Environmental Policy Integrated Climate Model

User's Manual Version 0810

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EPIC - Environmental Policy Integrated Climate

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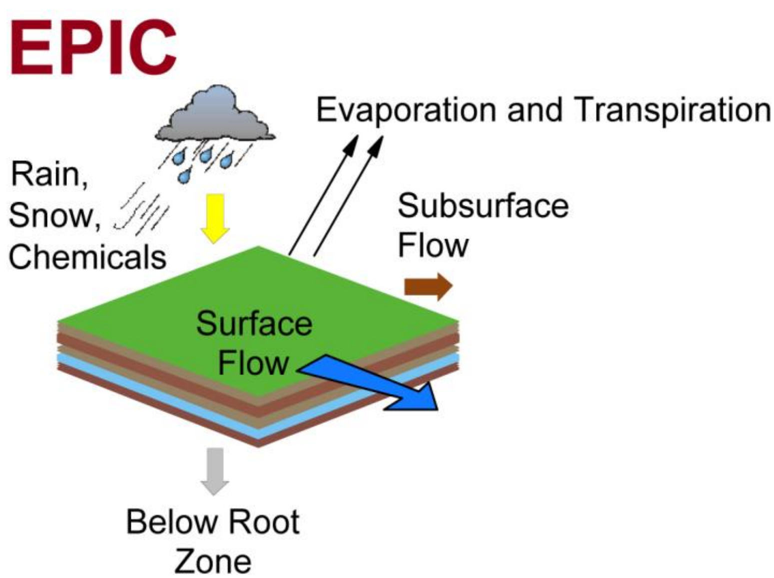

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Model Objectives

Assess the effect of soil erosion on productivity;
Predict the effects of management decisions on soil, water, nutrient and pesticide movements;
Predict the combined impact of changes to soil, water, and nutrient flux and pesticide fate on water quality and crop yields for areas with homogeneous soils and management.

Model Operation:

Daily time step
Long term simulations (1 - 4,000 years)
Soil, weather, tillage and crop parameter data supplied with model
Soil profile can be divided into ten layers
Choice of actual weather or weather generated from long term averages
Homogeneous areas up to large fields or small watersheds

Model Components:

Weather	Soil temperature	Evapotranspiration	Snow melt
Surface runoff	Return flow	Percolation	Lateral subsurface flow
Water erosion	Wind erosion	Nitrogen leaching	N & P loss in runoff
Organic N & P transport by sediment	N & P immobilization and uptake	N & P mineralization	Denitrification
Mineral P cycling	N fixation	Tillage practices	Crop rotations
Crop growth & yield for over 100 crops	Plant environment control	Fertilization	Pesticide fate & transport
Liming	Drainage	Irrigation	Furrow diking
Feed yards	Lagoons	Waste management	Economic accounting

Model Applications:

1985 RCA analysis
1988 Drought assessment
Soil loss tolerance tool
Australian sugarcane model (AUSCANE)
Pine tree growth simulator
Global climate change analysis
Farm level planning
Drought impacts on residue cover
Nutrient and pesticide movement estimates for alternative farming systems for water quality analysis
Users:
NRCS (Temple and other locations)
Universities -Iowa State, Texas A & M, University of Missouri, Washington State and others
INRA -Toulouse, France
Other Countries -Australia, Syria, Jordan, Canada, Germany, Taiwan (over ¾ of the world)
USDA, ARS and other research and extension agencies

Executive Summary

The Environmental Policy Integrated Climate (EPIC) model was developed for use in field manage-ment; several fields may be simulated to comprise a whole farm. Originally called Erosion Productivity Impact Calculator, EPIC was constructed to evaluate the effect of various land management strategies on soil erosion. Later developments extended EPIC's scope to encompass aspects of agricultural sustainability, including wind, sheet, and channel erosion, water supply and quality, soil quality, plant competition, weather, pests, and economics. Management capabilities include irrigation, drainage, furrow diking, buffer strips, terraces, waterways, fertilization, manure management, lagoons, reservoirs, crop rotation and selection, pesticide application, grazing, and tillage. Besides these farm management functions, EPIC can be used to evaluate the effects of global climate/CO_2 change; design environment-ally safe, economic landfills; designing biomass energy production systems; and other applications.

EPIC was developed in the early 1980's to assess the effect of erosion on productivity (Williams, et al. 1984). Various components from CREAMS (Knisel, 1980) and SWRRB (Williams, et al. 1985) were used in developing EPIC, and the GLEAMS (Leonard, et al. 1987) pesticide model- used to estimate runoff, leaching, sediment transport, and decay - was added later (Sabbagh et al. 1991). EPIC was used to respond to the soil conservation questions raised by the 1985 National Resource Conserv-ation Act (Putman,et al. 1988). Since then the model has been expanded and refined to allow simulation of many processes important in agricultural management (Sharpley and Williams, 1990; Williams, 1995). The computational unit or HLU (homogeneous land use unit), is an area homogeneous for soil, aspect and slope, weather, and management practice. The size of the HLU depends on the desired resolution and precision. The drainage area or HLU considered by EPIC is generally a field-size area, up to about 100 ha, where weather, soils, and management systems are assumed to be homogeneous. The major components in EPIC are weather simulation, hydrology, erosion-sedimentation, nutrient cycling, pesticide fate, crop growth, soil temperature, tillage, economics, and plant environment control. Although EPIC operates on a daily time step, the optional Green & Ampt (1911) infiltration equation simulates rainfall excess rates at shorter time intervals (0.1 h). The model is capable of simulating thousands of years if necessary.

The model offers options for simulating several other processes - five potential evapotran-spiration equations, six erosion/sediment yield equations, two peak runoff rate equations, etc. EPIC can be used to compare management systems and their effects on nitrogen, phosphorus, carbon, pesticides and sediment. The management components that can be changed are crop rotations, tillage operations, irrigation scheduling, drainage, furrow diking, liming, grazing, tree pruning, thinning, and harvest, manure handling, and nutrient and pesticide application rates and timing. Commercial fertilizer or manure may be applied at any rate and depth on specified dates or automatically. Water quality in terms of nitrogen (ammonium, nitrate, and organic), phosphorus (soluble and adsorbed/mineral and organic), and pesticide concentrations may be estimated at the edge of the field.

EPIC is a console application written in Fortan that reads and writes text files. Two convenient graphical interfaces are available for assembling inputs and interpreting outputs are **WinEPIC** and **iEPIC**.

Contents

Overview

EPIC is a process-based computer model that simulates the physico-chemical processes that occur in soil and water under agricultural management. It is designed to simulate a field, farm or small watershed that is homogenous with respect to climate, soil, land use, and topography – termed a hydrologic land use unit (HLU). The area modeled may be of any size consistent with required HLU resolution. EPIC operates solely in time; there is no explicitly spatial component. Output from the model includes files giving the water, nutrient, and pesticide flux in the HLU at time scales from daily to annual. The growth of crop plants is simulated depending on the availability of nutrients and water and subject to ambient temperature and sunlight. The crop and land management methods used by growers can be simulated in considerable detail.

The model can be subdivided into nine separate components defined as weather, hydrology, erosion, nutrients, soil temperature, plant growth, plant environment control, tillage, and economic budgets (Williams 1990). It is a field-scale model that is designed to simulate drainage areas that are characterized by homogeneous weather, soil, landscape, crop rotation, and management system parameters. It operates on a continuous basis using a daily time step and can perform long-term simulations for hundreds and even thousands of years. A wide range of crop rotations and other vegetative systems can be simulated with the generic crop growth routine used in EPIC. An extensive array of tillage systems and other management practices can also be simulated with the model. Seven options are provided to simulate water erosion and five options are available to simulate potential evapotranspiration (PET). Detailed discussions of the EPIC components and functions are given in Williams et al. (1984), Williams (1990), Sharply & Williams (1990), and Williams (1995).

Brief History of EPIC

The original function of EPIC was to estimate soil erosion by water under different crop and land management practices, a function reflected its original name: Erosion Productivity Impact Calculator. The development of the field-scale EPIC model was initiated in 1981 to support assessments of soil erosion impact on soil productivity for soil, climate, and cropping practices representative on a broad spectrum of U.S. agricultural production regions. The first major application of EPIC was a national analysis performed in support of the 1985 Resources Conservation Act (RCA) assessment. The model has continuously evolved since that time and has been used in a wide range of field, regional, and national studies both in the U.S. and in other countries. The range of EPIC applications has also expanded greatly over that time including studies of:

Irrigation;

Climate change effects on crop yields;

Nutrient cycling and nutrient loss;

Wind and water erosion;

Soil carbon sequestration;

Economic and environmental;

Comprehensive regional assessments.

Modeling pesticide fate

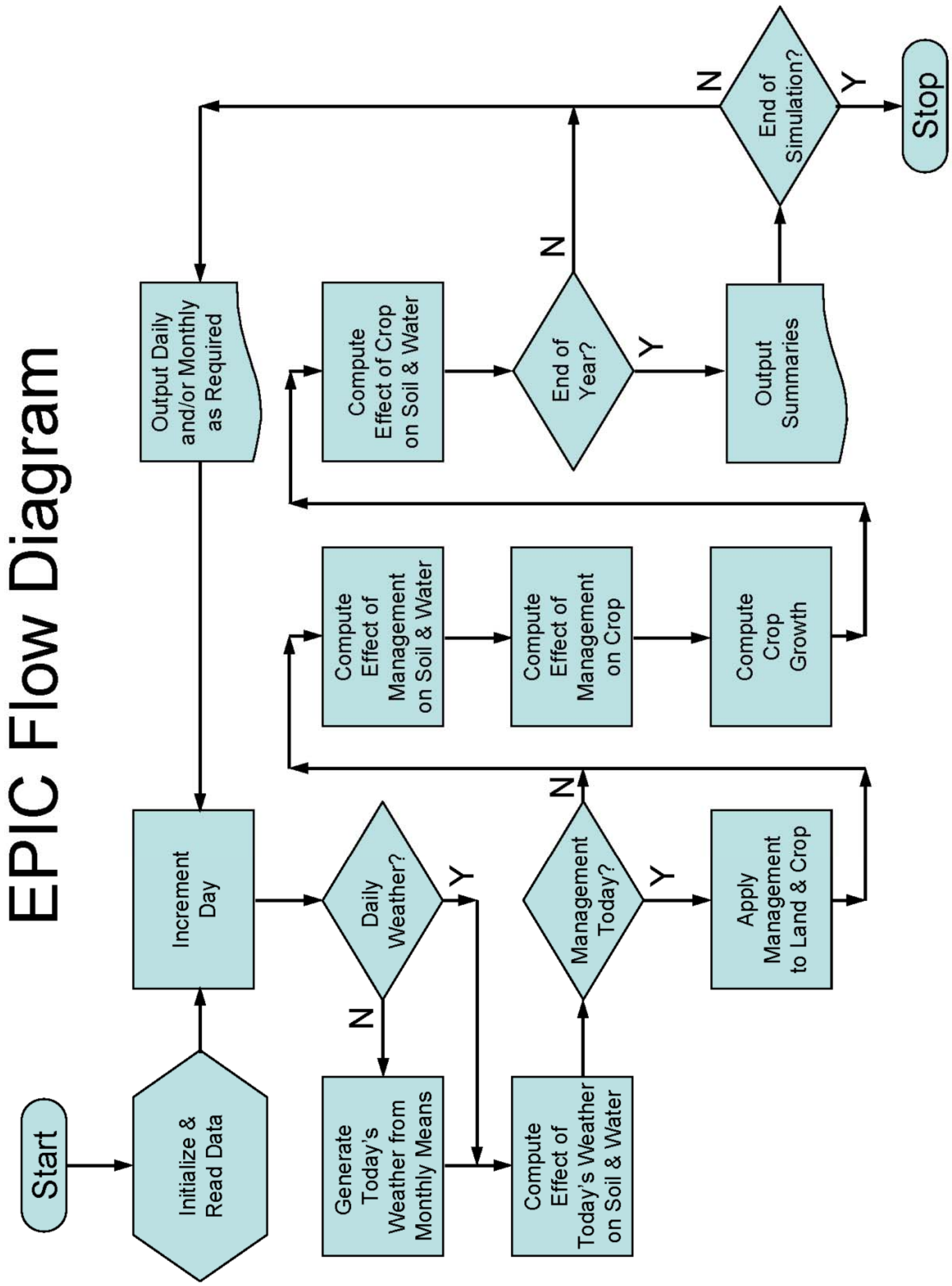
The EPIC acronym now stands for Environmental Policy Integrated Climate, to reflect the greater diversity of problems that the model is currently applied to. EPIC has continued to evolve and to be applied to an ever increasing range of scenarios since the 1985 RCA analysis. Some applications have focused specifically on testing EPIC components. Enhancements to facilitate the needs of various users continue to be made. Table 1 lists examples of modifications that have been made to the EPIC model up to 2004. Several "spin-off" versions have been developed for region- or task-specific applications; e.g., the AUSCANE model created to simulate Australian sugar cane production (Jones et al. 1989).

Table 1: Developmental History of EPIC (from Gassman et al. 2004)

Modified component or input data	Reference
Original model used for RCA in 1985	Williams et al. (1984)
Improved and expanded crop growth sub-model	Williams et al. (1989)
Enhanced root growth functions	Jones et al. (1991)
Improved nitrogen fixation routine for legume crops that calculates fixation as a function of soil water, soil nitrogen & crop physiological stage	Bouniols et al. (1991)
Incorporation of pesticide routines from GLEAMS model	Sabbagh et al. (1991)
Improved crop growth parameters for sunflower	Kiniry et al. (1992)
Incorporation of CO_2 & vapor pressure effects on radiation use efficiency, leaf resistance, and transpiration of crops	Stockle et al. (1992a)
Incorporation of functions that allow two or more crops to be grown simultaneously	Kiniry et al. (1992)
Improved soil temperature component	Potter & Williams (1994)
Improved crop growth parameters for cereal, oilseed, and forage crops grown in the northern Great Plains of North America	Kiniry et al. (1995)
Improved and expanded weather generator component Incorporation of NRCS TR-55 peak runoff rate component Incorporation of MUSS, MUST & MUSI water erosion routines Incorporation of nitrification-volatilization component Improved water table dynamics routine	Williams (1995)
Incorporation of RUSLE water erosion equation	Renard (1997)
Improved snowmelt runoff and erosion component	Purveen et al. (1997)
Improved EPIC wind erosion model (WESS)	Potter et al. (1998)
Incorporation of Baier-Robertson PET routine	Roloff et al. (1998)
Incorporation of Green & Ampt infiltration function	Williams et al. (2000)
Enhanced carbon cycling routine that is based on the Century model approach	Izaurralde et al. (2004)
Incorporation of a potassium (K) cycling routine (experimental)	de Barros et al. (2004)

A key output provided by EPIC is crop yield predictions. Studies in the U.S. and abroad have specifically tested the accuracy of EPIC crop growth and yield predictions. A comprehensive test of the crop growth submodel comparing simulated barley, corn, rice, soybean, sunflower, and wheat yields with published values found average predicted yields were within 7% of the average measured yields (Williams et al. 1989). Calibration and validation of an EPIC implementation is frequently most

Flow Diagram –EPIC Logic & Operations



conveniently accomplished using published crop yield data.

Definitions: EPIC Projects, Scenarios & Runs

A project is a study designed to model and explore an idea or concept regarding the impact of agricultural management practice(s), geography (location and/or topography), or climate on crop yield, environmental impact, and/or economics of the agricultural enterprise. It will involve the manipulation of one or more variables (e.g. presence or absence of a management practice or constant versus increasing atmospheric CO_2). Each model execution with a defined set of input data is a scenario. A scenario may be run standalone or as a member of a batch run. A scenario is therefore a single specific model configuration within a project or study which will typically consist of one or more runs of one or more scenarios. The following examples illustrate the flexibility of EPIC to simulate the environmental impact of agriculture:

An EPIC project may involve the same crop and land management scenario applied to several separate parcels of land (a field, farm, or small watershed), each with different soil and/or weather input in a series of runs;

An EPIC project may involve a variety of management scenarios applied in a series of runs to the same parcel of land having the same soil and weather files;

An EPIC project may be created for a virtual or real parcel of land subjected to the same scenario (management practices, soil, and weather kept constant), while the geographic characteristics (latitude, longitude, altitude, slope, or aspect) of the site are varied in a series of runs.

EPIC Applications

Irrigation studies

Yield estimates by EPIC simulations of irrigation experiments in California, Minnesota, Oklahoma, Texas, Virginia, Ontario, and Quebec agreed well with the observed yields of a wide range of crops (reviewed in Gassman et al. 2004).

Climate change effects on crop yields

EPIC simulates the effects of changes in CO_2 concentrations and vapor pressure deficit on crop growth and yield via radiation-use efficiency, leaf resistance, and transpiration. Assessments of potential CO_2 and climate change impacts on crop yields of corn, wheat, and soybean cropping systems in the central U.S predicted increases in yield in response to increased CO_2 and variable changes in yield in response to changing temperature and precipitation (Stockle et al. 1992a,b). The impact of tropical Pacific El Niño Southern Oscillation (ENSO) phenomena on crop yields has been assessed using EPIC (Izaurralde et al. 1999, Legler et al. 1999, Adams et al. 2003) and the effect of sea surface temperature anomalies (SSTA) on potato fertilization management has been investigated in Chile (Meza & Wilks 2004).

Nutrient cycling and nutrient loss studies

Validation studies show that EPIC satisfactorily simulates measured soil nitrogen (N) and/or crop N uptake levels and leached N below the root zone or in tile flow are generally accurately predicted (See Tables 2 & 3 in Gassman et al. 2004). Sensitivity analyses shows that EPIC N leaching estimates can be very sensitive to choice of evapotranspiration routine, soil moisture estimates, curve number, precipitation, solar radiation, and soil bulk density (Roloff et al. 1998c, Benson et al. 1992).

Wind and water erosion studies

Several water erosion models are implemented in EPIC: Universal Soil Loss Equation (USLE); Onstad-Foster (AOF) version of USLE ; Modified USLE (MUSLE & RUSLE); and three MUSLE variants, MUST, MUSS & MUSI. These models differ primarily in how the energy component is modeled (Williams et al. 1983, 1984, Williams 1995). The wind erosion model is the Wind Erosion Stochastic Simulator (WESS; Potter et al. 1998). Numerous EPIC applications have been performed for soil erosion (see Gassman et al. [2004] for example applications including validation and scenario studies).

Soil carbon sequestration

Based on concepts used in the Century model (Parton et al. 1994), EPIC simulates carbon and nitrogen compounds stored in and converted between biomass, slow, and passive soil pools. Carbon leaching from surface litter to deeper soil layers and the effect of soil texture on organic matter stabilization are also modeled. Simulations of sites in Nebraska, Kansas, Texas, and Alberta showed EPIC satisfactorily replicated the soil carbon dynamics over a range of environmental conditions and cropping/vegetation and management systems (Izaurralde et al. 2004). EPIC performed robustly for simulations of deforested conditions, cropping systems, and native vegetation in Argentina (Apezteguía et al. 2002). Soil organic carbon (SOC) values estimated in an EPIC simulation of a conservation tillage compared favorably with measured SOC rates (Zhao et al. 2004).

Economic and environmental studies

EPIC tracks production costs and crop income for input to economic models. The FLIPSIM whole farm economic model has been coupled with EPIC to perform economic analyses of irrigated agriculture in Texas (Ellis et al. 1993, Gray et al. 1997). Other examples of economic analyses using EPIC are given in Table 4 of Gassman et al. (2004).

Comprehensive regional assessments

EPIC has been used in a number of studies to evaluate the impacts of cropping systems, management practices, and environmental conditions on multiple environmental indicators. Studies have focused on evaluating specific agricultural policy options, including those conducted by the USDA Natural Resources Conservation Service (NRCS). The first application of EPIC by the NRCS was to evaluate the potential loss in cropland productivity into the future for the 2nd Resources Conservation Act evaluation. Other examples of Comprehensive regional assessments using EPIC are given in Table 5 of Gassman et al. (2004).

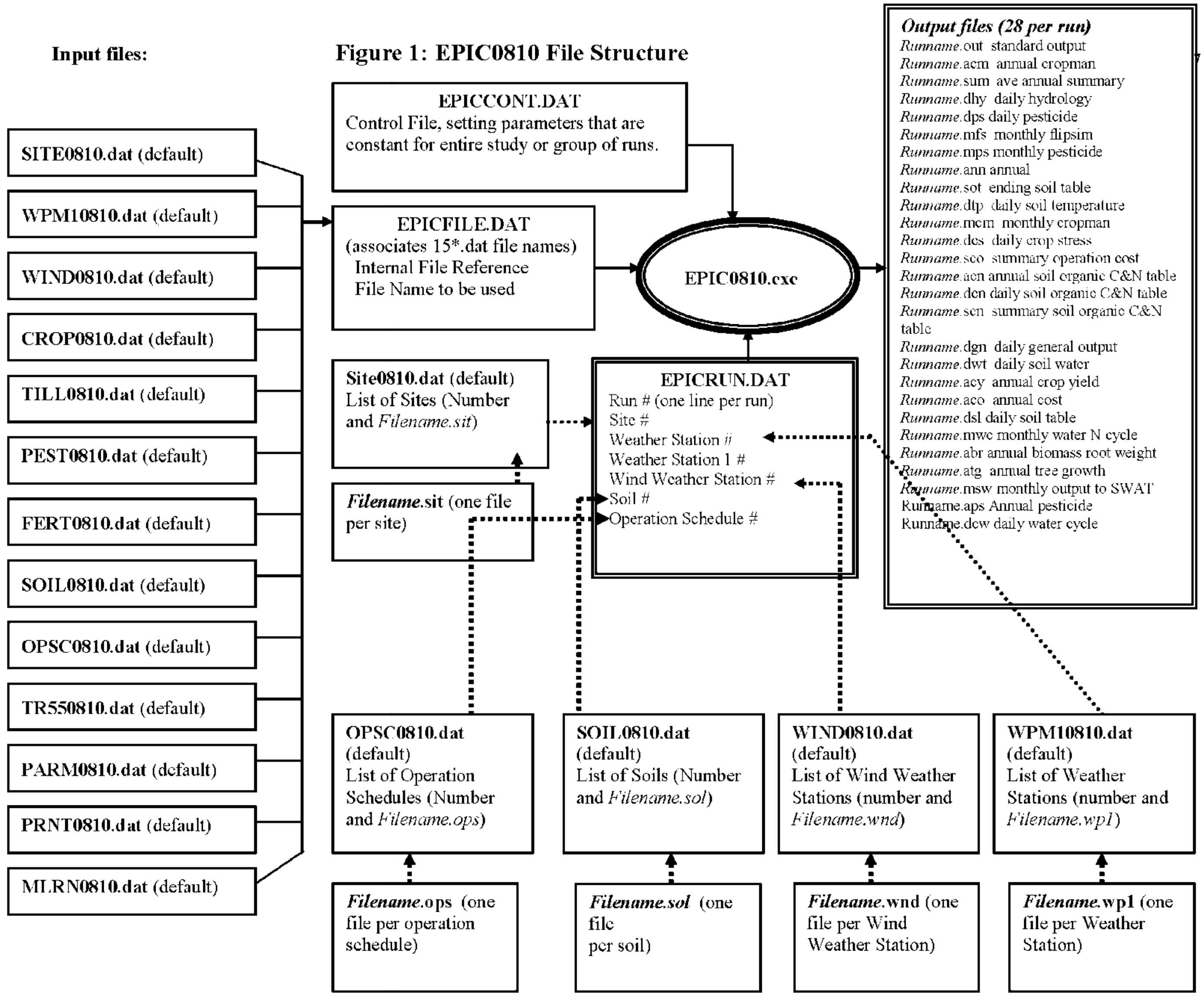
Modeling pesticide fate

Leonard et al.'s (1987) GLEAMS pesticide fate model is incorporated into EPIC (Sabbagh et al. 1991); it has been tested for pesticide movement and losses by Williams et al. (1992) and Sabbagh et al. (1992), and used to estimate the impact of atrazine loss on water quality (Harman et al. 2004).

EPIC Data Structure

For a given study, a Run Definition file specifies which site, soil, weather, and schedule files are to be used for each scenario in a run. For a given study, the major data elements to be developed by a user include descriptions of sites, soils, field operation schedules, weather, and the constant data. An overview of the files and data flow is given in Figure 1 and the file structure and linkage are briefly discussed below.

Figure 1: EPIC0810 File Structure



Master File (*EPICFILE.dat*)

The user must specify the file names to be associated with internal EPIC file references in the *EPICFILE.dat* file, as shown here in Table 2. As one example of how some of these files are referenced, consider the problem of where the analyst desires to change management after a long period, i.e., 25 years of one system followed by 25 years of another system. Instead of specifying 50 years of tillage operations in an OPSC file, the same effect can be achieved with two runs. The first run will use the first OPSC file and the desired soil file. The second run will use the second OPSC file, but for the soil, will be linked by a soil identification number in the EPICRUN.dat and FSOIL to the EPIC0001.SOT file, which is the final soil table from the first run. The final soil table written by an EPIC run has the identical format to the soil input data files!

Table 2: Input data file names are defined in *EPICFILE.dat* file.

Internal File Reference	Default File Name (**.dat*)	Description
FSITE	*SITE0810*	Catalog of site files available for the project
FWPM1	*WPM10810*	Catalog of weather stations with monthly weather data
FWPM5	*WPM50810*	Alternate weather station catalog (used with FWIDX)
FWIND	*WIND0810*	Catalog of weather stations with monthly wind data
FWIDX	*WIDX0810*	Southern oscillation coefficients file
FCROP	*CROP0810*	Database of crop parameters
FTILL	*TILL0810*	Database of field operations & machines
FPEST	*PEST0810*	Database of pesticide properties
FFERT	*FERT0810*	Database of fertilizer properties
FSOIL	*SOIL0810*	Catalog of soil data files
FOPSC	*OPSC0810*	Catalog of available operation schedules
FTR55	*TR550810*	Data for stochastic runoff estimation
FPARM	*PARM0810*	Contains equation parameters to be used for the run
FMLRN	*MLRN0810*	Sets up a multi run application
FPRNT	*PRNT0810*	Controls printing of output
FCMOD	*CMOD0810*	Database of crop prices (for economic analysis)
FWLST	*WLST0810*	Catalog of weather stations with daily weather data

Execution of Runs. EPIC0810 is a compiled Fortran program. It may be run from the command line or via a dedicated interface, such as WinEPIC or i_EPIC. When run from the command line, the directory containing the ***EPIC0810.exe*** must contain all the input files.

A set of three files controls the flow and scope of an EPIC simulation:

EPICFILE.dat lists the run-specific data files and renames them if required;

EPICCONT.dat controls the run length, various run options and defaults for the project;

EPICRUN.dat lists the site-specific data files and initiates a run of one or more scenarios.

These files may be edited but not renamed; all other files may be renamed with the new names defined in EPICFILE.dat (Table 1).

Files Definition	*EPICFILE.dat* file provide EPIC with the names of the data files. This file cannot be renamed, but can be edited.
Project Constants	*EPICCONT.dat* file contains parameters that will be held constant for the entire study, e.g., number of years of simulation, period of simulation, output print specification, weather generator options, etc. This file cannot be renamed, but can be edited.
Runs	*EPICRUN.dat* file includes one row of data for each scenario. Each row of data assigns a unique run number to the scenario and specifies which site, weather station, soil, and tillage operation schedule files will be used. Scenarios are listed one to a line; a run is terminated when a blank line or EOF is reached. Two weather files may be specified: the weather and wind weather files. If the regular weather and wind station identification parameters are zero, EPIC will use the latitude and longitude data from the *filename.sit* file and choose the closest weather and wind stations, listed in the *WPM1MO.dat* and *WINDMO.dat* files, respectively. This file cannot be renamed, but can be edited.
Sites	EPIC looks in the site catalog file *SITE0810.dat* (or the catalog named in *EPICFILE.dat*) for the site number referenced in *EPICRUN.dat* and obtains the name of the file containing the site-specific data. The site-specific file is used to describe each Hydrologic Landuse Unit (HLU), which is homogenous with respect to climate, soil, landuse, and topography. The site may be of any size consistent with required HLU resolution. Site files (*filename.sit*) describe each site: latitude, longitude, elevation, area, etc. A project may involve several sites (typically fields, but could be a larger area). Sites (fields) may contain buffers and filter strips, etc. The site catalog *SITE0810.dat* and the site files can be renamed and edited.

Soils	EPIC looks in the soil catalog file *SOIL0810.dat* (or the catalog named in *EPICFILE.dat*) for the soil number referenced in *EPICRUN.dat* and obtains the name of the file containing the soil-specific data. The soil-specific file named *filename.sol* listed in the catalog file contains data describing the soil profile and the individual horizons. The study may involve several different soils for the farm or watershed analysis and are selected for use in the subarea file. The soil catalog *SOIL0810.dat* and the soil files can be renamed and edited.
Weather	Weather and wind data files are listed in three catalogs *WLST0810.dat*, *WPM10810.dat* & *WIND0810.dat* for daily weather, monthly climate averages, and average monthly wind roses respectively. *EPICRUN.dat* defines the run-specific catalog entries to be used. The daily catalog points to files containing daily weather data and the monthly catalogs point to individual files containing long term climate and wind averages (typically 30 years). Databases of averages at U.S. weather stations are included with the program. If no weather or wind file is specified in *EPICRUN.dat*, EPIC will find the closest station given the latitude and longitude given in *SITE08010.da* and generate daily weather from the long-term averages in the wind and weather files. Daily weather data are: solar radiation (mJ/m^2 or Langley); maximum and minimum temperatures (°C); precipitation (mm); relative humidity (fraction) or dew point temperature (>1°C); and wind speed averaged over the month (m/s). Monthly climate data are: mean and standard deviation of maximum air temperature (°C); mean and standard deviation of minimum air temperature (°C); mean (mm), standard deviation (mm), and skewness of precipitation; the probability of wet day after dry day and the probability of a wet day after wet day; number days of rain per month; maximum half hour rainfall (mm); mean solar radiation (MJ/m^2 or Langley); mean relative humidity (fraction); and mean wind speed (m/s). Monthly wind data are: average monthly wind speed (m/s); and % of time the wind is from the 16 cardinal points starting with North (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW).
WLST0810	EPIC looks in the daily weather file catalog *WLST0810.dat* for the numbered daily weather station file referenced in *EPICRUN.dat*. Daily weather files have the form *filename.dly* and contain the date and the 6 weather variables listed above. The weather catalog *WLST0810.dat* and the weather file can be renamed and edited.
WPM10810	EPIC looks in the monthly weather file catalog *WPM10810.dat* for the numbered monthly weather station file referenced in *EPICRUN.dat*. Monthly weather files have the form *filename.wpm* and contain the 13 weather variables listed above. The weather catalog *WPM10810.dat* and the weather file can be renamed and edited.
WIND0810	EPIC looks in the monthly wind file catalog *WIND0810.dat* for the numbered monthly wind station file referenced in *EPICRUN.dat*. Monthly wind station files have the form *filename.wnd* and contain monthly average wind run and the 16 cardinal points wind rose. The wind catalog *WIND0810.dat* and the wind file can be renamed and edited.

WPM50810	EPIC looks in an alternate catalog of monthly weather stations for use with the southern oscillation coefficients in *WIDX0810.dat*. Monthly weather files have the form *filename.wp5* and contain 13 weather variables. *filename.wp5* files have the same structure as *filename.wpm* which may be referenced in W*PM50810.dat.* *This feature is experimental and should be validated if used.*
WIDX0810	EPIC reads a file containing coefficients for adjusting monthly averages according to the phase of the southern oscillation, if this correction is requested. *This feature is experimental and should be validated if used.*
Operation Schedules	EPIC looks in the operation schedule catalog file *OPSC0810.dat* (or the catalog named in *EPICFILE.dat*) for the operation schedule number referenced in *EPICRUN.dat* and obtains the name of the file containing the required operation schedule. The operations file named *filename.ops* listed in the catalog file contains the schedule of management events for the HLU in the field, farm or small watershed study. It describes the unique landuse operations such as crops and crop rotations with typical tillage operations, ponds or reservoir, farmstead with or without lagoon, etc. for the HLU over a defined period. The events defined in the selected *filename.ops* are repeated until the simulation terminates after NBYR years. Schedules may be combined to create a new cropping system. The operations catalog *OPSC0810.dat* and the operations files can be renamed and edited. New schedules may be added by appending a new record with unique reference number to *OPSC0810.dat*.
Crops	Crops are maintained in a database *CROP0810.dat*.This file contains data crop characteristics in 56 fields containing parameters describing the crop and its growth characteristics. The crops database *CROP0810.dat* can be renamed and edited. New plants may be added by appending a new record with unique reference number to *CROP0810.dat*.
Tillage	Tillage operations are maintained in the database *TILL0810.dat*. This file includes the operations (e.g. sowing, fertilizing, harvesting, etc.) and the equipment used in the operation. An operation therefore may have several entries, one for each of several pieces of machinery designed to execute the operation (e.g. different kinds of planter, sprayer, or harvester). The tillage database *TILL0810.dat* can be renamed and edited. New tillage operations may be added by appending a new record with unique reference number to *TILL0810.dat*.
Fertilizers	Fertilizer properties are maintained in the database *FERT0810.dat*. The database includes both organic and inorganic nutrient components in 8 fields, plus name and cost. Some commercial fertilizers have potassium in the mix but EPIC does not utilize K20 in the simulated nutrient uptake/yield relationship. The fertilizer database *FERT0810.dat* can be renamed and edited. New fertilizers may be added by appending a new record with unique reference number to *FERT0810.dat*.
Pesticides	Pesticide properties are maintained in the database *PEST0810.dat*. Properties include solubility, half-life, and carbon absorption coefficient. Database includes most common pesticides used in the USA during the past 20 years. The pesticides database *PEST0810.dat* can be renamed and edited. New pesticides may be added by appending a new record with unique reference number to *PEST0810.dat*.

Print	Includes the control data for printing selected output variables in the sections of the EPIC0810.out file and 19 other summary files. The print definition file *PRNT0810.dat* can be renamed and edited.
Parameter	Includes numerous model parameters. The parameter file *PARM0810.dat* can be renamed but should not be edited without first consulting the developers.
Multi-Run	There are circumstances in which a number of runs of the same scenario must be executed; for example, with different generated weather in order to obtain a distribution of soil erosion. This file defines the options for selecting different consecutive weather runs without reloading the inputs. The multi-run control file *MLRN0810.dat* can be renamed and edited.

EPIC Version 0810 is a compiled Fortran program with very specific format and file structure requirements. Description of the input files and definitions of the input variables follows.

Run File (*EPICRUN.dat*)

When EPIC is executed, each row in the *EPICRUN.dat* file is read to determine the configuration of the scenario to be run (one row per scenario). A blank line or EOF terminates execution; definitions of old scenarios can be kept at the end of the file, if preceded by a blank line.

Each Line: (blank line or EOF terminates run)

Column	Variable	Description
1-8	ASTN	Run name and/or #; provides a unique ID for each run so that output files are not overwritten
9-12	ISIT	Site #, must be one of the sites listed in the file *SITE0810.dat*
13-16	IWP1	Monthly weather station # , must be one of the stations listed in *WPM10810.dat*; if left blank, EPIC will use the latitude and longitude given in the site file (*filename.sit*) to choose a station
17-20	IWP5	Monthly weather station # , must be one of the stations listed in*WPM50810.dat*; if left blank, EPIC will use the latitude and longitude given in the site file (*filename.sit*) to choose a station if southern oscillation option (XXXX) is chosen
21-24	IWND	Monthly wind Station #, must be one of the stations listed in*WIND0810.dat*; if left blank, EPIC will use the latitude and longitude given in the site file (*filename.sit*) to choose a station
25-28	INPS	Soil #, must be one of the soils listed in *SOIL0810.dat*
29-32	IOPS	Operations Schedule #, must be one of the schedules listed in *OPSC0810.dat*
33-36	IWTH	Daily weather station #, must be one of the stations listed in*WLST0810.dat*; if left blank, EPIC will use the monthly weather station listed in IWP1 or will use the latitude and longitude given in the site file (*filename.sit*) to choose a station.

Control File (*EPICCONT.dat*)

EPICCONT.DAT includes a variety of data parameters that will be held constant for all of the scenarios to be run from *EPICRUN.dat*. *EPICCONT.DAT* includes the following data elements

Line 1:

Column	Variable		Description
1-4	NBYR0	=	Number of years of simulation
5-8	IYR0	=	Beginning year of simulation
9-12	IMO0	=	Month simulation begins
13-16	IDA0	=	Day of month simulation begins
17-19	NIPD	=	N, the printout interval, i.e., annually, monthly, daily enter a 5 if interval is every 5 days, months, or year
20	IPD		Controls printing
		=	N1 for annual printout
		=	N2 for annual with soil table
		=	N3 for monthly
		=	N4 for monthly with soil table
		=	N5 for monthly with soil table at harvest
		=	N6 for N day interval
		=	N7 for soil table only n day interval
		=	N8 for N day interval, rainfall days only
		=	N9 for N day interval during growing season
21-24	NGN	=	ID number of weather variables input Precip = 1; Temp = 2; SolarRad = 3; WindSpd = 4; RelHum = 5 If any variables are input, rain must be included. Thus it is not necessary to specify ID=1 unless rain is the only input variable Examples: NGN = 1 inputs rain NGN = 23 inputs rain, temp, and RAD NGN = 2345 inputs all 5 variables If *MLRN0810.dat* is activated with NBYR > 0, then NGN must equal 0 for measured weather to be actually simulated.
25-28	IGN	=	Number of times random number generator cycles before simulations starts.
29-32	IGS0		Determines day weather generator stops generating daily weather
		=	0 for normal operation of weather model
		=	N duplicate weather in a given year up to date N
		=	-N for a rewind of weather after N years

		=	366 will simulate entire year, etc.
33-36	LPYR	=	0 if leap year is considered, 1 if leap year is ignored
37-40	IET		Potential evapotranspiration (PET) method code
		=	0 or 1 for Penman-Monteith (usually for windy conditions)
		=	2 for Penman
		=	3 for Priestly-Taylor
		=	4 for Hargreaves
		=	5 for Baier-Robertson
41-44	ISCN	=	0 for stochastic curve number estimator
		>	0 for rigid curve number estimator
45-48	ITYP	=	0 for modified rational EQ peak rate estimate
		>	0 for SCS TR55 Peak Rate estimate
		=	1 for type 1 rainfall pattern
		=	2 for type 1A rainfall pattern
		=	3 for type 2 rainfall pattern
		=	4 for type 3 rainfall pattern
49-52	ISTA	=	0 for normal erosion of soil profile
		=	1 for static soil profile
53-56	IHUS	=	0 for normal operation
		=	1 for automatic heat unit schedule (PHU must be input at planting in operations schedule file)
57-60	NDUM	=	Not used
61-64	NVCN	=	0 variable daily CN with depth soil water weighting
		=	1 variable daily CN without depth weighting
		=	2 variable daily CN linear CN/SW no depth weighting
		=	3 non-varying CN – CN2 used for all storms
		=	4 variable daily CN SMI (soil moisture index)
65-68	INFL	=	0 for CN estimate of Q
		=	1 for Green & Ampt estimate of Q, rainfall exponential distribution, peak rain fall rate simulated
		=	2 for G&A Q, rainfall exponential distribution, peak rainfall input
		=	3 for G&A Q, rainfall uniformly distribution, peak rainfall input
69-72	MASP	<	0 for mass only no pesticide in .OUT
		=	0 for mass only pesticides in .OUT
		>	0 for pesticide & nutrient output in mass and concentration
73-76	LBP	=	0 for soluble P runoff estimate using GLEAMS pesticide approach
		>	0 for modified nonlinear approach
77-80	NSTP	=	real time day of year

Line 2:

Column	Variable		Description
1-4	IGMX	=	# times generator seeds are initialized for a site
5-8	IERT	=	0 for EPIC enrichment ratio method
		=	1 for GLEAMS enrichment ratio method
9-12	ICG	=	0 for traditional EPIC radiation to biomass conversion
		>	0 for new experimental water use to biomass
13-16	LMS	=	0 applies lime
		=	1 does not apply lime
17-20	ICF	=	0 uses RUSLE C factor for all erosion equations
		>	0 uses EPIC C factor for all erosion equations except RUSLE
21-24	ISW	=	0 field capacity/wilting point estimate Rawls dynamic method
		=	1 field capacity/wilting point estimate Baumer dynamic method
		=	2 field capacity/wilting point input Rawls dynamic method
		=	3 field capacity/wilting point input Baumer dynamic method
		=	4 field capacity/wilting point estimate Rawls static method
		=	5 field capacity/wilting point estimate Baumer static methold
		=	6 field capacity/wilting point static input
		=	7 field capacity /wilting point nearest neighbor dynamic method
		=	8 field capacity /wilting point nearest neighbor static method
		=	9 field capacity /wilting point Norfleet dynamic method
		=	10 field capacity /wilting point Norfleet static method
25-28	IRW	=	0 for normal runs with daily weather input
		>	0 for continuous daily weather from run to run (no rewind)
29-32	ICO2	=	0 for constant atmospheric CO_2
		=	1 for dynamic atmospheric CO_2
		=	2 for inputting atmospheric CO_2
33-36	IDUM	=	0 for reading data from working directory
		>	0 for reading from \WEATDATA directory
37-40	ICOR	=	0 Normal run – no southern oscillation
		>	0 Day of year when southern oscillation correction to stop
44-48	IDN	=	0 for Cesar Izaurralde denitrification method.
		=	1 for Armen Kemanian denitrification method
		=	2 for original EPIC denitrification method
49-52	NUPC		N & P plant uptake concentration code
		=	0 for Smith curve
		>	0 for S-curve
52-56	IOX	=	0 for original EPIC oxygen/depth function
		>	0 for Amen Kamanian carbon/clay function
57-60	IDIO	=	0 for reading data from working directory
		=	1 for reading from \WEATDATA directory
		>	2 for reading from working directory plus 3 other directories
61-64	ISAT	=	0 for reading saturated conductivity in soil file
		>	0 for computing saturated conductivity with Rawls method
65-68	IAZM	=	0 for using input latitudes for subareas
		>	0 for equivalent latitude based on azimuth orientation of land slope

68-72	IPAT	=	0 turns off auto P application	
		>	0 for auto P application	
73-76	ISCI		0 for new SCI equations	
			0 for original EPIC SCI equations	
77-80	NDM	=	0 for no metal simulation	
		>	0 for metal simulation	

Line 3:

Column	Variable		Description	
1-8	RFN0	=	Average concentration of nitrogen in rainfall	ppm
9-16	CO20	=	CO_2 concentration in atmosphere	ppm
17-24	CNO30	=	Concentration of NO_3 in irrigation water	ppm
25-32	CSLT	=	Concentration of salt in irrigation water	ppm
33-40	PSTX		Pest damage scaling factor (0.0–10.)	
		=	0.0 shuts off pest damage function.	
		>	0.0 damage function can be regulated from very mild (0.05 – 0.10) to very severe (1.0 – 10.0)	
41-48	YWI	=	Number years of maximum monthly 0.5 h rainfall record	
49-56	BTA	=	Coefficient (0-1) governing wet-dry probabilities given number of days of rain (blank if unknown or if W/D probabilities are input)	
57-64	EXPK	=	Parameter used to modify exponential rainfall amount distribution (blank if unknown or if standard deviation & skewness are input)	
65-72	FL	=	Field length (if wind erosion is to be considered)	km
73-80	FW	=	Field width (if wind erosion is to be considered)	km

Line 4:

Column	Variable		Description	
1-8	ANG0	=	Clockwise angle of field length from north (if wind erosion is to be considered)	
9-16	STD0	=	Standing dead crop residue	
17-24	UXP	=	Power parameter of modified exponential distribution of wind speed (if wind erosion is to be considered)	
25-32	DIAM	=	Soil particle diameter in micron (if wind erosion is to be considered)	
33-40	ACW	=	Wind erosion adjustment factor	
41-48	BIR		Irrigation trigger (3 options)	
		=	1. Plant water stress factor (0-1)	
		=	2. Soil water tension in top 200 mm (> 1 kpa)	
		=	3. Plant available water deficit in root zone	mm
49-56	EFI	=	Runoff volume / volume irrigation water applied	blank if IRR=0
57-64	VIMX	=	Maximum annual irrigation volume allowed	mm
65-72	ARMN	=	Minimum single application volume allowed	mm

73-80	ARMX	=	Maximum single application volume allowed	mm

Line 5:

Column	Variable		Description	
1-8	BFT0		Auto fertilizer trigger (2 options)	
		=	1. plant N stress factor (0-1)	
		=	2. soil N concentration in root zone	g/T
9-16	FNP		Fertilizer application variable (2 meanings)	
		=	1. application rate auto/fixed	kg/ha
		=	2. manure input to lagoon	kg/cow/day
17-24	FMX	=	Maximum annual N fertililzer application for a crop	kg/ha
25-32	DRT	=	Time required for drainage system to reduce plant stress	days
33-40	FDS0	=	Furrow dike safety factor (0-1.)	
41-48	PEC0	=	Conservation practice factor (=0.0 eliminates water erosion)	
49-56	VLGN	=	Lagoon volume ratio –normal / maximum	
57-64	COWW	=	Lagoon input from wash water	mm
65-72	DDLG	=	Time to reduce lagoon storage from maximum to normal	days
73-80	SOLQ	=	Ratio liquid/total manure applied	

Line 6:

Column	Variable		Description	
1-8	GZLM	=	Above ground plant material grazing limit	T/ha
9-16	FFED	=	Fraction of time herd is in feeding area	
17-24	DZ	=	Layer thickness for solution of gas diffusion differential equation	m
25-32	DRV		Specifies water erosion driving equation:	
		=	0 MUST – Modified MUSLE theoretical equation	
		=	1 AOF - Onstad-Foster	
		=	2 USLE - Universal Soil Loss Equation	
		=	3 MUSS - Small Watershed MUSLE	
		=	4 MUSL - Modified USLE	
		=	5 MUSI - MUSLE with input parameters (see BUS(1))	
		=	6 RUSLE – Revised Universal Loss Equation	
		=	7 RUSL2 – Modified RUSLE	
33-40	RST0	=	Base stocking rate	ha/head
41-48	RFP0	=	Return flow + deep percolation	

41-48	BUS(1)		YSD(6) = BUS(1)*QD**BUS(2)*QP**BUS(3)*WSA**BUS(4)*KCPLS

		=	Input for MUSI equation parameter 1	
49-56	BUS(2)	=	MUSI input parameter 2	
57-64	BUS(3)	=	MUSI input parameter 3	
65-72	BUS(4)	=	MUSI input parameter 4	

Line 7:

Column	Variable		Description	
1-8	COIR	=	Cost of irrigation water	$/m^3
9-16	COL	=	Cost of lime	$/T
17-24	FULP	=	Cost of fuel	$/gal
25-32	WAGE	=	Labor cost	$/ha
33-40	CSTZ	=	Miscellaneous costs	$/ha

Site File (*SITE0810.dat & filename.sit*)

A study may involve several sites (fields, farms, or watersheds) described and saved in *filename.sit*. This file must be listed in the database file *SITE0810.dat* (or user-defined name) with a unique reference number corresponding to the variable ISIT in the run file *EPICRUN.dat*. *filename.sit* includes following data elements:

Line1-3:

TITLE - Description.

Line4:

Column	Variable		Description	
1-8	XLAT	=	Latitude	decimal degrees
9-16	XLOG	=	Longitude (-ve for West of Greenwich)	decimal degrees
17-24	ELEV	=	Elevation	m
25-32	APM	=	Peak rate – EI adjustment factor	BIU
33-40	CO2X	=	CO_2 concentration in atmosphere	ppm
		>	0 overrides CO_2 input in *EPICCONT.dat*	ppm
41-48	CNO3X	=	Concentration of NO_3 in irrigation water	ppm
		>	0 overrides CNO_3 input in *EPICCONT.dat*	ppm
49-56	RFNX	=	Average concentration of N in rainfall	ppm
		>	0 overrides N_2 input in *EPICCONT.dat*	ppm
56-64	X1	=	Not used	
65-72	X2	=	Not used	
73-80	SNO0	=	Water content of snow on ground at start of simulation	mm
81-88	AZM	=	Azimuth orientation of land slope (degrees clockwise from North)	

Line5:

Column	Variable		Description	
1-8	WSA	=	HLU (field, farm or watershed) area	ha
9-16	CHL	=	Mainstream channel length (km)	BIU
17-24	CHS	=	Mainstream channel slope (m/m)	BIU
25-32	CHD	=	Channel depth	m
33-40	CHN	=	Manning's N for channel	BIU
41-48	SN	=	Surface N for channel	BIU
49-56	UPSL	=	Upland slope length	m
57-64	UPS	=	Upland slope steepness	m/m

65-72	PEC	=	Conservation practice factor (=0.0 eliminates water erosion)	
73-80	DTG	=	Time interval for gas diffusion equations	h

Line6:

Column	Variable		Description	
1-4	IRR		Input value created from two digits: N followed by values defined below: N = 0 applies volume defined by ARMX; N = 1 applies input or ARMX	
		=	N0 for dryland areas	
		=	N1 from sprinkler irrigation	
		=	N2 for furrow irrigation	
		=	N3 for irrigation with fertilizer added	
		=	N4 for irrigation from lagoon	
		=	N5 for drip irrigation	
5-8	IRI	=	N day application interval for automatic irrigation	
9-12	IFA	=	Minimum fertilizer application interval (blank for user specified)	
13-16	IFD	=	0 without furrow dikes	
		=	1 with furrow dikes	
17-20	IDR0	=	0 No drainage	
		=	Depth of drainage system	mm
21-24	IDF0	=	Fertilizer # for auto fertilizer & fertigation (blank is elemental N)	
25-28	MNU	=>	0 automatic dry manure application without trigger	
29-32	IMW	=	Minimum interval between automatic mow	
33-36	IDFP	=	Fertilizer number for automatic P application (blank is elemental P)	

BIU: leave blank if the parameter value is unknown – it will be estimated by EPIC from other data.

Soil Files (*SOIL0810.dat & filename.sol*)

Data for each soil is maintained in a separate soil file named *filename.sol*. This file must be listed in the database file *SOIL0810.dat* (or user-defined name) with a unique reference number, which corresponds to the variable *INPS* in the run file *EPICRUN.dat*. *filename.sol* includes the following data elements:

Line1:

Title & Description

Line2:

Column	Variable		Description	
1-8	**SALB**	=	Soil albedo	
9-16	**HSG**	=	Soil hydrologic group (1=A, 2=B, 3=C, 4=D).	
17-24	FFC	=	Initial soil water content, fraction of field capacity	BIU
25-32	WTMN	=	Min depth to water table (m)	BIU
33-40	WTMX	=	Max depth to water table (m)	BIU
41-48	WTBL	=	Initial water table height (m)	BIU
49-56	GWST	=	Groundwater storage (mm)	BIU
57-64	GWMX	=	Maximum groundwater storage (mm)	BIU
65-72	RFT0	=	Groundwater residence time (days)	BIU
73-80	RFPK	=	Return flow/(return flow + deep percolation)	BIU

Line3:

Column	Variable		Description	
1-8	**TSLA**	=	Maximum number of soil layers after splitting (3 – 15).	
		=	0 no splitting occurs initially.	
9-16	**XIDP**		Soil weathering code.	
		=	0 for calcareous and non-calcareous soils without weathering information.	
		=	1 for non $CaCO_3$ slightly weathered.	
		=	2 for non $CaCO_3$ moderately weathered.	
		=	3 for non $CaCO_3$ highly weathered.	
		=	4 input PSP or active + stable mineral P (kg/ha).	
17-24	RTN0	=	Number of years of cultivation at start of simulation	BIU
25-32	**XIDK**	=	1 for kaolinitic soil group.	
		=	2 for mixed soil group.	
		=	3 for smectitic soil group.	
33-40	**ZQT**	=	Minimum thickness of maximum layer (m) (splitting stops when ZQT is reached).	

41-48	**ZF**	=	Minimum profile thickness – stops simulation if reached	m
49-56	**ZTK**	=	Minimum layer thickness for beginning simulation layer splitting – model splits first layer with thickness greater than ZTK; if none exists the thickest layer is split.	m
57-64	**FBM**	=	Fraction of organic carbon in biomass pool (0.03 – 0.05)	
65-72	**FHP**	=	Fraction of organic carbon in passive pool (0.3 – 0.7)	
73-80	**XCC**		Code written automatically for **.sot* (not user input)	

Line4 et seq.: One column of data per soil layer (up to 10 layers; fields of 8 columns)

Line	Variable		Description	
1	**Z**	=	Depth to bottom of layer	m
2	**BD**	=	Bulk Density	T/m^3
3	U	=	Soil water content at wilting point (1500 KPA)	m/m; BIU
4	FC	=	Water content at field capacity (33 KPA)	m/m; BIU
5	**SAN**	=	Sand content	%
6	**SIL**	=	Silt content	%
7	WN	=	Initial organic N Concentration	g/T; BIU
8	**PH**	=	Soil pH	
9	SMB	=	Sum of bases	cmol/kg; BIU
10	**WOC**	=	Organic carbon concentration	%
11	CAC	=	Calcium carbonate content of soil	%; BIU
12	CEC	=	Cation exchange capacity	cmol/kg; BIU
13	**ROK**	=	Coarse fragment content	% by volume; BIU
14	CNDS	=	Initial NO_3 concentration	g/T; BIU
15	PKRZ	=	Initial labile P concentration	g/T; BIU
16	RSD	=	Initial crop residue	T/ha; BIU
17	**BDD**	=	Bulk density (oven dry)	T/m^3
18	**PSP**	<=	1 Phosphorus sorption ratio	
		>	1 Active & stable mineral P	kg/ha
19	**SATC**	=	Saturated conductivity	mm/h
20	HCL	=	Lateral hydraulic conductivity	mm/h; BIU
21	WPO	=	Initial organic P concentration	g/T; BIU
22	**EXCK**	=	Exchangeable K concentration	g/T
23	**ECND**	=	Electrical condition	mmho/cm
24	STFR	=	Fraction of storage interacting with NO_3 leaching	BIU
25	**ST**	=	Initial soil water storage (fraction of field capacity)	
26	CPRV	=	Fraction inflow partitioned to vertical crack or pipe flow	BIU.

27	CPRH	=	Fraction inflow partitioned to horizontal crack or pipe flow	BIU.
28	**WLS**	=	Structural litter	kg/ha
29	**WLM**	=	Metabolic litter	kg/ha
30	WLSL	=	Lignin content of structural litter	kg/ha; BIU
31	WLSC	=	Carbon content of structural litter	kg/ha; BIU
32	WLMC	=	Carbon content of metabolic litter	kg/ha; BIU
33	WLSLC	=	Carbon content of lignin of structural litter	kg/ha; BIU
34	WLSLNC	=	N content of lignin of structural litter	kg/ha; BIU
35	WBMC	=	Carbon content of biomass	kg/ha; BIU
36	WHSC	=	Carbon content of slow humus	kg/ha; BIU
37	WHPC	=	Carbon content of passive humus	kg/ha; BIU
38	WLSN	=	N content of structural litter	kg/ha; BIU
39	WLMN	=	N content of metabolic litter	kg/ha; BIU
40	WBMN	=	N content of biomass	kg/ha; BIU
41	WHSN	=	N content of slow humus	kg/ha; BIU
42	WHPN	=	N content of passive humus	kg/ha; BIU
43	OBC	=	Observed carbon content at end of simulation (used only in *.*sot*)	T/ha

Variables in **BOLD** are required – all others can be estimated by EPIC

Monthly Weather Files (*WPM10810.dat* & *filename.wpl*)

Monthly weather statistics of a single weather station are maintained in f*ilename.wp1*. This file must be listed in the database file *WPM10810.dat* (or user-defined name) with a unique reference number, which corresponds to the variable IWP1 in the run file *EPICRUN.dat*. *filename.ops* includes the following data elements:

Lines 1&2:

Title & Description

Line 3 et seq.: Each line has 14 variables in 12 columns; one for each month, January – December

Line	Variable		Description	
3	OBMX	=	Average monthly maximum air temperature	°C
4	OBMN	=	Average monthly minimum air temperature	°C
5	SDTMX	=	Monthly average standard deviation of daily maximum temperature	°C
6	SDTMN	=	Monthly average standard deviation of daily minimum temperature	°C
7	RMO	=	Average monthly precipitation	mm
8	RST2	=	Monthly standard deviation of daily precipitation May be left zero if unknown or daily rainfall is input	mm
9	RST3	=	Monthly skew coefficient for daily precipitation May be left zero if unknown or daily rainfall is input	
10	PRW1	=	Monthly probability of wet day after dry day May be left zero if unknown or daily rainfall is input.	
11	PRW2	=	Monthly probability of wet day after wet day May be left zero if unknown or daily rainfall is input.	
12	DAYP	=	Average number days of rain per month May be left zero if rainfall is generated and wet/dry probabilities are input	days
13	WI		Monthly max 0.5h rainfall (3 options);	mm
		=	Monthly maximum .5 hour rainfall (mm) for period in YWI.	
		=	Alpha (Mean 0.5 hour rain/mean storm amount).	
		=	May be left blank or zero if unknown.	
14	OBSL	=	Ave monthly solar radiation (3 options); Average monthly solar radiation. May be input in mJ/m^2 or LY. Special note if you intend to use daily weather files: Entering MJ/M3 here indicates you will be reading mJ/m^2. Entering LY here indicates you will be reading Langleys. $mJ/m^2 = 0\ .0419*LY$ May be left blank or zero if unknown.	mJ/m^2 or Langley
15	RH		Monthly average relative humidity (fraction), (3 options).	

		=	1. Average Monthly relative humidity (Fraction, e.g. 0.75)	
		=	2. Average Monthly dew point temp	°C
		=	3. Blanks or zeros if unknown.	
			NOTE: May be left zero unless a PENMAN equation is used to estimate potential evaporation see variable IET.	
16	UAV0	=	Average monthly wind speed	m/s

The *WPM50810.dat* file has the same format.

Daily Weather Files (*WLST0810.dat & filename.dly*)

Daily weather statistics of a single weather station are maintained in *filename.dly.* This file must be listed in the database file *WLST0810.dat* (or user-defined name) with a unique reference number, which corresponds to the variable IWTH in the run file *EPICRUN.dat*. *filename.dly* includes the following data elements:

Line 1 et seq.:

Column	Variable		Description	Units
3-6	YEAR	=		
7-10	MNTH	=		
11-14	DAY	=		
15-20	SRAD	=	Solar radiation	mJ/m^2 or Langleys
21-26	TMAX	=	Maximum temperatures	°C
26-32	TMIN	=	Minimum temperatures	°C
33-38	PRCP	=	Precipitation	Mm
39-44	RHUM	=	Relative humidity	Fraction
45-50	WIND	=	Wind speed	m/s

Wind Files (*WIND0810.dat & filename.wnd*)

Monthly wind statistics of a single wind weather station are maintained in *filename.wnd.* This file must be listed in the database file *WIND0810.dat* (or user-defined name) with a unique reference number, which corresponds to the variable IWND in the run file *EPICRUN.dat*. *filename.ops* includes the following data elements:

Lines 1&2:

Title & Description

Line 3 et seq.: Each line has 12 variables in 6 columns; one for each month, January – December

Line	Variable		Description	
3	WVL	=	Average monthly wind speed UAVM = Average monthly wind speed (m/s) (required to simulate wind erosion [ACW>0] and potential ET if Penman or Penman-Montheith equation are used). Wind speed is measured at a 10m height. To convert 2m height wind speed to a 10m height equivalent multiply the 2m height speed by 1.3. Required to simulate wind erosion (ACW > 0, See ACW, LINE23). Also required if Penman or Penman-Monteith equations are used to calculate potential ET (See IET, Line4).	m/s
4	DIR1	=	Monthly % wind from North – Ignored if wind erosion is not estimated.	
5	DIR2	=	Monthly % wind from North North East – Ignored if wind erosion is not estimated.	
6	DIR3	=	Monthly % wind from North East – Ignored if wind erosion is not estimated.	
7	DIR4	=	Monthly % wind from East North East – Ignored if wind erosion is not estimated.	
8	DIR5	=	Monthly % wind from East – Ignored if wind erosion is not estimated.	
9	DIR6	=	Monthly % wind from East South East – Ignored if wind erosion is not estimated.	
10	DIR7	=	Monthly % wind from South East – Ignored if wind erosion is not estimated.	
11	DIR8	=	Monthly % wind from South South East – Ignored if wind erosion is not estimated.	
12	DIR9	=	Monthly % wind from South – Ignored if wind erosion is not estimated.	
13	DIR10	=	Monthly % wind from South South West – Ignored if wind erosion is not estimated.	

14	DIR11	=	Monthly % wind from South West – Ignored if wind erosion is not estimated.
15	DIR12	=	Monthly % wind from West South West – Ignored if wind erosion is not estimated.
16	DIR13	=	Monthly % wind from West – Ignored if wind erosion is not estimated.
17	DIR14	=	Monthly % wind from West North West – Ignored if wind erosion is not estimated.
18	DIR15	=	Monthly % wind from North West. – Ignored if wind erosion is not estimated
19	DIR16	=	Monthly % wind from North North West – Ignored if wind erosion is not estimated.

NOTE: EPIC considers 16 wind directions, which are crucial for estimates of wind erosion and dust distribution, and air quality from feedlots.

How to Prepare Weather Input Files

Historical daily weather data can be used in two ways: First, these data can be directly used in EPIC simulation when the length of historical daily weather is the same as the simulation period. Second, in general the historical daily weather data are primarily used to generate monthly weather data, which then are used to generate EPIC weather input data. The format for historical daily weather data is explained below:

Line1:

Weather file name

Line2:

Number of the years in the actual daily weather data (col.1-4) followed by the beginning year. For example: 131981 means that there are 13 years of weather data beginning with year of 1981.

Line3:

From this line forward, every line includes nine variables. These nine variables are:

Column	Variable
1-6	Year
7-10	Month
11-14	Day
15-20	Solar Radiation
21-26	Maximum temperature
27-32	Minimum temperature
33-38	Precipitation
39-44	Relative humidity
45-50	Wind velocity

After completing the following steps to develop the *WPM10810.dat* file, if any daily record of maximum temperature, minimum temperature, or precipitation are missing, enter 9999.0 in the missing field(s) of the record(s). EPIC will generate the missing record automatically when using measured weather in a simulation.

NOTE: DO NOT USE 9999.0 FOR ANY RECORD BEFORE DEVELOPING THE *WPM10810.dat* BELOW.

Format of Daily Weather Input Files

The easiest way to build a historical daily weather input file is to enter the data in an Excel spreadsheet and then save it as *.prn file and rename the *.prn file to a *.txt file. The included EPIC weather program WXGN3020.exe will read this *.txt file to create the generated monthly weather file (*.wp1).

Run EPIC Weather Program

Put the historical daily weather input file under the weather program directory. Before starting to run the weather generating program (WXGN3020.exe), one needs to set up *WXGNRUN.dat* file. This can be done by putting the actual daily weather file name (*.dly) on the first line in WXGNRUN.dat file if only one weather data set needs to be generated. In the event of several weather data sets need to be generated by WXGN3020.exe, each individual actual daily weather data set name has to be listed in *WXGNRUN.dat* file. By doing so, the WXGN3020.exe will read all the daily weather files listed in *WXGNRUN.dat* and generate all the monthly weather files. When *WXGNRUN.dat* is set up, one can execute the weather generation program by typing WXGN3020 under the appropriate driver path prompt where both actual daily weather and weather generating program are stored. Then press ENTER key. The weather program will start to run until it is finished. When it is finished, it produces three files: *.DLY (an actual daily weather file), *.OUT, and *.INP files. In which only *.INP file is needed for EPIC simulation. To be consistent, this *.INP file should be renamed as *.WP1. The *.WP1 file will be listed in the weather list file (WPM10810.dat). For the content of *.WP1 file, please refer to the next section of *WPM10810.dat*.

Operation Schedule Files (*OPSC0810.dat* & *filename.ops*)

Data of field operation schedules are maintained in a separate file named *filename.ops*. This file must be listed in the database file *OPSC0810.data* (or user-defined name) with a unique reference number, which corresponds to the variable IOPS in the run file *EPICRUN.dat*. *filename.ops* includes the following data elements:

Line1:

Title & Description

Line2:

Column	Variable		Description
1-4	LUN	=	*Land use number from NRCS Land Use-Hydrologic Soil Group Table* Refer to the column labeled Land User Number in the table on Page 33. This number along with the hydrologic soil group is used to determine the curve number. (Range: 1-35)
5-8	IAUI	=	*Auto irrigation;* apply irrigation operation from *TILL0810.dat* (Range: 1-∞). If auto irrigation is used, this irrigation operation (found in the *TILL0810.dat* file) will be used to apply irrigation water. If none is specified, the default is operation #500.

Line3 et seq.: (one line per operation)

Column	Variable		Description
1-3	IYEAR	=	*Year of operation* (Range: 1–N)
4-6	MON	=	*Month of operation* (Range 1-12)
7-9	DAY	=	*Day of operation* (Range: 1-31) NOTE • It is recommended not to schedule something for 29 February.
10-14	CODE	=	*Tillage ID number* (Refers to the ID number that is given to each tillage operation or piece of equipment in *TILL0810.dat*)
15-19	TRAC	=	*Tractor ID number* (Refers to the ID number given to each tractor in *TILL0810.dat*) NOTE • This may be omitted if economic analysis is not required
20-24	CRP	=	*Crop ID number* (Refers to the crop ID number given to each crop as listed in *CROP0810.dat*)
25-29	XMTU	=	*Time from planting to maturity in Years* (for tree crops only)
		=	*Time from planting to harvest in Years* (for tree crops at planting only). This refers to the time to complete maturity of the tree (full life of the tree). No potential heat units are entered for trees. This value is calculated from XMTU (Range: 5-300)

	LYR	=	*Time from planting to harvest in years*, if JX(4) is a harvest operation for trees (proportion of full maturity) (Range: 5-100)
		=	Pesticide ID number from *PEST0810.dat* (for pesticide application only)
		=	Fertilizer ID number from *FERT0810.dat* (for fertilizer application only)
30-37	OPV1	=	Potential heat units (PHU) from germination required by the plant to reach maturity. Total number of heat units or growing degree days needed to bring the plant from emergence to physiological maturity. Used in determining the growth curve. Enter 0 if unknown. (Range: 1-5000) NOTE • For trees, no PHU are entered. They are calculated from XMTU. For crops other than trees PHU are accumulated annually and reset to 0 at the end of the year. Trees are a special case in which PHUs continue to accumulate from year to year. Deciduous trees are also a special case within trees in which PHUs are calculated annually (similar to non-tree crops) in order to simulate leaf drop as well as accumulate PHUs from year to year to simulate the maturity of the tree.
		=	*Application volume in mm for irrigation*. (Range: 1-5000)
		=	F*ertilizer application rate in kg/ha;* For variable rate set equal to 0. (Range: 0-500)
		=	*Pesticide application rate in kg/ha*. (Range: 0-500)
		=	*Stocking rate for grazing in ha/head*. On a Start Grazing operation this variable is used to set the stocking rate in number of hectares/animal. Using this feature, the user can change the number of animals in the herd at any point in time simulating buying/selling of animals. (Range: 0-200)
38-45	OPV2	=	Two (2) condition SCS Runoff Curve number, or Land Use number (optional) . The land use number set previously can be overridden at this point if an operation has caused the land condition to change. (Range: 1-35)
		=	*Fraction of pests controlled by pesticide application.* This factor is used to control pest populations by applying pesticides. It only applies to insects and diseases. Weeds are handled through intercropping. (Range: 0-1) NOTE • If this factor is set to 0.99, 99% of the pests will be killed. After each treatment, the population will begin to regrow based on several parameters set in the Control file (PSTX), Crop file (PST) and Parm file (parms 9 & 10). • Currently the model is set so that very minimal damage is caused by pests and therefore does not reduce yield. Pest growth is dependent on temperature and humidity. Warm and wet conditions favor pest growth while dry and cool conditions inhibit pest growth.

46-53	OPV3	=	*Automatic Irrigation Trigger* This is the same irrigation trigger function as in the control file. The control file value can be overridden by setting the trigger value in the operation schedule. Leaving OPV3 = 0 no modifications will be made to the irrigation trigger as set in the control file. To trigger automatic irrigation, the water stress factor is set: = 0 - Manual irrigation or model uses BIR set in control file (*EPICCONT.dat*) = 0-1.0 - Plant water stress factor. (1 – BIR) equals the fraction of plant water stress allowed 1.0 Does not allow water stress < 0.0 - Plant available water deficit in root zone (number is in mm and must be negative) > 1.0 - Soil water tension in top 200mm (Absolute number is in kilopascals) = 1000 - Sets water deficit high enough that only manual irrigations will occur. This effectively turns auto irrigation off. NOTE • When using a BIR based on anything other than plant water stress (0-1), be aware that irrigation will be applied outside of the growing season if the soil water deficit or soil water tension reaches BIR. This will reduce the amount of water available for irrigation during the growing season. • Once the trigger has been set within a operation schedule, it will remain in effect until changed within the operation schedule. If the schedule is used in rotation with other schedules, the trigger will stay as set even into the next schedule. When setting the irrigation trigger within an operation schedule, it is wise to set the irrigation trigger to -1000 mm at the end of the schedule so that when the operation schedule is used in rotation with another non-automatically irrigated crop, the second crop is not influenced by the irrigation trigger.
54-61	OPV4	=	*Proportion of irrigation water applied lost to runoff (vol/vo)l.* Setting the runoff fraction (EFI) within the operation schedule overrides the EFI set within the control file. The irrigation runoff ratio specifies the fraction of each irrigation application that is lost to runoff. Soluble nutrient loss through runoff applies. Changes in soil slope do not affect this amount dynamically. (Range: 0-1)
62-69	OPV5	=	*Plant population at planting* (plants/m^2 for small plants; plants/ha for larger plants with densities < 1/m^2, e.g. trees). NOTE • EPIC does not simulate tillering. In crops such as wheat and sugarcane which produce higher numbers of yielding tillers compared to the number of seeds or shoots planted, the plant population must be estimated based on the final yield producing tiller number. (Range: 0-500)
70-77	OPV6	=	*Maximum annual N fertilizer applied to a crop*
		=	0 (or blank) does not change FMX (*EPICCONT.dat*)

		>	0 sets new FMX for planting only. In the control file FMX was set to limit the amount of fertilizer that could be applied on an annual basis regardless of the number of crops grown within a year. Refer to FMX (page 17) for further information. The maximum annual amount of nitrogen fertilizer can also be set here in the operation schedule and can be set per crop so that each crop has a specified amount of nitrogen fertilizer available to it. This is especially important when automatically applying fertilizer. NOTE If this variable is set either in the control file or in the operation schedule and manual fertilization is applied, the model will only apply up to this maximum amount regardless of the amount specified in the manual fertilization operation.
78-85	OPV7	=	*Time of operation as fraction of growing season* This is also referred to as heat unit scheduling. Heat unit scheduling can be used to schedule operations at a particular stage of growth. For example, irrigation could be scheduled at 0.25, 0.5, and 0.75 which might represent varying stages of crop growth. Irrigation would then be applied at 25%, 50%, and 75% of the potential heat units set at planting. Enter earliest possible Month & Day in JX(2) & JX(3). NOTE When setting up an operation using heat unit scheduling it is best to enter earliest possible Month and day (JX(2) & JX(3)) that the operation could occur on because in order for the operation to occur the date of the operation as well as the number of heat units scheduled must be met. This is especially true for harvest operations. It is recommended that the harvest date be set 10-14 days before actual harvest is expected to occur. This is recommended so that the date of the operation will be met before the heat units are met. If the date is set too late and the heat units are met before the date of the operation is met, the crop will continue to grow longer than expected which can affect yield. EPIC first checks to see that the date of the operation has been met; then it checks to see if the fraction of heat units has been met as defined below:.

Date	Heat Units	Action
Date is met	Heat unit fraction not met	Operation will not occur until heat units requirement is met
Date is not met	Het unit fraction met	Operation will occur as soon as date is met. Note: Excess GDUs will accumulate causing the operation to occur later in the growing cycle than expected
Date is met	Heat unit fraction met	Operation will occur immediately

			Heat unit scheduling can also be used to adjust operations to the weather (temperatures) from year to year. If heat units are not scheduled (set to 0), operations will occur on the date as scheduled in the operation schedule. They will occur on the same date every year the crop is grown. Heat unit scheduling operations which occur from planting to harvest are based on the heat units set at planting. Operations which occur before planting are based on the total annual heat units which are calculated by the model. For some grain crops an in-field dry-down period is allowed. It is expressed as a fraction of the total heat units set at planting. In most cases the dry-down period is 10% to 15% of the total heat units. If a dry-down period is required, heat unit schedule the harvest operation to occur at 1.10, 1.15 or another appropriate fraction. In the case of forage harvesting, the forage is actually harvested well before the crop reaches full maturity. In this case heat unit schedule the forage harvest to 0.55 or another appropriate fraction.
86-93	OPV8	=	*Minimum USLE C-Factor*
94-101	OPV9	=	*Moisture content of grain required for harvest*

NOTE:

Variables LYR, OPV1& OPV2 are context dependent, i.e. they have different meanings and variable names depending on the type of operation.

Runoff Curve Numbers for Hydrologic Soil-cover complexes[1]

Land use	Cover Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D	Land Use Number
Fallow	Straight row		77	86	91	94	1
Row crops	Straight row	Poor	72	81	88	91	2
"	"	Good	67	78	85	89	3
"	Contoured	Poor	70	79	84	88	4
"	"	Good	65	75	82	86	5
"	Contoured & terraced	Poor	66	74	80	82	6
"	"	Good	62	71	78	81	7
Small grain	Straight row	Poor	65	76	84	88	8
"	"	Good	63	75	83	87	9
"	Contoured	Poor	63	74	82	85	10
"	"	Good	61	73	81	84	11
"	Contoured & terraced	Poor	61	72	79	82	12
"	"	Good	59	70	78	81	13
Close-seeded	Straight row	Poor	66	77	85	89	14
Legumes[2] or	"	Good	58	72	81	85	15
rotation meadow	Contoured	Poor	64	75	83	85	16
"	"	Good	55	69	78	83	17
"	Contoured & terraced	Poor	63	73	80	83	18
"	"	Good	51	67	76	80	19
Pasture or range							
<50% ground cover or heavily grazed		Poor	68	79	86	89	20
50-75% ground cover & not heavily grazed		Fair	49	69	79	84	21
>75%g round cover & lightly grazed		Good	39	61	74	80	22
As above & Contoured		Poor	47	67	81	88	23
	"	Fair	25	59	75	83	24
	"	Good	6	35	70	79	25
Meadow (continuous grass, not grazed, mown for hay)		Good	30	58	71	78	26
Woods							
Small trees and brush (heavy grazing & regular burning)		Poor	45	66	77	83	27
Woods grazed, not burned, some litter covers soil		Fair	36	60	73	79	28
Woods not grazed, litter & brush cover soil		Good	25	55	70	77	29
Farmsteads			59	74	82	86	30
Roads(dirt)[3]			72	82	87	89	31
(hard surface)[3]			74	84	90	92	32
Sugarcane			39	61	74	80	33
Bermuda grass			49	69	79	84	34
Impervious (Pavement, urban area)			98	98	98	98	35

1 National Engineering Handbook (USDA Soil Conservation Service 1972).
2 Close-drilled or broadcast.
3 Including rights of way.

Crop File (*CROP0810.dat*)

The crops database *CROP0810.dat* includes over 100 crops, including trees and other perennials. There are 59 parameters used to describe each crops' growth characteristics. Those parameters are all listed in a single line in *CROP0810.dat* file which includes the following data elements:

Each Line:

Column	Variable		Description
1-5	CNUM		Crop reference number
7-10	CPNM		Crop name abbreviation
11-18	WA	=	Biomass-Energy Ratio (CO_2 = 330ppm). This is the potential (unstressed) growth rate (including roots) per unit of intercepted photosynthetically active radiation. This parameter should be one of the last to be adjusted. Adjustments should be based on research results. This parameter can greatly change the rate of growth, incidence of stress during the season and the resultant yield. Care should be taken to make adjustments in the parameter only based on data with no drought, nutrient or temperature stress.
19-26	HI	=	Harvest index. This crop parameter should be based experimental data where crop stresses have been minimized to allow the crop to attain its potential. EPIC adjusts HI as water stress occurs from near flowering to maturity.
27-34	TOPC	=	Optimal temperature for plant growth. °C TB and TG are very stable for cultivars within a species. They should not be changed once they are determined for a species. Varietal or maturity type differences are accounted for by different sums of thermal units.
35-42	TBSC	=	Minimum temperature for plant growth. °C TB and TG are very stable for cultivars within a species. They should not be changed once they are determined for a species. Varietal or maturity type differences are accounted for by different sums of thermal units.
43-50	DMLA	=	Maximum potential leaf area index. The parameters in the *CROP8190.dat* data set are based on the highest expected plant densities for crops not expected to have water stress. DMLA is internally adjusted for drought-prone regions as planting densities are much smaller in these areas unless irrigation is used.

51-58	DLAI	=	Fraction of growing season when leaf area declines. The fraction of the growing season in heat units in divided by the total heat units accumulated between planting and crop maturity. If the date at which leaf area normally declines is known, one of the options in EPIC can be used to estimate the fraction of heat units accumulated. A multi-run EPIC simulation is setup with IGSD equal to 366. A one-year simulation followed by a one-year multi-run will produce a multi-run simulation, which has average heat units per month and the total heat units to maturity. The harvest date kill operations should be set to the crop maturity date. The estimated heat units at maximum leaf area can then be divided by the heat units at maturity to estimate the fraction of the growing season at which leaf-area index start to decline.
59-66	DLAP1	=	First point on optimal leaf area development curve. Two points on optimal (nonstress) leaf area development curve. Numbers before decimal are % of growing season. Numbers after decimal are fractions of maximum potential LAI. Research results or observations on the % of maximum leaf area at two points in the development of leaf area can be used in conjunction with an EPIC simulation like that described for DLAI. The results of the one-year multi-run will establish the cumulative heat units by month from planting to maturity. Then calculate percent of cumulative heat units by dividing estimated cumulative heat units for each of the two dates where you've estimated percent of Max LAI by the average annual heat units shown on the bottom of the crop parameter set at the beginning of the EPIC run. **NOTE**: The percent of heat units for first monthly estimate is the number on the left of the decimal for DLAP1 and the estimated percent of the Max LAI is the number in the right of the decimal.
67-74	DLAP2	=	Second point on optimal leaf area development curve. Two points on optimal (nonstress) leaf area development curve. Numbers before decimal are % of growing season. Numbers after decimal are fractions of maximum potential LAI. Research results or observations on the % of maximum leaf area at two points in the development of leaf area can be used in conjunction with an EPIC simulation like that described for DLAI. The results of the one-year multi-run will establish the cumulative heat units by month from planting to maturity. Then calculate percent of cumulative heat units by dividing estimated cumulative heat units for each of the two dates where you've estimated percent of Max LAI by the average annual heat units shown on the bottom of the crop parameter set at the beginning of the EPIC run. **NOTE**: The percent of heat units for second date estimate is the number on the left of the decimal for DLAP2 and the estimated percent of the Max LAI is the number in the right of the decimal.
75-82	RLAD	=	Leaf area index decline rate parameter. Leaf-area-index decline rate parameter (estimated LAI decline between DLAI and harvest) -1.0 is linear; > 1 accelerates decline; < 1 retards decline rate. Values range from 0 to 10.

83-90	RBMD	=	Biomass-energy ratio decline rate parameter Biomass-energy ratio decline rate parameter for late in the cropping season. This crop parameter functions like the RLAD above for values ranging from 0-10. It reduces the efficiency of conversion of intercepted photosynthetically active radiation to biomass due to production of high energy products like seeds and/or translocation of N from leaves to seeds.
91-98	ALT	=	Index of crop tolerance to aluminum saturation (1-5; 1=sensitive, 5=tolerant).
99-106	GSI	=	Maximum Stomatal Conductance m/s The crop parameter GSI is the maximum stomatal conductance (m/s) at high solar radiation and low vapor pressure deficit. Korner et al. (1979) reported maximum stomatal conductance values for 246 species and cultivars.
107-114	CAF	=	Critical aeration factor Fraction of soil porosity where poor aeration starts limiting plant growth. This is set at 0.85 for most crops, with rice being the major exception with a value of 1.0.
115-122	SDW	=	Seeding rate. Kg/ha Normal planting rate. Note this does not change the plant population. It only impacts seed cost and start crop biomass.
123-130	HMX	=	Maximum crop height in m.
131-138	RDMX	=	Maximum root depth in m. This effects soil moisture extraction.
139-146	WAC2	=	CO_2 Concentration /Resulting WA value (Split Variable). In EPIC, radiation use efficiency is sensitive to atmospheric CO_2 concentration. WAC2 is an "S" curve parameter used to describe the effect of CO_2 concentration on the crop parameter WA. The value on the left of the decimal is a value of CO_2 concentration higher that ambient (i.e., 450 or 660 ul/l). The value on the right of the decimal is the corresponding value WA. This elevated value of WA can be estimated from experimental data on short-term crop growth at elevated CO_2 levels. Calculate the ratio of crop growth rate at elevated CO_2 to crop growth at approximately 330 ul l-1 CO_2. Multiply that ratio by the value of WA at 330 ul l-1 to obtain the value on the right of the decimal. Typical values of the ratio are 1.1 to 1.2, 1.15 used in crop8190. for crops with the C4 photosynthetic pathway and 1.3 to 1.4, 1.35 used in crop8190 for C3 crops. (Kimball, B.A. 1983 Carbon dioxide and agricultural yield: an assemblage and analysis of 770 prior observations. Water Conservation Laboratory Report 14. USDA/ARS. Phoenix, Arizona).
147-154	CNY	=	Fraction of nitrogen in yield. g/g Normal fraction N in yield. This was estimated from Morrison's Feeds and Feeding and other data sources plant nutrition. The percentage N in Morrison was adjusted to a dry weight by dividing by the fraction of dry matter to total yield.
155-162	CPY	=	Fraction of phosphorus in yield. g/g Normal fraction of P in yield. Estimated by same procedure as CNY above.
163-170	CKY	=	Fraction of K in yield g/g

171-178	WSYF	=	Lower limit of harvest index. Fraction between 0 and HI value that represents the lowest harvest index expected due to water stress. A few crops can have slight increases in harvest index ie. the sugar content is higher in somewhat stressed sugar crops.
179-186	PST	=	Pest damage factor (insects, weeds, disease) Fraction of yield remaining after damage. Usually set at 0.60. EPIC has an adjustment process that is function of moisture, temperature and residue. This presently is a reasonable estimate, but future versions may include more detailed procedures. You may wish to adjust the parameter in geographic areas known to have large amounts of damage from pests.
187-194	CSTS	=	Seed cost $/kg
195-202	PRYG	=	Price for yield $/T
203-210	PRYF	=	Price for forage yield $/T
211-218	WCY	=	Fraction water in yield.
219-226	BN1	=	Nitrogen uptake parameter (N fraction in plant at emergence). Normal fraction of N in crop biomass at emergence -This parameter is based on research results published in the literature for this or a similar crop.
227-234	BN2	=	Nitrogen uptake parameter (N fraction in plant at 0.5 maturity). Normal fraction of N in crop biomass at mid-season -Same as BN1.
235-242	BN3	=	Nitrogen uptake parameter (N fraction in plant at maturity). Normal fraction of N in crop biomass at maturity -Same as BN1.
243-250	BP1	=	Phosphorus uptake parameter (P fraction in plant at emergence). Normal fraction of P in crop biomass at emergence -Same as BN1.
251-258	BP2	=	Phosphorus uptake parameter (P fraction in plant at 0.5 maturity). Normal fraction of P in crop biomass at mid-season -Same as BN1.
259-266	BP3	=	Phosphorus uptake parameter (P fraction in plant at maturity). Normal fraction of P in crop biomass at maturity -Same as BN1.
267-274	BK1	=	K uptake at emergence
275-282	BK2	=	K uptake at 0.5 maturity
283-290	BK3	=	K uptake at maturity
291-298	BW1	=	Wind erosion factor for standing live biomass Based on the Manhattan wind erosion equations for this crop or a similar crop used in the Manhattan wind erosion equations.
299-306	BW2	=	Wind erosion factor for standing dead crop residue Same as BW1.
307-314	BW3	=	Wind erosion factor for flat residue Same as BW1.
315-322	IDC		Crop category number:
		=	1 - Warm season annual legume.
		=	2 - Cold season annual legume.
		=	3 - Perennial legume.
		=	4 - Warm season annual.

		=	5 - Cold season annual.
		=	6 - Perennial.
		=	7 - Evergreen tree
		=	8 - Deciduous tree
		=	9 - Cotton
		=	10 - N-fixing tree
			NOTE: Other crop parameters (TB, TG, FRS1, FRS2) also differentiate between cold and warm climate crops. Precise data for field application is subject to microclimate variation across the landscape. Current parameters are reasonable estimates. However, they are more likely to understate frost damage than to overstate frost damage.
323-330	FRST1	=	First point on frost damage curve. Two points on the frost damage curve. Numbers before decimal are the minimum temperatures (degrees C) and numbers after decimal are the fraction of biomass lost each day the specified minimum temperature occurs. **NOTE**: 10.20 means 20 percent of the biomass is lost each day a temperature of -10C is reached. The negative sign on degrees is added by EPIC since no frost damage is assumed to occur above 0 degrees C. These two parameters should be based on a combination of research results and observation. Precise data for field application is subject to microclimate variation across the landscape. Current parameters are reasonable estimates; However, they are more likely to understate frost damage than to overstate frost damage.
331-338	FRST2	=	Second point on frost damage curve. Two points on the frost damage curve. Numbers before decimal are the minimum temperatures (C) and numbers after decimal are the fraction of biomass lost each day the specified minimum temperature occurs. **NOTE**: 10.20 means 20 percent of the biomass is lost each day a temperature of -10C is reached. The negative sign on degrees is added by EPIC since no frost damage is assumed to occur above 0 degrees C. These two parameters should be based on a combination of research results and observation.
339-346	WAVP	=	Parm relating vapor pressure deficit to WA. In EPIC, radiation use efficiency (RUE) is sensitive to vapor pressure deficit (VPD). As VPD increases, RUE decreases. The crop parameter WAVP is the rate of the decline in RUE per unit increase in VPD. The value of WAVP varies among species, but a value of 6 to 8 is suggested as an approximation for most crops.
347-354	VPTH	=	Threshold VPD (SPA) (F=1.). In EPIC, leaf conductance is insensitive to VPD until VPD (calculated hourly) exceeds the threshold value, VPTH (usually 0.5 to 1.0 kPa).

355-362	VPD2	=	VPD value (KPA) / F2 1. In EPIC, leaf conductance declines linearly as VPD increases above VPTH. VPD2 is a double parameter in which the number on the left of the decimal is some value of VPD above VPTH (e.g. 4.0), and the number of the right of the decimal is the corresponding fraction of the maximum leaf conductance at the value of VPD (e.g., 0.7).
363-370	RWPC1	=	Fraction of root weight at emergence. Partitioning parameters to split biomass between above ground and roots. RWPC1 is the partitioning fraction at emergence and RWPC2 is partitioning fraction at maturity. Between those two points there is a linear interpolation of the partitioning fraction relative to accumulative heat units.
371-378	RWPC2	=	Fraction of root weight at maturity. Partitioning parameters to split biomass between above ground and roots. RWPC1 is the partitioning fraction at emergence and RWPC2 is partitioning fraction at maturity. Between those two points there is a linear extrapolation
379-386	GMHU	=	Heat Units required for Germination degree-days This delays germination from the planting date or the date at which the temperature of soil layer 2 exceeds TG.
387-394	PPLP1	=	Plant Population Crops & Grass 1st Point. Plant Population for crops, grass etc., except trees or plants requiring more than 1 m2/plant, 1st point on population curve. The number to the left of the decimal is the number of plants and the number to right is the fraction of maximum leaf area at the population. Plant population is expressed as plants per square meter. If trees, the population is expressed as plants per hectare and the second plant population point is placed in the SMR1 position and the first point placed in the SMR2 position. The first point should be the higher population. Thus PPLP1(SMR1)<PPLP2(SMR2) PLANTS/M**2 PPLP1(SMR1)>PPLP2(SMR2) PLANTS/HA
395-402	PPLP2	=	Plant Population Crops & Grass 2nd Point. The number to the left of the decimal is the number of plants and the number to right is the fraction of maximum leaf area at the population. Plant population is expressed as plants per square meter. If trees, the population is expressed as plants per hectare and the second plant population point is placed in the SMR1 position and the first point placed in the SMR2 position. The first point should be the higher population. Thus PPLP1(SMR1)<PPLP2(SMR2) PLANTS/M**2 PPLP1(SMR1)>PPLP2(SMR2) PLANTS/HA For example, in corn, PPLP1 = 30.43 and PPLP2 = 50.71, which mean 30 plants per square meter and .43 of maximum leaf area in 1st point on population curve and 50 plants per square meter and .71 of maximum leaf area in 2nd point on population curve in corn production. Since PPLP1 is less than PPLP2, it shows the population density of crop instead of tree. However, for pine tree, PPLP1 = 1000.95 and PPLP2 = 100.10. While the numbers before and after decimal have the same explanations as given for corn, it tells the population density of tree instead of crop because here PPLP1 is greater than PPLP2. Plant population for crops and grass 2nd point Plant population for trees 1st point

403-410	STX1	=	Yield decreases/salinity increase ((T/ha)/(mmho/cm))	
411-418	STX2	=	Salinity threshold	mmho/cm
419-426	BLG1	=	Lignin fraction in plant at 50% maturity	
427-434	BLG2	=	Lignin fraction in plant at maturity	
435-442	WUB	=	Water use conversion to biomass	T/mm
443-450	FTO	=	Fraction turnout for cotton	
451-458	FLT	=	Fraction lint for cotton	
459-466	CCEM	=	Carbon emission/seed weight	kg/kg
468+	NAME	=	Full name of crop – this is optional and not read	

Tillage File (*TILL0810.dat*)

The tillage operations database *TILL0810.dat* includes most common field management activities in agricultural land use. There are 31 parameters used to describe each tillage operation and those parameters are all listed in a single line in *TILL0810.dat* file which includes the following data elements:

Each Line:

Column	Variable		Description	
1-5	TNUM	=	Equipment number, for reference purposes only. Operations are accessed by their sequential location in the file. For example, an operation number 9 will access the ninth operation regardless of the setting of this variable.	
7-14	TIL	=	Tillage operation name abbreviation.	
16-19	PCD	=	Power code. POWE: the machine with its own engine for power used to pull other machinery or equipment (e.g. a tractor); SELF: the machine has its own engine for power but it does the operation by itself (e.g. a combine); NON: the machine (or equipment) has no engine for power and it must be pulled by other machinery with engine power; IRRI: irrigation equipment; CUST: customized equipment.	
20-27	PRIC	=	Purchase price ($) –exception custom = cost	$/ha
28-35	XLP	=	Initial list price in current	$
36-43	HRY	=	Annual use	hours
44-51	HRL	=	Life of equip	hours
52-59	PWR	=	Power of unit	kW
60-67	WDT	=	Width of pass	m
68-75	SPD	=	Operating speed	kph
76-83	RC1	=	Repair cost coefficient 1	
84-91	RC2	=	Repair cost coefficient 2	
92-99	XLB	=	Lubricant factor	
100-107	FCM	=	Fuel consumption multiplier	
108-115	RFV1	=	Remaining farm value PARM 1	
116-123	RFV2	=	Remaining farm value PARM 2	
124-131	EFM	=	Machine efficiency	
132-139	RTI	=	Annual real interest rate	$/$

140-147	EMX	=	Mixing efficiency (0-1) The mixing efficiency of the operation (EMX) is the fraction of materials crop residue and nutrients) that is mixed uniformly in the plow depth of the implement. Suggested values for EMX, random roughness (RR), tillage depth (TLD), ridge height(RHT), and ridge interval (RIN) are given in V.1. However, since these values may vary with soils and management, modifications may be needed.	
148-155	RR	=	Random surface roughness created by tillage operation	mm
156-163	TLD	=	Tillage depth in mm. Also used as the lower limit of grazing height	mm
		>	0 Indicates depth is below the surface	
		<	0 Indicates above ground cutting height	
164-171	RHT	=	Ridge height	mm
172-179	RIN	=	Ridge interval	m
180-187	DKH	=	Height of furrow dikes (ignored if no dikes)	mm
188-195	DKI	=	Distance between furrow dikes (ignored if no dikes)	m
196-203	IHC		Operation Code:	
		=	1 kill crop.	
		=	2 harvest without kill.	
		=	3 harvest once during simulation without kill.	
		=	4	
		=	5 Plant in rows.	
		=	6 Plant with drill.	
		=	7 apply pesticide.	
		=	8 irrigate.	
		=	9 fertilize	
		=	10 bagging & ties (cotton)	
		=	11 ginning	
		=	12 hauling	
		=	13 drying	
		=	14 burn	
		=	15 puddle	
		=	16 destroy puddle	
		=	17 build furrow dikes	
		=	18 destroy furrow dikes	
		=	19 start grazing	
		=	20 stop grazing	
		=	21 Scrape manure from pens	
		=	22 auto mow	
		=	23 place plastic cover	
		=	24 remove plastic cover	

		=	25 stop drainage system flow
		=	26 Resume drainage system flow
204-211	HE	=	Harvest efficiency (0-1) As a harvest operation (IHC=2.0), this is the ratio of crop yield removed from the field to total crop yield. Besides its normal function, harvest efficiency can be used in simulating grazing (HE approx. equal to 0.1) or growing green manure crops (HE=0.0).
		=	Pesticide application efficiency if Operation Code IHC=7
212-219	ORHI	=	Overrides simulated Harvest Index (HI) if 0. < ORHI < 1 Near optimal harvest index values (HI) are contained in the crop parameters database. As the crop grows, these values may be adjusted for water stress. For some crops like hay, the harvest index is not affected by water stress and should maintain the original value. Thus, the harvest index override (ORHI) is used to give a constant harvest index. Another important feature of ORHI is the provision for two different types of harvest of the same crop. For example, the seed could be removed from a crop and the later the straw could be baled. The water-stress-adjusted HI is appropriate for the seed harvest but probably not for baling the straw. Thus, two separate harvest machines are required. The second harvester sets ORHI approx.. equal to 0.9 to override the adjusted HI used in the first harvest.
		>	1 Grazing rate kg/head/day Values greater than 1 are kg/ha of biomass removed per head per day by grazing. For example, one adult cow or beef consumes the equivalent of ~24 kg/day (12 kg/day consumed and an equivalent amount trampled).
220-227	FRCP	=	Fraction of soil compacted (tire width/tillage width).
228-235	FPOP	=	Fraction plant population reduced by operation.
236-243	CFEM	=	Carbon emission kg/ha
244-251	EFI	=	Not used in EPIC
252-259	STIR	=	Not used in EPIC
264+	NAME	=	Full tillage operation name – this is optional and not read

Fertilizer File (*FERT0810.dat*)

The fertilizer database *FERT0810.dat* includes most common fertilizers and/or other nutrient materials used in agricultural management. There are 12 parameters used to describe each fertilizer's properties. Those parameters are all listed in a single line in *FERT0810.dat* file which includes the following data elements:

Each Line:

Column	Variable		Description	
1-5	FTNO	=	Fertilizer reference number.	
7-14	FTNM	=	Fertilizer name abbreviation	
15-22	FN	=	Mineral N fraction.	
23-30	FP	=	Mineral P fraction	
31-38	FK	=	Mineral K fraction	
39-46	FNO	=	Organic N fraction	
47-54	FPO	=	Organic P fraction	
55-62	FNH3	=	Ammonia N fraction	
63-70	FOC	=	Organic C fraction	
71-78	FSLT	=	Salt fraction	
79-86	FCST	=	Fertilizer cost	$/kg
87-94	FCEM	=	Carbon emission per unit fertilizer	kg/kg
96+	NAME	=	Full name of fertilizer – this is optional and not read	

Pesticide File (*PEST0810.dat*)

The fertilizer database *PEST0810.dat* includes most common pesticides used in agricultural management. There are 9 parameters used to describe each fertilizer's properties. Those parameters are all listed in a single line in *PEST0810.dat* file which includes the following data elements:

Each Line:

Column	Variable		Description	
1-5	PSTNO	=	Pesticide reference number.	
7-22	PSTN	=	Pesticide name abbreviation	
23-38	PSOL	=	Pesticide solubility in ppm.	
39-54	PHLS	=	Pesticide half-life in soil in days.	
55-70	PHLF	=	Pesticide half-life in foliage in days.	
71-86	PWOF	=	Pesticide wash off fraction.	
87-102	PKOC	=	Pesticide organic C absorption coefficient.	
103-118	PCST	=	Pesticide cost	$/kg
119-134	PCEM	=	Carbon emission per unit pesticide	kg/kg
136+	NAME	=	Full name of pesticide – this is optional and not read	

Multi-Run File (*MLRN0810.dat*)

An EPIC study may involve the analysis of consecutive weather seeds on wind and water erosion without reloading the model. That can be easily done with the multi-run option in EPIC. The simulation continues until a zero NBYR is encountered.

Line 1 et seq.:

Column	Variable		Description
1-4	NBYR	=	Number of years for second through the last simulation
5-8	I1	=	0 for normal erosion of soil profile
		=	1 for static soil profile erosion control practice factor
9-12	I2		Output code
		=	0 for annual watershed output
		=	1 for annual output
		=	2 for annual with soil table
		=	3 for monthly output
		=	4 for monthly with soil table
		=	5 for monthly with soil table at harvest
		=	6 for N days interval
		=	7 for soil table only n day interval
		=	8 for soil table only during growing season N day interval
		=	9 for N day interval during growing season
13-16	N2		Weather ID number – concatenated from following:
		=	1 Precipitation
		=	2 Temperature (max & min)
		=	3 Solar radiation
		=	4 Wind speed
		=	5 Relative humidity
			If any variables are input, precipitation must be included. Therefore, it is not necessary to specify N2 = 1 unless precipitation is the only input variable.

Parameter File (*PARM0810.dat*)

The *PARM0810.dat* file plays a very sensitive part in EPIC, because many coefficients of equations are maintained in that file. The equation coefficients should not be changed without first consulting the model developer. This file contains definitions of S-curve and miscellaneous parameters used in EPIC0810.

S-Curves

An S shaped curve is used to describe the behavior of many processes in EPIC. The Y-axis is scaled from 0-1 to express the effect of a range in the X-axis variable on the process being simulated. The S-curve may be described adequately by two points contained in this file. It is convenient to represent the X and Y coordinates of the two points with two numbers contained in this file. The numbers are split by EPIC (the X value is left of the decimal and the Y value is right of the decimal). The two points are contained in an array called SCRP.

To illustrate the procedure consider the two SCRP values in the first line of the *PARM0810.dat* file (90.05,99.95). SCRP(1,1)=90.05, SCRP(1,2)=99.95. When split we have X1=90. Y1=0.05; X2=99. Y2=0.95. EPIC uses these two points to solve the exponential equation for two parameters that guarantee the curve originates at zero, passes through the two given points, and Y approaches 1.0 as X increases beyond the second point. The form of the equation is Y=X/[X+exp(B1-B2*X)] where B1 and B2 are the EPIC determined parameters.

S-Curve parameter definitions: (2 fields of 8 columns – 30 lines)

Point 1	Point 2	Description
SCRP1(1)	SCRP2(1)	Expresses the effect of soil course fragment content on (N=1,2) plant root growth restriction. X = % course fragment.
SCRP1(2	SCRP2(2)	Governs soil evaporation as a function of soil depth. X = soil depth (mm)
SCRP1(3)	SCRP2(3)	Drives harvest index development as a function of crop Maturity. X = % of growing season.
SCRP1(4)	SCRP2(4)	NRCS runoff curve number soil water relationship. Exception to normal S-curve procedure; soil water fractions taken from SCRP(30,N) to match with CN2 and CN3 (average and wet condition runoff curve numbers).
SCRP1(5)	SCRP2(5)	Estimates soil cover factor used in simulating soil temperature. X = total above ground plant material dead and Alive.
SCRP1(6)	SCRP2(6)	Settles after tillage soil bulk density to normal value as a Function of rainfall amount, soil texture, and soil depth. X = rainfall (mm) adjusted for soil texture and depth.
SCRP1(7)	SCRP2(7)	Determines the root growth aeration stress factor as a function Of soil water content and the critical aeration factor For the crop. X = soil water-critical aeration factor.
SCRP1(8)	SCRP2(8)	Determines the plant stress caused by N or P deficiency. X = % of optimal n or P content present in plant.

SCRP1(9)	SCRP2(9)	Calculates the pest damage factor as a function of temperature and relative humidity, considering thresholds for 30-day rainfall and above ground plant material. X = sum of Product of daily average temperature and relative humidity.
SCRP1(10)	SCRP2(10	Calculates the effect of water stress on harvest index as a Function of plant water use. X = plant water use as a % of Potential plant water use during critical period.
SCRP1(11)	SCRP2(11)	Estimates plant water stress as a function of plant available Water stored. X = soil water stored divided by total Plant available water storage (FC-WP).
SCRP1(12)	SCRP2(12)	Governs N volatilization as a function of soil depth. X = Depth at the center of a soil layer (mm).
SCRP1(13)	SCRP2(13)	Calculates wind erosion vegetative cover factor as a function of above ground plant material. X = vegetative equivalent (C1*BIOM+C2*STD+C3*RSD), where C1, C2 & C3 are coefficients, BIOM is above ground biomass, STD is standing dead plant residue, and RSD is flat residue.
SCRP1(14)	SCRP2(14)	Calculates soil temperature factor used in regulating microbial Processes. X = soil temperature (deg C).
SCRP1(15)	SCRP2(15)	Expresses plant population effect on epic water erosion cover factor. X = plant population (plants/m^2).
SCRP1(16)	SCRP2(16)	Increases snow melt as a function of time since the last snow fall. X = time since the last snowfall (d)
SCRP1(17)	SCRP2(17)	Estimates the snow cover factor as a function of snow present X = snow present (mm water)
SCRP1(18)	SCRP2(18)	Expresses soil temperature effect on erosion of frozen soils. X = temperature of second soil layer (deg C).
SCRP1(19)	SCRP2(19)	Drives water table between maximum and minimum limits as a function of ground water storage. X = % of maximum ground water storage.
SCRP1(20)	SCRP2(20)	Simulates oxygen content of soil as a function of depth. Used in microbial processes of residue decay. X = depth to center of each soil layer (m)
SCRP1(21)	SCRP2(21)	Governs plant water stress as a function of soil water tension. X = gravimetric + osmotic tension.
SCRP1(22)	SCRP2(22)	Not used
SCRP1(23)	SCRP2(23)	Estimates fraction plant ground cover as a function of LAI. X = LAI.
SCRP1(24)	SCRP2(24)	Simulates oxygen content of soil as a function of C and clay. Used in microbial processes of residue decay. X = F(C/clay)
SCRP1(25)	SCRP2(25)	Regulates denitrification as a function of soil water content. X=(ST-FC)/(PO-FC).
SCRP1(26)	SCRP2(26)	Estimates plant ground cover as a function of standing Live biomass. X = standing live biomass (T/ha).
SCRP1(27)	SCRP2(27)	Not used
SCRP1(28)	SCRP2(28)	Not used
SCRP1(29)	SCRP2(29)	Not used

SCRP1(30)	SCRP2(30)	**Exception** to normal S-Curve procedure – **sets soil water contents** coinciding with CN2 and CN3. X1 = soil water content as % of field capacity – wilting point X2 = soil water content as % of saturation – field capacity. NOTE THIS PARAMETER DOES NOT FOLLOW THE SAME X,Y FORMAT AS THE OTHER PARAMETERS. IN THIS CASE Y IS ALWAYS 0. EXAMPLE: X1 = 45.00; this indicates that CN2 is 45% of the volume between field capacity and wilting point → (0.45*(FC-WP) + WP). X2 = 10.00; this indicates that CN3 is 10% of the volume between saturation and field capacity → (0.10*(SAT-FC) + FC).

Parameter Definitions: (10 fields of 8 columns – 11 lines)

PARM	Definition, Units and/or Range.
1	Crop canopy - PET factor used to adjust crop canopy resistance in the Penman - Monteith PET equation. (Range: 1 - 2).
2	Root growth - soil strength. Normally 1.15 < PARM(2) <1.2. Set to 1.5 to minimize soil strength constraint on root growth. PARM(2) > 2 eliminates all root growth stress. (Range: 1 - 2).
3	Water stress - harvest index (0 - 1) sets fraction of growing season when water stress starts reducing harvest index. (Range:0 - 1).
4	Denitrification rate constant limits daily denitrification loss from each soil layer. (Range: 0.1 - 5).
5	Soil water lower limit of water content in the top 0.5 m soil depth expressed as a fraction of the wilting point water content. (Range: 0 - 1).
6	Winter dormancy (h) causes dormancy in winter grown crops. Growth does not occur when day length is less than annual minimum day length + PARM(6). (Range: 0 - 1). NOTE This parm can cause problems at sites close to the equator where day length variation is very small
7	Nitrogen fixation is limited by soil water or nitrate content or by crop growth stage. At 0 fixation meets crop n uptake demand. A combination of the 2 fixation estimates is obtained by setting 0 < PARM(7) < 1. (Range: 0 - 1).
8	Soluble P runoff coefficient. ($0.1*m^3/t$). P concentration in sediment divided by that of the water. (Range: 10 - 20)
9	Pest damage moisture threshold (mm), previous 30 - day rainfall minus runoff. (Range: 25 - 150). One of several parameters to regulate pest (insect & disease) growth; see also parm 10, PSTX in the control file, PST in the crop file & SCRP (9).
10	Pest damage cover threshold, (t/ha), crop residue + above ground biomass. This is the amount of cover required for pests to begin to grow. (Range: 1 - 10 Setting parm 10 at a large number (50) will result in little or no pest growth because it will be impossible to reach such high levels of cover. One of several parameters used to regulate pest growth. See also parm 9, PSTX in the control file, PST in the crop file and SCRP (9))

11	Moisture required for seed germination, (mm), soil water stored minus wilting point storage in the plow depth (plow layer depth = parm(43)). If the amount of moisture in the plow layer is not equal to or greater than Parm 11, germination will not occur. Setting this parm to a negative number (such as - 100) essentially turns this parm off and the seed will germinate regardless of moisture amount in the soil (Range: 10 - - 30)
12	Soil evaporation coefficient, governs rate of soil evaporation from top 0.2 m of soil. (Range: 1.5 - 2.5)
13	Hargreaves PET equation exponent. Original value = 0.5. Modified to 0.6 to increase PET. (Range: 0.5 - 0.6)
14	Nitrate leaching ratio, Ratio of nitrate concentration in surface runoff to nitrate concentration in percolate. (Range: 0.1 - 1)
15	Runoff CN Residue Adjustment Parameter. Increases runoff for crop residue, RSD < 1.0 t/ha and decreases for RSD > 1.0 t/ha. (Range: 0.0 - 0.3)
16	Plow layer depth (m) used to track soluble phosphorus concentration or weight, organic carbon, and soil water content.
17	Crack flow coefficient. Fraction inflow partitioned to vertical crack or pipe flow (Range: 0 - 0.5).
18	Pesticide leaching ratio Ratio of pesticide concentration in surface runoff to pesticide concentration in percolation. (Range: 0.1 - 1)
19	Fraction of maturity at spring growth initiation allows fall growing crops to reset heat unit index to a value greater than 0 when passing through the minimum temperature month. (Range: 0 - 1)
21	KOC for carbon loss in water and sediment; KD = KOC * C. (Range: 500. - 1500)
22	K pool flow coefficient regulates flow between exchangeable and fixed k pools. (Range: 0.00001 - 0.0005)
23	Exponential coefficient in RUSLE C residue factor equation used in estimating the residue effect. (Range: 0.01 - 0.5)
24	Maximum depth for biological mixing (m) (Range: 0.1 - 0.3).
25	Biological mixing efficiency simulates mixing in top soil by earth worms etc. (Range: 0.1 - 0.5)
26	Exponential coefficient in RUSLE C live plant factor equation used in estimating the effect of growing plants. (Range: 0.01 - 0.2)
27	Lower limit nitrate concentration maintains soil nitrate concentration at or above PARM(27). (Range: 0 - 10.)
28	Acceptable plant N stress level used to estimate annual N application rate as part of the automatic fertilizer scheme. (Range: 0 – 1)
29	K pool flow coefficient regulates flow between soluble and exchangeable K pools. (Range: 0.001 - 0.02)
30	Denitrification soil - water threshold fraction of field capacity soil water storage to trigger denitrification. (Range: 0.9 - 1.1)
31	Furrow irrigation sediment routing exponent. Exponent of water velocity function for estimating potential sediment concentration. (Range: 1 - 1.5)
32	Minimum C factor value in EPIC soil erosion equation (Range: 0.0001 - 0.8).
33	Puddling saturated conductivity (mm/h) simulates puddling in rice paddies by setting second soil layer saturated conductivity to a low value. (Range: 0.00001 - 0.1)

34	Soluble P runoff exponent modified GLEAMS method makes soluble P runoff concentration a nonlinear function of organic P concentration in soil layer 1. (Range: 1 - 1.5)
35	Water stress weighting coefficient; at 0 plant water stress is strictly a function of soil water content; at 1 plant water stress is strictly a function actual ET divided by potential ET. 0 < PARM(35) < 1 considers both approaches. (Range: 0.0 - 1.0).
36	Furrow irrigation base sediment concentration (T/m^3) potential sediment concentration when flow velocity = 1 (m/s). (Range: 0.01 - 0.2)
37	Pest kill scaling factor scales pesticide kill effectiveness to magnitude of pest growth index. (Range: 100 - 10000)
38	Hargreaves PET equation coefficient; original value = 0.0023, modified to 0.0032 to increase PET. (Range; 0.0023 - 0.0032)
39	Auto N fertilizer scaling factor sets initial annual crop N use considering WA & BN3. (Range: 50 - 500)
40	Crop growth climatic factor adjustment (c/mm) ratio of average annual precipitation / temperature PARM(40) = 0.0 (recommended) or irrigation > 0 sets CLF = 1. (Range: 40 - 100)
41	Soil evaporation – plant cover factor. Reduces effect of plant cover as related to LAI in regulating soil evaporation. (Range: 0.00 - 0.5)
42	NRCS curve number index coefficient regulates the effect of PET in driving the NRCS curve number retention parameter. (Range: 0.5 - 1.5)
43	Upward movement of soluble P by evaporation coefficient (Range: 1.0 - 20.0).
44	Ratio of soluble C concentration in runoff to percolate (Range: 0.1 - 1.0).
45	Coefficient in century equation allocating slow to passive humus; original value = 0.003. (Range: 0.001 - 0.05)
46	Auto fertilizer weighting factor ; 0.0 sets N application = average annual N in crop yield. 1.0 uses N stress function to set N application. The two methods are weighted with Parm(46) for values between 0.0 and 1.0. (Range: 0.0 - 1.0)
47	Century slow humus transformation rate (D** - 1) original value = 0.000548. (Range: 0.00041 - 0.00068)
48	Century passive humus transformation rate (D** - 1); original value = 0.000012. (Range: 0.0000082 - 0.000015)
49	Fraction of above ground plant material burned. Burning operation destroys specified fraction of above ground biomass, and standing and flat residue. (Range: 0 - 1.)
50	Technology annual rate coefficient. Linear adjustment to harvest index – base year = 2000. Set to 0. For level technology. Increase to increase technology effect on crop yield. (Range: 0.0 - 0.01)
51	Coefficient in oxygen equation used in modifying microbial activity with soil depth. See also SCRP(20). (Range: 0.8 - 0.95)
52	Exponential coefficient in equation expressing tillage effect on residue decay rate (Range: 5 – 15)
53	Coefficient in oxygen equation used in modifying microbial activity with soil depth (0.8 – 0.95)
54	Exponential coefficient in potential water use root growth distribution equation (Range: 2.5 - 7.5).

55	Coefficient used in allocating root growth between two functions = 0.0 root growth exponential distribution of depth = 1.0 root growth function of water use; values between 0.0 and 1.0 weight the two functions. (Range: 0.0 - 1.0)
56	Exponential coefficient in root growth distribution by depth function (Range: 5. - 10.).
57	Volatilization/nitrification partitioning coefficient. Fraction of process allocated to volatilization. (Range: 0.05 - 0.5)
58	Runoff amount to delay pest application (mm) pesticide is not applied on days with runoff greater than PARM(58). (Range: 0.0 - 25.0)
59	Soil water value to delay tillage tillage delayed when PDSW/FCSW > PARM(59). PDSW = Plow depth soil water content; FCSW = Field capacity soil water content. (Range: 0.0 - 1.0)
60	Exponential coefficient in EPIC soil erosion C factor equation relates C factor to soil cover by flat and standing residue and growing biomass. (Range: 0.5 - 2.0)
61	Weighting factor for estimating soil evaporation at 0 total compensation of water deficit is allowed between soil layers. At 1.0 no compensation is allowed. 0 < PARM(61) < 1.0 gives partial compensation. (Range: 0.0 - 1.0)
62	Exponential coefficient regulates upward N movement by evaporation. Increasing PARM(62) increases upward N movement. (Range: 0.2 - 2.0)
63	Upper limit of N concentration in percolating water (ppm) (Range: 100 - 10000).
64	Upper limit of nitrification - volatilization as a fraction of NH_3 present (Range: 0.0 - 1.0).
65	Reduces NRCS runoff CN retention PARM for frozen soil fraction of S frozen soil. Reduce to increase runoff from frozen soils. (Range: 0.05 - 0.5)
66	Converts standing dead residue to flat residue. Daily fall rate as a fraction of standing live (STL). (Range: 0.0001 - 0.05).
67	Wind erosion threshold wind speed. (Normal value: 6.0; Range:4.0 - 10.0).
68	N fixation upper limit (kg/ha/d) (Traditional value: 20.0; Range: 1.0 - 30.0).
69	Heat unit adjustment at harvest replaces setting back to 0.0 or to a fraction set by harvest index (Range: 0.0 - 1.0).
70	Power of change in day length component of LAI growth equation. Causes faster growth in spring and slower growth in fall. (Traditional value: 3.0; Range: 1.0 - 10.).
71	RUSLE 2 transport capacity parameter. Regulates deposition as a function of particle size and flow rate. (Range: 0.001 - 0.1)
72	RUSLE 2 Threshold transport capacity coefficient. Adjusts threshold (flow rate * slope steepness). (Range: 1.0 - 10.0)
73	Upper limit of curve number retention parameter S. SUL = PARM(73)*S1 allows CN to go below CN1. (Range: 1.0 - 2.0)
74	Penman - Monteith adjustment factor adjusts PM PET estimates. (Range: 0.5 - 1.5)
75	Runoff CN residue adjustment parameter. Increases runoff for RSD<1.0 t/ha; decreases for RSD>1.0.(Range: 0.0 - 0.3)
76	Harvest index adjustment for fruit and nut trees. Reduces yield when crop available soil water is less than PARM (76). (Range: 100 - 1500)
77	Coefficient regulating p flux between labile and active pool. RMN = PARM(77)*(WPML(ISLl) - WPMA(ISL)*RTO). (Range: 0.0001 - 0.001)

78	Coefficient regulating p flux between active and stable pool. ROC = PARM(78)*BK(ISL)*4.*WPMA(ISL) - WPMS(ISL). (Range: 0.0001 - 0.001)
79	Weighting factor for locating appropriate weather stations. (1 gives strictly distance; 0 gives strictly elevation. Recommended value 0.9; Range: 0.0 - 1.0)
80	Partitions N_2 and N_2O. N2 fraction of denitrification in original EPIC denitrification function. (Range: 0.1 - 0.9)
81	Weights the effect of TMX - TMN and RAD on soil temperature. Large values reduce the effect of TMX - TMN and RAD relative to TX. (Range: 5.0 - 20.0)
82	Damping depth adjustment for soil temperature. Regulates soil temperature change with depth (Range: 0.0 - 2.0)
83	Runoff volume adjustment for direct link (NVCN=0). Inversely related to runoff. Used like PARM(42) in CN index method (NVCN=4). (Range: 0.1 - 2.0)

Print File (*PRNT0810.dat*)

The file PRNT0810.DAT controls printing of output (see also IPD in *EPICCONT.DAT*): The user can select output variables from the following lists. The simulated output and summary files are numerous and some output variables are repeated in several files (see KFL below).

Line	Variable		Description
1-5	KA		Output variable ID (accumulated and average values) Select up to 100 variables by number from Table 3 Right justified, 4 spaces each, 20 per line.
6	JC		Output variable ID (concentration variables). Select up to 4 variables from Table 3 Right justified, 4 spaces each, 20 per line
7-8	KS		Output variable ID (monthly state variables). Select up to 40 variables from this list (input number) Right justified, 4 spaces each, 20 per line Enter -1 to omit all accumulated variables
9-10	KD		Output variable ID (daily output variables). Select up to 40 variables by number from Table 3 Right justified, 4 spaces each, 20 per row
11-12	KY		Annual output variable ID (accumulated and average values) Select up to 40 variables by number from Table 3 Right justified, 4 spaces each, 20 per row Enter -1 to omit all accumulated variables
13-14	KFS		Monthly variables for Flipsim economic analysis
15-16	KF	=	0 gives no output
		>	0 gives output for selected files; there are 35 possible output files These lines have 20 right justified variables of 4 spaces each. For a desired file, enter a 1 in the appropriate variable space. For example: 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 prints files # 1, 9, 16, and 20 from Table 2. File names are runname.* where runname refers to run # (ASTN) and * is the filename extension.

Table 2: Output Files

File	Name		Description
1	**.OUT**	=	Standard output file
2	**.ACM**	=	Annual cropman file
3	**.SUM**	=	Average annual summary
4	**.DHY**	=	Daily hydrology
5	**.DPS**	=	Daily pesticide
6	**.MFS**	=	Monthly flipsim
7	**.MPS**	=	Monthly pesticide
8	**.ANN**	=	Annual summary
9	**.SOT**	=	Ending soil table
10	**.DTP**	=	Daily soil temperature
11	**.MCM**	=	Monthly cropman
12	**.DCS**	=	Daily crop stress
13	**.SCO**	=	Summary operation cost
14	**.ACN**	=	Annual soil organic C & N table
15	**.DCN**	=	Daily soil organic C & N table
16	**.SCN**	=	Organic C & N summary table
17	**.DGN**	=	Daily general table
18	**.DWT**	=	Daily soil water in control section and 0.5m soil table
19	**.ACY**	=	Annual crop yield
20	**.ACO**	=	Annual cost
21	**.DSL**	=	Daily soil table
22	**.MWC**	=	Monthly water cycle & N cycle
23	**.ABR**	=	Annual biomass root weight
24	**.ATG**	=	Annual tree growth
25	**.MSW**	=	Monthly output to SWAT
26	**.APS**	=	Annual pesticide
27	**.DWC**	=	Daily water cycle
28	**.DHS**	=	
29	**.R84**	=	
30	**.APP**		
31	**.RTS**		
32	**.DBG**		
33	**.MBG**		
34	**.ABG**		
35	**.DSV**		

Table 3: List of Output Variables the User can choose from.

#	Name	Description	Units
1	TMX	Maximum temperature	°C
2	TMN	Minimum temperature	°C
3	RAD	Solar radiation	MJ/m2
4	PRCP	Precipitation	mm
5	SNOF	Snow fall	mm
6	SNOM	Snow melt	mm
7	WSPD	Wind velocity	m/s
8	RHUM	Relative humidity	
9	VPD	Vapor pressure deficit	kPa
10	PET	Potential evaporation	mm
11	ET	Evapotranspiration	mm
12	PEP	Potential transpiration	mm
13	EP	Transpiration	mm
14	Q	Annual surface runoff	mm
15	CN	SCS runoff curve number	
16	SSF	Lateral subsurface flow	m
17	PRK	Percolation below the root zone	mm
18	QDRN	Flow from a drainage system	mm
19	IRGA	Irrigation water applied	mm
20	QIN	Inflow to the root zone from the water table	mm
21	TLGE	Lagoon evaporation	mm
22	TLGW	Water wash to lagoon	mm
23	TLGQ	Runoff to lagoon	mm
24	TLGF	Lagoon overflow	mm
25	LGIR	Irrigation water from a lagoon	mm
26	LGMI	Manure input to lagoon	kg/ha
27	LGMO	Manure output from lagoon	kg/ha
28	EI	Rainfall energy factor	
29	CVF	Average water erosion/crop management factor	
30	USLE	Soil loss from water erosion using USLE	T/ha
31	MUSL	Soil loss from water erosion using MUSLE	T/ha
32	AOF	Soil loss from water erosion using Onstad-Foster	T/ha
33	MUSS	Soil erosion-water	T/ha
34	MUST	Soil loss from water erosion using modified MUSLE	T/ha

35	RUS2	Soil loss from water erosion using RUSLE2	T/ha
36	RUSL	Soil erosion by water estimated with RUSLE	T/ha
37	RUSC	Soil erosion by water estimated with Modified RUSLE	T/ha
38	WK1	Wind erosion soil erodibility factor	
39	RHTT	Ridge Height	mm
40	RRUF	Random roughness of soil	
41	RGRF	Wind erosion ridge roughness factor	
42	YW	Soil erosion by wind	T/ha
43	YON	Nitrogen transported from area in sediment	kg/ha
44	QNO3	Nitrogen in runoff	kg/ha
45	SSFN	Mineral Nitrogen lost in the horizontal movement of water in the soil	kg/ha
46	PRKN	Mineral Nitrogen loss in percolate	kg/ha
47	NMN	Nitrogen mineralized from stable organic matter	kg/ha
48	GMN	Nitrogen mineralized	kg/ha
49	DN	Nitrogen loss by denitrification	kg/ha
50	NFIX	Nitrogen fixed by leguminous crops	kg/ha
51	NITR	Nitrification	kg/ha
52	AVOL	Nitrogen volatilization	kg/ha
53	DRNN	Soluble Nitrogen in drainage outflow`	
54	YP	Phosphorus loss with sediment	kg/ha
55	QAP	Phosphorus in runoff	kg/ha
56	MNP	Phosphorus mineralized	kg/ha
57	PRKP	Phosphorus loss in percolate	kg/ha
58	ER	Enrichment ratio	mm
59	FNO	Organic Nitrogen fertilizer (manure)	kg/ha
60	FNO3	Nitrate Nitrogen fertilizer	kg/ha
61	FNH3	Ammonium Nitrogen fertilizer	kg/ha
62	FPO	Organic Phosphorus fertilizer (manure)	kg/ha
63	FPL	Mineral Phosphorus fertilizer (labile)	kg/ha
64	FSK	Potassium fertilizer applied	kg/ha
65	FCO	Organic Carbon fraction in fertilizer	
66	LIME	Limestone applied ($CaCO_3$ equivalent)	T/ha
67	TMP	Temperature in second soil layer	°C
68	SW10	Ratio soil water/wilting point in top 10mm	
69	SLTI	Salt in irrigation water	kg/ha
70	SLTQ	Salt in runoff	kg/ha

71	SLTS	Salt in lateral subsurface flow	kg/ha
72	SLTF	Salt in fertilizer	kg/ha
73	RSDC	Carbon contained in crop residue	kg/ha
74	RSPC	CO2 respiration	kg/ha
75	CLCH	Soluble Carbon leached	kg/ha
76	CQV	Carbon in runoff	
77	YOC	Carbon loss with sediment	kg/ha
78	YEFK		
79	QSK	Soluble Potassium in surface runoff	kg/ha
80	SSK	Potassium in subsurface flow	kg/ha
81	VSK	Potassium in percolate	kg/ha
82	SLTV	Salt percolated out of root zone	kg/ha
83	MUSI	Soil erosion by water estimated with Modified MUSLE	T/ha
84	IRDL	Irrigation distribution loss	mm
85	HMN	Nitrogen mineralized from stable organic matter	kg/ha
86	RNAD		
87	NIMO		
88	FALF	Leaf fall	kg/ha
89	DN2	Loss of dinitrogen gas	kg/ha
90	RLSF		
91	REK		
92	FULU	Fuel use	L/ha
93	DN2O	Nitrous oxide loss	kg/ha
94	FO2	Surface flux of O2	kg/ha
95	FCO2	Surface flux of CO2	kg/ha
96	CFEM	Carbon emission	kg/ha
97	BURC	Carbon loss from burning crop residue or forest	kg/ha
98	BURN	Nitrogen loss from burning crop residue or forest	kg/ha
99	NPPC		
100	SSFP	Soluble Phosphorus in subsurface flow	kg/ha
101	DRNP	Soluble Phosphorus loss through drainage system	kg/ha

Output File Variable Definitions

.ABR - Annual Biomass Root Weight

Variable		Description	Units
Y	=	Year	
Y#	=	Year sequence #	
M	=	Month	
D	=	Day	
CROP	=	Crop name	
BIOM	=	Biomass	T/ha
RWT	=	Root weight in layer Repeated 10 times for 10 soil layers at depth in mm	T/ha
TOT	=	Total root weight	T/ha

.ACM - Annual Cropman

Variable		Description	Units
Y	=	Year	
RT#	=	Rotation number	
PRCP	=	Precipitation	mm
ET	=	Potential evapotranspiration	mm
ET	=	Evapotranspiration	mm
Q	=	Runoff	mm
SSF	=	Subsurface flow	mm
PRK	=	Percolation	mm
CVF	=	MUSLE crop cover factor	
MUSS	=	Water erosion	T/ha
YW	=	Wind erosion	T/ha
GMN	=	N mineralized	kg/ha
NMN	=	Humus mineralization	kg/ha
NFIX	=	Nitrogen fixation	kg/ha
NITR	=	Nitrification	kg/ha
AVOL	=	Nitrogen volatilization	kg/ha
DN	=	Denitrification	kg/ha
YON	=	Nitrogen loss with sediment	kg/ha
QNO3	=	Nitrate loss in surface runoff	kg/ha
SSFN	=	Nitrogen in subsurface flow	kg/ha
PRKN	=	Nitrogen loss in percolate	kg/ha

MNP	=	Phosphorus mineralized	kg/ha
YP	=	Phosphorus loss in sediment	kg/ha
QAP	=	Labile phosphorus loss in runoff	kg/ha
PRKP	=	Phosphorus loss in percolate	kg/ha
LIME	=	Lime applied	kg/ha
OCPD	=	Organic carbon in plow layer depth set by PARM(16)	kg/ha
TOC	=	Organic carbon in soil profile	kg/ha
APBC	=	Labile phosphorus content in plow layer	%
TAP	=	Total labile p in soil profile	kg/ha
TNO3	=	Total nitrate in soil profile	kg/ha

.ACN - Annual Soil Organic Carbon & Nitrogen Table

Variable		Description	Units
DEPTH	=	Depth of layer	m
BD33	=	Bulk density at 33 kPa	T/m^3
SAND	=	% Sand	%
SILT	=	% Silt	%
CLAY	=	% Clay	%
ROCK	=	% Rock	%
WLS	=	Structural litter	%
WLM	=	Metabolic litter	kg/ha
WLSL	=	Lignin content of structural litter	kg/ha
WLSC	=	Carbon content of structural litter	kg/ha
WLMC	=	Carbon content of metabolic litter	kg/ha
WLSLC	=	Carbon content of lignin of structural litter	kg/ha
WLSLNC	=	Nitrogen content of lignin of structural litter	kg/ha
WBMC	=	Carbon content of biomass	kg/ha
WHSC	=	Carbon content of slow humus	kg/ha
WHPC	=	Carbon content of passive humus	kg/ha
WOC	=	Organic carbon concentration	%
WLSN	=	Nitrogen content of structural litter	kg/ha
WLMN	=	Nitrogen content of metabolic litter	kg/ha
WBMN	=	Nitrogen content of biomass	kg/ha
WHSN	=	Nitrogen content of slow humus	kg/ha
WHPN	=	Nitrogen content of passive humus	kg/ha
WON	=	Organic nitrogen concentration	%

.ACO - Annual Cost

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
OP	=	Tillage operation	
CROP	=	Crop name	
MT#	=	Fertilizer or pesticide number	
HC	=	Operation code	
EQ	=	Equipment number	
TR	=	Tractor number	
COTL	=	Cost of tillage operation	$/ha
COOP	=	Operation cost	$/ha
MTCO	=	Cost of fertilizer or pesticide operation	$/kg
MASS	=	Mass of fertilizer or pesticide applied	kg/ha

.ACY - Annual Crop Yield

Variable		Description	Units
Y	=	Year	
RT#	=	Fertilizer ID	
CPNM	=	Crop name	
YLDG	=	Grain yield	T/ha
YLDF	=	Forage yield	T/ha
BIOM		Biomass	T/ha
YLN	=	Nitrogen used by crop	kg/ha
YLP	=	Phosphorus used by crop	kg/ha
FTN	=	Nitrogen applied	kg/ha
FTP	=	Phosphorus applied	kg/ha
IRGA	=	Irrigation volume applied	mm
IRDL	=	Irrigation water lost in delivery system	mm
WUEF	=	Water use efficiency (crop yield / growing season ET)	kg/mm
GSET	=	Growing season et (mm)	mm
CAW	=	Crop available water (soil water at planting + growing season rainfall - runoff)	mm
CRF	=	Growing season rainfall	mm
CQV	=	Growing season runoff	mm
COST	=	Cost of production	$/ha

COOP	=	Operating cost	$/ha
RYLG	=	Return for grain yield	$/ha
RYLF	=	Return for forage yield	$/ha
PSTF	=	Pest damage factor (fraction of yield remaining after pest damage	
WS	=	Water stress days	d/yr
NS	=	Nitrogen stress days	d/yr
PS	=	Phosphorus stress days	d/yr
KS	=	Potassium stress days	d/yr
TS	=	Temperature stress days	d/yr
AS	=	Aeration stress days	d/yr
SS	=	Salinity stress factor	
PPOP	=	Plant population	plants/m^2
IPLD	=	Planting date	
IGMD	=	Germination date	
IHVD	=	Harvest date	

.ANN - Annual Water Summary

Variable		Description	Units
RUN #			
YR	=	Year	
AP15	=	Labile p concentration in top soil to a depth set by PARM(16)	ppm
PRCP	=	Precipitation (mm)	mm
Q	=	Runoff (mm)	mm
MUST	=	Water erosion (MUST) (t/ha)	T/ha
MUSI	=	Water erosion (MUSI) (t/ha)	T/ha
SSF	=	Subsurface flow (mm)	mm
PRK	=	Percolation (mm)	mm
YOC	=	Carbon loss with sediment (kg/ha)	kg/ha

.APS - Annual Pesticide

Variable		Description	Units
YR	=	Year	
YR#	=	Year sequence	
Q	=	Runoff	mm
SSF	=	Subsurface flow	mm
PRK	=	Percolation	mm
QDRN	=	Drain tile flow	mm
Y	=	Sediment yield	T/ha

YOC	=	Carbon loss with sediment	kg/ha
		Variables repeated 10 times	
PSTN	=	Pesticide name	
PAPL	=	Pesticide applied	g/ha
PSRO	=	Pesticide in runoff	g/ha
PLCH	=	Pesticide in percolate from root zone	g/ha
PSSF	=	Pesticide in subsurface flow	g/ha
PDGF	=	Pesticide degradation from foliage	g/ha
PDGS	=	Pesticide degradation from soil	g/ha
PDRN	=	Pesticide in drainage system outflow	g/ha
CMX4D	=	Pesticide 4-day runoff	g/ha

.ATG - Annual Tree Growth

Variable		Description	Units
Y	=	Year	
Y#	=	Year sequence	
CROP	=	Crop name	
YLD	=	Yield	T/ha
BIOM	=	Biomass	T/ha
RWT	=	Root weight	T/ha
LAI	=	Leaf area index	
STD	=	Standing dead crop residue	T/ha

.DCN - Daily Soil Organic Carbon & Nitrogen Table

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
		Table with the following variable lines and 11 across consisting of 10 soil layers and a total:	
Z		Depth	m
SW	=	Soil water	mm
TEMP	=	Soil temperature	°C
RSD	=	Crop residue	T/ha
CLOSS	=	CO_2 loss	kg/ha
NETMN	=	Net mineralization	kg/ha

.DCS - Daily Crop Stress

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
RT	=	#	
		The following variables are repeated 4 times:	
CPNM	=	Crop name	
WS	=	Water stress factor	
NS	=	Nitrogen stress factor	
PS	=	Phosphorus stress factor	
KS	=	Potassium stress factor	
TS	=	Temperature stress factor	
AS	=	Aeration stress factor	
SS	=	Salinity stress factor	

.DGN - Daily General Output

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
PDSW	=	Plow depth soil water content	mm
TMX	=	Maximum temperature	°C
TMN	=	Minimum temperature	°C
RAD	=	Solar radiation	mJ/m^2
PRCP	=	Precipitation	mm
TNO3	=	Total nitrate present in soil profile	kg/ha
WNO3	=	Nitrate content	kg/ha
PKRZ	=	Initial labile P concentration	g/ha
SS03	=	Nitrate in lateral subsurface flow	kg/ha
HUI	=	Heat unit index	
BIOM	=	Biomass	T/ha
YLDF	=	Forage yield	T/ha
UNO3	=	nitrogen uptake by the crop	kg/ha

.DHY - Daily Hydrology

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
CN	=	Curve number	
PRCP	=	Precipitation	mm
Q	=	Runoff	mm
TC	=	Time of concentration of the watershed	h
QP	=	Peak runoff rate	mm/h
DUR	=	Rainfall duration	h
ALTC	=	Maximum rainfall of duration tc / total storm rainfall	
AL5	=	Maximum 0.5 hour rainfall / total storm rainfall	

.DPS - Daily Pesticide

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
RT#	=	Pesticide number	
PAPL	=	Pesticide applied	g/ha
PSRO	=	Pesticide in runoff	g/ha
PLCH	=	Pesticide in percolate from root zone	g/ha
PSSF	=	Pesticide in subsurface flow	g/ha
PSED	=	Pesticide transported by sediment	g/ha
PDGF	=	Pesticide degradation from foliage	g/ha
PDGS	=	Pesticide degradation from soil	g/ha
PFOL	=	Pesticide on the plant foliage	g/ha
PSOL	=	Pesticide present in soil	g/ha
PDRN	=	Pesticide in drainage system outflow	g/ha
Q	=	Surface runoff	mm
SSF	=	Total subsurface flow	mm
PRK	=	Percolation	
ROCONC	=	Pesticide concentration in runoff	ppb

.DWC - Daily Water Cycle

Variable	Description	Units

Y	=	Year	
M	=	Month	
D	=	Day	
PRCP	=	Precipitation	mm
PET	=	Potential evapotranspiration	mm
ET	=	Evapotranspiration	mm
EP	=	Plant evaporation	mm
Q	=	Runoff	mm
SSF	=	Subsurface flow	mm
PRK	=	Percolation	mm
QDRN	=	Soluble nitrogen from drainage system	kg/ha
IRGA	=	Irrigation water	mm
QIN	=	Inflow for water table	mm
RZSW	=	Root zone soil water	mm
WTBL	=	Water table	mm
GWST	=	Groundwater storage	mm

.DWT - Daily Soil Water In Control Section And 0.5m Soil Table

Variable		Description	Units
Y#	=	Year sequence	
Y	=	Year	
M	=	Month	
D	=	Day	
SW1	=		
SW2	=		
TMP	=	Soil temperature at 0.5 meters	°C

.MCM - Monthly Cropman

Variable		Description	Units
Y	=	Year	
M	=	Month	
RT#	=		
CPNM	=	Crop name	
WS	=	Water stress factor	
NS	=	Nitrogen stress factor	
PS	=	Phosphorus stress factor	
KS	=	Potassium stress factor	
TS	=	Temperature stress factor	

AS	=	Aeration stress factor	
SS	=	Salinity stress factor	
RZSW	=	Root zone soil water	mm
PRCP	=	Precipitation	mm
ET	=	Evapotranspiration	mm
Q	=	Runoff	mm
PRK	=	Percolation	mm
SSF	=	Subsurface flow	mm

.MFS - Monthly Flipsim

Variable		Description	Units
Y	=	Year	
M	=	Month	
RT#	=		
PRCP	=	Precipitation (mm)	mm
PET	=	Potential evapotranspiration (mm)	mm
ET	=	Evapotranspiration (mm)	mm
EP	=	Plant evaporation (mm)	mm
Q	=	Runoff (mm)	mm
PRK	=	Percolation (mm)	mm
SSF	=	Subsurface flow (mm)	mm
QDRN	=	Soluble nitrogen from drainage system (kg/ha)	kg/ha
IRGA	=	Irrigation water (mm)	mm
QIN	=	Inflow for water table (mm)	mm
RZSW	=	Root zone soil water (mm)	mm
WTBL	=	Water table (mm)	mm
GWST	=	Groundwater storage (mm)	mm

.MSW - Monthly Output To Swat

Variable		Description	Units
Y	=	Year	
M	=	Month	
Q	=	Runoff	mm
Y	=	Sediment lost	T/ha
YN	=	Nitrogen lost in sediment	kg/ha
YP	=	Phosphorus lost in sediment	kg/ha
QN	=	Nitrogen lost in runoff	kg/ha
QP	=	Phosphorus lost in runoff	kg/ha

.MWC - Monthly Water & Nitrogen Cycle

Variable		Description	Units
Y	=	Year	
M	=	Month	
PRCP	=	Precipitation	mm
PET	=	Potential evapotranspiration	mm
ET	=	Evapotranspiration	mm
EP	=	Plant evaporation	mm
Q	=	Runoff	mm
SSF	=	Subsurface flow	mm
PRK	=	Percolation	mm
QDRN	=	Soluble nitrogen from drainage system	kg/ha
QIN	=	Inflow for water table	mm
RZSW	=	Root zone soil water	mm
WTBL	=	Water table	mm
GWST	=	Groundwater storage	mm
RNO3	=		
YON	=	Nitrogen loss with sediment	kg/ha
QNO3	=	Nitrate lost in runoff	kg/ha
SSFN	=	Nitrogen in subsurface flow	kg/ha
PRKN	=	Nitrogen in percolate	kg/ha
DN	=	Denitrification	kg/ha
AVOL	=	Nitrogen volatilization	kg/ha
HMN	=	Change in organic carbon caused by soil respiration	kg/ha
NFIX	=	Nitrogen fixation	kg/ha
FNO	=	Organic n fertilizer	kg/ha
FNO3	=	Nitrogen fertilizer nitrate	kg/ha
FNH3	=	Nitrogen fertilizer ammonia	kg/ha
UNO3	=	Nitrogen uptake by crop	kg/ha
YLN	=	Nitrogen in crop yield	kg/ha
CPMN	=	Crop name	
YLD	=	Yield	T/ha
TOTN	=	Total nitrogen fertilizer applied	kg/ha

.OUT - Standard Output File

Variable		Description	Unit
TMX	=	Max temperature	°C

TMN	=	Min temperature	°C
RAD	=	Solar radiation	mJ/m^2
PRCP	=	Rainfall	mm
SNOF	=	Snowfall	mm
SNOM	=	Snowmelt	mm
WSPD	=	Wind Speed	m/s
RHUM	=	Relative Humidity	%
VPD	=	Vapor Pres. Deficit	
PET	=	Potential ET	mm
ET	=	Evapotranspiration	mm
PEP	=	Potential plant evaporation	mm
EP	=	Plant evaporation	mm
Q	=	Runoff	mm
CN	=	SCS Curve Number	mm
SSF	=	Subsurface Flow	mm
PRK	=	Percolation	mm
QDRN	=	Drain Tile Flow	mm
IRGA	=	Irrigation	mm
QIN	=	Inflow for watertable	mm
TLGE	=	Lagoon evaporation	mm
TLGW	=	Water wash to lagoon	mm
TLGQ	=	Runoff to lagoon	mm
TLGF	=	Lagoon overflow	mm
LGIR	=	Irrigation volume from a lagoon	mm
LGMI	=	Manure input to lagoon	kg
LGMO	=	Manure output from lagoon	kg
EI	=	Rainfall energy	T/ha
CVF	=	MUSLE crop cover factor	
USLE	=	Water erosion (USLE)	T/ha
MUSL	=	Water erosion (MUSL)	T/ha
AOF	=	Onstad-Foster MUSLE	T/ha
MUSS	=	Water erosion (MUSS)	T/ha
MUST	=	Water erosion (MUST)	T/ha
MUSI	=	Water erosion (MUSI)	T/ha
RUSL	=	RUSLE soil loss estimate	T/ha
RUSC	=	RUSLE crop cover factor	
WKI	=	NO3 loss in runoff	kg/ha
RHTT	=	Ridge Height	m

RRUF	=	Surface Random Roughness	
RGRF	=	Wind erosion ridge roughness factor	
YW	=	Wind erosion	T/ha
YON	=	N loss with sediment	kg/ha
QNO3	=	Nitrate loss in surface runoff	kg/ha
SSFN	=	N in subsurface flow	kg/ha
PRKN	=	N leaching	kg/ha
NMN	=	Humus mineralization	kg/ha
GMN	=	N mineralized	kg/ha
DN	=	Denitrification	kg/ha
NFIX	=	Nitrogen fixation	kg/ha
NITR	=	Nitrification	kg/ha
AVOL	=	N volatilization	kg/ha
DRNN	=	Nitrogen in drain tile flow	kg/ha
YP	=	P loss with sediment	kg/ha
QAP	=	Labile P loss in runoff	kg/ha
MNP	=	P mineralized	kg/ha
PRKP	=	P in percolation	kg/ha
ER	=	Enrichment Ratio	
FNO	=	Organic N fertilizer	kg/ha
FNO3	=	N fertilizer nitrate	kg/ha
FNH3	=	N fertilizer ammonia	kg/ha
FPO	=	Organic P fertilizer	kg/ha
FPL	=	Labile P fertilizer	kg/ha
FSK	=	Soluble K fertilizer rate	kg/ha
FCO	=	Organic C content of fertilizer	kg/ha
LIME	=	Lime applied	kg/ha
TMP	=	Soil temperature in 2nd layer	°C
SW10	=	Soil water in top layer	mm
SLTI	=	Salt content of irrigation application	kg/ha
SLTQ	=	Salt content of runoff	kg/ha
SLTS	=	Salt content of lateral subsurface flow	kg/ha
SLTF	=	Salt content of fertilizer application	kg/ha
RSDC	=	Carbon content of crop residue	kg/ha
RSPC	=	Carbon respiration from residue decay	kg/ha
CLCH	=	C leached from soil profile	kg/ha
CQV	=	C lost with runoff	kg/ha
YOC	=	Carbon loss with sediment	kg/ha

YEFK	=	K lost with sediment	kg/ha
QSK	=	K lost with runoff	kg/ha
SSK	=	K lost with lateral subsurface flow	kg/ha
VSK	=	K leached from soil profile	kg/ha
SLTV	=	Salt leached from soil profile	kg/ha
IRDL	=	Irrigation water lost in delivery system	mm
HMN	=	Change in organic C caused by soil respiration	kg/ha
RNAD	=	N content of plant residue added to soil	kg/ha
NIMO	=	Immobilized N	kg/ha
FALF	=	Leaf fall from plant to soil surface	kg/ha

.SCN - Summary Soil Organic Carbon & Nitrogen Table

15 soil layers going across plus a total for the following variable lines

Variable		**Description**	**Units**
Z	=	Soil depth (m)	m
SWF	=	Soil water factor	
TEMP	=	Soil temperature	°C
SWTF	=	Combined soil water and temp factor	
TLEF	=	Tillage factor	
SPDM	=	N supply/demand	
RSDC	=	Carbon input in residue	kg/ha
RSPC	=	Carbon respiration from residue	kg/ha
RNMN	=	Net N mineralization	kg/ha
DN03	=	—	
HSCO	=	Initial slow humus C pool	kg/ha
HSCF	=	Final slow humus C pool	kg/ha
HPCO	=	Initial passive humus C pool	kg/ha
HPCF	=	Final passive humus C pool	kg/ha
LSCO	=	Initial structural litter C pool	kg/ha
LSCF	=	Final structural litter C pool	kg/ha
LMCO	=	Initial metabolic litter C pool	kg/ha
LMCF	=	Final metabolic litter C pool	kg/ha
BMCO	=	Initial biomass C pool	kg/ha
BMCF	=	Final biomass C pool	kg/ha
WOCO	=	Initial total C pool	kg/ha
WOCF	=	Final total C pool	kg/ha
DW0C	=	Change in total C pool	kg/ha
OBCF	=	Observed total C pool final	kg/ha

HSNO	=	Initial slow humus N pool	kg/ha
HSNF	=	Final slow humus N pool	kg/ha
HPNO	=	Initial passive humus N pool	kg/ha
HPNF	=	Final passive humus N pool	kg/ha
LSNO	=	Initial structural litter N pool	kg/ha
LSNF	=	Final structural litter N pool	kg/ha
LMNO	=	Initial metabolic litter N pool	kg/ha
LMNF	=	Final metabolic litter N pool	kg/ha
BMNO	=	Initial biomass N pool	kg/ha
BMNF	=	Final biomass N pool	kg/ha
WONO	=	Initial total N pool	kg/ha
WONF	=	Final total N pool	kg/ha
DWON	=	Change in total N pool	kg/ha
C/NO	=	Initial C/N ratio	
C/NF	=	Final C/N ratio	

.SCO - Summary Operation Cost

Variable		Description	Units
Y	=	Year	
M	=	Month	
D	=	Day	
OP	=	Tillage operation	
CROP	=	Crop name	
MT#	=	Fertilizer or pesticide number	
HC	=	Operation code	
EQ	=	Equipment number	
TR	=	Tractor number	
COTL	=	Cost of tillage operation ($)	$/ha
COOP	=	Operation cost ($)	$/ha
MTCO	=	Cost of fertilizer or pesticide operation ($)	$/ha
MASS	=	Mass of fertilizer or pesticide applied (kg/ha)	kg/ha

Output Analyzer

Failed runs

1. **Soil data (*.*sol*):**

   Missing essential data.

   Layer depths out of order.

   Curve number input instead of hydrologic soil group number (line 2).

2. **Operation schedule (*.*ops*):**

   Land use number not input (line 2).

   Format problems--data in wrong columns.

   Dates not in sequence.

3. **When daily weather is input:**

   Incorrect format.

Problems that may or may not cause failed run

1. **Soil data:**

   Inconsistent data.

   Bulk density/texture.

   Texture/plant available water.

   Organic C/N/P.

2. **Operation Schedule:**

   No kill after harvest of annual crop.

Problems that cause near 0 crop yield

1. **CO_2 = 0.**

2. **When daily weather is input:**

   Monthly and daily solar radiation units don't match

3. **Plant population = 0. (was not input at planting in *.*ops*)**

General problems

1. Working files don't match those contained in *EPICFILE.dat*

   For example you are working with *CROP0810. dat* and *EPICFILE. dat* contains *USERCROP. dat*.

2. When daily weather is input:

   The date must be input on the first line (year, month, day)--format is (2X, 3I4). The beginning simulation date in *EPICCONT.dat* must be equal or greater than the one appearing on line one of the weather file (**.wth*).

Completed runs--examine **.out* files

Select monthly output in *EPICCONT.dat* (IPD = 3).

Preliminary investigation

Check nutrient and water balances for each run (look for BALANCE). They should be near 0.

Check water balance for the entire watershed (TOTAL WATER BALANCE).

Check average annual surface runoff, water yield, and sediment and nutrient

Runoff problems--things to check

1. PET is not reasonable:

Try another PET eq that may be more appropriate for the site. Hargreaves is the most robust and can be adjusted by varying the coefficient (PARM(23)0.0023-0.0032) or the exponential (PARM(34) 0.5-0.6) in PARM0810.DAT. Penman-Monteith is generally considered the most accurate but is sensitive to wind speed which is subject to measurement errors. It can also be adjusted through the stomatal conductance coefficient (PARM(1)1.0-2.0) in PARM0810.DAT. The Baier-Robertson equation developed in Canada is a good choice in cold climates.

2. ET is not reasonable:

Crop growing season may be incorrect--check planting and harvest dates and potential heat units (*crg.ops*). Also check harvest time each year in *txbell.out* for the value of HUSC (look for CORN YLD=). HUSC should normally range from 1. to 1.2. If HUSC is < 1. PHU is too large or harvest date is too early. If HUSC is > 1.2 PHU is too small or harvest date is too late. For many annual crops the value of HUSC should be set to 1.2 using an early harvest date (*crg.ops*). Harvest can't occur until the input harvest date and then only after the accumulated heat units have reached the input HUSC value. Forage crops may be grazed too closely or cut too often to allow leaf area to develop properly for normal plant water use.

3. Check Runoff equations:

NRCS curve number equation:
The CN equation varies with soil water. EPIC has four different methods of linking CN and soil

water plus a constant CN option. The methods are:

1. Variable daily CN nonlinear CN/SW with depth soil water weighting.
2. Variable daily CN nonlinear CN/SW no depth weighting.
3. Variable daily CN linear CN/SW no depth weighting
4. Non-Varying CN--CN2 used for all storms.
5. Variable Daily CN SMI (Soil Moisture Index)

Generally the soil moisture index (5)is the most robust and reliable because it is not sensitive to errors in soil data. This method is adjustable using PARM(42) (PARM0810.DAT). PARM(42) usually is in the range 0.5-2.0 (small values reduce runoff). The nonlinear forms (1,2) also perform very well in many situations. The constant CN method (4) is a good choice when soil water is not a dominant factor.

Green and Ampt infiltration equation:

The G&A equation is available for use in special cases where CN is not performing well. The three variations of G&A are:

1. Rainfall intensity is simulated with a double exponential distribution and peak rainfall rate is simulated independently.
2. Same as (1) except peak rainfall rate is input.
3. Rainfall intensity is uniformly distributed and peak rainfall rate is input (useful in rainfall simulator studies).

4. Erosion/sedimentation problems:

1. Runoff must be realistic.
2. Crop growth must be realistic to provide proper cover and residue.
3. Tillage must mix residue with soil properly.
4. Erosion equations:

The USLE and five modifications are available. MUSLE, MUSS, and MUST usually give similar results and are appropriate for estimating sediment yield from small watersheds up to about 250 km^2. The USLE is an erosion equation that is useful in studies like assessing the effect of erosion on productivity.

5. Slope length and steepness factor:

Both USLE and RUSLE equations are available. RUSLE is preferred for steep slopes > 20%.

6. Crop growth:

In **.out* go to AVE ANNUAL CROP YLD and AVE STRESS DAYS. The stress days reveal the stresses that are constraining crop growth.

Root growth stresses of bulk density (BD) or aluminum saturation (ALSAT) can reduce crop yields greatly. Go to SOIL PHYSICAL DATA and check for unreasonably high BD. Go to SOIL CHEMICAL DATA and check for high aluminum saturation values > 90 caused by low pH <5. BD can be lowered by deep tillage or simply corrected if the data are erroneous. Aluminum saturation can be lowered by applying lime or by correcting erroneous pH data.

Water stress is the most common constraint to crop growth. Excessive PET or runoff estimates are major causes. Plant available water is another important limitation that causes water stress. Erroneous estimates of plant available water occur when field capacity or wilting point are incorrect. Soil water storage is particularly important in dry climates.

Nitrogen and Phosphorus stress is caused by low mineralization rates, inadequate fertilizer, or excessive leaching of N. Go to SOIL CHEMICAL DATA and examine organic N, P, and C. C/N should be near 10. N/P should be near 8. The mineralization rate can be increased by decreasing the number of years of cultivation at the beginning of simulation (*.*sol* line 3). Check N leaching in the last table (AVERAGE ANNUAL DATA) under QNO3. If large values relative to annual N fertilizer are found go to SUMMARY TABLE and look at PRKN and PRK. High percolation values (PRK) may result from low ET or runoff, low soil plant available water storage (FC -WP), or high saturated conductivity values. PRK is sensitive to the user choice to use manual irrigation applications of rigid amounts.

How to Validate Crop Yields

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN0810.DAT) and the pre-run results are of no interest, then open *.out and go to or find TOTAL WATER BALANCE. The applicable simulation results follow this section beginning with a new epic descriptive title. Likewise, use only the second set of results given in *.man. *.asa, *.asw, *.wss, *.msw, etc. files.

First, check the accuracy of soil depths if specific simulated yields are low-

To determine if soil depth and the important related water-holding capacity is curtailing a specific crop yield, open the *.acy file where both grain and forage yields are listed by crop. Data entry errors in the depth of soil data can be checked by opening the appropriate *.sol file and referring to the accumulated depth (m) of the last soil layer.

Second, check the accuracy of the heat units from planting to harvest

-After completing a run if automatic heat unit scheduling is not selected in EPICCONT.dat (line 1: IHUS), open the *.out file and find TOTAL WATER BALANCE, scroll down a few lines to the beginning of the appropriate simulation to SA(# ID). Scroll down until a HARV operation is found. This is a list of harvest operations in year 1 for each subarea. Scroll to the right to HUSC= for each crop harvested. If any HUSC values for a crop are outside the range of 0.9 to 1.1, scroll down to check following years. If all years are outside the range, check both the planting (above the harvest operations) and the harvest date for accuracy. If they are accurate to the best of your knowledge, then open the appropriate *.ops file(s) which contains the specific crop for which the heat units need adjusted. If HUSC in the **.out* file is less than 1.0, decrease the heat units at the planting operation and if greater than 1.0, increase the heat units.

If automatic heat unit scheduling **<u>is</u>** selected in *EPICCONT.dat* (line 1: IHUS), open the **.out* file and follow the same procedure as above except instead of changing the heat units, change either the plant or harvest date to result in a more optimum HUSC = approx. 1.0 in the **.out* file for the HARV operation.

Third, check the plant population for accuracy-

If a crop yield is too low, check the plant population in the **.ops* file. Correct to the best of your knowledge. Increasing (Decreasing) it will increase (lower) the simulated yield. Increasing plant population usually increases yield but not always—sometimes in very dry climates lower populations produce more yield.

Fourth, check plant stress levels if a crop yield is low-

To determine the cause of stress to biomass and root development from lack of water, nutrients, bulk density, excessive aluminum toxicity, or insufficient air for biomass or roots, open the *.out file and find TOTAL WATER BALANCE and then find AVE ANNUAL CROP YLD DATA. If the crop of interest is not in the first listing, scroll down to subsequent listings. Then scroll to the right of the screen and view the stress days for the crop. If a large number of days of N stress are observed, for example, open the **.ops* file(s) that contains the stressed crop(s) and add more N fertilizer; continue to do the same for the crop(s) with P stress, and if irrigation is being applied manually and water stress days are high, add more irrigations if appropriate. In contrast, if air stress days are high in either roots or biomass, reduce irrigation applications. Aluminum toxicity stress is usually a soil condition treated by adding lime (automatically applied if selected in the *.sub file, line 7). If soil bulk density causes root stress, check all *.sol file(s) for errors in the bulk density data entries for each subarea that produces the affected crop. Also, check PARM(2)—the original value is 1.15 but may need increasing to 1.5 for many cases to reduce bulk density stress. Setting PARM(2) to 2.0 eliminates all root stresses.

Fifth, check the leaf area index (MXLA)-

To determine if the leaf area setting is inadequate for optimum yields of a crop, open **.out* and find CROP PARAMETERS. Scroll down to a row indicating MXLA for the value of a low yielding crop and compare it with the value DMLA in line 1 of the *CROP0810.dat* file for the appropriate crop. In the Crop Parameters table each row with the same parameter name a different subarea. If the two leaf area indices are near equal and the crop yield is low, increase the index value in *CROP0810.dat*. DMLA is set at the maximum LAI that the crop can obtain under ideal conditions so it seldom needs increasing. MXLA the adjusted DMLA based on plant population can be increased by increasing population.

Sixth, revise the Harvest Index and Biomass-Energy Ratios-

If after the first five checks are completed and crop yields remain inaccurate, some basic crop parameters can be revised as a last resort. Normally these parameters are not to be revised, being accurate for crops in the U.S. They may need to be revised slightly for international use. In *CROP0810.dat*, the harvest index (HI) relates to the grain yield only as a ratio of the above-ground biomass. The higher the ratio, the more grain yield reported for a given level of biomass. Similarly, the biomass to energy ratio (WA) increases yields through biomass changes and, therefore, both grain and forage yields increase.

How to Validate Runoff, Sediment Losses & Sediment Losses

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in *MLRN0810.dat*) and the pre-run results are of no interest, then open **.out* and find TOTAL WATER BALANCE. The applicable simulation results follow this section beginning with a new EPIC descriptive title.

Likewise, use only the second set of results given in **.man*. **.asa*, **.asw*, **.wss*, **.msw*, etc. files.

TO CHECK THE ACCURACY OF SIMULATED RUNOFF/SEDIMENT LOSSES AND SEDIMENT LOSSES FOR THE WATERSHED OUTLET, open the **.asw* file for the yearly simulated losses and consult your EPIC0810 manual for the definitions of the column headings. If QTW values for the years being validated are unacceptable, usually YW will also be in error, follow the instructions below:

First, check land use values-

Correct runoff/sediment losses by checking the accuracy of estimated curve numbers that dictate runoff/sediment losses. This may be done by checking the land use number in line 2 (LUN) of each **.ops* file. If multiple crop rotations are used, simulated runoff/sediment losses accuracy will be enhanced if LUN is revised at planting and harvest of each crop by entering a value on the appropriate operation line.

Second, check hydrologic soil group values-

Correct runoff/sediment losses by checking the accuracy of the hydrologic soil group in line 2 (HSG) in each of the **.sol* files.

Third, check upland and chanel hydrology values-

Correct runoff/sediment losses by checking the hydrology of the subareas. Open the **.out* file and find HYDROLOGIC DATA which describes the channel and upland hydrology of each subarea. Note: check the accuracy of each subarea upland and channel slopes.

Fourth, check monthly and annual rainfall values-

Correct runoff/sediment losses by checking the simulated monthly and annual rainfall for the years being validated in the **.wss* file.

Fifth, check the saturated conductivity values for soils-

Correct runoff/sediment losses by checking the accuracy of the saturated conductivity values of each soil.

Sixth, check the accuracy of the erosion control practice factor-

Correct runoff/sediment losses by checking the accuracy of the erosion control practice factor in line 9 (PEC) of each **.ops* file.

Seventh, check the choice of water erosion equation-

For watershed analyses, sediment losses need to be indicated with the recommended choices of #3 (MUSS) or #0 (MUST).

Eighth, revise the method of calculating the daily adjusted curve numbers-

Revise the method of calculating daily adjusted curve numbers in line 2 of each **.sub* file. Usually #4 or #0 are recommended.

Nineth, revise the irrigation runoff ratios if irrigation operations are used-

Revise the global irrigation runoff ratio in line 8 of each **.sub* file or for individual irrigation applications, the runoff ratio may be entered on the line of the irrigation operation in each **.ops* file having irrigated crops.

NOTE: if automatic irrigation has been selected with a value = 0.0 in line 7 (NIRR) of each *.sub file that is irrigated, irrigation runoff will be significantly lower than when using rigid applications of the amounts indicated in the **.ops* files.

✓ **What type of runoff is in error,** Q, SSF, QRF, QDRN, or RTF?

If Q and/or QDRN are in error, follow the next twelve steps. If SSF, QRF, and RTF are in error, go to the next □ item.

First, check land use (curve number) values

Correct runoff/sediment losses by checking the accuracy of estimated curve numbers that dictate runoff/sediment losses. This may be done by checking the land use number in line 2 (LUN) of each *.ops file. If multiple crop rotations are used, simulated runoff/sediment losses accuracy will be enhanced if LUN is revised at planting and harvest of each crop by entering a value on the appropriate operation line. NOTE: Land use numbers may be substituted with curve numbers.

Second, check the saturated conductivity values for soils

Correct runoff/sediment losses by checking the accuracy of the saturated conductivity values of each soil in the *.sol files.

Third, check hydrologic soil group values

Correct runoff/sediment losses by checking the accuracy of the hydrologic soil group in line 2 (HSG) in each of the *.sol files. This value should be consistent with the % sand, % silt, and the residual % clay.

Fourth, check upland and channel hydrology values

Correct runoff/sediment losses by checking the hydrology of the subareas. Open the *.out file and find HYDROLOGIC DATA which describes the channel and upland hydrology of each subarea. Note: check the accuracy of each subarea upland and channel slopes.

Fifth, check monthly and annual rainfall values

Correct runoff/sediment losses by checking the simulated annual rainfall for the years being validated in the *.aws file. To determine the monthly average rainfall for the years simulated, open the *.wss file and again go to the second set of results to find the row with ―PRCP‖.

Sixth, check the accuracy of the erosion control practice factor

Correct runoff/sediment losses by checking the accuracy of the erosion control practice factor in line 9 (PEC) of each *.sub file.

Seventh, check the choice of water erosion equation

For watershed analyses, open *EPICCONT.dat*, line 5 (DRV), where sediment losses need to be indicated with the recommended choices of #3 (MUSS) or #0 (MUST).

Eighth, revise the method of calculating the daily adjusted curve numbers-

Revise the method of calculating daily adjusted curve numbers in line 2 of each *.sub file. Usually #4 or #0 are recommended. The choice made for a run can be checked by opening *.out and finding VARIABLE CN.

Nineth, revise the irrigation runoff ratios if irrigation operations are used

Revise the global irrigation runoff ratio in line 8 of each *.sub file or for individual irrigation applications, the runoff ratio may be entered on the line of the irrigation operation in each *.ops file having irrigated crops.

NOTE: if automatic irrigation has been selected with a value = 0.0 in line 7 (NIRR) of each *.sub file that is irrigated, irrigation runoff will be significantly lower than when using rigid applications of the amounts indicated in the *.ops files.

Tenth, revise the land uses

To check the accuracy of the land use by major land use category such as forest, grass, and crops, open the *.out file and find LAND USE SUMMARY. This listing provides the proportionate breakdown of the watershed into the land uses by crop or other use.

NOTE: Since runoff and erosion are highly correlated with cropland and its land condition (straight row, contoured, contoured and terraced), carefully verify the proportion of each crop in the watershed in this listing.

✓ **To check another runoff component: RTF**

Open *EPICCONT.dat* and determine the value of RFPO on line 4, fourth variable. If this is 0.0, change it to 0.01 or higher until you have validated RTF.

✓ **To check other runoff components: SSF and QRF-**

Open each *.sol file and determine the value for each layer of HCL, line 23. If this is 0.0, change it to 0.1 or higher until SSF and/or QRF are validated.

✓ **After validating runoff, check MUST or MUSS for accuracy**.

To validate erosion, adjust PARM(46) for a more accurate simulation of MUST/MUSS. Increasing PARM(46) increases the effect of crop residue and therefore reduces erosion.

Pesticide Fate – The GLEAMS Model

GLEAMS (Leonard et al., 1987) technology for simulating pesticide transport by runoff, percolate, soil evaporation, and sediment was added to EPIC. Pesticides may be applied at any time and rate to plant foliage or below the soil surface at any depth. When the pesticide is applied, there is a loss to the atmosphere. Thus the amount that reaches the ground or plants is expressed by the equation:

$$PAPE = PAPR*PAEF$$

where PAPE is the effective amount of pesticide applied in kg/ha
PAPR is the actual amount applied in kg/ha, and PAEF is an application efficiency factor.

To determine how much pesticide reaches the ground, the amount of ground cover provided by plants is estimated with the equation:

$$GC = (1.0 - erfc(1.33*LAI - 2.))/2.0$$

where GC is the fraction of the ground that is covered by plants
LAI is the leaf area index.

Therefore, the pesticide application is partitioned between plants and soil surface with the equations:

$$FP = GC*PAPE$$

$$GP = PAPE - FP$$

where FP is the amount of pesticide that is intercepted by plants
GP is the amount that reaches the ground

Pesticide that remains on the plant foliage can be washed off by rain storms. It is assumed that the fraction of pesticide that is potentially dislodgeable is washed off the plants once a threshold rainfall amount is exceeded. The model uses a threshold value of 2.5 mm and potential washoff fractions for various pesticides have been estimated (Leonard et al., 1987). The appropriate equations for computing washoff are:

$$WO = WOF*FP;\ RFV > 2.5\text{ mm}\quad WO = 0.0;\ RFV < 2.5\text{ mm}$$

where WO is the amount of pesticide washed off the plants by a rainstorm of RFV mm
WOF is the washoff fraction for the particular pesticide.

Washed off pesticide is added to GP and subtracted from FP. Pesticide on the plants and in the soil is lost from the system based on the decay equations:

$$GP = GPo*exp(-0.693/HLS)$$

$$FP = FPo*exp(-0.693/HLP)$$

where GPo and GP are the initial and final amounts of pesticide on the ground
FPo and FP are the initial and final amounts of pesticide on the plants
HLS is the half life for pesticide in the soil in days
HLP is the half life of the foliar residue in days.

Values of HLP and HLS have been established for various pesticides (Leonard et al., 1987).

Another way that pesticide can be lost is through leaching. The GLEAMS leaching component is used here with slight modification. The change is the amount of pesticide contained in a soil layer is expressed as a function of time, concentration, and amount of flow from the layer using the equation:

$$dGP/dt = PSQC*q$$

where GP is the amount of pesticide in the soil layer at time t
PSQC is the pesticide concentration in the water in g/t
q is the water flow rate through the layer in mm/hour

The total amount of pesticide contained in the soil layer is the sum of adsorbed and mobile phases:

$$GP = 0.01*PSQC*ST + 0.1*PSYC*BD$$

where ST is the amount of water stored in the soil layer in mm
PSYC is the concentration of adsorbed pesticide in g/t
BD is the soil bulk density in t/m**3

The ratio of the concentration of pesticide adsorbed to the concentration of pesticide in the water has been estimated for various pesticides (Leonard et al., 1987) and is expressed by the equation:

$$KD = PSYC/PSQC$$

where KD is the portioning constant in m**3/t

The value of KD is computed from the equation:

$$KD = KOC/OC$$

where KOC is the linear adsorption coefficient for organic carbon
OC is the fraction of organic carbon in the soil layer

Substituting equation (214) into equation (213) gives:

$$GP = 0.01*PSQC*ST + 0.1*PSQC*KD*BD$$

Solving equation (216) for PSQC gives:

$$PSQC = GP/(0.01*ST + 0.1*KD*BD)$$

Substituting PSQC from equation (217) into equation (212) yields:

$$dGP/dt = GP*q/(0.01*ST + 0.1*KD*BD)$$

Rearranging equation (218) and integrating gives the equation expressing the amount of pesticide as a function of the amount of water flowing through the zone:

$$GP = GPo*\exp(-QT/(0.01*ST + 0.1*KD*BD))$$

where GPo is the initial amount of pesticide in the soil layer in kg/ha
GP is the amount that remains after the amount of flow (QT) passes through the zone
ST is the initial water storage in mm.

To obtain the amount of pesticide leached by the amount of water QT, GP is subtracted from GPo using the equation:

$$PSTL = GPo * (1.0 – \exp(-QT/(0.01*ST + 0.1*KD*BD))$$

where PSTL is the amount of pesticide leached by QT.

The average concentration during the percolation of QT is:

$$PSTC = PSTL/QT$$

Since percolation usually starts before runoff, the vertical flow concentration is usually higher than that of the horizontal. The relative concentrations may be user specified with the parameter p24.

$$P24 = PCH/PCV$$

where P24 is a parameter ranging from near 0.0 to 1.0 (usually 0.5),
PCH is the horizontal concentration
PCV is the vertical concentration
PSTL is partitioned into vertical and horizontal components using the equation:

$$PSTL = PCV*QV + PCH*QH$$

Substituting equation (222) into equation (223) and solving for PCV gives:

$$PCV = PSTL / (QV+P24*QH)$$

$$PCH= P24 * PCV$$

Amounts of PSTL contained in runoff, lateral flow, quick return flow, and horizontal pipe flow are estimated as the products of the flow component and PCH. Percolation and vertical pipe flow loads are estimated similarly using PCV. The total amount of pesticide lost in the runoff is estimated by adding the soluble fraction computed with equations (220) – (224) to the amount adsorbed to the sediment. Pesticide yield from the adsorbed phase is computed with an enrichment ratio approach.

$$PSTY = 0.001 * PSYC * ER$$

where PSTY is the pesticide yield adsorbed to the sediment in kg/ha
Y is the sediment yield in t/ha
ER is the enrichment ratio (concentration of pesticide in the sediment divided by the pesticide concentration in the top 10 mm of soil), computed with equation (157)

The pesticide concentration in the soil is calculated by substituting (214) into (217) and solving for PSYC:

$$PSYC = KD*GP/(0.01*ST + 0.1*KD*BD)$$

Soil layers with low storage volumes have high leaching potentials not only because percolation is greater, but also because storage volume displacement is greater (higher concentration). Pesticides with low KD values and high solubility are transported rapidly with water. Conversely, high KD value pesticides are adsorbed to soil particles and travel largely with sediment.

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