60   0 3
 77  78  79  7.3 3 200  2.4 99.9 .040 .29 .01 1.00 .01 3 3 0    0 0  80   60   0 2
 78  79  79  9.2 3 200  4.8 99.9 .040 .30 .01 1.00 .01 3 3 0    0 0   0   60   0 1
 79  80  79  4.0 3 250  0.9 99.9 .040 .30 .01 1.00 .01 3 3 0    0 0  30   60   0 1
 80  81  79  4.4 3 250  0.6 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0  30   60   0 2
 81  82  79  4.1 1 250  1.8 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0  30   60   0 3
 82  83  79  5.6 3 250  3.5 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0   0   60   0 3
 83  84  79  5.2 3 250  1.3 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0   0   60   0 2
 84  85  79  6.1 3 250  3.4 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0   0   60   0 1
 85  86  79  6.0 3 250  2.1 99.9 .040 .31 .01 1.00 .01 3 2 0    0 0   0   60   0 1
 86  87  79  5.4 3 250  2.7 99.9 .040 .30 .01 1.00 .01 3 2 0    0 0   0   60   0 2
 87 108  79  4.2 3 250  1.8 99.9 .040 .28 .01 1.00 .01 5 3 0    0 0  80   60   0 3
 88 109  79  4.4 3 250  3.6 99.9 .040 .28 .25 0.50 .29 5 3 2   50 0  80   80   0 2
 89 110  88  4.6 2 250  4.5 99.9 .040 .36 .01 1.00 .01 5 3 0    0 0  80   60   0 1
 90 111  86  3.8 2 250  2.5 10.0 .080 .32 .01 1.00 .01 5 3 0    0 0  30   60   0 1
 91  90  88  3.5 1 250  3.0 10.0 .080 .37 .01 1.00 .01 7 2 0    0 0  30   60   0 1
 92  93  89  5.9 2 250  4.0 10.0 .080 .37 .01 1.00 .01 3 3 0    0 0   0   60   0 1
 93  94  79  5.4 1 250  1.9 99.9 .040 .29 .01 1.00 .01 3 3 0    0 0  30   60   0 1
 94  95  79  6.0 1 250  2.0 99.9 .040 .29 .01 1.00 .01 3 3 0    0 0  30   60   0 1
 95  74  79  5.4 3 250  1.6 99.9 .040 .29 .01 1.00 .01 1 3 0    0 0  30   60   0 2
 96  75  86  5.0 2 250  3.0 99.9 .040 .34 .01 1.00 .01 1 3 0    0 0  80   60   0 1
 97  76  86  5.5 2 250  3.9 99.9 .040 .32 .01 1.00 .01 1 3 0    0 0  80   60   0 1
 98 122  86  4.6 2 250  7.1 99.9 .040 .32 .01 1.00 .01 5 3 0    0 0  30   60   0 1
 99  78  83  6.1 3 250  1.0 99.9 .040 .30 .01 1.00 .01 1 3 0    0 0   0   60   0 1
100  79  86  6.5 1 200  3.3 99.9 .040 .32 .01 1.00 .01 1 3 0    0 0   0   60   0 0
101  80  79  5.3 3 250  3.5 99.9 .040 .28 .01 1.00 .01 1 3 0    0 0   0   60   0 2
102 103  79  6.0 3 250  5.1 99.9 .040 .28 .01 1.00 .01 3 3 0    0 0   0   60   0 2
103  82  79  5.3 3 250  1.4 99.9 .040 .28 .01 1.00 .01 1 3 0    0 0  30   60   0 1
104  83  83  4.9 1 250  3.3 99.9 .040 .30 .01 1.00 .01 1 3 0    0 0  80   60   0 2
105  84  83  5.1 2 250  3.3 99.9 .040 .30 .01 1.00 .01 1 3 0    0 0  80   60   0 2
106  85  86  5.4 1 250  4.8 99.9 .040 .32 .01 1.00 .01 1 3 0    0 0  80   60   0 1
107  86  79  4.5 3 250  0.5 99.9 .040 .28 .01 1.00 .01 1 3 0    0 0  30   60   0 1
108 109  79  6.0 3 250  1.9 99.9 .040 .28 .01 1.00 .01 3 3 0    0 0   0   60   0 2
109 133  88  2.1 1 100  0.2 99.9 .040 .37 .25 0.50 .29 5 2 2   50 0   0   80   0 1
110 134  85  4.3 3 250  2.2 99.9 .040 .36 .25 0.50 .29 5 2 2   50 0  80   80   0 0
111 135  79  4.2 2 250  1.6 99.9 .040 .30 .01 1.00 .01 5 2 0    0 0  30   60   0 1
112 136  89  3.8 2 250  2.8 10.0 .080 .37 .01 1.00 .01 5 3 0    0 0  30   60   0 1
113 137  89  4.3 2 250  4.1 10.0 .080 .37 .01 1.00 .01 5 3 0    0 0  30   60   0 1
114 138  84  2.5 1 250  1.3 10.0 .080 .32 .25 0.50 .29 5 2 2   50 0  30   80   0 0
115 116  82  2.8 1 250  1.4 10.0 .080 .37 .25 0.50 .29 3 2 2   50 0   0   80   0 0
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01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
116	140	84	3.2	1	250	1.1	10.0	.080	.32	.25	0.50	.29	5	2	2	50	0	0	80	0	1
117	118	79	5.5	1	250	2.7	10.0	.080	.28	.01	1.00	.01	3	3	0	0	0	0	60	0	1
118	94	79	4.1	2	250	3.0	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	0	60	0	2
119	95	83	7.1	3	200	2.3	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	0	60	0	2
120	96	89	3.6	2	200	3.8	99.9	.040	.37	.01	1.00	.01	1	3	0	0	0	30	60	0	1
121	122	79	4.6	2	200	3.8	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	30	60	0	2
122	123	79	5.0	1	200	1.4	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	30	60	0	1
123	99	83	6.1	2	250	3.6	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	30	60	0	2
124	100	83	4.1	2	250	4.3	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	30	60	0	2
125	101	83	3.7	2	250	2.1	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	80	60	0	1
126	127	79	5.0	2	250	3.3	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	80	60	0	1
127	103	79	5.2	1	250	3.8	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	80	60	0	2
128	129	86	4.0	2	250	3.5	99.9	.040	.32	.01	1.00	.01	3	3	0	0	0	30	60	0	2
129	130	79	4.1	1	250	1.7	99.9	.040	.29	.01	1.00	.01	3	3	0	0	0	30	60	0	1
130	131	79	5.1	1	250	2.2	99.9	.040	.30	.01	1.00	.01	3	3	0	0	0	30	60	0	2
131	107	86	5.1	2	250	3.1	99.9	.040	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	2
132	133	83	4.1	2	250	4.2	99.9	.040	.30	.01	1.00	.01	3	3	0	0	0	30	60	0	2
133	134	79	4.8	2	250	1.2	99.9	.040	.30	.01	1.00	.01	3	2	0	0	0	80	60	0	2
134	135	79	2.0	1	100	0.3	99.9	.040	.34	.25	0.50	.29	3	2	2	50	0	0	80	0	1
135	161	79	3.8	3	250	1.0	99.9	.040	.33	.01	1.00	.01	5	2	0	0	0	0	60	0	1
136	135	89	4.1	2	250	2.4	99.9	.040	.37	.01	1.00	.01	7	3	0	0	0	80	60	0	2
137	163	79	3.6	1	250	1.7	10.0	.080	.30	.01	1.00	.01	5	2	0	0	0	80	60	0	2
138	139	85	2.6	2	250	2.9	10.0	.080	.30	.25	0.50	.29	3	3	2	50	0	80	80	0	1
139	165	79	3.8	1	250	2.2	99.9	.040	.29	.01	1.00	.01	5	3	0	0	0	80	60	0	1
140	141	83	3.4	1	250	1.7	10.0	.080	.37	.25	0.50	.29	3	2	2	50	0	0	80	0	0
141	167	84	4.1	2	250	1.2	10.0	.080	.36	.25	0.50	.29	5	3	2	50	0	30	80	0	1
142	168	86	3.0	2	250	3.3	10.0	.080	.37	.25	0.50	.29	5	3	2	50	0	30	80	0	1
143	117	86	3.8	2	250	3.3	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	1
144	118	86	4.2	2	250	2.8	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	80	60	0	2
145	119	86	5.3	2	250	3.5	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	80	60	0	2
146	145	86	4.4	2	250	3.4	10.0	.080	.32	.01	1.00	.01	7	3	0	0	0	30	60	0	1
147	121	83	5.4	2	250	4.2	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	30	60	0	2
148	149	79	5.3	2	250	3.2	10.0	.080	.28	.01	1.00	.01	3	3	0	0	0	0	60	0	2
149	123	86	4.8	1	250	3.2	99.9	.040	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	2
150	124	79	4.2	2	250	1.9	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	30	60	0	1
151	125	83	4.3	1	250	4.0	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	30	60	0	1
152	153	83	4.7	1	250	2.5	99.9	.040	.30	.01	1.00	.01	3	3	0	0	0	30	60	0	2
153	127	79	4.6	1	250	6.8	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	30	60	0	2
154	128	79	5.0	2	250	2.9	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	30	60	0	1
155	129	79	3.9	2	250	2.7	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	30	60	0	2
156	130	79	7.5	1	200	1.8	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	30	60	0	2
157	156	79	4.2	1	250	4.0	99.9	.040	.30	.01	1.00	.01	7	3	0	0	0	80	60	0	1
158	159	86	6.4	2	250	2.8	99.9	.040	.32	.01	1.00	.01	3	3	0	0	0	80	60	0	2
159	133	79	6.0	3	250	1.7	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	80	60	0	2
160	161	79	6.6	3	200	3.3	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	80	60	0	1
161	162	81	4.3	3	250	0.3	99.9	.040	.33	.01	1.00	.01	3	2	0	0	0	30	60	0	1
162	182	79	3.8	3	250	1.1	99.9	.040	.32	.01	1.00	.01	5	2	0	0	0	30	60	0	2
163	162	75	3.5	2	250	2.2	99.9	.040	.28	.25	0.50	.29	7	1	2	50	0	80	80	0	2
164	184	87	4.4	2	250	3.6	99.9	.040	.30	.19	0.62	.23	5	3	2	50	0	80	75	0	2
165	185	88	4.9	3	250	1.6	99.9	.040	.36	.01	1.00	.01	5	3	0	0	0	80	60	0	1
166	186	88	3.3	2	250	0.9	99.9	.040	.36	.01	1.00	.01	5	3	0	0	0	80	60	0	1
167	168	88	2.4	1	100	0.6	99.9	.040	.37	.01	1.00	.01	3	2	0	0	0	80	60	0	1
168	188	79	4.0	3	250	2.5	99.9	.040	.30	.01	1.00	.01	5	2	0	0	0	30	60	0	2
169	189	79	4.6	1	250	3.1	10.0	.080	.28	.01	1.00	.01	5	3	0	0	0	30	60	0	1
170	148	83	4.9	1	250	3.5	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	30	60	0	3
171	170	86	4.8	2	250	2.4	10.0	.080	.32	.01	1.00	.01	7	3	0	0	0	30	60	0	0
172	150	86	4.9	1	250	2.5	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	0
173	151	86	5.0	1	250	2.5	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	0
174	152	79	4.8	2	250	2.7	10.0	.080	.28	.01	1.00	.01	1	3	0	0	0	30	60	0	3
175	174	86	6.5	2	200	3.7	10.0	.080	.32	.01	1.00	.01	7	3	0	0	0	30	60	0	1
176	154	86	3.6	2	250	1.8	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	80	60	0	0
177	156	75	3.9	1	250	2.5	10.0	.080	.28	.25	0.50	.29	1	3	2	50	0	30	80	0	1
178	158	86	7.6	2	200	4.3	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	1
179	159	86	5.1	1	250	4.2	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	30	60	0	1
180	181	79	7.0	2	200	4.4	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	30	60	0	2

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 0   0    0   0  0  0    0    0    0   1   1    1   1  1 1 1   1 1   1   2  2 2
 1   2    3   4  5  6    7    8    9   0   1    2   3  4 5 6   7 8   9   0  1 2

181 161  79  5.9 3 250  1.4 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  30  60  0 1
182 183  79  4.7 3 250  2.7 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0  30  60  0 2
183 184  75  5.6 3 250  0.4 99.9 .040 .29 .25 0.50 .29 3 3 2  50 0  30  80  0 1
184 185  77  3.2 3 250  0.6 99.9 .040 .31 .13 0.75 .15 3 2 1  50 1  30  70  0 1
 2.00  91
  .50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 5.0  .10 100  0.0 0.00   0  0.0 0.00   0
  50 1.96 0.92 1.68    0 0.00 0.00 0.00    0 0.00 0.00 0.00
185 186  75  3.6 3 250  2.1 99.9 .040 .31 .25 0.50 .29 3 2 2  50 0  30  80  0 3
186 187  60  5.4 3 250  0.2 99.9 .040 .29 .01 1.00 .29 3 2 0   0 0   0  60  0 1
187 188  60  6.7 3 200  0.2 99.9 .040 .30 .01 1.00 .29 3 3 0   0 0   0  60  0 1
188 189  69  4.3 3 250  0.7 99.9 .040 .30 .01 1.00 .15 3 3 0   0 0   0  60  0 2
189 201  65  6.5 3 200  0.4 99.9 .040 .30 .01 1.00 .23 5 2 0   0 0   0  60  0 1
190 202  69  2.8 3 250  0.3 99.9 .040 .30 .01 1.00 .15 5 2 0   0 0   0  60  0 1
191 214  69  3.2 3 250  0.3 99.9 .040 .34 .01 1.00 .23 3 2 0   0 0   0  60  0 1
192 180  86  6.1 2 250  5.0 10.0 .080 .32 .01 1.00 .01 1 3 0   0 0  30  60  0 1
193 181  83  6.2 2 200  4.2 10.0 .080 .30 .01 1.00 .01 1 3 0   0 0  30  60  0 1
194 195  83  6.0 2 250  5.4 10.0 .080 .30 .01 1.00 .01 3 3 0   0 0  30  60  0 3
195 183  79  5.4 1 250  7.2 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  30  60  0 2
196 184  79  4.9 1 250  2.6 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  80  60  0 1
197 185  79  4.5 2 250  2.9 99.9 .040 .36 .01 1.00 .01 1 3 0   0 0  80  60  0 2
198 199  88  4.4 2 250  2.2 99.9 .040 .36 .01 1.00 .01 3 3 0   0 0  30  60  0 0
199 187  79  4.7 2 250  2.4 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  30  60  0 0
200 188  79  5.1 2 250  2.3 99.9 .040 .29 .01 1.00 .01 1 3 0   0 0  30  60  0 2
201 202  86  5.3 2 250  6.7 99.9 .040 .32 .01 1.00 .01 3 3 0   0 0  30  60  0 1
202 191  79  5.9 3 250  3.6 99.9 .040 .29 .01 1.00 .01 2 3 0   0 0  30  60  0 1
203 202  79  5.1 3 250  1.8 99.9 .040 .29 .01 1.00 .01 7 3 0   0 0  30  60  0 1
204 195  81  6.6 1 200  4.4 10.0 .080 .36 .01 1.00 .15 1 3 0   0 0  30  60  0 1
205 196  81  5.1 2 250  3.8 10.0 .080 .36 .01 1.00 .15 1 3 0   0 0  30  60  0 1
206 197  84  5.1 2 250  3.8 10.0 .080 .37 .01 1.00 .15 1 3 0   0 0   0  60  0 1
207 208  81  3.5 2 250  1.8 10.0 .080 .36 .08 1.00 .15 3 3 0   0 0   0  60  0 0
208 199  79  3.7 2 250  2.5 99.9 .040 .30 .25 0.50 .29 1 3 2  50 0  30  80  0 1
209 200  77  4.1 2 250  2.9 99.9 .040 .30 .25 0.50 .29 1 3 2  50 0  30  80  0 1
210 211  81  5.3 2 250  5.3 10.0 .080 .37 .01 1.00 .15 3 3 0   0 0  30  60  0 1
211 202  81  4.5 2 250  4.1 99.9 .040 .30 .01 1.00 .15 1 3 0   0 0  30  60  0 2
212 203  83  3.7 2 250  2.5 10.0 .080 .30 .01 1.00 .15 1 3 0   0 0  30  60  0 1
213 208  82  2.7 1 250  1.4 10.0 .080 .32 .25 0.50 .29 1 3 2  50 0   0  80  0 0
```

Table 3. Input file for Barnes Creek.

```
Barnes Creek
40.0 110  5.8 130.0

   0   0   0   0 0  0   0    0    0    1   1   1    1 1 1 1   1 1  1   2   2 2
   1   2   3   4 5  6   7    8    9    0   1   2    3 4 5 6   7 8  9   0   1 2

   1   4  74  4.1 1 250 3.7 10.0 .080 .30 .01 1.00 .01 5 3 0   0 0   0  60  0 2
   2  11  82  5.3 2 250 4.1 10.0 .080 .32 .25 0.50 .29 5 3 2  50 0 120  80  0 1
   3  12  79  4.9 2 250 1.1 10.0 .080 .36 .25 0.50 .29 5 3 2  50 0   0  80  0 1
   4   5  74  5.1 1 250 2.8 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0 120  60  0 1
   5  14  74  4.9 2 250 1.6 10.0 .080 .29 .01 1.00 .01 5 3 0   0 0 120  60  0 1
   6  15  79  3.4 2 250 2.5 10.0 .080 .32 .25 0.50 .29 5 3 2  50 0 160  80  0 1
   7  16  74  5.4 2 250 2.6 10.0 .080 .32 .01 1.00 .01 5 3 0   0 0 160  60  0 1
   8  17  74  4.7 2 250 2.4 10.0 .080 .32 .01 1.00 .01 5 3 0   0 0 120  60  0 1
   9  10  79  4.8 3 250 3.2 10.0 .080 .32 .25 0.50 .29 3 3 2  50 0 160  80  0 3
  10  11  75  4.3 3 250 2.9 99.9 .040 .28 .25 0.50 .29 3 3 2  50 0 160  80  0 5
  11  22  75  5.1 3 250 1.4 99.9 .040 .28 .25 0.50 .29 5 3 2  50 0 120  80  0 3
  12  23  74  5.1 3 250 3.1 99.9 .040 .32 .01 1.00 .01 5 3 0   0 0 120  60  0 2
  13  24  69  4.9 2 250 3.0 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0 120  60  0 1
  14  25  69  4.9 3 250 1.3 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0 120  60  0 1
  15  16  79  5.1 2 250 3.7 99.9 .040 .32 .01 1.00 .01 3 3 0   0 0   0  60  0 1
  16  17  69  4.9 3 250 1.9 99.9 .040 .34 .01 1.00 .01 3 3 0   0 0   0  60  0 2
  17  28  69  5.4 3 250 2.4 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0 120  60  0 3
  18  29  69  4.5 2 250 4.1 10.0 .080 .32 .01 1.00 .01 5 3 0   0 0 120  60  0 1
  19  35  79  4.6 2 250 2.4 10.0 .080 .32 .01 1.00 .01 5 3 0   0 0   0  60  0 1
  20   9  79  5.1 2 250 4.3 99.9 .040 .32 .01 1.00 .01 1 3 0   0 0 120  60  0 2
  21  10  79  5.9 2 250 5.1 99.9 .040 .32 .01 1.00 .01 1 3 0   0 0 120  60  0 3
  22  23  79  6.7 2 200 3.4 99.9 .040 .32 .01 1.00 .01 3 3 0   0 0 120  60  0 2
  23  24  69  6.8 3 200 4.6 99.9 .040 .30 .01 1.00 .01 3 3 0   0 0 160  60  0 2
  24  40  69  4.4 3 250 6.0 99.9 .040 .30 .01 1.00 .01 5 2 0   0 0 160  60  0 2
  25  41  69  5.7 3 250 1.3 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0   0  60  0 1
  26  27  69  4.0 1 250 5.3 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0 120  60  0 1
  27  43  69  4.2 2 250 3.8 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0   0  60  0 1
  28  29  69  5.4 2 250 0.7 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0 120  60  0 1
  29  45  69  4.7 3 250 1.7 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0 120  60  0 2
  30  46  75  4.1 2 250 3.7 10.0 .080 .28 .25 0.50 .29 5 3 2  50 0 120  80  0 1
  31  48  69  5.5 3 250 2.3 10.0 .080 .28 .01 1.00 .01 5 3 0   0 1 120  60  0 1
2 2.00  91
  0.50  0.00  0.00  0.00  0.00  0.00  0.00   0    0    0    0    0    0
  0.00  0.00  0.00  0.00  0.00  0.00   0    0    0    0    0    0
  5.0  .10 100  0.0 0.00   0  0.0 0.00   0
  100 1.00 1.00 1.00     0 0.00 0.00 0.00     0 0.00 0.00 0.00
  32  49  81  4.8 2 250 3.8 10.0 .080 .36 .01 1.00 .01 5 3 0   0 0   0  60  0 1
  33  50  79  4.2 2 250 4.8 10.0 .080 .34 .01 1.00 .01 5 3 0   0 0   0  60  0 2
  34  51  79  5.6 2 250 4.9 10.0 .080 .34 .01 1.00 .01 5 3 0   0 0 120  60  0 2
  35  36  74  4.9 2 250 5.2 10.0 .080 .32 .01 1.00 .01 3 3 0   0 0   0  60  0 1
  36  53  74  5.7 2 250 3.5 99.9 .040 .32 .01 1.00 .01 5 3 0   0 0 160  60  0 2
  37  54  74  6.0 1 250 3.2 99.9 .040 .32 .01 1.00 .01 5 3 0   0 0 160  60  0 1
  38  55  60  4.7 2 250 4.0 99.9 .040 .28 .01 1.00 .29 5 3 0   0 0 160  60  0 2
  39  56  69  5.6 2 250 6.0 99.9 .040 .28 .01 1.00 .01 5 3 0   0 0 160  60  0 1
  40  41  69  5.7 3 250 0.3 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0 120  60  0 2
  41  42  60  6.4 3 250 1.2 99.9 .040 .30 .01 1.00 .29 3 2 0   0 0   0  60  0 2
  42  43  69  5.1 3 250 0.4 99.9 .040 .31 .01 1.00 .01 3 2 0   0 0   0  60  0 1
  43  60  69  4.5 3 250 1.6 99.9 .040 .30 .01 1.00 .01 5 2 0   0 0   0  60  0 3
  44  45  69  4.1 2 250 3.6 99.9 .040 .28 .01 1.00 .01 3 3 0   0 0 120  60  0 2
  45  46  69  3.7 3 250 0.8 99.9 .040 .31 .01 1.00 .01 3 2 0   0 0   0  60  0 1
  46 111  69  4.6 3 250 0.6 99.9 .040 .30 .01 1.00 .01 3 2 0   0 0   0  60  0 2
  47  48  83  4.1 3 250 2.9 10.0 .080 .36 .01 1.00 .01 3 3 0   0 0 120  60  0 3
  48  66  69  4.9 2 250 1.9 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0 120  60  0 1
  49  67  74  4.1 1 250 2.4 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0   0  60  0 1
  50  68  74  5.0 2 250 3.6 99.9 .040 .29 .01 1.00 .01 5 3 0   0 0 120  60  0 2
  51  69  69  5.4 2 250 2.7 99.9 .040 .28 .01 1.00 .01 5 3 0   0 0 160  60  0 2
  52  70  74  4.9 2 250 4.2 99.9 .040 .30 .01 1.00 .01 5 3 0   0 0 160  60  0 1
  53  54  69  6.1 2 250 4.3 99.9 .040 .29 .01 1.00 .01 3 3 0   0 0 120  60  0 3
  54  55  69  6.3 3 250 1.3 99.9 .040 .30 .01 1.00 .01 3 2 0   0 0   0  60  0 2
  55  56  69  6.6 3 200 1.9 99.9 .040 .31 .01 1.00 .01 3 2 0   0 0   0  60  0 3
```

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
56	57	69	5.7	3	250	2.5	99.9	.040	.29	.01	1.00	.01	3	3	0	0	0	120	60	0	2
57	40	69	6.5	3	200	1.7	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	3
58	41	69	5.5	2	250	5.4	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	120	60	0	2
59	42	74	5.8	1	250	5.5	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	120	60	0	1
60	61	69	5.4	3	250	0.2	99.9	.040	.30	.01	1.00	.01	3	2	0	0	0	0	60	0	1
61	62	69	5.7	3	250	0.6	99.9	.040	.31	.01	1.00	.01	3	2	0	0	0	0	60	0	1
62	63	69	7.8	3	200	0.6	99.9	.040	.30	.01	1.00	.01	3	2	0	0	0	120	60	0	1
63	46	76	7.3	3	200	1.9	99.9	.040	.30	.13	0.75	.29	1	3	1	50	0	120	70	0	2
64	46	74	7.9	3	200	2.5	10.0	.080	.30	.01	1.00	.01	8	3	0	0	0	120	60	0	1
65	66	86	6.7	2	200	3.6	99.9	.040	.32	.01	1.00	.01	3	3	0	0	0	0	60	0	2
66	67	70	4.9	2	250	2.9	99.9	.040	.30	.19	0.62	.29	3	3	1	50	0	120	75	0	2
67	68	62	4.4	3	250	1.5	99.9	.040	.30	.07	0.87	.08	3	3	0	0	0	120	60	0	2
68	69	75	4.9	3	250	1.9	99.9	.040	.29	.25	0.50	.29	3	3	2	50	0	120	80	0	3
69	70	75	8.3	3	200	2.4	99.9	.040	.30	.25	0.50	.29	3	2	2	50	0	120	80	0	5
70	71	72	6.2	3	250	2.4	99.9	.040	.30	.13	0.75	.15	3	2	1	50	0	0	70	0	2
71	72	69	5.5	3	250	1.3	99.9	.040	.30	.01	1.00	.01	3	2	0	0	0	0	60	0	3
72	54	69	6.1	2	250	3.3	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	160	60	0	2
73	55	69	5.8	2	250	5.4	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	120	60	0	2
74	75	69	6.4	1	250	3.3	99.9	.040	.29	.01	1.00	.01	3	3	0	0	0	120	60	0	2
75	57	74	7.0	2	200	5.0	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	2
76	92	74	5.2	2	250	3.5	99.9	.040	.30	.01	1.00	.01	5	3	0	0	0	0	60	0	1
77	78	79	6.2	3	250	3.1	99.9	.040	.29	.25	0.50	.29	3	3	2	50	0	160	80	0	2
78	79	72	5.1	3	250	1.1	99.9	.040	.30	.13	0.75	.15	3	3	1	50	0	120	70	0	2
79	61	60	6.8	3	200	1.9	99.9	.040	.29	.01	1.00	.29	1	3	0	0	0	120	60	0	2
80	62	69	7.2	1	200	4.6	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	160	60	0	1
81	63	80	8.7	2	200	8.8	10.0	.080	.32	.19	0.62	.29	1	3	1	50	0	160	75	0	1
82	66	74	5.0	1	250	2.1	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	0	60	0	1
83	67	69	4.4	1	250	1.9	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	0	60	0	1
84	68	67	4.9	2	250	1.9	99.9	.040	.30	.01	1.00	.29	1	3	0	0	0	120	60	0	1
85	69	74	5.9	2	250	3.8	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	2
86	70	69	5.1	2	250	1.2	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	120	60	0	1
87	71	74	5.7	2	250	2.2	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	0	60	0	1
88	87	74	4.6	2	250	3.6	99.9	.040	.30	.01	1.00	.01	7	3	0	0	0	120	60	0	2
89	90	69	5.6	3	250	3.2	99.9	.040	.28	.01	1.00	.01	3	3	0	0	0	120	60	0	2
90	74	69	5.2	3	250	1.7	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	120	60	0	2
91	75	74	6.1	2	250	5.7	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	1
92	93	75	5.1	3	250	2.8	99.9	.040	.28	.25	0.50	.29	3	3	2	50	0	120	80	0	3
93	77	69	5.9	2	250	3.9	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	160	60	0	3
94	78	69	5.9	3	250	3.7	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	160	60	0	2
95	79	74	4.9	2	250	3.9	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	160	60	0	1
96	95	79	6.7	2	200	3.4	99.9	.040	.32	.01	1.00	.01	7	3	0	0	0	160	60	0	0
97	84	79	4.6	2	250	3.1	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	120	60	0	1
98	85	79	4.9	2	250	4.1	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	120	60	0	2
99	86	69	4.3	2	250	2.5	99.9	.040	.28	.01	1.00	.01	1	3	0	0	0	120	60	0	2
100	87	74	4.6	1	250	2.2	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	160	60	0	2
101	100	74	4.8	2	250	3.7	99.9	.040	.30	.01	1.00	.01	7	3	0	0	0	120	60	0	2
102	103	79	5.2	2	250	4.2	10.0	.080	.32	.01	1.00	.01	3	3	0	0	0	120	60	0	2
103	90	69	5.8	3	250	3.2	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	160	60	0	2
104	105	79	4.4	3	250	3.7	99.9	.040	.32	.01	1.00	.01	3	3	0	0	0	160	60	0	2
105	92	79	6.1	2	250	3.3	99.9	.040	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	1
106	93	79	4.7	1	250	2.9	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	2
107	94	69	5.1	2	250	3.0	99.9	.040	.29	.01	1.00	.01	1	3	0	0	0	160	60	0	2
108	95	79	5.8	2	250	2.9	10.0	.080	.32	.01	1.00	.01	1	3	0	0	0	160	60	0	1
109	110	81	4.3	1	250	2.2	10.0	.080	.36	.01	1.00	.01	3	3	0	0	0	0	60	0	1
110	100	74	4.0	2	250	4.0	10.0	.080	.30	.01	1.00	.01	1	3	0	0	0	120	60	0	3

Table 4. Input file for Soldier Creek.

```
    Soldier Creek
40.0  32   5.8 130.0

  0   0   0   0 0 0    0    0    0   1   1    1   1 1 1 1    1 1   1   2   2 2
  1   2   3   4 5 6    7    8    9   0   1    2   3 4 5 6    7 8   9   0   1 2

  1   4  83  2.3 1 100  1.2 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  12  56  0 2
  2   5  82  2.2 1 100  1.4 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  12  80  0 1
  3   4  82  2.6 1 100  1.3 10.0 .080 .37 .13 0.75 .15 3 2 1  50 0  12  58  0 0
  4   5  85  2.5 2 100  1.8 10.0 .080 .37 .25 0.50 .29 3 3 2  50 0  16  80  0 3
  5   9  83  3.8 2 250  1.1 99.9 .040 .37 .25 0.50 .29 5 2 2  50 0  16  80  0 3
  6  10  82  2.4 2 100  1.4 10.0 .080 .37 .19 0.62 .23 5 2 2  50 1  16  75  0 1
 2.00  91
  .50  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 5.0  .10 100  0.0 0.00   0  0.0 0.00   0
 100 1.00 1.00 1.00    0 0.00 0.00 0.00    0 0.00 0.00 0.00
  7  11  83  2.6 1 100  2.3 10.0 .080 .37 .25 0.50 .29 5 2 2  50 0  12  80  0 1
  8   9  76  2.1 2 100  1.3 10.0 .080 .36 .19 0.62 .23 3 3 2  50 0  12  75  0 2
  9  10  82  2.9 2 250  1.1 99.9 .040 .34 .25 0.50 .23 3 2 2  50 0  12  80  0 3
 10  13  84  3.3 1 250  1.2 99.9 .040 .37 .25 0.50 .23 5 2 2  50 0   0  80  0 3
 11  10  83  2.6 1 100  1.1 10.0 .080 .37 .25 0.50 .29 7 2 2  50 0   0  80  0 1
 12  17  82  2.5 2 100  1.1 10.0 .080 .34 .25 0.50 .29 5 3 2  50 0   0  80  0 1
 13  14  82  3.7 2 250  0.5 99.9 .040 .34 .25 0.50 .29 3 3 2  50 0   0  80  0 1
 14  19  79  3.3 1 250  1.1 99.9 .040 .34 .01 1.00 .01 5 3 0   0 0  12  60  0 3
 15  14  82  2.6 2 100  1.3 10.0 .080 .37 .25 0.50 .29 7 2 2  50 0   0  80  0 1
 16  17  80  3.3 1 250  2.5 10.0 .080 .37 .13 0.75 .15 3 2 1  50 0   0  70  0 1
 17  21  88  2.9 1 250  1.7 99.9 .040 .37 .25 0.50 .29 5 3 2  50 0  16  80  0 2
 18  19  84  3.4 2 250  1.7 99.9 .040 .37 .13 0.75 .15 3 2 2  50 0  12  70  0 0
 19  23  82  3.7 3 250  1.5 99.9 .040 .36 .07 0.87 .08 5 3 1  50 0  16  65  0 2
 20  25  87  2.8 2 250  1.8 10.0 .080 .37 .25 0.50 .29 4 3 2  50 0   0  80  0 1
 21  25  88  3.1 2 250  1.1 99.9 .040 .36 .25 0.50 .29 5 3 2  50 0  12  80  0 2
 22  23  84  2.9 2 100  1.5 99.9 .040 .37 .25 0.50 .29 3 2 2  50 0  12  80  0 0
 23  27  84  4.3 1 250  0.8 10.0 .080 .36 .25 0.50 .29 5 3 1  50 1  16  80  0 1
 4.00  91
 1.00  0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 0.00  0.00  0.00  0.00  0.00  0.00   0   0   0   0   0   0
 5.0  .10 100  0.0 0.00   0  0.0 0.00   0
 200 1.96 0.92 1.68    0 0.00 0.00 0.00    0 0.00 0.00 0.00
 24  25  82  2.7 1 100  1.9 10.0 .080 .37 .13 0.75 .15 3 3 1  50 0   0  80  0 1
 25  29  82  4.4 1 250  1.5 99.9 .040 .36 .13 0.75 .15 5 3 2  50 0  12  80  0 3
 26  29  84  4.0 3 250  1.2 99.9 .040 .36 .25 0.50 .25 6 3 2  50 0  12  80  0 2
 27  26  84  3.6 2 100  1.5 10.0 .080 .37 .25 0.50 .25 7 2 2  50 0  12  80  0 1
 28  31  84  2.8 2 100  2.6 10.0 .080 .37 .25 0.50 .25 4 3 2  50 0  16  80  0 1
 29  30  85  3.9 2 250  1.6 99.9 .040 .37 .25 0.50 .25 3 3 2  50 0  12  80  0 2
 30  32  84  4.3 1 250  0.5 99.9 .040 .36 .25 0.50 .25 5 3 2  50 0  12  80  0 1
 31  32  86  4.0 1 250  1.8 99.9 .040 .37 .25 0.50 .25 3 3 2  50 0  16  80  0 1
 32  33  81  3.9 1 250  0.8 99.9 .040 .34 .01 1.00 .15 7 2 0   0 0  12  60  0 1
```

Table 5. Input file for Kings Creek.

```
 Konza Prairie NRA
40.0  69    5.8 130.0

 0   0   0     0 0    0     0     0     0    1    1     1    1 1 1 1  1 1  1   2  2 2
 1   2   3     4 5    6     7     8     9    0    1     2    3 4 5 6  7 8  9   0  1 2

 1   4  74  10.7 3  200  10.7  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 2
 2   1  74   9.6 2  200  13.7  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
 3   6  74   8.3 2  200  11.5  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 2
 4  11  74  10.7 3  200   3.0  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 1
 5  12  74  10.2 3  200   7.5  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 2
 6  13  74  10.4 3  200   4.2  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 2
 7   6  74  10.7 2  200   5.1  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
 8  15  74  10.4 1  200   8.2  20.0  .048  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 4
 9   8  74   8.0 2  200   7.4  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 3
10  70  74   6.0 3  250   0.6  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
11  10  74   8.6 3  200   0.8  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
12  11  74  11.7 3  200   4.0  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
13  12  74  15.5 3  150   6.6  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 4
14  13  74   9.4 3  200   2.9  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
15  14  74  10.0 1  200   6.3  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
16  23  74   7.8 2  200   7.0  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 1
17  18  74   7.9 3  200   5.8  10.0  .100  .37  .01  1.00  .22 3 2 0  0 0  0  60  0 2
18  11  74  12.5 3  200   3.7  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
19  12  74  15.2 2  150  11.8  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
20  13  74   8.2 2  200   9.3  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 1
21  14  74  11.0 3  200   7.6  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 4
22  21  74   8.5 3  200   3.0  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 3
23  22  74   8.2 2  200   4.3  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 1
24  23  74   9.2 3  200   7.0  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
25  24  74  10.3 3  200   7.8  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 1
26  17  74   9.5 2  200   6.8  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
27  18  74   9.2 3  200   2.9  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
28  37  74  13.0 1  150   7.7  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 1
29  38  74   7.9 2  200   8.1  10.0  .100  .37  .01  1.00  .22 5 2 0  0 0  0  60  0 4
30  21  74   9.7 2  200  10.5  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
31  22  74   7.7 2  200   5.9  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
32  31  74   6.4 1  250   4.1  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 4
33  32  74   7.1 1  200   3.8  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 5
34  33  74   7.5 2  200   8.6  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
35  36  74   9.0 2  200  11.6  10.0  .100  .37  .01  1.00  .22 3 2 0  0 0  0  60  0 3
36  27  74   9.3 1  200   4.9  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
37  36  74   7.4 3  200   3.3  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 4
38  37  74   8.7 3  200   5.6  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
39  38  74   5.6 1  250   2.5  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
40  39  74   6.5 2  250   4.8  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
41  32  74   9.7 2  200   4.0  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
42  33  74  12.7 3  150   3.8  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
43  42  74   7.1 3  200   4.6  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
44  45  74  11.4 1  200   6.1  10.0  .100  .37  .01  1.00  .22 3 2 0  0 0  0  60  0 3
45  36  74  10.0 1  200   4.5  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
46  37  74   9.7 3  200   3.8  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
47  46  74   9.1 2  200   7.5  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 1
48  39  74  11.3 2  200   2.1  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 1
49  40  74   7.1 2  200   3.0  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 1
50  49  74   8.9 1  200   6.3  20.0  .048  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 3
51  42  74   6.9 2  200   5.2  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
52  51  74   6.3 2  250   6.3  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 1
53  54  74   9.4 2  200   8.4  10.0  .100  .37  .01  1.00  .22 3 2 0  0 0  0  60  0 2
54  44  74  14.4 2  140   5.0  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
55  45  74  11.1 2  100   5.8  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
56  46  74   9.1 1  200   2.9  20.0  .048  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
57  47  74   7.5 2  200   3.7  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 2
58  48  74   9.7 2  200   3.2  10.0  .100  .37  .01  1.00  .22 1 2 0  0 0  0  60  0 3
59  58  74  10.9 3  200   6.9  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
60  59  74   8.9 2  200   9.1  10.0  .100  .37  .01  1.00  .22 7 2 0  0 0  0  60  0 2
```

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
61	54	74	12.2	2	200	10.9	10.0	.100	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	5
62	63	74	11.3	2	200	10.2	10.0	.100	.37	.01	1.00	.22	3	2	0	0	0	0	60	0	3
63	56	74	10.2	3	200	5.0	20.0	.048	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	3
64	57	74	8.5	1	200	4.4	20.0	.048	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	2
65	58	74	8.6	3	200	5.9	10.0	.100	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	2
66	59	74	10.3	3	200	5.8	10.0	.100	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	1
67	60	74	7.3	2	200	7.6	10.0	.100	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	1
68	63	74	8.0	2	200	6.9	20.0	.048	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	2
69	64	74	10.6	2	200	12.4	10.0	.100	.37	.01	1.00	.22	1	2	0	0	0	0	60	0	1

APPENDIX 3 — DATA AND PROCEDURES FOR CREATING GULLY INPUTS

Table 1. Developing gully inputs for the 15 storms used in annualizing for the 1.0 ton/ac annual data.

The following table is the summation of AGNPS model simulations for Webster Creek watershed, using 14 different return period storms and an input file which included no gully erosion inputs.

Return period, (years)	Runoff: (inches)	Runoff: weighted, (in./yr)	Sediment: (tons)	Sediment: (t/a)	Sediment: weighted, (t/a-yr)	Ratio: run/sed, (in/(t/a))
200	5.86		13987.9	1.99		2.95
100	5.39	0.03	12323.7	1.75	0.01	3.08
50	4.45	0.05	10686.8	1.52	0.02	2.93
25	3.81	0.08	9076.6	1.29	0.03	2.96
20	3.72	0.04	8838.5	1.26	0.01	2.96
10	3.17	0.17	7218.7	1.03	0.06	3.09
5	2.30	0.27	5573.7	0.79	0.09	2.91
2	1.63	0.59	3787.6	0.54	0.20	3.03
1	1.16	0.70	2629.4	0.37	0.23	3.11
0.5	0.73	0.95	1443.6	0.21	0.29	3.56
0.25	0.36	1.09	345.7	0.05	0.25	7.33
0.10	0.12	1.44	64.4	0.01	0.17	0.00
0.05	0.01	0.65	1.0	0.00	0.05	
0.025	0.00	0.10	0.0	0.00	0.00	
	annual sum	6.16			1.41	

The average ratio of runoff to sediment (r/s) is 3.06 (excluding 0.25-yr and less). The distribution for sediment produced from the individual storms that would yield 1.0 ton/acre per year is built around the value of 1.5 ton/acre for the 25-year storm (Drees), which is multiplied by the average r/s ratio to find the runoff that would produce 1.5 ton/acre of sediment (4.59 inches). This is 1.2 times greater than the actual runoff and all remaining runoff values are adjusted upward. The r/s ratio is then applied to the adjusted runoff, giving an estimate for gully erosion. These values are adjusted so as to yield a weighted value of 1 ton/acre per year.

Adjusted runoff, (inches)	Erosion estimate: (ton/acre)	Erosion estimate: weighted, (t/ac-yr)	Adjusted erosion: (ton/acre)	Adjusted erosion: weighted, (t/ac-yr)	Ratio: adjusted/ estimate
7.05	2.31		3.00		1.30
6.49	2.12	0.01	2.50	0.01	1.18
5.36	1.75	0.02	2.00	0.02	1.14
4.59	1.50	0.03	1.50	0.04	1.00
4.48	1.46	0.01	1.40	0.01	0.96
3.82	1.25	0.07	1.20	0.07	0.96
2.77	0.91	0.11	0.80	0.10	0.88
1.96	0.64	0.23	0.50	0.20	0.78
1.40	0.46	0.27	0.30	0.20	0.66
0.88	0.29	0.37	0.15	0.23	0.52
0.43	0.14	0.43	0.00	0.15	0.00
0.14	0.05	0.57	0.00	0.00	
0.01	0.00	0.26	0.00	0.00	
0.00	0.00	0.04	0.00	0.00	
	Annual sum	2.42		1.02	

Table 2. Inputs for the 15 storms used in annualizing for various annual amounts of gully erosion.

0.10 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	0.30			12
100	0.25	0.00	1.22	10
50	0.20	0.00	1.99	8
25	0.15	0.00	3.10	6
20	0.15	0.00	1.33	6
10	0.13	0.01	6.08	5
5	0.08	0.01	8.85	3
2	0.05	0.02	16.59	2
1	0.03	0.02	16.59	1
0.5	0.03	0.03	22.12	1
0.25	0.00	0.03	22.12	0
	Sum	0.11	100.00	

0.20 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	0.60			24
100	0.50	0.00	1.46	20
50	0.40	0.00	2.40	16
25	0.30	0.01	3.73	12
20	0.28	0.00	1.53	11
10	0.25	0.01	6.99	10
5	0.15	0.02	10.65	6
2	0.10	0.04	19.97	4
1	0.05	0.04	19.97	2
0.5	0.03	0.04	19.97	1
0.25	0.00	0.03	13.32	0
	Sum	0.19	100.00	

0.50 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	1.50			60
100	1.25	0.01	1.35	50
50	1.00	0.01	2.20	40
25	0.75	0.02	3.43	30
20	0.70	0.01	1.42	28
10	0.60	0.03	6.37	24
5	0.40	0.05	9.80	16
2	0.25	0.10	19.10	10
1	0.15	0.10	19.59	6
0.5	0.08	0.11	22.04	3
0.25	0.00	0.08	14.70	0
	Sum	0.51	100.00	

1.00 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	3.00			120
100	2.50	0.01	1.35	100
50	2.00	0.02	2.20	80
25	1.50	0.04	3.43	60
20	1.40	0.01	1.42	56
10	1.20	0.07	6.37	48
5	0.80	0.10	9.80	32
2	0.50	0.20	19.10	20
1	0.30	0.20	19.59	12
0.5	0.15	0.23	22.04	6
0.25	0.00	0.15	14.70	0
	Sum	1.02	100.00	

1.25 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	3.75			150
100	3.13	0.02	1.33	125
50	2.50	0.03	2.17	100
25	1.88	0.04	3.38	75
20	1.75	0.02	1.40	70
10	1.50	0.08	6.28	60
5	1.00	0.13	9.65	40
2	0.63	0.24	18.83	25
1	0.38	0.25	19.31	15
0.5	0.20	0.29	22.21	8
0.25	0.00	0.20	15.45	0
	Sum	1.29	100.00	

2.00 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	6.00			240
100	5.00	0.03	1.35	200
50	4.00	0.05	2.20	160
25	3.00	0.07	3.43	120
20	2.80	0.03	1.42	112
10	2.40	0.13	6.37	96
5	1.60	0.20	9.80	64
2	1.00	0.39	19.10	40
1	0.60	0.40	19.59	24
0.5	0.30	0.45	22.04	12
0.25	0.00	0.30	14.70	0
	Sum	2.04	100.00	

3.00 tons/acre per year

Return period, years	Gully erosion ton/ac.	Weighted gully er. ton/ac-yr	% of annual value	Tons per 40-acre cell
200	9.00			360
100	7.50	0.04	1.35	300
50	6.00	0.07	2.20	240
25	4.50	0.11	3.43	180
20	4.20	0.04	1.42	168
10	3.60	0.20	6.37	144
5	2.40	0.30	9.80	96
2	1.50	0.59	19.10	60
1	0.90	0.60	19.59	36
0.5	0.45	0.68	22.04	18
0.25	0.00	0.45	14.70	0
	Sum	3.06	100.00	

APPENDIX 4 — RESULTS OF AGNPS SIMULATIONS

Table 1. Summary of data from AGNPS model simulations for 25-year storms.

MODEL OUTPUTS FOR DIFFERENT CONDITIONS

File (1)	Condition	Runoff:		Sediment			Nitrogen				Phosphorous				COD	
		in.	cfs	tons	t/ac	del %	sed lb/ac	sol. lb/ac	total lb/ac	conc ppm	sed lb/ac	sol. lb/ac	total lb/ac	conc ppm	sol. lb/ac	conc ppm
Webster Creek																
W.DAT	core	3.81	5867	9076.6	1.29	54	3.88	3.03	6.91	3.5	1.94	0.62	2.56	0.7	63.97	74
WA	+fd lt	3.81	5867	9076.6	1.29	54	3.88	3.18	7.06	3.7	1.94	0.68	2.62	0.8	66.61	77
WB	+pt sr	3.81	5867	9076.6	1.29	54	3.88	3.22	7.10	3.7	1.94	0.69	2.63	0.8	67.30	78
WWHL	+gully	3.81	5867	12604.5	1.79	53	5.04	3.22	8.26	3.7	2.52	0.69	3.21	0.8	67.30	78
WWHL15	C=.15	3.62	5585	9202.5	1.31	52	3.92	2.38	6.30	2.9	1.96	0.48	2.44	0.6	63.88	78
WWHL35	C=.35	3.95	6072	16105.5	2.29	54	6.13	4.05	10.18	4.5	3.07	0.90	3.97	1.0	69.77	78
WC	T	3.77	5813	10732.1	1.52	52	4.43	3.04	7.47	3.6	2.22	0.65	2.87	0.8	66.65	78
WCT	terr	3.61	5571	9478.9	1.35	50	4.01	3.04	7.05	3.7	2.01	0.65	2.66	0.8	66.65	82
Mosquito Creek																
M.DAT	core	3.74	4600	3506.1	0.41	54	1.55	1.11	2.66	1.3	0.78	0.14	0.92	0.2	53.14	63
MA	+fd lt	3.74	4600	3506.1	0.41	54	1.55	1.21	2.76	1.4	0.78	0.18	0.96	0.2	55.10	65
MWHL	+gully	3.74	4600	7876.3	0.92	54	2.97	1.21	4.18	1.4	1.49	0.18	1.67	0.2	55.10	65
MC	T	3.73	4587	7369.8	0.86	53	2.82	1.18	4.00	1.4	1.41	0.17	1.58	0.2	54.90	65
MCT	terr	3.71	4563	7211.4	0.85	53	2.77	1.18	3.95	1.4	1.38	0.17	1.55	0.2	54.90	65
Barnes Creek																
B.DAT	core	2.91	2948	2597.4	0.59	61	2.08	0.72	2.80	1.1	1.04	0.07	1.11	0.1	41.40	63
BA	+fd lt	2.91	2948	2597.4	0.59	61	2.08	0.75	2.83	1.1	1.04	0.09	1.13	0.1	42.00	64
BWHL	+gully	2.91	2948	8984.1	2.04	59	5.60	0.75	6.35	1.1	2.80	0.09	2.89	0.1	42.00	64
BC	T	2.90	2936	8524.1	1.94	59	5.37	0.72	6.09	1.1	2.68	0.08	2.76	0.1	41.79	64
BCT	terr	2.86	2897	8325.9	1.89	59	5.27	0.72	5.99	1.1	2.63	0.08	2.71	0.1	41.79	65
Soldier Creek																
S.DAT	core	3.92	1632	1591.9	1.24	56	3.77	4.14	7.91	4.7	1.88	0.90	2.78	1.0	67.54	76
SA	+fd lt	3.92	1632	1591.9	1.24	56	3.77	4.75	8.52	5.4	1.88	1.06	2.94	1.2	80.43	91
SWHL	+gully	3.92	1632	1761.7	1.38	56	4.09	4.75	8.84	5.4	2.04	1.06	3.10	1.2	80.43	91
S.TER	terrac	2.14	932	1150.2	0.90	36	2.90	4.75	7.65	9.8	1.45	1.06	2.51	2.2	80.43	166
SP.TER	terr/P	2.14	932	924.8	0.72	42	2.44	4.75	7.19	9.8	1.22	1.06	2.28	2.2	80.43	166
Kings Creek																
K.DAT	core	3.02	2447	1125.5	0.41	43	1.54	0.57	2.11	0.8	0.77	0.03	0.80	0.1	41.01	60
K1C	C=.02	3.02	2447	2232.2	0.81	43	2.67	0.57	3.24	0.8	1.33	0.03	1.36	0.1	41.01	60
KIII	AMC 3	4.43	3513	1211.3	0.44	47	1.64	0.86	2.50	0.9	0.82	0.05	0.87	0.1	60.25	60

(1) Key to watershed file names:

__.DAT	core watershed conditions as currently found, not including feedlots, point sources or gullies.
__A	core watershed plus feedlots.
__WHL	complete watershed conditions, including feedlots, point sources and gullies.
WB	Webster Creek with feedlots and point sources.
WWHL15	Webster Creek with cropping factor changed to C=0.15 for all cropland, with a corresponding decrease in curve number by 3.
WWHL35	Webster Creek with cropping factor changed to C=0.35 for all cropland, with a corresponding increase in curve number by 2.
K1C	Kings Creek with C=0.02 for all cells.
__C	Conservation tillage on all cells above T.
__CT	Storage-type terraces added to all cells with conservation tillage above T.
KIII	Kings Creek with AMC III
SP.TER	Soldier Creek with 2/3 of cells with storage-type terraces.

Table 2. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Webster Creek, present conditions.

Site:	Webster Creek
Area, acres:	7040
Condition:	AMC II

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	8852	5.86	21503.6		
100	8170	5.39	18515.5	0.03	100
50	6841	4.45	15506.6	0.05	170
25	5867	3.81	12604.5	0.08	281
20	5733	3.72	12118.3	0.04	124
10	4932	3.17	9956.8	0.17	552
5	3622	2.30	7293.2	0.27	863
2	2609	1.63	4787.0	0.59	1812
1	1885	1.16	3181.8	0.70	1992
0.5	1209	0.73	1686.4	0.95	2434
0.25	613	0.36	345.7	1.09	2032
0.10	222	0.12	64.4	1.44	1230
0.05	11	0.01	1.0	0.65	327
			Annual sum	6.06	11917

Annual amount per acre, ton/year 1.69

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	7.73	3.80	11.53			
100	6.86	3.64	10.50	0.04	0.02	0.06
50	5.95	3.43	9.38	0.06	0.04	0.10
25	5.04	3.22	8.26	0.11	0.07	0.18
20	4.89	3.19	8.08	0.05	0.03	0.08
10	4.17	3.00	7.17	0.23	0.15	0.38
5	3.25	2.63	5.88	0.37	0.28	0.65
2	2.32	2.26	4.58	0.84	0.73	1.57
1	1.68	1.93	3.61	1.00	1.05	2.05
0.5	1.01	1.53	2.54	1.35	1.73	3.08
0.25	0.28	1.02	1.30	1.29	2.55	3.84
0.10	0.07	0.51	0.58	1.05	4.59	5.64
0.05	0.00	0.04	0.04	0.35	2.75	3.10
			Annual sum	6.73	13.99	20.72
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	2.15	4.48	6.63

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble. lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	3.86	0.83	4.69			
100	3.43	0.80	4.23	0.018	0.004	0.022
50	2.98	0.74	3.72	0.032	0.008	0.040
25	2.52	0.69	3.21	0.055	0.014	0.069
20	2.44	0.68	3.12	0.025	0.007	0.032
10	2.09	0.64	2.73	0.113	0.033	0.146
5	1.63	0.55	2.18	0.186	0.060	0.246
2	1.16	0.46	1.62	0.419	0.152	0.570
1	0.84	0.39	1.23	0.500	0.213	0.713
0.5	0.50	0.31	0.81	0.670	0.350	1.020
0.25	0.14	0.20	0.34	0.640	0.510	1.150
0.10	0.04	0.10	0.14	0.540	0.900	1.440
0.05	0.00	0.01	0.01	0.200	0.550	0.750
			Annual sum	3.398	2.799	6.197
			Annual /ac	0.000	0.000	0.001
			Annual/sqm	1.087	0.896	1.983

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	103.07	
100	94.84	0.49
50	78.54	0.87
25	67.30	1.46
20	65.71	0.67
10	56.24	3.05
5	40.89	4.86
2	29.17	10.51
1	20.89	12.52
0.5	13.27	17.08
0.25	6.67	19.94
0.10	2.44	27.33
0.05	0.20	13.20
Annual sum, lb/ac-yr		111.96
tons/sq mile - yr		35.83

Table 2a. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Webster Creek with conservation tillage added.

Site:	Webster Creek
Area, acres:	7040
Condition:	C=0.15

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	8533	5.64	16287.1		
100	7858	5.17	13915.7	0.03	76
50	6516	4.25	11506.9	0.05	127
25	5585	3.62	9202.5	0.08	207
20	5453	3.53	8805.5	0.04	90
10	4667	3.00	7241.4	0.16	401
5	3387	2.14	5183.9	0.26	621
2	2405	1.50	3341.8	0.55	1279
1	1709	1.05	2169.9	0.64	1378
0.5	1068	0.64	1122.4	0.85	1646
0.25	516	0.30	210.7	0.94	1333
0.10	168	0.09	38.6	1.17	748
0.05	4	0.00	0.6	0.45	196
			Annual sum	5.20	8102
	Annual amount per acre, ton/year				1.15

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	6.19	2.85	9.04			
100	5.46	2.75	8.21	0.03	0.01	0.04
50	4.69	2.54	7.23	0.05	0.03	0.08
25	3.92	2.38	6.30	0.09	0.05	0.14
20	3.78	2.35	6.13	0.04	0.02	0.06
10	3.24	2.21	5.45	0.18	0.11	0.29
5	2.48	1.93	4.41	0.29	0.21	0.49
2	1.74	1.66	3.40	0.63	0.54	1.17
1	1.23	1.42	2.65	0.74	0.77	1.51
0.5	0.73	1.12	1.85	0.98	1.27	2.25
0.25	0.19	0.72	0.91	0.92	1.84	2.76
0.10	0.05	0.32	0.37	0.72	3.12	3.84
0.05	0.00	0.01	0.01	0.25	1.65	1.90
			Annual sum	4.91	9.62	14.53
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	1.57	3.08	4.65

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	3.09	0.58	3.67			
100	2.73	0.56	3.29	0.015	0.003	0.017
50	2.34	0.52	2.86	0.025	0.005	0.031
25	1.96	0.48	2.44	0.043	0.010	0.053
20	1.89	0.48	2.37	0.019	0.005	0.024
10	1.62	0.45	2.07	0.088	0.023	0.111
5	1.24	0.39	1.63	0.143	0.042	0.185
2	0.87	0.33	1.20	0.317	0.108	0.425
1	0.62	0.28	0.90	0.373	0.153	0.525
0.5	0.36	0.22	0.58	0.490	0.250	0.740
0.25	0.10	0.14	0.24	0.460	0.360	0.820
0.10	0.02	0.06	0.08	0.360	0.600	0.960
0.05	0.00	0.00	0.00	0.100	0.300	0.400
			Annual sum	2.432	1.859	4.291
			Annual /ac	0.000	0.000	0.001
			Annual/sqm	0.778	0.595	1.373

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	99.13	
100	91.00	0.48
50	74.94	0.83
25	63.89	1.39
20	62.33	0.63
10	53.05	2.88
5	38.10	4.56
2	26.79	9.73
1	18.87	11.42
0.5	11.69	15.28
0.25	5.61	17.30
0.10	1.88	22.47
0.05	0.14	10.10
Annual sum, lb/ac-yr		97.06
tons/sq mile - yr		31.06

Table 2b. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Webster Creek with clean tillage.

Site:	Webster Creek
Area, acres:	7040
Condition:	C=0.35

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	9080	6.02	26861.2		
100	8393	5.54	23240.5	0.03	125
50	7024	4.60	19617.2	0.05	214
25	6072	3.95	16105.5	0.09	357
20	5936	3.85	15528.5	0.04	158
10	5126	3.31	12753.7	0.18	707
5	3797	2.41	9472.1	0.29	1111
2	2764	1.73	6285.6	0.62	2364
1	2020	1.25	4237.0	0.75	2631
0.5	1320	0.80	2280.1	1.03	3259
0.25	693	0.41	491.7	1.21	2772
0.10	270	0.15	93.4	1.68	1755
0.05	21	0.01	1.5	0.80	475
			Annual sum	6.75	15928
	Annual amount per acre, ton/year				2.26

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	9.24	4.75	13.99			
100	8.23	4.61	12.84	0.04	0.02	0.07
50	7.18	4.30	11.48	0.08	0.04	0.12
25	6.13	4.05	10.18	0.13	0.08	0.22
20	5.96	4.01	9.97	0.06	0.04	0.10
10	5.09	3.78	8.87	0.28	0.19	0.47
5	4.01	3.31	7.32	0.46	0.35	0.81
2	2.89	2.85	5.74	1.04	0.92	1.96
1	2.11	2.43	4.54	1.25	1.32	2.57
0.5	1.28	1.93	3.21	1.70	2.18	3.88
0.25	0.38	1.31	1.69	1.66	3.24	4.90
0.10	0.10	0.69	0.79	1.44	6.00	7.44
0.05	0.00	0.09	0.09	0.50	3.90	4.40
			Annual sum	8.63	18.31	26.93
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	2.76	5.86	8.62

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	4.62	1.10	5.72			
100	4.11	1.06	5.17	0.022	0.005	0.027
50	3.59	0.97	4.56	0.039	0.010	0.049
25	3.07	0.90	3.97	0.067	0.019	0.085
20	2.98	0.89	3.87	0.030	0.009	0.039
10	2.54	0.83	3.37	0.138	0.043	0.181
5	2.01	0.71	2.72	0.228	0.077	0.305
2	1.44	0.60	2.04	0.518	0.197	0.714
1	1.05	0.50	1.55	0.623	0.275	0.898
0.5	0.64	0.39	1.03	0.845	0.445	1.290
0.25	0.19	0.26	0.45	0.830	0.650	1.480
0.10	0.05	0.14	0.19	0.720	1.200	1.920
0.05	0.00	0.02	0.02	0.250	0.800	1.050
			Annual sum	4.308	3.730	8.037
			Annual /ac	0.001	0.001	0.001
			Annual/sqm	1.378	1.194	2.572

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	105.87	
100	97.58	0.51
50	81.13	0.89
25	69.77	1.51
20	68.15	0.69
10	58.56	3.17
5	42.95	5.08
2	30.97	11.09
1	22.44	13.35
0.5	14.51	18.48
0.25	7.54	22.05
0.10	2.94	31.44
0.05	0.29	16.15
Annual sum, lb/ac-yr		124.40
tons/sq mile - yr		39.81

Table 3. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Mosquito Creek for present conditions.

Site:	Mosquito Creek
Area, acres:	8520
Condition:	AMC II

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	6972	5.78	14368.0		
100	6429	5.31	12147.2	0.03	66
50	5349	4.38	9872.2	0.05	110
25	4600	3.74	7705.9	0.08	176
20	4493	3.65	7317.5	0.04	75
10	3859	3.12	6041.3	0.17	334
5	2823	2.25	4178.0	0.27	511
2	2026	1.59	2623.5	0.58	1020
1	1458	1.13	1641.3	0.68	1066
0.5	931	0.71	831.6	0.92	1236
0.25	469	0.35	131.1	1.06	963
0.10	170	0.12	28.7	1.41	479
0.05	11	0.01	2.5	0.65	156
			Annual sum	5.93	6193

Annual amount per acre, ton/year 0.73

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	4.81	1.64	6.45			
100	4.20	1.54	5.74	0.02	0.01	0.03
50	3.56	1.35	4.91	0.04	0.01	0.05
25	2.92	1.21	4.13	0.06	0.03	0.09
20	2.80	1.19	3.99	0.03	0.01	0.04
10	2.40	1.07	3.47	0.13	0.06	0.19
5	1.79	0.86	2.65	0.21	0.10	0.31
2	1.23	0.69	1.92	0.45	0.23	0.69
1	0.85	0.56	1.41	0.52	0.31	0.83
0.5	0.49	0.41	0.90	0.67	0.49	1.16
0.25	0.11	0.25	0.36	0.60	0.66	1.26
0.10	0.03	0.12	0.15	0.42	1.11	1.53
0.05	0.00	0.01	0.01	0.15	0.65	0.80
			Annual sum	3.31	3.66	6.97
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	1.06	1.17	2.23

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	2.40	0.23	2.63			
100	2.10	0.22	2.32	0.011	0.001	0.012
50	1.78	0.20	1.98	0.019	0.002	0.022
25	1.46	0.18	1.64	0.032	0.004	0.036
20	1.40	0.18	1.58	0.014	0.002	0.016
10	1.20	0.16	1.36	0.065	0.009	0.074
5	0.89	0.13	1.02	0.105	0.015	0.119
2	0.62	0.11	0.73	0.227	0.036	0.263
1	0.42	0.09	0.51	0.260	0.050	0.310
0.5	0.25	0.07	0.32	0.335	0.080	0.415
0.25	0.06	0.04	0.10	0.310	0.110	0.420
0.10	0.02	0.02	0.04	0.240	0.180	0.420
0.05	0.00	0.00	0.00	0.100	0.100	0.200
			Annual sum	1.718	0.588	2.306
			Annual /ac	0.000	0.000	0.000
			Annual/sqm	0.550	0.188	0.738

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	84.91	
100	78.04	0.41
50	64.46	0.71
25	55.10	1.20
20	53.78	0.54
10	45.92	2.49
5	33.21	3.96
2	23.55	8.51
1	16.76	10.08
0.5	10.55	13.66
0.25	5.23	15.78
0.10	1.88	21.33
0.05	0.16	10.20
Annual sum, lb/ac-yr		88.87
tons/sq mile - yr		28.44

Table 4. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Barnes Creek for present conditions.

Site:	Barnes Creek
Area, acres:	4400
Condition:	AMC II

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	4719	4.78	18081.0		
100	4309	4.34	15151.8	0.02	83
50	3501	3.49	12151.8	0.04	137
25	2948	2.91	9280.3	0.06	214
20	2870	2.83	8745.9	0.03	90
10	2408	2.35	7273.8	0.13	400
5	1671	1.60	4880.6	0.20	608
2	1124	1.05	2992.0	0.40	1181
1	751	0.69	1794.6	0.44	1197
0.5	424	0.38	850.8	0.54	1323
0.25	168	0.14	89.8	0.52	941
0.10	35	0.03	14.7	0.51	314
0.05	1	0.00	0.2	0.15	75
			Annual sum	3.03	6561
	Annual amount per acre, ton/year				1.49

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	9.80	1.10	10.90			
100	8.51	1.02	9.53	0.05	0.01	0.05
50	7.13	0.86	7.99	0.08	0.01	0.09
25	5.75	0.75	6.50	0.13	0.02	0.14
20	5.48	0.73	6.21	0.06	0.01	0.06
10	4.73	0.64	5.37	0.26	0.03	0.29
5	3.44	0.49	3.93	0.41	0.06	0.47
2	2.32	0.38	2.70	0.86	0.13	0.99
1	1.54	0.29	1.83	0.97	0.17	1.13
0.5	0.85	0.20	1.05	1.20	0.25	1.44
0.25	0.14	0.11	0.25	0.99	0.31	1.30
0.10	0.03	0.04	0.07	0.51	0.45	0.96
0.05	0.00	0.00	0.00	0.15	0.20	0.35
			Annual sum	5.65	1.63	7.28
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	1.81	0.52	2.33

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	4.90	0.12	5.02			
100	4.25	0.11	4.36	0.023	0.001	0.023
50	3.57	0.10	3.67	0.039	0.001	0.040
25	2.87	0.09	2.96	0.064	0.002	0.066
20	2.74	0.09	2.83	0.028	0.001	0.029
10	2.36	0.08	2.44	0.128	0.004	0.132
5	1.72	0.06	1.78	0.204	0.007	0.211
2	1.16	0.05	1.21	0.432	0.017	0.449
1	0.77	0.04	0.81	0.483	0.023	0.505
0.5	0.42	0.03	0.45	0.595	0.035	0.630
0.25	0.07	0.02	0.09	0.490	0.050	0.540
0.10	0.02	0.01	0.03	0.270	0.090	0.360
0.05	0.00	0.00	0.00	0.100	0.050	0.150
			Annual sum	2.855	0.280	3.135
			Annual /ac	0.001	0.000	0.001
			Annual/sqm	0.914	0.089	1.003

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	68.83	
100	62.57	0.33
50	50.31	0.56
25	42.00	0.92
20	40.84	0.41
10	33.97	1.87
5	23.17	2.86
2	15.30	5.77
1	10.04	6.34
0.5	5.55	7.80
0.25	2.13	7.68
0.10	0.44	7.71
0.05	0.01	2.25
Annual sum, lb/ac-yr		44.50
tons/sq mile - yr		14.24

Table 5. **Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Soldier Creek for present conditions.**

Site:	Soldier
Area, acres:	1280
Condition:	AMC II

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	2420	5.99	2663.5		
100	2241	5.51	2335.4	0.03	12
50	1883	4.57	2011.3	0.05	22
25	1632	3.92	1693.8	0.08	37
20	1597	3.83	1647.8	0.04	17
10	1383	3.28	1350.7	0.18	75
5	1030	2.39	1029.5	0.28	119
2	754	1.70	700.7	0.61	260
1	553	1.22	483.1	0.73	296
0.5	363	0.78	270.8	1.00	377
0.25	191	0.39	65.4	1.17	336
0.10	74	0.14	13.5	1.59	237
0.05	4	0.01	0.4	0.75	70
			Annual sum	6.52	1857

Annual amount per acre, ton/year 1.45

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	5.69	5.60	11.29			
100	5.12	5.42	10.54	0.03	0.03	0.05
50	4.54	5.05	9.59	0.05	0.05	0.10
25	3.96	4.75	8.71	0.09	0.10	0.18
20	3.87	4.71	8.58	0.04	0.05	0.09
10	3.30	4.43	7.73	0.18	0.23	0.41
5	2.66	3.88	6.54	0.30	0.42	0.71
2	1.95	3.35	5.30	0.69	1.08	1.78
1	1.45	2.86	4.31	0.85	1.55	2.40
0.5	0.91	2.27	3.18	1.18	2.57	3.75
0.25	0.29	1.53	1.82	1.20	3.80	5.00
0.10	0.08	0.78	0.86	1.11	6.93	8.04
0.05	0.00	0.08	0.08	0.40	4.30	4.70
			Annual sum	6.11	21.10	27.21
			Annual /ac	0.00	0.02	0.02
			Annual/sqm	1.95	6.75	8.71

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble. lb/ac	P total. lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total. lb/ac/yr
200	2.84	1.29	4.13			
100	2.56	1.24	3.80	0.014	0.006	0.020
50	2.27	1.14	3.41	0.024	0.012	0.036
25	1.98	1.06	3.04	0.043	0.022	0.065
20	1.94	1.05	2.99	0.020	0.011	0.030
10	1.65	0.97	2.62	0.090	0.051	0.140
5	1.33	0.83	2.16	0.149	0.090	0.239
2	0.98	0.70	1.68	0.347	0.230	0.576
1	0.73	0.59	1.32	0.428	0.323	0.750
0.5	0.46	0.46	0.92	0.595	0.525	1.120
0.25	0.15	0.31	0.46	0.610	0.770	1.380
0.10	0.04	0.16	0.20	0.570	1.410	1.980
0.05	0.00	0.02	0.02	0.200	0.900	1.100
			Annual sum	3.088	4.348	7.436
			Annual /ac	0.002	0.003	0.006
			Annual/sqm	0.988	1.391	2.379

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	121.69	
100	112.21	0.58
50	93.43	1.03
25	80.43	1.74
20	78.59	0.80
10	67.62	3.66
5	49.75	5.87
2	36.02	12.87
1	26.22	15.56
0.5	17.10	21.66
0.25	9.05	26.15
0.10	3.69	38.22
0.05	0.53	21.10
Annual sum, lb/ac-yr		149.23
tons/sq mile - yr		47.75

Table 5a. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Soldier Creek with storage-type terraces.

Site: Soldier
Area, acres: 1280
Condition: Storage-type terraces and changed P

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	1350	3.19	1354.5		
100	1256	2.95	1188.4	0.02	6
50	1065	2.47	1027.2	0.03	11
25	932	2.14	864.8	0.05	19
20	913	2.09	841.4	0.02	9
10	799	1.81	695.2	0.10	38
5	609	1.35	530.2	0.16	61
2	459	1.00	364.6	0.35	134
1	349	0.74	252.4	0.44	154
0.5	243	0.50	145.3	0.62	199
0.25	144	0.29	36.2	0.79	182
0.10	73	0.14	8.7	1.29	135
0.05	18	0.03	0.8	0.85	48
			Annual sum	4.70	996

Annual amount per acre, ton/year 0.78

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	3.31	5.60	8.91			
100	2.98	5.42	8.40	0.02	0.03	0.04
50	2.65	5.05	7.70	0.03	0.05	0.08
25	2.31	4.75	7.06	0.05	0.10	0.15
20	2.26	4.71	6.97	0.02	0.05	0.07
10	1.94	4.43	6.37	0.11	0.23	0.33
5	1.56	3.88	5.44	0.18	0.42	0.59
2	1.16	3.35	4.51	0.41	1.08	1.49
1	0.86	2.86	3.72	0.51	1.55	2.06
0.5	0.55	2.27	2.82	0.71	2.57	3.27
0.25	0.18	1.53	1.71	0.73	3.80	4.53
0.10	0.06	0.78	0.84	0.72	6.93	7.65
0.05	0.01	0.08	0.09	0.35	4.30	4.65
			Annual sum	3.81	21.10	24.92
			Annual /ac	0.00	0.02	0.02
			Annual/sqm	1.22	6.75	7.97

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	1.66	1.29	2.95			
100	1.49	1.24	2.73	0.008	0.006	0.014
50	1.33	1.14	2.47	0.014	0.012	0.026
25	1.16	1.06	2.22	0.025	0.022	0.047
20	1.13	1.05	2.18	0.011	0.011	0.022
10	0.97	0.97	1.94	0.053	0.051	0.103
5	0.78	0.83	1.61	0.088	0.090	0.178
2	0.58	0.70	1.28	0.204	0.230	0.434
1	0.43	0.59	1.02	0.253	0.323	0.575
0.5	0.28	0.46	0.74	0.355	0.525	0.880
0.25	0.09	0.31	0.40	0.370	0.770	1.140
0.10	0.03	0.16	0.19	0.360	1.410	1.770
0.05	0.00	0.02	0.02	0.150	0.900	1.050
			Annual sum	1.890	4.348	6.238
			Annual /ac	0.001	0.003	0.005
			Annual/sqm	0.605	1.391	1.996

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	121.69	
100	112.21	0.58
50	93.43	1.03
25	80.43	1.74
20	79.59	0.80
10	67.62	3.68
5	49.75	5.87
2	36.02	12.87
1	26.22	15.56
0.5	17.10	21.66
0.25	9.05	26.15
0.10	3.69	38.22
0.05	0.53	21.10
Annual sum, lb/ac-yr		149.26
tons/sq mile - yr		47.76

Table 6. Average annual values for sediment, N, P and COD from summation of AGNPS model simulations for Kings Creek for present conditions.

Site:	Kings Creek
Area, acres:	2760
Condition:	AMC II

MODEL OUTPUTS FOR DIFFERENT STORMS - RUNOFF AND SEDIMENT

Return period, years	Peak flow, cfs	Runoff, inches	Sediment, tons	Weighted runoff, in./year	Weighted sediment, ton/year
200	3878	4.93	1792		
100	3548	4.48	1571	0.02	8
50	2896	3.61	1343	0.04	15
25	2447	3.02	1126	0.07	25
20	2383	2.93	1094	0.03	11
10	2007	2.44	880	0.13	49
5	1403	1.67	653	0.21	77
2	951	1.10	422	0.42	161
1	640	0.72	275	0.46	174
0.5	364	0.40	136	0.56	206
0.25	143	0.15	28	0.55	164
0.10	25	0.02	5	0.51	99
0.05	0	0.00	0	0.10	25
			Annual sum	3.09	1014

Annual amount per acre, ton/year 0.37

MODEL OUTPUTS FOR DIFFERENT STORMS - NITROGEN

Return period, years	Nitrogen in sed. lb/ac	Nitrogen soluble, lb/ac	Nitrogen total, lb/ac	Weighted N in sed. lb/ac/yr	Weighted N soluble lb/ac/yr	Weighted N total, lb/ac/yr
200	2.64	0.92	3.56			
100	2.02	0.84	2.86	0.01	0.00	0.02
50	1.78	0.68	2.46	0.02	0.01	0.03
25	1.54	0.57	2.11	0.03	0.01	0.05
20	1.51	0.56	2.07	0.02	0.01	0.02
10	1.27	0.47	1.74	0.07	0.03	0.10
5	1.00	0.32	1.32	0.11	0.04	0.15
2	0.70	0.22	0.92	0.26	0.08	0.34
1	0.50	0.15	0.65	0.30	0.09	0.39
0.5	0.28	0.08	0.36	0.39	0.12	0.51
0.25	0.09	0.03	0.12	0.37	0.11	0.48
0.10	0.02	0.01	0.03	0.33	0.12	0.45
0.05	0.00	0.00	0.00	0.10	0.05	0.15
			Annual sum	2.01	0.66	2.67
			Annual /ac	0.00	0.00	0.00
			Annual/sqm	0.64	0.21	0.85

MODEL OUTPUTS FOR DIFFERENT STORMS - PHOSPHOROUS

Return period, years	P in sed. lb/ac	P soluble, lb/ac	P total, lb/ac	Weighted P in sed. lb/ac/yr	Weighted P soluble lb/ac/yr	Weighted P total, lb/ac/yr
200	1.20	0.06	1.26			
100	1.01	0.05	1.06	0.006	0.000	0.006
50	0.89	0.04	0.93	0.010	0.000	0.010
25	0.77	0.03	0.80	0.017	0.001	0.017
20	0.75	0.03	0.78	0.008	0.000	0.008
10	0.63	0.03	0.66	0.035	0.002	0.036
5	0.50	0.02	0.52	0.057	0.003	0.059
2	0.35	0.01	0.36	0.128	0.005	0.132
1	0.25	0.00	0.25	0.150	0.003	0.153
0.5	0.14	0.00	0.14	0.195	0.000	0.195
0.25	0.04	0.00	0.04	0.180	0.000	0.180
0.10	0.01	0.00	0.01	0.150	0.000	0.150
0.05	0.00	0.00	0.00	0.050	0.000	0.050
			Annual sum	0.983	0.013	0.995
			Annual /ac	0.000	0.000	0.000
			Annual/sqm	0.314	0.004	0.319

MODEL OUTPUTS FOR DIFFERENT STORMS - COD

Return period, years	Soluble COD, lb/ac	Weighted COD, lb/ac-yr
200	66.94	
100	60.90	0.32
50	49.06	0.55
25	41.01	0.90
20	39.88	0.40
10	33.22	1.83
5	22.70	2.80
2	15.00	5.66
1	9.84	6.21
0.5	5.40	7.62
0.25	2.00	7.40
0.10	0.32	6.96
0.05	0.00	1.60
Annual sum 1/a-yr		42.24
tons/sq mile - yr		13.52

APPENDIX 5 — VARIOUS STUDIES

Table 1. Results from test watersheds for examining AGNPS outputs for ponds (25-year storm).

Two-cell test watershed
Pipe diameter = 12 inches
Ponds in Cell 2

Drainage area, acres	Runoff Cell 2, inches	Discharge Cell 2, cfs
0	3.8	317
20	2.0	241
30	1.0	200
40	0.1	158
80	0.1	159

Five-cell test watershed

Drainage area acres	Pipe diameter, inches	Pond in cell	Runoff, inches:			Discharge, cfs
			cell 1	cell 2	cell 3	cell 3
0	0	0	3.0	3.8	3.0	361
20	6	1	1.5	3.8	3.0	311
20	6	3	3.0	3.8	1.5	311
40	6	1	0.0	3.8	3.0	261
40	6	3	3.0	3.8	0.0	261
40	12	1	0.1	3.8	3.0	263
40	12	3	3.0	3.8	0.1	263
40	24	1	0.5	3.8	3.0	276
40	24	3	3.0	3.8	0.5	276
90	12	1	0.1	3.8	3.0	264
90	12	3	3.0	3.8	0.1	264

Note:
The infiltration within an impoundment is not reasonable. A 40-acre pond in Cell 1 with a 24-inch diameter pipe is simulated to reduce the depth of runoff from 3.0 to 0.5 inches, a reduction of 83 percent for a 25-year storm. The reduction is increased to 97 percent if the pipe diameter is reduced to 6 inches. .pa

Table 2. Achieving soil loss tolerance, T.

Part A. Annualizing data from Cell 20, Webster Creek, for "T"-reduction studies.

Cell: 20
Area, acres: 40
Condition: present
25-year, storm, t/a 3.98

MODEL OUTPUTS FOR DIFFERENT STORMS - SEDIMENT

Return period, years	Sediment, tons	Weighted sediment, ton/year
200	232.4	
100	206.7	1
50	183.5	2
25	159.0	3
20	155.4	2
10	129.7	7
5	105.2	12
2	75.8	27
1	56.3	33
0.5	34.3	45
0.25	9.8	44
0.10	2.4	37
0.05	0.0	12
	Annual sum	225
	Annual ton/acre	5.63

Part B. Results of reducing all cells below T for three watersheds.

MODEL OUTPUTS FOR DIFFERENT CONDITIONS

File	Condi-	Runoff:		Sediment			Nitrogen				Phosphorous				COD	
(1)	tion	in.	cfs	tons	t/ac	del %	sed lb/ac	sol. lb/ac	total lb/ac	conc ppm	sed lb/ac	sol. lb/ac	total lb/ac	conc ppm	sol. lb/ac	conc ppm
Webster Creek																
WWHL	+gully	3.81	5867	12604.5	1.79	53	5.04	3.22	8.26	3.7	2.52	0.69	3.21	0.8	67.30	78
WC	T	3.77	5813	10732.1	1.52	52	4.43	3.04	7.47	3.6	2.22	0.65	2.87	0.8	66.65	78
	% red	1	1	15	15	2	12	6	10	3	12	6	11	0	1	0
WCT	terr	3.61	5571	9478.9	1.35	50	4.01	3.04	7.05	3.7	2.01	0.65	2.66	0.8	66.65	82
	% red	4	4	12	11	4	9	0	6	-3	9	0	7	0	0	-5
Total	% red	5	5	25	25	6	20	6	15	0	20	6	17	0	1	-5
Mosquito Creek																
MWHL	+gully	3.74	4600	7876.3	0.92	54	2.97	1.21	4.18	1.4	1.49	0.18	1.67	0.2	55.10	65
MC	T	3.73	4587	7369.8	0.86	53	2.82	1.18	4.00	1.4	1.41	0.17	1.58	0.2	54.90	65
	% red	0	0	6	7	2	5	2	4	0	5	6	5	0	0	0
MCT	terr	3.71	4563	7211.4	0.85	53	2.77	1.18	3.95	1.4	1.38	0.17	1.55	0.2	54.90	65
	% red	1	1	2	1	0	2	0	1	0	2	0	2	0	0	0
Total	% red	1	1	8	8	2	7	2	6	0	7	6	7	0	0	0
Barnes Creek																
BWHL	+gully	2.91	2948	8984.1	2.04	59	5.60	0.75	6.35	1.1	2.80	0.09	2.89	0.1	42.00	64
BC	T	2.90	2936	8524.1	1.94	59	5.37	0.72	6.09	1.1	2.68	0.08	2.76	0.1	41.79	64
	% red	0	0	5	5	0	4	4	4	0	4	11	4	0	1	0
BCT	terr	2.86	2897	8325.9	1.89	59	5.27	0.72	5.99	1.1	2.63	0.08	2.71	0.1	41.79	65
	% red	1	1	2	3	0	2	0	2	0	2	0	2	0	0	-2
Total	% red	2	2	7	7	0	6	4	6	0	6	11	6	0	1	-2

Application of AGNPS Model
to Watersheds in Northeast Kansas

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ABSTRACT

With continued significance being placed on water quality, particularly non-point pollution it is becoming important to examine the effects of erosion and erosion control on surface water systems. The Agricultural Non-Point Pollution (AGNPS) model is a computer simulation tool that is being developed for use nationally to estimate the pollution potential from agricultural lands. The model can be used to demonstrate the effects of different management techniques on non-point pollution potential. AGNPS was originally developed and tested for conditions in Minnesota.

The objective of this study is to examine the AGNPS model and its applicability to five small northeastern Kansas watersheds as a planning tool for water quality management for use by the USDA Soil Conservation Service (SCS). For AGNPS to be useful for the SCS, it must first be shown to be applicable for Kansas conditions and that it can be used efficiently.

This study demonstrated four important facts about the AGNPS model. First, the model produced results which agreed reasonably with the limited data available on non-point pollution. Second, the model outputs are usable for comparing relative changes in yield or pollutants for different management techniques when applied to a specific watershed. Third, a method to estimate annual pollutant yield from the outputs of the AGNPS model was developed. This technique to predict annual yields is an important tool in studying water quality management. Fourth, AGNPS has two major limitations; its inability to

model ponds and erosion and sedimentation in channels and gullies. At a minimum, these limitations need to be addressed before the full potential of the model can be achieved.

Finally, it is concluded from this study that AGNPS presently has some usefulness as a water quality management tool for north-east Kansas watersheds. The most promising use of AGNPS is to develop predictions for relative changes in yields for specific changes in watershed conditions.