EPIC USERS GUIDE
v. 0509

by

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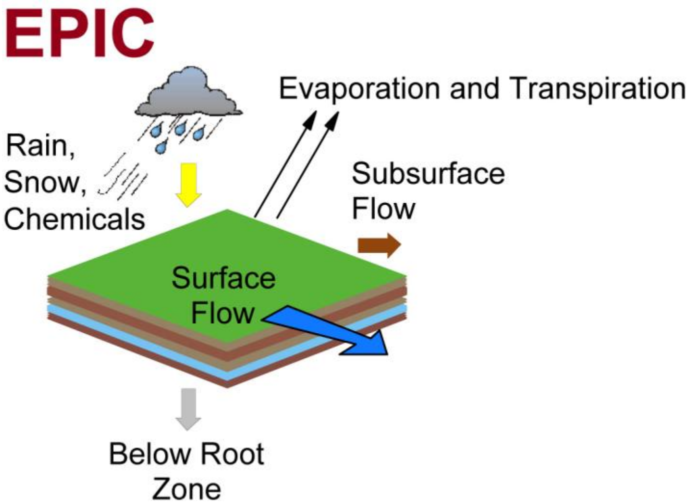
EPIC Fact Sheet
Environment Policy Impact Calculator



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Model Objective: Assess the effect of soil erosion on productivity. Predict the effects of management decisions on soil, water, nutrient and pesticide movements and their combined impact on soil loss, water quality and crop yields for areas with homogeneous soils and management.

Model Components:
Weather, surface runoff, return flow, percolation, ET, lateral subsurface flow and snow melt. Water erosion; Wind erosion; N & P loss in runoff , nitrogen leaching; Organic N & P transport by sediment; N & P mineralization, immobilization and uptake; Denitrification; Mineral P cycling; N fixation; Pesticide fate and transport; Soil temperature; Crop growth and yield for over 80 crops; Crop rotations; Tillage, Plant environment control (drainage, irrigation, fertilization, furrow diking, liming); Economic accounting; Waste management (feed yards dairies with or without lagoons).

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.
• Weather generation is optional.
Homogeneous areas up to large fields.

Management Capabilities:

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, 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**

• Universities (Iowa State University, University of Missouri, Texas A&M

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Overview

EPIC is a compiled FORTRAN program and therefore a specific format and file structure is crucial. A **U**niversial **T**ext **I**ntegrated **L**anguage (UTIL) has been developed to support EPIC and help the user to create his or her own data sets. Pressing the F1 key within UTIL provide additional information on each single input variable in EPIC.

Most recent developments in EPIC0509 include:

- Wind dust distribution from feedlots.
- Manure erosion from feedlots and grazing fields.
- Optional pipe and crack flow in soil due to tree root growth.
- Extend lagoon pumping and manure scraping options.
- Enhanced burning operation.
- Various slope length/steepness factor estimations.
- Carbon pools and transformation equations similar to those in the Century model.

Each EPIC run may involve individual EPIC type simulations on separate parcels of land, with the drainage relationships between the parcels specified defined here:

- An EPIC study may involve simulations for several ***sites***, each site being a farm, watershed, etc., and each site having an assigned weather station.
- Multiple ***runs*** may be defined for each ***site***, with alternative ***weather***, ***soil***, or ***field*** operation schedule data sets specified for each, e.g, run #1 might have field of corn and soybeans, while run #2 splits field into two sub-areas by defining edge-of-field buffer strip as 2nd sub-area.

The data and file structure for EPIC0509 have been changed from previous versions toward a more relational database type format to reduce data duplication of multiple simulation runs. Previous versions duplicated constant weather, soil, and management data in the data file for one or more runs. Now, for a given study, the site, and weather data are only entered once, in site, weather and soil files. A run definition file specifies which site and weather file are used for each run. An overview of the files and data flow is given in Figure 1. 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. The file structure and linkage are now briefly discussed.

Runs. The *EPICRUN.dat* file includes one row of data for each run. Each row of data assigns a run identification number and specifies which site, weather station, soil and tillage operation schedule file will be used for the respective run; this file can be edited with the “UTIL RUN” command. Two weather files may be specified: the weather and wind weather files. If the regular weather and wind station identification parameters are left null, EPIC will use the latitude and longitude data from the *filename.sit* file and choose a weather station, provided that the files are available and referenced in the *WPM1MO.dat* and *WINDMO.dat* files (note: in the following, where *filename.** is used, that indicates that the user may supply the file name, with the appropriate * extension; those file names must be listed appropriately in *EPICFILE.dat*).

Constant Data. The *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 with the “UTIL CONT” command.

Sites. The study may involve several sites (fields, farms, or watersheds). A file named *filename.sit* is used to describe each site and can be edited by the “UTIL SITE” command. *EPICFILE.dat* tells EPIC to look in *SITE2110.dat* (or user chosen name) to reference the numbered list of the sites and their file names. The list of site files in *SITE2110.dat* can be edited with the “UTIL SITELIST” command and *EPICFILE.dat* can be edited with the “UTIL FILE” command.

Weather. Weather stations are numbered and identified in *WPM1MO.dat* and wind data for the stations are numbered and identified in *WINDMO.dat*. *EPICFILE.dat* tells EPIC to look in *WPM1MO.dat* (or user chosen name), and *WINDMO.dat* (or user chosen name) to reference the numbered list of the weather station and their file names. The list of weather stations in *WPM1MO.dat* can be edited with the “UTIL WPMLIST” command, and the list of wind weather stations in *WINDMO.dat* can be edited with the “UTIL WINDLIST” command. A file named *filename.wp1* is used to describe each weather station statistics and can be edited by the “UTIL WPM” command. Furthermore, a file named *filename.wnd* is used to describe each wind station statistics and can be edited by the “UTIL WIND” command.

Soils. The study may involve several different soils for the farm or watershed analysis. A file named *filename.sol* is used to describe each subarea and can be edited by the “UTIL SOIL” command. *EPICFILE.dat* tells EPIC to look in *SOIL0509.dat* (or user chosen name to reference the numbered list of the soils and their file names). The list of soils can be edited with the “UTIL SOILLIST” command.

Operation Schedules. Each field or farm study is described with a unique landuse unit or operation schedule (e.g. crops and crop rotations with typical tillage operations, ponds or reservoir, farmstead with or without lagoon, etc.). Each operation schedule is in a file named *filename.ops* and may be edited with the “UTIL OPSC” command. Each operation schedule must be numbered and listed in the *OPSC0509.dat* (or user specified file), which can be edited with the “UTIL OPSCLIST” command. *EPICFILE.dat* tells EPIC to look in *OPSC0509.dat* (or user chosen name to reference the numbered list of the operation schedules and their file names.

Execution of Runs. EPIC0509 is a compiled Fortran program, which is executed by opening a DOS command prompt window, changing to the directory where the program files have been copied, and typing the command “EPIC0509”.

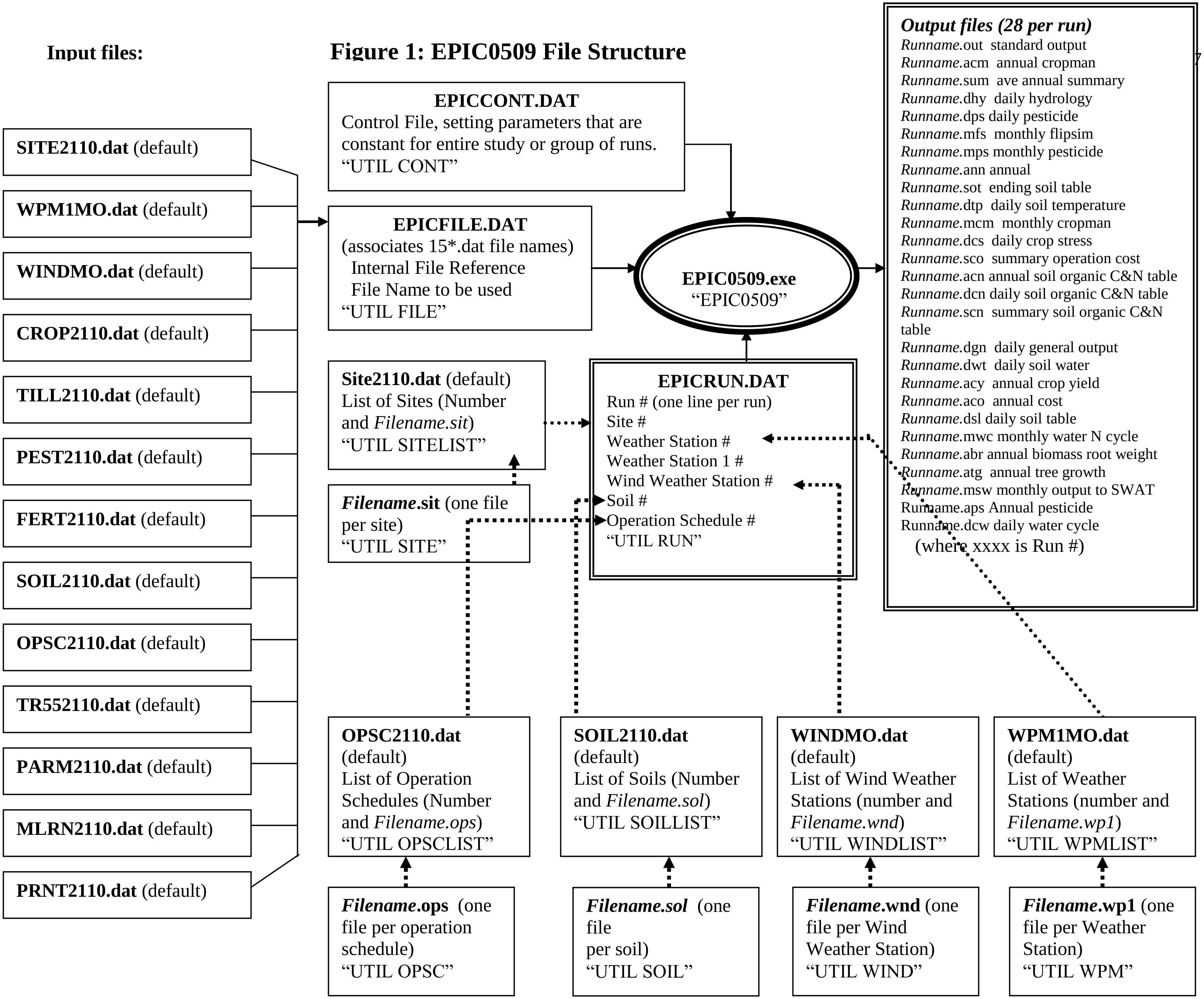

Figure 1: EPIC0509 File Structure

EDITING FILES – USING UTIL

UTIL Commands

UTIL, a **U**niversial Text **I**ntegration **L**anguage, is a data file editor that has been developed to help users of large computer models (e.g. EPIC, APEX, SWAT) and other programs (e.g. PHU-program). It is designed to edit any data file with a fixed number of variables, cells or fields and is very easy to use since it combines command-line and full-screen editing. Each variable of each field is provided with a description, the range limits for the variable and a complete interactive help file that completely explains that variable's usage (by pressing the F1 key). There may also be extra commands to load blocks of data from data base files for a particular model or application. This greatly speeds data entry in a large data file. All commands used in UTIL are designed to be entered interactively or to be stored in files (UTIL-batch files) to allow groups of commands to be executed in an unattended mode. This technique facilitates the generation of many different scenarios for use in testing computer models.
In the following several important UTIL commands are listed and explained:

Function Keys:

F1 = Interactive help and variable explanation
F2 = Analyzing variable of field
F3 = Exit UTIL and save data file
F4 = Saving data file
F5 = Line editing
F6 = UTIL statistics
F7 = UTIL auto-editing
F8 = Quit UTIL without saving data file

To start the UTIL program:

UTIL FILE EPICFILE.dat <enter>

Where:
UTIL is the command to execute the UTIL-program. FILE is the name of the driver (i.e., *.drv files) to be used by the UTIL program. The list of drivers for UTIL in EPIC include: FILE, SITELIST, SITE, WINDLIST, WIND, WPMLIST, WPM, CROP, TILL, PEST, FERT, SOILLIST, SOIL, OPSCLIST, OPSC, PARM, MLRN, and PRNT. And EPICFILE.dat is the file name to be loaded which needs to associate with the current driver name in UTIL (e.g. UTIL OPSCLIST OPSC2110.dat <enter>). The file name can be either any default names or any user specified names.

Once in UTIL, the user can use some UTIL commands in the command-line such as, LOAD *dataset.dat* <enter>, or SAVE *dataset.dat* <enter>, or even run some UTIL-batch files (usually are characterized by the file extension: *.utl). UTIL Batch files are any files, created by the user, that is a list of UTIL commands. These commands could be calculations or repetitive changes to be made to many DATASETs. This file will be opened by UTIL and each line read in as a command to UTIL. An "@" is used to distinguish the BATCH file name from a VARIABLE name in the DATASET or a UTIL command.

MASTER FILE – EPICFILE.dat

(Components of the EPIC Model)

EPIC File Name Links

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 1. 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 1: File name references for the *EPIC2110 dat* file.

Internal File Reference	**Default File Name (*.dat)**	**UTIL Editor**	**Description**
FSITE	SITE0509	SITELIST	A numbered list of sites being studied
FWPM1	WPM1MO	WPMLIST	Weather data, ordered by Weather station #
FWIND	WINDMO	WINDLIST	Wind data, ordered by Wind Weather station #
FCROP	CROP0509	CROP	Crop parameter file
FTILL	TILL0509	TILL	Parameters for various field operations (machines)
FPEST	PEST0509	PEST	Parameters of pesticides
FFERT	FERT0509	FERT	Parameters of fertilizers
FSOIL	SOIL0509	SOILLIST	List of soil data files
FOPSC	OPSC0509	OPSCLIST	List of available operation schedules
FTR55	TR550509		Data for stochastic runoff estimation
FPARM	PARM0509	PARM	Contains equation parameters to be used for the ru
FMLRN	MLRN0509	MLRN	Sets up a multi run ap
FPRNT	PRNT0509	PRNT	Controls printing of output

INPUT FILES

The input files are discussed in this section along with these supporting data files. The files include:

EPICRUN.dat – Determines the number of runs and their configuration by site file #, weather and wind stations, and subarea file #.

EPICCONT.dat – Includes input data that does not change between runs included in EPICRUN.dat.

SITE****.dat – Lists the site files to be selected in the filename.sit files. *Filename.sit – Includes Input Data that does not vary across subarea associated with the site.*

SOIL****.dat – Lists the soil files to be selected in the filename.sol files.

Filename.sol – Includes input data that characterize each soil.

OPSC****.dat – Lists the management (operations) files to select from the filename.ops files

Filename.ops – Includes input data for each grass, tree, crop or crop rotation produced in the watershed.

WPM1MO.dat – Lists the weather station files to select from the filename.wp1 files.

Filename.wp1 – Includes weather input data characteristics of each weather station.

WINDMO.dat – Lists the wind station files to select from the filename.wnd files.

Filename.wnd – Includes wind input data characteristic of each wind station.

TILL****.dat – Includes tillage input data by machine.
CROP****.dat – Includes crop input data for 47 parameters.
FERT****.dat – Includes fertilizer input data by nutrient (note that some commercial fertilizers have potassium in the mix but EPIC does not utilize K20 in the simulated nutrient uptake/yield relationship.
MLRN****.dat – Includes the option of selecting consecutive weather needs and water erosion without reloading the inputs.
PARM****.dat – Includes numerous model parameters.
PRNT****.dat – Includes the control data for printing select output variables in the sections of the EPIC****.out file and 19 other summary files.

EPICRUN.DAT
(EPIC Run file)

When EPIC is executed, each row in the *EPICRUN.dat* file is read to determine the configuration of the runs to be made (one row per run). Definitions of old runs can be kept at the end of the file, if preceded by a blank line. Table 2 shows the structure of the *EPICRUN.dat* file.

Table 2: Definition of the *EPICRUN.dat* file.

Column	Variable	Description
1	ASTN	Run name and/or # (provides a unique id for each run so that output files are not written over) (col. 1-8)
2	ISIT	Site #, must be one of the sites listed in the file assigned to FSITE. (col. 9-12)
3	IWP1	Weather station # , must be one of the stations in the file assigned to FWPM1; if left blank, EPIC will use the lat and long from ISIT to choose a station. (col. 13-16)
4	IWP5	Weather station # , must be one of the stations in the file assigned to FWPM1; if left blank, EPIC will use the lat and long from ISIT to choose a station. (col. 17-20)
5	IWND	Wind Station #, must be one of the stations in the file assigned to FWIND; if left blank, EPIC will use the lat and long from ISIT to choose a station. (col. 21-24)
6	INPS	Soil #, must be one of the soils listed in the file assigned to FSOIL . (col. 25-28)
7	IOPS	Operations Schedule #, must be one of the schedules in the file assigned to FOPSC. (col. 29-32)

EPICCONT.dat
(The EPIC Control File)

One file, **EPICCONT.DAT**, includes a variety of data parameters that will be held constant for all of the runs defined in the EPICRUN.dat. **EPICCONT.DAT** includes the following data elements and is edited using the "UTIL CONT" command:

line 1:

1	NBYR	=	Number of years of simulation (col. 1-4)
2	IYR0	=	Beginning year of simulation (col. 5-8)
3	IMO0	=	Month simulation begins (col. 9-12)
4	IDA0	=	Day of month simulation be (col. 13-16)
5a	NIPD	=	The printout interval, i.e., annually, every month, every year, daily, etc., e.g., enter a 5 if interval is every 5 days, months, or years(col. 17-19)
5b	IPD	=	Controls printing (col. 20) 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 N year interval N=0 same as N=1 except N=0 prints operations
6	NGN	=	ID number of weather variables input (col. 21-24) rain = 1, temp = 2, RAD = 3, wind speed = 4, Rel HUM = 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 Note: if MLRN****.dat is activated with years>0, then NGN must be equal to 0 for measured weather to be actually simulated in MLRN****.dat.
7	IGN	=	number of times random number generator cycles before simulations starts. (col. 25-28)
8	IGS0	=	determines day weather generator stops generating daily weather (col. 29-32) 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.
9	LPYR	=	0 if leap year is considered, 1 if leap year is ignored (col. 33-36)
10	IET		PET method code (col. 37-40)
		=	0 (default) or 1 for Penman-Monteith (usually for windy conditions)
		=	2 for Penman
		=	3 for Priestly-Taylor
		=	4 for Hargreaves
		=	5 for Baier-Robertson
11	ISCN	=	0 for stochastic curve number estimator, > 0 for rigid curve number estimator

			(col. 41-44)
12	ITYP	=	0 for modified rational EQ peak rate estimate (col. 45-48)
		>	0 for SCS TR55 Peak Rate estimate
		=	1 for type 1 rainfall pattern
		=	2 for type 1A “
		=	3 for type 2 “
		=	4 for type 3 “
13	ISTA	=	0 for normal erosion of soil profile (col. 49-52)
		=	1 for static soil profile
14	IHUS	=	0 for normal operation (col. 53-56)
		=	1 for automatic heat unit schedule (phu must be input at planting)
15	NCOW	=	# cows
16	NVCN	=	0 variable daily CN with depth soil water weighting (col. 57-60)
		=	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)
17	INFL	=	0 for CN estimate of Q (col. 61-64)
		=	1 for Green & Ampt estimate of Q, Rain Fall Exponential Distribution, Peak
		=	Rain Fall Rate simulated
		=	2 for G&A Q, Rain Fall Exponential Distribution, Peak Rain Fall Input
			3 for G&A Q, Rain Fall uniformly Distribution, Peak RF Input
18	MSNP	<	0 for mass only no pesticide in .OUT (col. 65-68)
		=	0 for mass only pesticides in .OUT
		>	0 for pesticide & nutrient output in mass and concentration
19	LBP	=	0 for Sol P runoff estimate using GLEAMS pesticide approach (col. 69-72)
		>	0 for modified nonlinear approach
20	NSTP	=	real time day of year (col. 73-76)

line 2: (fields of 4 columns)

21	IGMX	=	# times generator seeds are initialized for a site
22	IERT	=	0 for EPIC enrichment ratio method
			1 for GLEAMS enrichment ratio method
23	ICG		Crop growth biomass conversion option
		=	0 for traditional EPIC radiation to biomass
		>	0 for new experimental water use to biomass
24	LMS	=	0 applies lime
		=	1 does not apply lime
25	ICF	=	0 uses RUSLE C factor for all erosion equations
		>	0 uses EPIC C factor for all erosion equations except RUSLE
26	ISW	=	0 field capacity/wilting point estimate Rawls method dynamic
		=	1 field capacity/wilting point estimate Baumer method dynamic
			2 field capacity/wilting point inp Rawls method dynamic
			3 field capacity/wilting point inp Baumer methold dynamic
			4 field capacity/wilting point estimate Rawls method static
			5 field capacity/wilting point estimate Baumer methold static
			6 field capacity/wilting point inp static

27	IRW	=	0 for normal runs with daily weather input
		>	0 for continuous daily weather from run to run (no rewind)
28	ICO2		Atmospheric CO2
		=	0 Constant atmospheric CO2
		>	0 Dynamic atmospheric CO2
29	ISAP	=	0 for normal run
		=	Number of runs for uncertainty sensitivity
30	IUNS	=	0 Normal run
		>	0 Number of runs for uncertainty sensitivity
31	ICOR	=	0 Normal run
		>	0 Day of year when weather correction to simulate input MO means stoop

line 3:(fields of 8 columns)

30	RFN0	=	Average concentration of nitrogen in rainfall in ppm
31	CO20	=	CO2 concentration in atmosphere in ppm
32	CNO30	=	Concentration of NO3 in irrigation water (ppm)
33	CSLT	=	Concentration of salt in irrigation water (ppm)
34	PSTX	=	pest damage scaling factor (0.0–10.) - - 0. shuts off pest damage function. pest damage function can be regulated from very mild (0.05 – 0.10) to very severe (1.0 – 10.0)
35	YWI	=	Number years of max. monthly 0.5 h rainfall record
36	BTA	=	COEF (0-1) governing wet-dry probabilities given days of rain (blank if unknown or if W/D probabilities are input)
37	EXPK	=	Parameter used to modify exponential rainfall amount distribution (blank if unknown or if standard deviation & SK CF are input)
38	FL	=	Field length (if wind erosion is to be considered)
39	FW	=	Field width (if wind erosion is to be considered)

line 4: (fields of 8 columns)

40	ANG0	=	Clockwise angle of field length from north (if wind erosion is to be considered)
41	STD0	=	Standing dead crop residue
42	UXP	=	Power Parameter of modified exponential distribution of wind speed (if wind erosion is to be considered)
43	DIAM	=	Soil Particle Diameter in micron (if wind erosion is to be considered)
44	ACW	=	Wind erosion adjustment factor
45	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)
46	EFI	=	Runoff volume / volume irrigation water applied (blank if IRR=0)
47	VIMX	=	Maximum annual irrigation volume allowed (mm)
48	ARMN	=	Minimum single application volume allowed (mm)
49	ARMX	=	Maximum single application volume allowed (mm)

line 5: (fields of 8 columns)

50	BFT0	=	Auto fertilizer trigger – 2 options 1. plant N stress factor (0-1) 2. soil N concentration in root zone (g/t)
51	FNP	=	Fertilizer application variable – 2 meanings 1. application rate auto/fixed (kg/ha) 2. manure input to lagoon (kg/cow/day)
52	FMX	=	Maximum annual N fertililzer application for a crop (kg/ha)
53	DRT	=	Time required for drainage system to reduce plant stress (days)
54	FDS0	=	Furrow dike safety factor (0-1.)
55	PEC	=	Conservation practice factor (=0.0 eliminates water erosion)
56	VLGN	=	Lagoon volume ratio - normal / maximum
57	COWW	=	Lagoon input from wash water (mm)
58	DDLG	=	Time to reduce lagoon storage from maximum to normal (days)
59	SOLQ	=	Ratio liquid/total manure applied

line 6: (fields of 8 columns)

60	GZLM	=	Above ground plant material grazing limit (t/ha)
61	FFED	=	Fraction of time herd is in feeding area
62	DRV		specifies water erosion driving equation
		=	0 MUST theoretical
		=	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
63	BUS(1)	=	MUSI input YSD(6) = BUS(1)*QD**BUS(2)*QP**BUS(3)*WSA**BUS(4)*KCPLS
61	BUS(2)	=	MUSI input
62	BUS(3)	=	MUSI input
63	BUS(4)	=	MUSI input

line 7: (fields of 8 columns)

64	COIR	=	Cost of irrigation water ($/m**3)
65	COL	=	Cost of lime ($/t)
66	FULP	=	Cost of fuel ($/gal)
67	WAGE	=	Labor cost ($/ha)
68	CSTZ	=	Miscellaneous cost ($/ha)

The EPIC Site Files

A study may involve several sites (fields, farms, or watersheds), which can be listed in **SITE2110.dat** (or user chosen name)**.** The file can be called up with the UTIL command "UTIL SITELIST" and therefore available for individual changes. Each site is described and saved with *filename.sit* and can be created and edited by the "UTIL SITE" command. The *filename.sit* includes following data elements:

line 1-3: (col. 1-n)

Three title lines are available for individual site description.

line 4: (fields of 4 columns)

4	IRR	=	N = 0 applies volume input, 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	IRI	=	N day application interval for automatic irrigation
6	IFA	=	Minimum fertilizer application interval (blank for user specified)
7	IFD	=	0 without furrow dikes
		=	1 with furrow dikes
8	IDR0	=	0 no drainage
		=	Depth of drainage system (mm)
9	IDF0	=	Fertilizer # for auto fertilizer & fertigation – blank defaults to elemental N
10	MNU	=	> 0 automatic dry manure application without trigger
11	IMW	=	Minimum interval between automatic mow

line 5: (fields of 8 columns)

12	WSA	=	Watershed area (ha)
13	XLAT	=	Latitude (degree)
14	XLOG	=	Longitude (degree)
15	ELEV	=	Elevation (m)
16	UPSL	=	Upland slope length (m)
17	UPS	=	Upland slope steepness (m/m)
18	APM	=	Peak rate – EI adjustment factor (blank if unknown)
19	CHL	=	Mainstream channel length (km) (blank if unknown)
20	CHS	=	Mainstream channel slope (m/m) (blank if unknown)
21	CHN	=	Mannings N for channel (blank if unknown)

line 6: (fields of 8 columns)

22	SN	=	Surface N for channel (blank if unknown)
23	SNO0	=	Water content of snow on ground at start of simulation (mm)
24	CHD	=	Channel depth (m)
25	CO2X	=	CO2 concentration in atmosphere (ppm) – non zero value overrides CO2 input in EPICCONT.DAT

26	CNO3X	=	Concentration of NO3 in irrigation water (ppm) – non zero overrides CNO3 input in EPICCONT.DAT
27	RFNX	=	Average concentration of N in rainfall (ppm)

line 7: (col. 1 -n)

28	WTH1	=	Daily weather file name (*filename.wth*) for daily weather input

SOIL****.dat
(The Soil Files)

Data for each soil is maintained in a separate soil file, *filename.sol*, and can be edited by the "UTIL SOIL" command. In *SOIL2110.dat* (or user chosen name), each soil has to be listed, which correspond with the variable *INPS* in the subarea file. The list of soils can be edited with the "UTIL SOILLIST" command.
The *filename.sol* includes following data elements:

line 1: (columns 1-n)

General description line for soil type.

line 2: (fields of 8 columns)

2	SALB	=	soil albedo.
3	HSG	=	soil hydrologic group (1=A, 2=B, 3=C, 4=D).
4	FFC	=	Initial soil water content, fraction of field capacity (blank if unknown).
5	WTMN	=	min depth to water table in m, (blank if unknown).
6	WTMX	=	max depth to water table in m, (blank if unknown).
7	WTBL	=	initial water table height in m, (blank if unknown).
8	GWST	=	groundwater storage in mm (blank if unknown).
9	GWMX	=	maximum groundwater storage in mm (blank if unknown).
10	RFT0	=	groundwater residence time in days, (blank if unknown).
11	RFPK	=	return flow/(return flow + deep percolation), (blank if unknown).

line 3: (fields of 8 columns)

12	TSLA	=	maximum number of soil layers after splitting (3 – 10).
		=	0 no splitting occurs initially.
13	XIDP	=	soil weathering code.
		=	0 for calcareous and non-calcareous soils without weathering information.
		=	1 for non CACO3 slightly weathered.
		=	2 for non CACO3 moderately weathered.
		=	3 for non CACO3 highly weathered.
		=	4 input PSP or active + stable mineral P (kg/ha).
14	RTN0	=	number of years of cultivation at start of simulation
15	XIDK	=	1 for kaolinitic soil group.
		=	2 for mixed soil group.
		=	3 for smectitic soil group.
16	ZQT	=	minimum thickness of maximum layer (M) (splitting stops when ZQT is reached).
17	ZF	=	minimum profile thickness (M) – stops simulation.
18	ZTK	=	minimum layer thickness for beginning simulation layer. splitting – model splits first layer with thickness greater than ZTK (M); if none exists the thickest layer is split.
19	FBM	=	Fraction of Org C in biomass Pool (0.03 – 0.05)
20	FHP	=	Fraction of Org C in passive Pool (0.3 – 0.7)

from **line 4** onward, one column of data per soil layer (up to 10 layers) (fields of 8 columns)

line 4:	Z	=	Depth to bottom of layer (M)
line 5:	BD	=	Bulk Density (T/M**3)
line 6:	UW	=	Soil water content at wilting point (1500 KPA) (M/M) (blank if unknown).
line 7:	FC	=	Water content at field capacity (33 KPA) (M/M) (blank if unknown).
line 8:	SAN	=	% sand.
line 9:	SIL	=	% silt.
line 10:	WN	=	Initial organic N Concentration (G/T) (blank if unknown).
line 11:	PH	=	soil PH.
line 12:	SMB	=	sum of BASES (CMOL/KG) (blank if unknown).
line 13:	WOC	=	organic carbon concentration (%).
line 14:	CAC	=	Calcium carbonate content of soil (%), (blank if unknown).
line 15:	CEC	=	Cation exchange capacity (cmol/kg), (blank if unknown).
line 16:	ROK	=	Coarse fragment content (% vol), (blank if unknown).
line 17:	CNDS	=	Initial NO3 concentration (G/T), (blank if unknown).
line 18:	PKRZ	=	Initial labile P concentration (1) (g/t), (blank if unknown).
line 19:	RSD	=	Crop residue (t/ha), (blank if unknown).
line 20:	BDD	=	Bulk density (oven dry) (t/m**3).
line 21:	PSP	=	<= 1 Phosphorus sorption ratio > 1 Active & stable mineral P (kg/ha)
line 22:	SATC	=	Saturated conductivity (mm/h).
line 23:	HCL	=	Lateral hydraulic conductivity (mm/h), (blank if unknown).
line 24:	WPO	=	Initial organic P concentration (g/t), (blank if unknown).
line 25:	EXCK	=	Exchangeable K concentration (g/t)
line 26 :	ECND	=	Electrical condition (mmho/cm)
line 27 :	STFR	=	Fraction of storage interacting with NO3 leaching (blank if unknown)
line 28:	ST	=	Initial soil water storage (fraction of field capacity)
line 29:	CPRV	=	Fraction inflow partitioned to vertical crack or pipe flow (blank if unknown).
line 30:	CPRH	=	Fraction inflow partitioned to horizontal crack or pipe flow (blank if unknown).
line 31:	WLS	=	Structural litter (kg/ha)
line 32:	WLM	=	Metabolic litter (kg/ha)
line 33:	WLSL	=	Lignin content of structural litter (kg/ha) (BUI)
line 34:	WLSC	=	Carbon content of structural litter (kg/ha) (BUI)
line 35:	WLMC	=	Carbon content of metabolic litter (kg/ha) (BUI)
line 36:	WLSLC	=	Carbon content of lignin of structural litter (kg/ha) (BUI)
line 37:	WLSLNC	=	N content of lignin of structural litter (kg/ha) (BUI)
line 38:	WBMC	=	Carbon content of biomass (kg/ha) (BUI)
line 39:	WHSC	=	Carbon content of slow humus (kg/ha) (BUI)
line 40:	WHPC	=	Carbon content of passive humus (kg/ha) (BUI)
line 41:	WLSN	=	N content of structural litter (kg/ha) (BUI)
line 42:	WLMN	=	N content of metabolic litter (kg/ha) (BUI)
line 43:	WBMN	=	N content of biomass (kg/ha) (BUI)
line 44:	WHSN	=	N content of slow humus (kg/ha) (BUI)
line 45:	WHPN	=	N content of passive humus (kg/ha) (BUI)
line 46:	OBC	=	Observed Carbon content at end of simulation (t/ha)

OPSC****.dat
(The Operation Schedule Files)

The field operations file, typically named *filename.ops* has the following configuration (note that opv1 to opv7 variables are context specific, i.e., different meanings, and variable names, depending on type of operation row). The *filename.ops* files can be edited by "UTIL OSPC" command and have to be listed in OPSC2110.dat (or user specified name) which can be edited by "UTIL OPSCLIST" command.

line 1:		=	Description (col. 1-n)
line 2:	LUN	=	Land use number from NRCS Land Use-Hydrologic Soil Group Table (for looking up CN). (col. 1-4)
line 3:	**line-x**	=	(one line per operation):
	IYEAR	=	Year of operation. (col. 1-2)
	MON	=	Month of operation.(col. 3-4)
	DAY	=	Day of operation.(col. 5-6)
	COD	=	Tillage ID Number (from TILL2110.dat). (col. 7-9)
	TRAC	=	Tractor ID (col. 10-12)
	CRP	=	Crop ID number (from CROP2110.dat). (col. 12-14)
	XMTU	=	Time from planting to maturity (Y), (for tree crops at planting only). (col.15-18)
	LYR	=	Time from planting to harvest in years, if JX(4) is harvest operation for trees (col. 15-18 multiple field, can also be XMTU see above)
		=	Pesticide ID number from PEST2110.dat, (for pesticide application only)
		=	Fertilizer ID number from FERT2110.dat (for fertilizer application only)
	OPV1	=	Potential heat units for planting (col. 19-28 multiple fields)
		=	Application volume in mm for irrigation.
		=	Fertilizer application rate in kg/ha; = 0 for variable rate.
		=	Pest Control factor for Pest application (fraction of pests controlled).
	OPV2	=	Condition SCS Runoff Curve number, or Land Use number (optional) (col.
		=	29-36 multiple fields)
		=	Pesticide application rate in kg/ha.
			Application depth in mm for fertilizer.
	OPV3	=	Plant water stress factor (0-1); Soil water tension (>1 KPA); or plant available water deficit in root zone (-mm) to trigger auto irrigation (0. or blank does not change trigger). (col. 37-44)
	OPV4	=	Runoff vol/vol irrigation water applied. (col. 45-52)
	OPV5	=	Plant population (plants/m**2 or plants/ha if plants/m**2 < 1.; e.g. trees), (for planting only). (col. 53-60)
	OPV6	=	Max annual N fertilizer applied to a crop (0. or blank does not change FMX; >0 sets new FMS (for planting only). (col. 61-68)
	OPV7	=	Time of operation as fraction of growing season (enter earliest possible Month & day -- JX(2) & JX(3)) (col. 69-76)

HOW TO PREPARE WEATHER INPUT FILES

Historical daily weather data can be used in two ways: First, it 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 is primarily used to generate monthly weather data, which then is used to generate EPIC weather input data.
The format for historical daily weather data is explained below:

1st line	Weather file name
2nd line	Number of the years in the actual daily weather data (col.1-4) following by the beginning year. For example: 131981, which means that there is 13 years of weather data with the beginning year of 1981.
3rd line	From this line forward, every line includes nine variables. These nine variables are: Year (col.1-6). Input the beginning year in column 3) Month (col.7-10) Day (col.11-14) Solar Rad. (col.15-20) Max Temp. (col.21-26) Min Temp. (col.27-32) Precipitation (col.33-38) Relative humidity (col.39-44) Wind velocity (col.45-50)

After completing the following steps to develop the WPM1MO.DAT file, if any daily record of max. temp., min. temp., 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 WPM1MO.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 EPIC weather program (WXPM3020.exe) will read this *.txt file to create the generated 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 (WXPM3020.exe), one needs to set up WXPMRUN.DAT file. This can be done by putting the actual daily weather file name (*.dly) on the first line in WXPMRUN.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 WXPM3020.exe, each individual actual daily weather data set name has to be listed in WXPMRUN.DAT file. By doing so, the WXPM3020.exe will read all the daily weather files listed in WXPMRUN.DAT and generate all the monthly weather files. When WXPMRUN.DAT is set up, one can execute the weather generation program by typing WXPM3020 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 (WPM12110.dat). For the content of *.WP1 file, please refer to the next section of WPM1MO.dat.

WPM1MO.dat
(The Weather Files)

Monthly weather statistics of a single weather station are maintained in *filename.wp1* and can be edited by the "UTIL WPM" command. The files need to be listed in *WPM1MO.dat* (or user chosen name) and can be edited with the "UTIL WPMLIST" command.

Filename.wp1 file (lines 3 to 15 each have 12 variables, one for each month, January – December):

line 1: TITLE = Description line.
line 2: TITLE = Description line.
line 3: OBMX = Average monthly maximum air temperature (deg C)
line 4: OBMN = Average monthly minimum air temperature (deg C)
line 5: SDTMX = Monthly average standard deviation of daily maximum temperature (deg C)
line 6: SDTMN = Monthly average standard deviation of daily minimum temperature (deg C)
line 7: RMO = Average monthly precipitation (mm)
line 8: RST2 = Monthly standard deviation of daily precipitation (4,1), (mm).
(4) May be left zero if daily rainfall is input
(1) May be left zero if unknown (enter zero).
line 9: RST3 = Monthly skew coefficient for daily precipitation (4,1).
(4) May be left zero if daily rainfall is input
(1) May be left zero if unknown (enter zero).
line 10: PRW1 = Monthly probability of wet day after dry day (5,4).
(5) May be left zero if unknown and average number of days of rain per month (WVL) is available
(4) May be left zero if daily rainfall is input.
line 11: PRW2 = Monthly probability of wet day after wet day (5,4).
(5) May be left zero if unknown and average number of days of rain per month (WVL) is available.
(4) May be left zero if daily rainfall is input.
line 12: DAYP = Average number days of rain per month (6), (days).
(6) May be left zero if rainfall is generated and wet/dry probabilities are available.
line 13: WI = Monthly max 0.5h rainfall (3 options), (mm).
1. Monthly maximum .5 hour rainfall (mm) for period in YWI.
2. Alpha (Mean .5 hour rain/mean storm amount).
3. Blanks or zeros if unknown.
line 14: OBSL = Ave monthly solar radiation (MJ/M**2 or LY (Langley)), (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/M**2 here indicates you will be reading MJ/M**2.
Entering LY here indicates you will be reading LY.
MJ/m**2 = LY * .0419
(1) May be left zero if unknown.
line 15: RH = Monthly average relative humidity (fraction), (3 options).
1. Average Monthly relative humidity (Fraction, e.g. .75)
2. Average Monthly dewpoint temp (Deg C)
3. Blanks or zeros if unknown.
NOTE: Conversion using 'E' in the number for English, will convert the number entered to Deg C for dewpoint temperature.
May be left zero unless a PENMAN equation is used to estimate potential evaporation see variable IET.

WINDMO.dat
(The wind data file)

Monthly wind weather statistics of a single wind weather station is maintained in *filename.wnd* and can be edited by the "UTIL WIND" command. The files need to be listed in *WINDMO.dat* (or user chosen name), which can be edited with "UTIL WINDLIST" command. EPIC considers 16 wind directions, which are crucial if the user analysis issues of wind erosion as well as dust distribution and air quality from feedlots.

Filename.wnd file (lines 3 to 15 each have 12 variables, one for each month, January – December):

line 1:	TITLE	= Description of dataset.
line 2:	TITLE	= More description
line 3:	WVL	= Average monthly wind speed (2&7) (m/s) 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, LINE 23). Also required if Penman or Penman-Monteith equations are used to calculate potential ET (See IET, Line 4).
line 4:	DIR1	= Monthly % wind from North. May be left zero if wind erosion is not estimated.
line 5:	DIR2	= Monthly % wind from North North East. May be left zero if wind erosion is not estimated.
line 6:	DIR3	= Monthly % wind from North East. May be left zero if wind erosion is not estimated.
line 7:	DIR4	= Monthly % wind from East North East. May be left zero if wind erosion is not estimated.
line 8:	DIR5	= Monthly % wind from East. May be left zero if wind erosion is not estimated.
line 9:	DIR6	= Monthly % wind from East South East. May be left zero if wind erosion is not estimated.
line 10:	DIR7	= Monthly % wind from South East. May be left zero if wind erosion is not estimated.
line 11:	DIR8	= Monthly % wind from South South East. May be left zero if wind erosion is not estimated.
line 12:	DIR9	= Monthly % wind from South. May be left zero if wind erosion is not estimated.
line 13:	DIR10	= Monthly % wind from South South West. May be left zero if wind erosion is not estimated.
line 14:	DIR11	= Monthly % wind from South West. May be left zero if wind erosion is not estimated.
line 15:	DIR12	= Monthly % wind from West South West. May be left zero if wind erosion is not estimated.
line 16:	DIR13	= Monthly % wind from West. May be left zero if wind erosion is not estimated.
line 17:	DIR14	= Monthly % wind from West North West. May be left zero if wind erosion is not estimated.
line 18:	DIR15	= Monthly % wind from North West. May be left zero if wind erosion is not estimated.
line 19:	DIR16	= Monthly % wind from North North West. May be left zero if wind erosion is not estimated.

TILL2110.dat
(The Tillage File)

The tillage operations in TILL2110.dat include most common field management activities in agricultural land use. There are 28 parameters being used to describe each tillage operation and those parameters are all listed in a single line in TILL2110.dat file. The TILL2110.dat file can be modified with the “UTIL TILLCMN” command.

	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. (col. 1-6)
	TIL	=	Tillage operation name. (col. 7-14)
	PCD	=	Power code. (col.15-19). POWE: the machine with its own engine for power is generally used to pull other machinery or equipment, like a tractor; SELF: the machine has its own engine for power but it does the operation by itself like 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; and CUST: customized equipment.
1	PRIC		Purchase price ($) -- exception custom = cost ($/ha) (col. 20-27)
2	XLP		Initial list price in current ($) (col. 28-35)
3	HRY		Annual use (H) (col. 36-43)
4	HRL		Life of equip (H) (col. 44-51)
5	PWR		Power of unit (KW) (col. 52-59)
6	WDT		Width of pass (M) (col. 60-67)
7	SPD		Operating speed (KM/H) (col. 68-75)
8	RC1		Repair cost coef 1 (col. 76-83)
9	RC2		Repair cost coef 2 (col. 84-91)
10	XLB		Lubricant factor (col. 92-99)
11	FCM		Fuel consumption multiplier (col. 100-107)
12	VR1		Remaining farm value parm 1 (col. 108-115)
13	VR2		Remaining farm value parm 2 (col. 116-123)
14	EFM		Machine efficiency (col. 124-131)
15	RTI		Annual real interest rate ($/$) (col. 132-139)
16	EMX	=	Mixing efficiency (0-1). (col. 140-147) 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.
17	RR	=	Random surface roughness created by tillage operation in mm. (col. 148-155)
18	TLD	=	Tillage depth in mm. (col. 156-163) + Positive depth is below the surface; - Negative indicates above ground cutting height. Also used as the lower limit of grazing height (MM)
19	RHT	=	Ridge height in mm. (col. 164-171)
20	RIN	=	Ridge interval in m. (col. 172-179)
21	DKH	=	Height of furrow dikes in mm. (blank if dikes are not used) (col. 180-187)
22	DKI	=	Distance between furrow dikes in m. (blank if dikes are not used).(col. 188-195)

23 IHC = Operation Code:
-3 = Stops grazing.
-2 = Destroys furrow dikes.
-1 = Builds furrow dikes.
1 = Harvest and kill crop.
2 = Harvest without kill.
3 = Harvest once during simulation without kill.
4 = Starts grazing.
5 = Plant in rows.
6 = Plant with drill.
7 = Apply pesticide.
8 = Irrigate.
9 = Fertilize
10 = Bagging and Ties
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
*11 = Scrape manure from pens.

24 HE = Harvest efficiency (0-1), or Pesticide application efficiency.
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).

25 ORHI = Over rides simulated Harvest Index (HI) if 0. < ORHI < 1, or = grazing rate (kg/ha/d) if ORHI > 1. Near optimal harvest index values (HI) are contained in table III.1, the crop parameters. 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 table III.1 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. Values greater than 1 are KG/HA of biomass removed per day by grazing. For example, one animal/month is about the equivalent to 24 KG/Day (12 KG/DAY consumed and an equivalent amount trampled).

26 FRCP = Fraction of soil compacted (tire width/tillage width).

27 FPOP = Fraction plant population reduced by operation.

28 COTL = Tillage cost ($/ha)

CROP2110.dat
(The Crop File)

Each crop is characterized with 49 parameters, which are all put in a single line in **CROP2110.dat**. The crop-parameters **should not** be changed without consulting the model designers. The crop-parameters can be listed with the "UTIL CROPCMN" command.

	CNUM	=	Crop Number. (col. 1-4)
	CPNM **(fields of 8 columns hereafter on each line)**	=	Crop Name. (col. 5-8) A four character name to represent the crop.
1	WA	=	Biomass-Energy Ratio(CO2=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.
2	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.
3	TOPC	=	Optimal temperature for plant growth. 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.
4	TBSC	=	Minimum temperature for plant growth. 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.
5	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.
6	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.

7 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. 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.

8 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. 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.

9 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.

10 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 photosyntheically active radiation to biomass due to production of high energy products like seeds and/or translocation of N from leaves to seeds.

11 ALT = Aluminum tolerance index (1=sensitive; 5=tolerant).
Index of crop tolerance to aluminum saturation (1-5; 1=sensitive, 5=tolerant).

12 GSI = Maximum Stomatal Conductance.
The crop parameter GSI is the maximum stomatal conductance (ms-1) at high solar radiation and low vapor pressure deficit. Korner et. al (1979) reported maximum stomatal conductance values for 246 species and cultivars. (Korner, C. H., J. A. Scheel, and H. Bauer. 1979. Maximum leaf diffusive conductance in vascular plants. Photosynthetica 13(1): 45-82.)

13 CAF = Critical aeration factor.
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.

14	SDW	=	Seeding rate. Normal planting rate (kg-ha-1). Note this does not change the plant population. It only impacts seed cost and start crop biomass.
15	HMX	=	Maximum crop height in m.
16	RDMX	=	Maximum root depth in m. This effects soil moisture extraction.
17	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).
18	CNY	=	Fraction of nitrogen in yield. Normal fraction N in yield (g g-1). 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.
19	CPY	=	Fraction of phosphorus in yield. Normal fraction of P in yield (g g-1). Estimated by same procedure as CNY above.
20	CKY	=	Fraction of K in yield (g g-1)
21	WSYF	=	Lower limit of harvest index. 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.
22	PST	=	Pest (insects, weeds, and disease) factor. 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.
23	COSD	=	Seed cost ($ kg-1).
24	PRYG	=	Price for yield ($ t-1).
25	PRYF	=	Price for forage yield ($/T).
26	WCY	=	Fraction water in yield.
27	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.
28	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.
29	BN3	=	Nitrogen uptake parameter (N fraction in plant at maturity).

Normal fraction of N in crop biomass at maturity - Same as BN1.

30	BP1	=	Phosphorus uptake parameter (P fraction in plant at emergence). Normal fraction of P in crop biomass at emergence - Same as BN1.
31	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.
32	BP3	=	Phosphorus uptake parameter (P fraction in plant at maturity). Normal fraction of P in crop biomass at maturity - Same as BN1.
33	BK1	=	K uptake at emergence
34	BK2	=	K uptake at 0.5 maturity
35	BK3	=	K uptake at maturity
36	BW1	=	Wind erosion factor for standing live. 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.
37	BW2	=	Wind erosion factor for standing dead. Wind erosion factor for standing dead crop residue - Same as BW1.
38	BW3	=	Wind erosion factor for flat residue. Wind erosion factor for flat residue - Same as BW1.
39	IDC	=	Crop category number:
		=	1.0 - Warm season annual legume.
		=	2.0 - Cold season annual legume.
		=	3.0 - Perennial legume.
		=	4.0 - Warm season annual.
		=	5.0 - Cold season annual.
		=	6.0 – Perennial.
		=	7.0 - Tree crop.
			8.0 – Stripper Cotton
			9.0 – Picker Cotton
			10.0 N-fixing Tree
			NOTE: Other crop parameters (TB, TG, FRS1, FRS2) also differentiate between cold and warm climate crops.
40	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.
41	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.

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.

42 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.

43 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).

44 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).

45 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.

46 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 of the partitioning fraction relative to accumulative heat units.

47 GMHU = Heat Units required for Germination.

This delays germination from the planting date or the date at which the temperature of soil layer 2 exceed TG.

48 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

49 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.

50 STX1 = Plant population for crops and grass 2nd point

51 STX2 = Plant population for trees 1st point

52 BLG1 = Yield decreases/salinity increase (CT/HA)/MMHO/(M))

53 BLG2 = Salinity threshold (MMHO/CM)

54 WUB = Water use conversion to biomass (T/MM)

55 FTO = Fraction turnout for cotton

56 FLT = Fraction lint for cotton

Crop Number and Name in Crop1310.DAT

Crop No.	Crop Name
1 SOYB	Soybean
2 CORN	Corn
3 GRSG	Grain Sorghum
4 COTS	Stripper Cotton
5 COTP	Picker Cotton
6 PNUT	Peanut
7 SUNF	Sunflower
8 CSUN	Canadian Sunflower
9 FALW	Fallow
10 WWHT	Winter Wheat
11 SWHT	Spring Wheat
12 CSWH	Canadian Spring Wheat
13 DWHT	Durum Wheat
14 BARL	Barley
15 CBAR	Canadian Barley
16 OATS	Oats
17 COAT	Canadian Oats
18 RICE	Rice
19 RYE	Rye
20 WPEA	Winter Pea
21 LEN1	Lentil
22 LENT	Lentil
23 CAN1	Canola (Argentina)
24 CAN2	Canola (Poland)
25 FLAX	Flax
26 FPEA	Field Pea
27 MUNG	Mung Bean
28 SESB	Sesame Bean
29 CSIL	Corn Silage
30 SGHY	Sorghum Hay
31 ALFA	Alfalfa
32 CLVA	Clover (Alsike)
33 CLVR	Clover (Red)
34 CLVS	Clover (Sweet)
35 TIMO	Timothy Hay
36 RNGE	Range Grass
37 SPAS	Spring Pasture
38 WPAS	Winter Pasture
39 RYEA	Annual Rye
40 RYER	Perennial Rye
41 RYEG	Rye Grass
42 WWGR	Western Wheat Grass
43 NWGR	Northern Wheat Grass
44 SWGR	Slender Wheat Grass
45 CWGR	Crested Wheat Grass
46 BROM	Crested Brome Grass
47 BROS	Smooth Brome Grass
48 CWPS	Cow Peas
49 BERM	Bermuda Grass
50 POTA	Potato
51 POT2	Sweet Potato

Crop No.	Crop Name
53 BROC	Broccoli
54 CABG	Cabbage
55 CAUF	Cauliflower
56 CELR	Celery
57 LETT	Lettuce
58 OLET	Lettuce
59 SPIN	Spinach
60 CRRT	Carrot
61 ONIO	Onion
62 SGBT	Sugarbeet
63 GRBN	Green Beans
64 LIMA	Lima Beans
65 PEAS	Black Eyed Peas
66 CUCM	Cucumber
67 EGGP	Egg plant
68 CANT	Cantaloupe
69 HMEL	Honey Melon
70 WMEL	Water Melon
71 PEPR	Pepper
72 STRW	Strawberry
73 TOMA	Tomato
74 GRWD	Grass & Weeds
75 SCRN	Sweet Corn
76 TOBC	Tobacco
77 SUGC	Sugar Cane
78 FESC	Fescue grass
79 PMIL	Pearl Millet
80 PINE	Pine tree
81 MESQ	Mesquite tree
82 APPL	Apple tree
83 SGUM	Sweet Gum tree
84 POPL	Poplar tree
85 SWCH	Switchgrass
86 LBST	Little Bluestem grass
87 SOAT	Sideoats Grama grass
88 GRMA	Grama grass
89 BUFF	Buffalo grass
90 BAHG	Bahia grass
91 BUWH	Buckwheat
92 PRMI	Proso Millet
93 COCB	Cocklebur
94 SEBK	Sea buckthorn
95 LOCT	Locus tree
96 MQBH	Mesquite bush

FERT2110.dat
(The Fertilizer File)

The fertilizer file, **FERT2110.dat**, includes most common fertilizers and/or other nutrient materials used in agricultural management, one row per material. The FERT2110.dat file can be modified with the “UTIL FERT” command.

line 1:

1	FTNM	=	Fertilizer name.
2	FN	=	Mineral N fraction.
3	FP	=	Mineral P fraction
4	FK	=	Mineral K fraction
5	FNO	=	Organic N fraction
6	FPO	=	Organic P fraction
7	FNH3	=	Ammonia N fraction
8	FOC	=	Organic C fraction
9	FSLT	=	Salt fraction
10	FCST	=	Cost of fertilizer

PEST2110.DAT
(The Pesticide File)

The pesticide file, **PEST2110.dat**, includes most common pesticides in agricultural management. The PEST2110.dat file can be modified with the “UTIL PEST” command, one row of data per pesticide.

line 1:

1	PSTN	=	Pesticide name.
2	PSOL	=	Pesticide solubility in ppm.
3	PHLS	=	Pesticide half life in soil in days.
4	PHLF	=	Pesticide half life in foliage in days.
5	PWOF	=	Pesticide wash off fraction.
6	PKOC	=	Pesticide organic C absorption coefficient.
7	PCST	=	Pesticide cost in $/KG.

MLRN2110.dat
(The EPIC Multi-Run File)

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. The **MLRN2110.dat** file can be edited with the "UTIL MLRN" command, one row or data per run.

1 nbyr = Number of years for second through the last simulation
2 I1 = 0 for normal erosion of soil profile
= 1 for static soil profile erosion control practice factor
3 I2 = Output
0) for annual atershed output
1) annual output
2) annual with soil table
3) monthly
4) monthly with soil table
5) monthly with soil table at harvest
6) for n days interval
7) for soil table only n day interval
8) for soilo table only during growing season N day interval
9) for N day interval during growing season
4 N2 = ID number pf weather variables input. Rain =1, Temp = 2, Rad. = 3, Wind Speed = 4, Rel. Hum. = 5

PARM0509.dat
(The EPIC Parm File)

The **PARM0509.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 consulting the model designer first. The user has the possibility of getting more information on each coefficient by using the ―UTIL PARM ‖ command and the F1 help key (See Output and Summary Files below). This file contains definitions of s-curve and miscellaneous parameters used in EPIC0509.

S-curve parameters
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 parm2110.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 $y=x/[x+\exp(b_1-b_2*x)]$ where b_1 and b_2 are the EPIC determined parameters.

S-CURVE PARAMETER DEFINITIONS:

SCRP1(1)	SCRP2(1)	**Root growth restriction by rock or coarse soil fragments**, x = % coarse fragments
SCRP1(2	SCRP2(2)	**Soil evaporation – depth**. soil evaporation as a function of soil depth . The # to the left of decimal is depth (mm), and the number to the right is fraction of soil evaporation between soil surface and specified depth.
SCRP1(3)	SCRP2(3)	**Potential harvest index.** The # to the left of decimal is % of growing season, and the number to the right is fraction of harvest index (drives potential harvest index development as a function of crop maturity).
SCRP1(4)	SCRP2(4)	**Runoff curve number**. The # to the left of the decimal is soil water content, and the number to the right is curve number. Soil water fraction taken from SCRP(25,n) to match 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 function of rainfall amount, soil texture, and soil depth. X = rainfall (mm) adjusted for soil texture and depth.
SCRP1(7)	SCRP2(7)	**Aeration stress – root growth**. The # to the left of decimal is % of soil water storage volume between critical aeration factor and saturation, and the number to the right is % reduction in root growth caused by aeration stress. Determines the root growth aeration stress factor as a function of soil water content and the critical aeration factor for the crop.
SCRP1(8)	SCRP2(8)	**N or P deficiency stress – based on plant N or P content**. The # to the left of decimal is % of difference between plant N or P content ratios (ratio of actual potential N or P content). The number to the right is the N or P stress factor (=0.0 when N or P ratio = 0.5; = 1.0 when N or P ratio = 1). Determines the plant stress caused by N or P deficiency.

SCRP1(9)	SCRP2(9)	**Pest damage – temp, water, cover**. The # to the left of the decimal is average daily minimum temperature adjusted for soil cover and 30 day antecedent rainfall minus runoff. The number to the right is crop yield reduction by pests expressed as a fractional of the difference between 1.0 and the minimum pest factor (PST crop parameter). Calculates the pest damage factor as a function of temperature, considering thresholds for 30-day rainfall and above ground plant material
SCRP1(10)	SCRP2(10	**Harvest Index – Plant Water Use**. The number to the left of the decimal is the % of actual to potential plant water use during the growing season. The # to the right is the fraction of actual to potential harvest index. Calculates the effect of water stress on harvest index as a function of plant water use.
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)	**N volatilization,** as a function of NH3 depth in soil. The # to the left of the decimal is depth at the center of soil layer (mm) and the number to the right is the N volatilization in (kg/ha). Governs n volatilization as a function of soil depth.
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, and C3 are coefficients, BIOM is above ground biomass, STD is standing dead plant residue, and RSD is flat residue. The # to the left of decimal is vegetative equivalent in (T/ha) and the number to the right is wind erosion cover factor (fraction).
SCRP1(14)	SCRP2(14)	Calculates **soil temperature factor used in regulating microbial processes**. X = soil temperature(C). The # to the left of the decimal is soil temperature and the number to the right is factor (fraction).
SCRP1(15)	SCRP2(15)	**Plant population in water erosion C-factor**. The # to the left is plant population in plants per m2 or plants per ha for trees and the number to the right is the water erosion cover factor (fraction).
SCRP1(16)	SCRP2(16)	Increases snow melt as a function of time since the fall. X = time since the last snowfall (days).
SCRP1(17)	SCRP2(17)	Estimates the snow cover factor as a function of snow present. X = snow present (mm H2O).
SCRP1(18)	SCRP2(18)	Expresses soil temperature effect on erosion of frozen soils. X = temperature of second soil layer (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 tension. X = gravimetric + osmotic tension.
SCRP1(22)	SCRP2(22)	Governs plant temperature stress as a function of daily average air temperature – crop base temperature. X=(TX-TB)/(TO-TB).
SCRP1(23)	SCRP2(23)	Estimates fraction plant ground cover as a function of LAI. X=LAI.
SCRP1(24)	SCRP2(24)	Not used.
SCRP1(25)	SCRP2(25)	**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 porosity – field capacity.

PARM(n)	Definition, units and/or range.
1	Crop canopy-PET (1-2) factor used to adjust crop canopy resistance in the Penman-Monteith PET equation.
2	Root growth-soil strength (1-2). 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.
3	Water stress-harvest index (0-1) sets fraction of growing season when water stress starts reducing harvest index.
4	Denitrification rate constant (.1-2) controls denitrification rate.
5	Soil water lower limit (0-1) lower limit of water content in the top 0.5 m soil depth expressed as a fraction of the wilting point water content.
6	Winter dormancy (h) (0-1) causes dormancy in winter grown crops. Growth does not occur when day length is less than annual minimum day length + Parm(6).
7	N fixation (0-1) at 1. 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.
8	Soluble P runoff coefficient. (1*m^3/t), (10-20). P concentration in sediment divided by that of the water.
9	Pest damage moisture threshold, (mm), (25-150), previous 30-day rainfall minus runoff.
10	Pest damage cover threshold, (t/ha), (1-10), crop residue + above ground biomass.
11	Moisture required for seed germination, (mm), (0.3-0.9) germination will not occur until PDSW/FCSW>Parm(11).
12	Soil evaporation coefficient, (1.5-2.5), governs rate of soil evaporation from top 0.2 m of soil.
13	Hargreaves PET equation exponent (0.5-0.6) original value = 0.5/. Modified to 0.6 to increase PET.
14	Nitrate leaching ratio, (0.1-1), nitrate concentration in surface runoff to nitrate concentration in percolate.
15	Ground water storage loss rate (mm/day) (1-10).
16	Plow layer depth (m) (.05-.15) used to track soluble P concentration or weight.
17	Crack flow coefficient (0-1) fraction of inflow to a soil layer allowed to flow in cracks.
18	Pesticide leaching ratio (0.1-1). Pesticide concentration in surface runoff to pesticide concentration in percolate.
19	Fraction of maturity at spring growth initiation (0-1) allows fall growing crops to reset heat unit index to a value greater than 0 when passing through the minimum temperature month.
20	Microbial decay rate coefficient (0.5-1.5) adjusts soil water – temperature – oxygen equation.
21	KOC for carbon loss in water and sediment (500.-1500) KD = KOC * C.
22	K pool flow coefficient (0.00001-0.0005).
23	Exponential coefficient in RUSLE C factor equation (0.5-1.5) used in estimating the residue effect.
24	Maximum depth for biological mixing (m) (0.1-0.5).
25	Biological mixing efficiency (0.1-0.5) simulates mixing in top soil by earth worms etc.
26	Exponential coefficient in RUSLE C factor equation (0.05-0.2) used in estimating the effect of growing plants.
27	Lower limit nitrate concentration (0-10.) maintains soil nitrate concentration at or above Parm(27).
28	Acceptable plant N stress level (0-1) used to estimate annual N application rate as part of the automatic fertilizer scheme.
29	K pool flow coefficient (0.001-0.02) regulates flow between soluble and exchangeable K pools.

30	Denitrification soil-water threshold (.9-1.1) fraction of field capacity soil water storage to trigger denitrification.
31	Furrow irrigation sediment routing exponent (1-1.5) exponent of water velocity function for estimating potential sediment concentration.
32	Minimum C factor value in EPIC soil erosion equation (0.0001-0.8).
33	Puddling saturated conductivity (mm/h) (0.00001-0.1) simulates puddling in rice paddies by setting second soil layer saturated conductivity to a low value.
34	Soluble P runoff exponent modified GLEAMS method (1-1.5) makes soluble P runoff concentration a non linear function of organic P concentration in soil layer 1.
35	Water stress weighting coefficient (0-1) 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.
36	Furrow irrigation base sediment concentration (t/m**3) (0.01-0.2) potential sediment concentration when flow velocity = 1. (m/s).
37	Pest kill scaling factor (100-10000) scales pesticide kill effectiveness to magnitude of pest growth index.
38	Hargreaves PET equation coefficient (0.0023-0.0032) original value = 0.0023. modified to 0.0032 to increase PET.
39	Auto N fertilizer scaling factor (50-500) sets initial annual crop N use considering WA & BN3.
40	Crop growth climatic factor adjustment (c/mm) (40.-100.) ratio of average annual precipitation / temperature Parm(40) = 0. or irrigation > 0 – CLF = 1.
41	Soil evaporation-cover coefficient (0.01-0.2) regulates soil water evaporation as a function of soil cover by flat and standing residue and growing biomass.
42	NRCS curve number index coefficient (.5-1.5) regulates the effect of PET in driving the NRCS curve number retention parameter.
43	Upward movement of soluble P by evaporation coefficient (1.-20.).
44	Ratio of soluble C concentration in runoff to percolate (0.1-1.).
45	Coefficient in century equation allocating slow to passive humus (0.001-0.05) original value = 0.003.
46	Auto fertilizer weighting factor (0.0-1.0) 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.
47	Century slow humus transformation rate (D**-1) (0.00041-0.00068) original value = 0.000548.
48	Century passive humus transformation rate (D**-1) (0.0000082-0.000015) original value = 0.000012.
49	Fraction of above ground plant material burned (0-1.) burning operation destroys specified fraction of above ground biomass, and standing and flat residue.
50	Technology coefficient (0.0-0.01) linear adjustment to harvest index – base year = 2000.
51	Coefficient adjusts microbial activity function in top soil layer (0.1-1.).
52	Exponential coefficient in equation expressing tillage effect on residue decay rate (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 (2.5-7.5).
55	Coefficient used in allocating root growth between two functions (0.0-1.0) – 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.
56	Exponential coefficient in root growth distribution by depth function (5.-10.).

57	N volatilization coefficient (0.05-0.5) fraction of potential nitrification + volatilization allocated to volatilization.
58	Runoff amount to delay pest application (mm) (0.0-25.0) pesticide is not applied on days with runoff greater than Parm(58).
59	Soil water value to delay tillage (0.0-1.0) tillage delayed when PDSW/FCSW>Parm(59).
60	Exponential coefficient in EPIC soil erosion C factor equation (0.5-2.) relates C factor to soil cover by flat and standing residue and growing biomass.
61	Weighting factor for estimating soil evaporation (0-1.) 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.
62	Exponential coefficient regulates upward N movement by evaporation (0.2-2.) increasing Parm(62) increases upward N movement.
63	Upper limit of N concentration in percolating water (ppm) (100.-10000).
64	Upper limit of nitrification-volatilization as a fraction of NH3 present (0.-1.).
65	Reduces NRCS runoff CN retention parm for frozen soil Fraction of S frozen soil (0.05-0.5).
66	Converts standing dead residue to flat residue. Daily fall rate as a fraction of STL (0.0001-0.05).
67	Wind erosion threshold wind speed (4.0-10.0) normal value = 6.0.
68	N fixation upper limit (kg/ha/d) (1.0-30.0). traditional value = 20.0.
69	Heat unit adjustment at harvest (0.0-1.0) replaces setting back to 0.0 or to a fraction set by harvest index.
70	Power of change in day length component of LAI growth equation (1.0-10.) traditional value = 3.0. Causes faster growth in spring and slower growth in fall.
71	RUSLE 2 transport capacity parameter (0.001-0.1) Regulates deposition as a function of particle size and flow rate.
72	RUSLE 2 Threshold transport capacity coefficient (1.0-10.0) Adjusts threshold (flow rate * slope steepness)
73	Upper limit of curve number retention parameter S (1.0-2.0)
74	Penman-Monteith adjustment factor (0.5-1.5) Adjusts PM PET estimates
75	Runoff CN residue adjustment parameter (0.0-0.3) Increases runoff for RSD<1.0 t/ha; decreases for RSD>1.0
76	Harvest index adjustment for fruit and nut trees (100-1500) Reduces yield when crop available soil water is less than Parm (76)

PRNT2110.dat
(The Print File)

The file PRNT2110.DAT controls printing of output (see also IPD in EPICCONT.DAT): The PRNT2110.dat can be edited with the "UTIL PRNT" command. The user can select output variables from the list in or by pressing the F1 key in UTIL. The simulated output and summary files are numerous and some output variables are repeated in several files (see KFL below).

line 1-3: KA = output variable ID for accumulated and average values. Select up to 60 items from table below (See Table 3 in next page) (right justified, 4 spaces each, 20 per line). A standard list of output variables includes 97 variables (Table 3).

line 4: JC = output variable ID no (concentration variables). Select up to 4 variables from table below, e.g.:
38 QN N03 loss in runoff
39 SSFN = NO3 in subsurface flow
40 PRKN = NO3 leaching
47 QP = P Loss with sediment

line 5-6: KS = output variable id (monthly state variables). Select up to 17 variables from this list (input number):

1 ZNMA = mineral N in NH3 form in root zone (kg/ha)
2 ZNMN = mineral N in NO3 form in root zone (kg/ha)
3 ZPML = mineral P in labile form in root zone (kg/ha)
4 UNM = plant N uptake (kg/ha)
5 UPM = plant P uptake (kg/ha)
6 RZSW = soil water content in root zone (mm)
7 WTBL = water table depth (m)
8 GWST = ground water storage (mm)
9 STDO = standing dead plant residue from old crops (t/ha)
10 RSD = crop residue on the soil surface and below (t/ha)
11 RSVQ = reservoir storage (mm)
12 RSVY = sediment contained in reservoir (t/ha)
13 RSSA = reservoir surface area (ha)
14 SWLT = water content of surface litter (mm)
15 SNO = water content of snow (mm)
16 RSDM = manure present on soil surface and below (t/ha)
17 GWSN = N contained in ground water (kg/ha)

line 7-8: KD = output variable ID (daily output variables). Select variables from the standard table below (up to 40 variables, 4 spaces each, 20 per row);

line 9-10: KYA = annual output variable ID (accumulated and average values). Select variables from the standard table below (up to 40 variables):

Line 11-12	KFS	=	Monthly flipsim variables; select from the average list above (up to 40 variables)
Line 13-14	KFL	=	0 gives no output, KFL > 0 gives output for selected files; there are 26 possible output files, this line has 20 variable spaces, 4 characters long. So for a desired file, enter a 1, right justified, 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 file # 1, 9, 16, and 20 from the following file list.

Files names are *runname*.* where *runname* refers to run # (ASTN) and * takes on file name ext.

1 OUT = STANDARD OUTPUT FILE
2 ACM = ANNUAL CROPMAN
3 SUM = AVERAGE ANNUAL SUMMARY
4 DHY = DAILY HYDROLOGY
5 DPS = DAILY PESTICIDE
6 MFS = MONTHLY FLIPSIM
7 MPS = MONTHLY PESTICIDE
8 ANN = ANNUAL
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 = SUMMARY SOIL ORGANIC C & N TABLE
17 DGN = DAILY GENERAL OUTPUT
18 DWT = DAILY SOIL WATER IN CONTROL SECTION AND .5M SOIL TABLE
19 ACY = ANNUAL CROP YIELD
20 ACO = ANNUAL COST
21 DSL = DAILY SOIL TABLE
22 MWC = MONTLY WATER CYCLE + N CYCLE
23 ABR = ANNUAL BIOMASS ROOT WEIGHT
24 ATG = ANNUAL TREE GROWTH
25 MSW = MONTLY OUTPUT TO SWAT
26 APS = ANNUAL PESTICIDE
27 DWC = DAILY WATER CYCLE
28 RUN0509.SUM = AVERAGE ANNUAL SUMMARY FILE FOR ALL SIMULATIONS IN A BATCH.
31 ANNUAL FILES FOR GIS

.ABR ANNUAL BIOMASS ROOT WEIGHT VARIABLE DEFINITIONS

Y = YEAR
Y# = YEAR SEQUENCE
M = MONTH
D = DAY
CROP = CROP NAME
BIOM = BIOMASS (T/HA)
REPEATED 10 TIMES FOR 10 SOIL LAYERS DEPTH = DEPTH OF SOIL LAYER (MM)
RWT = ROOT WEIGHT (T/HA) IN LAYER
TOT = TOTAL ROOT WEIGHT (T/HA)

.ACM ANNUAL CROPMAN VARIABLE DEFINITIONS

YR = YEAR DATE
RT# = ROTATION NUMBER
PRCP = PRECIPITATION (MM)
PET = POTENTIAL EVAPOTRANSPIRATION (MM)
ET = EVAPOTRANSPIRATION (MM)
Q = RUNOFF (MM)
SSF = SUBSURFACE FLOW (MM)
PRK = PERCOLATION (MM)
CVF = MUSLE CROP COVER FACTOR
MUSS = WATER EROSION (MUSS) (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 VOLITILIZATION (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 (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 C AND N TABLE VARIABLE DEFINITIONS

DEPTH (M)
BD33KPA = BULK DENSITY (T/M3)
SAND (%)
SILT (%)
CLAY (%)
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 DEFINITIONS

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 ($)
COOP = OPERATION COST ($)
MTCO = COST OF FERTILIZER OR PESTICIDE OPERATION ($)
MASS = MASS OF FERTILIZER OR PESTICIDE APPLIED (KG/HA)

.ACY ANNUAL CROP YIELD VARIABLE DEFINITIONS

YEAR
RT# = FERTILIZER ID
CPNM = CROP NAME
YLDG = GRAIN YIELD (T/HA)
YLDF = FORAGE YIELD (T/HA)
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)
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
NS = NITROGEN STRESS DAYS
PS = PHOSPHORUS STRESS DAYS
KS = POTASSIUM STRESS DAYS
TS = TEMPERATURE STRESS DAYS
AS = AERATION STRESS DAYS
SS = SALINITY STRESS FACTOR
PPOP = PLANT POPULATION (PLANTS/M)
IPLD = PLANTING DATE
IGMD = GERMINATION DATE
IHVD = HARVEST DATE
PSTN = PESTICIDE NAME
APRT = PESTICIDE APPLICATION RATE (G/HA)

.ANN ANNUAL VARIABLE DEFINITIONS

RUN
YR = YEAR
AP15 = LABILE P CONCENTRATION IN TOP SOIL TO A DEPTH SET BY PARM (16) (PPM)
PRCP = PERCIPITATION (MM)
Q = RUNOFF (MM)
MUST = WATER EROSION (MUST) (T/HA)
MUSI = WATER EROSION (MUSI) (T/HA)
SSF = SUBSURFACE FLOW (MM)
PRK = PERCOLATION (MM)
YOC = CARBON LOSS WITH SEDIMENT (KG/HA)

.APS ANNUAL PESTICIDE VARIABLE DEFINITIONS

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 DEFINITIONS

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 C AND N TABLE VARIABLE DEFINITIONS

YEAR
MONTH
DAY
TABLE WITH THE FOLLOWING VARIABLE LINES AND 11 ACROSS CONSISTING OF 10 SOIL LAYERS AND A TOTAL:
DEPTH (M)
SW = SOIL WATER (M/M)
TEMP = SOIL TEMPERATURE (C)
RSD = CROP RESIDUE (T/HA)
CO2 LOSS (KG/HA)
NET MN = NET MINERALIZATION (KG/HA)

.DCS DAILY CROP STRESS VARIABLE DEFINITIONS

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 DEFINITIONS

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 = INITITAL LABILE P CONCENTRATION (G/HA)
SS03 = NITRATE IN LATERAL SUBSURFACE FLOW (KG/HA)
HUI = HARVEST INDEX
BIOM = BIOMASS (T/HA)
YLDF = FORAGE YIELD (T/HA)

UNO3 = NITROGEN UPTAKE BY THE CROP (KG/HA)

.DHY DAILY HYDROLOGY VARIABLE DEFINITIONS

Y = YEAR
M = MONTH
D = DAY
CN = CURVE NUMBER
RAIN (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 PESICIDE VARIABLE DEFINITIONS

Y = YEAR DATE
M = MONTH DATE
D = DAY DATE
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 DEFINITIONS

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 .5M SOIL TABLE VARIABLE DEFINTIONS

Y# = YEAR SEQUENCE
Y = YEAR
M = MONTH
D = DAY
SW1 =
SW2 =
TMP = SOIL TEMPERATURE AT .5 METERS

.MCM MONTHLY CROPMAN VARIABLE DEFINTIONS

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 = EVAPOTRANSPORATION (MM)
Q = RUNOFF (MM)
PRK = PERCOLATION (MM)
SSF = SUBSURFACE FLOW (MM)

.MFS MONTHLY FLIPSIM VARIABLE DEFINTIONS

Y = YEAR
M = MONTH
RT# =
PRCP = PRECIPITATION (MM)
PET = POTENTIAL EVAPOTRANSPIRATION (MM)
ET = EVAPOTRANSPIRATION (MM)
EP = PLANT EVAPORATION (MM)
Q = RUNOFF (MM)
PRK = PERCOLATION (MM)
SSF = SUBSURFACE FLOW (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)

.MSW MONTHLY OUTPUT TO SWAT VARIABLE DEFINTIONS

YR = YEAR
MO = 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 CYCLE + N CYCLE VARIABLE DEFINTIONS
Y = YEAR
M = MONTH
PRCP = PRECIPITATION (MM)
PET = POTENTIAL EVAPOTRANSPIRATION (MM)
ET = EVAPOTRANSPIRATIION (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 DEFINITIONS

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

#	Variable	Description	Unit	KA, KD, or KY	JC	KS
1	TMX	Max temperature	Deg C			
2	TMN	Min temperature	Deg C			
3	RAD	Solar radiation	MJ/m2			
4	PRCP	Rainfall	Mm			
5	SNOF	Snowfall	Mm			
6	SNOM	Snowmelt	Mm			
7	WSPD	Wind Speed	m/s			
8	RHUM	Relative Humidity	%			
9	VPD	Vapor Pres. Deficit				
10	PET	Potential ET	Mm			
11	ET	Evapotranspiration	Mm			
12	PEP	Potential plant evaporation	Mm			
13	EP	Plant evaporation	Mm			
14	Q	Runoff	Mm			
15	CN	SCS Curve Number	Mm			
16	SSF	Subsurface Flow	Mm			
17	PRK	Percolation	Mm			
18	QDRN	Drain Tile Flow	Mm			
19	IRGA	Irrigation	Mm			
20	QIN	Inflow for watertable	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 volume from a lagoon	Mm			
26	LGMI	Manure input to lagoon	Kg			
27	LGMO	Manure output from lagoon	Kg			
28	EI	Rainfall energy	t/ha			
29	CVF	MUSLE crop cover factor				
30	USLE	Water erosion (USLE)	t/ha			
31	MUSL	Water erosion (MUSL)	t/ha			
32	AOF	Onstad-Foster MUSLE	t/ha			
33	MUSS	Water erosion (MUSS)	t/ha			
34	MUST	Water erosion (MUST)	t/ha			
35	MUSI	Water erosion (MUSI)	t/ha			
36	RUSL	RUSLE soil loss estimate	t/ha			
37	RUSC	RUSLE crop cover factor				
38	WKI	NO3 loss in runoff	Kg/ha			
39	RHTT	Ridge Height	M			
40	RRUF	Surface Random Roughness				
41	RGRF	Wind erosion ridge roughness factor				
42	YW	Wind erosion	t/ha			
43	YON	N loss with sediment	Kg/ha			
44	QNO3	Nitrate loss in surface runoff	Kg/ha			

45	SSFN	N in subsurface flow	Kg/ha			
46	PRKN	N leaching	Kg/ha			
47	NMN	Humus mineralization	Kg/ha			
48	GMN	N mineralized	Kg/ha			
49	DN	Denitrification	Kg/ha			
50	NFIX	Nitrogen fixation	Kg/ha			
51	NITR	Nitrification	Kg/ha			
52	AVOL	N volatilization	Kg/ha			
53	DRNN	Nitrogen in drain tile flow	Kg/ha			
54	YP	P loss with sediment	Kg/ha			
55	QAP	Labile P loss in runoff	Kg/ha			
56	MNP	P mineralized	Kg/ha			
57	PRKP	P in percolation	Kg/ha			
58	ER	Enrichment Ratio				
59	FNO	Organic N fertilizer	Kg/ha			
60	FNO3	N fertilizer nitrate	Kg/ha			
61	FNH3	N fertilizer ammonia	Kg/ha			
62	FPO	Organic P fertilizer	Kg/ha			
63	FPL	Labile P fertilizer	Kg/ha			
64	FSK	Soluble K fertilizer rate	Kg/ha			
65	FCO	Organic C content of fertilizer	Kg/ha			
66	LIME	Lime	Kg/ha			
67	TMP	Soil temperature in 2nd layer	Deg C			
68	SW10	Soil water in top layer	Mm			
69	SLTI	Salt content of irrigation application	Kg/ha			
70	SLTQ	Salt content of runoff	Kg/ha			
71	SLTS	Salt content of lateral subsurface flow	Kg/ha			
72	SLTF	Salt content of fertilizer application	Kg/ha			
73	RSDC	Carbon content of crop residue	Kg/ha			
74	RSPC	Carbon respiration from residue decay	Kg/ha			
75	CLCH	C leached from soil profile	Kg/ha			
76	CQV	C lost with runoff	Kg/ha			
77	YOC	Carbon loss with sediment	Kg/ha			
78	YEFK	K lost with sediment	Kg/ha			
79	QSK	K lost with runoff	Kg/ha			
80	SSK	K lost with lateral subsurface flow	Kg/ha			
81	VSK	K leached from soil profile	Kg/ha			
82	SLTV	Salt leached from soil profile	Kg/ha			
83	MUSC	Not used				
84	IRDL	Irrigation water lost in delivery system	Mm			
85	HMN	Change in organic C caused by soil respiration	Kg/ha			
86	RNAD	N content of plant residue added to soil	Kg/ha			
87	NIMO	Immobilized N	Kg/ha			
88	FALF	Leaf fall from plant to soil surface	Kg/ha			

.SCN SUMMARY SOIL ORGANIC C AND N TABLE VARIABLE DEFINITIONS

15 SOIL LAYERS GOING ACROSS PLUS A TOTAL FOR THE FOLLOWING VARIABLE LINES:

(C and N units are kg/ha unless otherwise designated)

Z	soil depth (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
RSPC	carbon respiration from residue
RNMN	net N mineralization
DN03	“
HSCO	initial slow humus C pool
HSCF	final slow humus C pool
HPCO	initial passive humus C pool
HPCF	final passive humus C pool
LSCO	initial structural litter C pool
LSCF	final structural litter C pool
LMCO	initial metabolic litter C pool
LMCF	final metabolic litter C pool
BMCO	initial biomass C pool
BMCF	final biomass C pool
W0CO	initial total C pool
W0CF	final total C pool
DW0C	change in total C pool
0BCF	observed total C pool final
HSNO	initial slow humus N pool
HSNF	final slow humus N pool
HPNO	initial passive humus N pool
HPNF	final passive humus N pool
LSNO	initial structural litter N pool
LSNF	final structural litter N pool
LMNO	initial metabolic litter N pool
LMNF	final metabolic litter N pool
BMNO	initial biomass N pool
BMNF	final biomass N pool
W0NO	initial total N pool
W0NF	final total N pool
DW0N	change in total N pool
C/NO	initial C/N ratio
C/NF	final C/N ratio

.SCO SUMMARY OPERATION COST VARIABLE DEFINITIONS

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 ($)
COOP = OPERATION COST ($)
MTCO = COST OF FERTILIZER OR PESTICIDE OPERATION ($)
MASS = MASS OF FERTILIZER OR PESTICIDE APPLIED (KG/HA)

EPIC 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. CO2 = 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 CROP2110.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

1. Check nutrient and water balances for each run (look for BALANCE). They should be near 0.
2. Check water balance for the entire watershed (TOTAL WATER BALANCE).
3. 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 PARM2110.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 PARM2110.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. APEX 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) (PARM2110.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 independantly.
   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:**
1. 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.

EPIC**.out**
(The detailed simulator output file)

The EPIC****.out file is far too lengthy and detailed to discuss each line of the file. The following listing describes the major sections of the file for reference purposes:

1. Input parameters
   EPICfile.dat listing
   Run #
   Weather data
   Management data
   Crop
   Soil
   Routing Reach
   Reservoir
   Routing Scheme

2. Output
   Simulation results
   Summary

STEPS 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 MLRN2110.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 APEXCONT.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 **is** 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 CROP2110.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 indeces are near equal and the crop yield is low, increase the index value in CROP2110.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 CROP2110.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 AND SEDIMENT LOSSES

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN2110.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 apex 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 EPIC0509 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 “SUBAREA 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.

HOW TO VALIDATE RUNOFF AND SEDIMENT LOSSES

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN2110.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 apex descriptive title. Likewise, use only the second set of results given in *.man. *.asa, *.aws, *.wss, *.msw, etc. files.

TO CHECK THE ACCURACY OF SIMULATED RUNOFF/SEDIMENT LOSSES AND SEDIMENT LOSSES FOR THE WATERSHED OUTLET, open the *.aws file for the yearly simulated losses and consult your EPIC0509 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:

✓ 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 "SUBAREA 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 (handout from Jimmy Williams, 11 May 2004)

GLEAMS (Leonard et al., 1987) technology for simulating pesticide transport by runoff, percolate, soil evaporation, and sediment was added to APEX. 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:

(205) 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:

(206) 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:

(207) FP = GC*PAPE
(208) 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:

(209) WO = WOF*FP; RFV > 2.5 mm
WO = 0.0; RFV < 2.5 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:

(210) GP = GPo*exp(-0.693/HLS)
(211) 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:

(212) 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:

(213) 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:

(214) KD = PSYC/PSQC where KD is the portioning constant in m**3/t

The value of KD is computed from the equation:

(215) 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:

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

Solving equation (216) for PSQC gives:

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

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

(218) 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:

(219) 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:

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

where PSTL is the amount of pesticide leached by QT.

The average concentration during the percolation of QT is:

(221) $PSTC = PSTL/QT$

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.

(222) $P24 = PCH/PCV$

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:

(223) $PSTL = PCV*QV + PCH*QH$

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

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

$PCH = P24 * PCV$

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.

(225) $PSTY = 0.001 * PSYC * ER$

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:

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

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.